Self Evaluation

Netherlands Research School for Astronomy

2003 – 2009

Astronomical Institute Anton Pannekoek, Universiteit van Amsterdam
Kapteyn Institute, University of Groningen
Sterrewacht, Leiden University
Department of Astrophysics, Radboud University Nijmegen
Astronomical Institute, Utrecht University

Appendices

Illustration on the cover

The deepest-ever near-infrared view of the Universe taken with NASA's Hubble Space Telescope using the Wide Field Camera 3 on the Ultra Deep Field by a team involving Bouwens and Franx. The image has uncovered a primordial population of compact and ultra-blue galaxies as they were just 600 to 800 million years after the Big Bang (credit: NASA/ESA/G. Illingworth and R. Bouwens and the HUDF09 team).

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Astronomical Institute, Utrecht University

Appendices

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APPENDIX A: Organization

A1. Organization (per 1 January 2010)

NOVA Board
Prof.dr. M. van der Klis, chair, UvA
Prof.dr. P. Groot, RU
Prof.dr. J.M. van der Hulst, RuG
Prof.dr. K.H. Kuijken, UL
Prof.dr. C.U. Keller, UU

Key Researchers
Prof.dr. A. Achterberg, UU
Prof.dr. P.D. Barthel, RuG
Prof.dr. H. Falcke, RU
Prof.dr. M. Franx, UL
Prof.dr. A. Helmi, RuG
Dr. M.R. Hogerheijde, UL
Prof.dr. L.V.E. Koopmans, RuG
Prof.dr. A. de Koter, UvA, UU
Dr. S.S. Larsen, UU
Prof.dr. R.F. Peletier, RuG
Prof. dr. S.F. Portegies Zwart, UL
Prof.dr. H.J.A. Röttgering, UL
Dr. J. Schaye, UL
Prof.dr. M.C. Spaans, RuG
Prof.dr. A.G.G.M. Tielens, UL
Prof.dr. E. Tolstoy, RuG
Prof.dr. F. Verbunt, UU
Prof.dr. L.B.F.M. Waters, UvA
Prof.dr. R.A.M.J. Wijers, UvA
Dr. R.A.D. Wijnands, UvA

Coordinators research networks
Network 1: Prof.dr. M. Franx
Network 2: Prof.dr. L.B.F.M. Waters
Network 3: Prof.dr. H. Falcke

Instrument Steering Committee
Prof.dr. P. Roche, chair, Oxford, UK
Prof.dr. R. Bacon, Univ. Lyon, Fr
Ing. F. Bettonvil, UU
Dr. B. Brandl, UL
Dr. M. Casali, ESO
Prof.dr. H.J. van Langevelde, JIVE
Prof.dr. L. Kaper, UvA
Dr. G. Nelemans, RU
Prof.dr. M. Verheijen, RuG
Dr. M. de Vos, ASTRON

Education Committee
Prof.dr. L. Kaper, chair, UvA, VU
Prof.dr. P. Barthel, RuG
Dr. M. Brentjens, ASTRON
Dr. J. Hörandel, RU
Prof.dr. F.P. Israel, UL
Prof.dr. F. Verbunt, UU
Prof.dr. R. Peletier, RuG (NOVA school)
Drs. T. Coenen (PhD student), UvA
Drs. S. Jiraskova (PhD student), RU
L. Einarsen (student), UU
P. Bos (student), RuG
E. Kuiper (student), UL

Minnaert Committee (outreach)
Prof.dr. A. de Koter, chair, UvA
Prof.dr. P.D. Barthel, RuG
Prof.dr. V. Icke, UL
Dr. G. Nelemans, RU
Dr. J. Vink, UU
Dr. W. Boland, observer, NOVA

NOVA Information Center (NIC, based at UvA**)**
Drs. M. Baan (1.0 fte)
Drs. A. Lenssen (0.6 fte)
Dhr. J Vreeling (0.5 fte)

Office
Prof.dr. E.F. van Dishoeck (scientific director)
Dr. W. Boland (executive director)
C.W.M. Groen (finance and control)
J.T.Quist (management assistant, 0.6 fte)

Postal address
P.O. Box 9513
2300 RA Leiden, The Netherlands
Phone: +31 (71) 527 5835
Fax: +31 (71) 527 5743
E-mail: nova@strw.leidenuniv.nl
Web: http://www.strw.leidenuniv.nl/nova

Visitors address
J.H.Oort building
Niels Bohrweg 2
2333 CA Leiden, The Netherlands

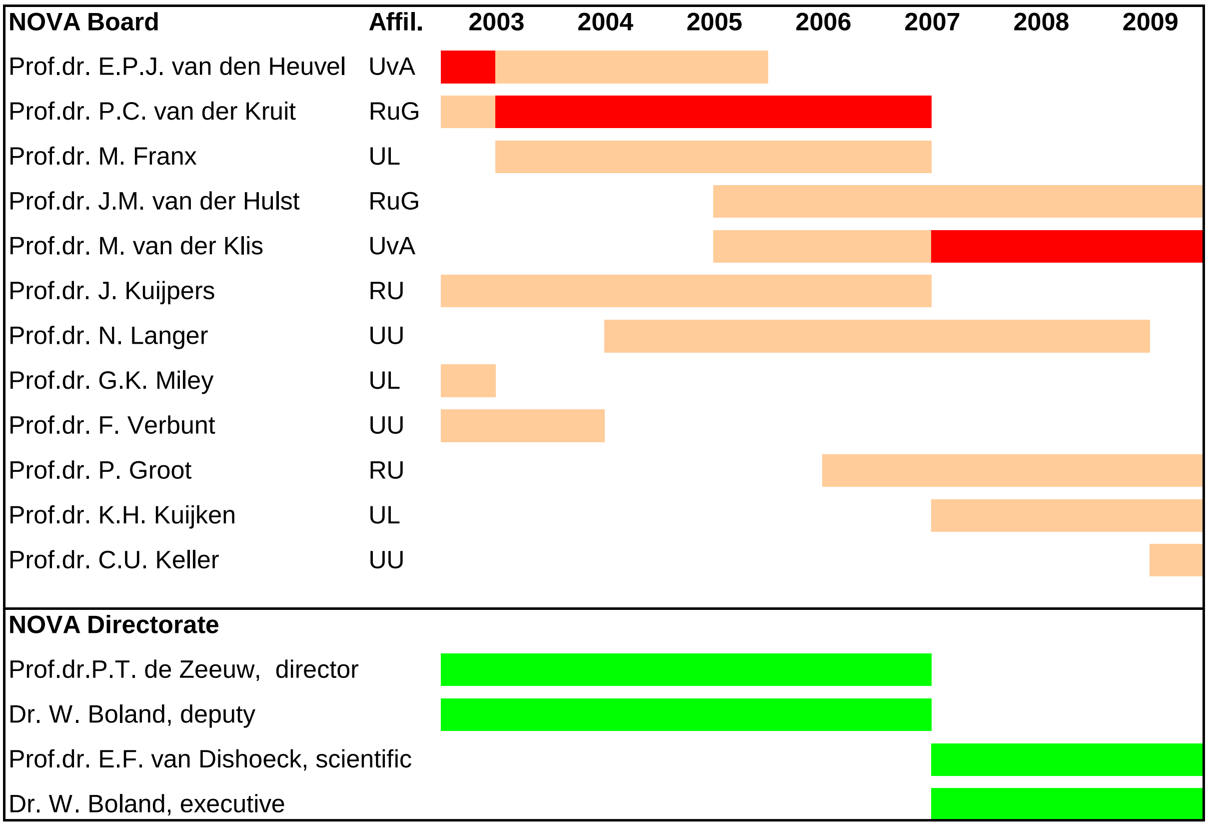
NOVA is a federation of the astronomical institutes at the universities of Amsterdam, Groningen, Leiden, Nijmegen en Utrecht, legally represented by Utrecht University.

A2. International Review Board

Prof.dr. F.H. Shu, chair, Academia Sinica Institute of Astronomy and Astrophysics, Taiwan, University of California, San Diego, USA
Prof.dr. R.D. Blandford, Stanford University, California, USA
Prof.dr. R.C. Kennicutt, University of Cambridge, UK
Prof.dr. H-W. Rix, MPIA, Heidelberg, Germany
Prof.dr. A. Sargent, Caltech, Pasadena, California, USA
Prof.dr. R.A. Sunyaev, MPA, Garching, Germany

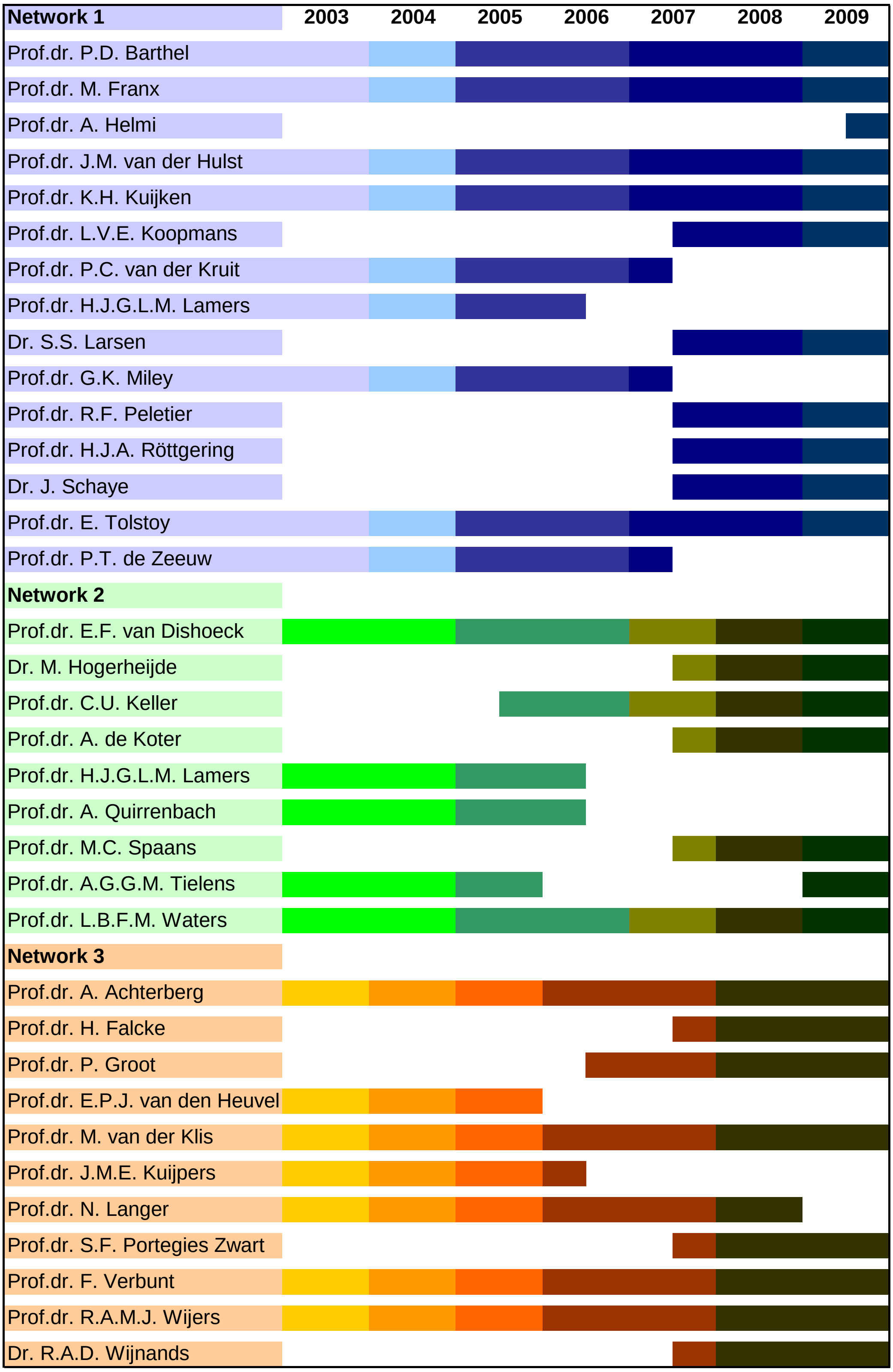
A3. Composition of the NOVA Board and Directorate for 2003-2009

The figure below lists the names of the members of the NOVA Board and Directorate. The bars indicate in which period they had these positions. Board chairs are indicated with the bright-red color of the bar.



A4. NOVA key researchers for the period 2003-2009

The figure below lists the names of the NOVA key researchers. The bars indicate in which period they had these positions.



A5. Membership NOVA Instrument Steering Committee for 2003-2009

The figure below lists the membership of the NOVA Instrument Steering Committee. The bars indicate in which period they had these positions. The chairs are indicated with the orange color of the bar.

Members	Affiliation
Prof.dr. R. Bacon	Univ Lyon
Dr. B. Brandl	UL
Dr. M. Casali	ESO
Prof.dr. L. Kaper	UvA
Dr. H.J. van Langevelde	JIVE
Dr. G. Nelemans	RU
Prof.dr. P. Roche	Oxford
Dr. M. Verheijen	RuG
Dr. M. de Vos	ASTRON
Prof.dr. W. Wild	ESO
Ing. F. Bettonvil	UU
Previous members	
Prof. dr. M.A.C. Perryman	ESA/UL
Ir. A. van Ardenne	ASTRON
Prof. dr. M. Franx	UL
Prof.dr. M.W.M. de Graauw	SRON/UL
Prof.dr. P. Groot	RU
Prof.dr. C. Keller	UU
Prof.dr. M. van der Klis	UvA
Prof.dr. K. Kuijken	UL
Prof. dr. G. Monnet	ESO
Prof.dr. A. Quirrenbach	UL/Heidelberg
Prif.dr. J.W. Pel	RuG
Dr. R.G.M. Rutten	ING, La Palma
Dr. R.J. Rutten	UU
Dr. B. Stappers	ASTRON/UvA
Prof.dr. E. Tolstoy	RuG

Abraham Achterberg

Education: University of Utrecht
M.Sc. Physics & Astronomy (cum laude) 15 01 1978
Ph.D. (cum laude) on thesis: Acceleration and propagation of high-energy particles
Advisors: M. Kuperus and J. Kuijpers 06 05 1981

Positions

Research Fellow in Theoretical Astrophysics, California Institute of Technology	01 09 1981-31 08 1983
Post Graduate Researcher, University of California, Berkeley	01 09 1983-31 08 1984
Huygens Research Fellow, NWO/Utrecht University	01 10 1984-30 09 1989
Assistant Professor, Utrecht University	01 10 1989-30 04 1998
Full Professor, Utrecht University	01 05 1998 – present

Memberships
International Astronomical Union

Other affiliations and honors
Visiting Professor, Research Institute for Theoretical Astrophysics, School of Physics, Sydney University (Sept. 1992-Dec. 1992)
Adjunct Professor, University of Amsterdam (Jan. 1995 – May 1998)
Scientific Director, Astronomical Institute Utrecht (May 1998 – Dec. 2002)

Research: High-energy astrophysics, cosmic rays, plasma astrophysics.

Publications
Authored or co-authored 50 refereed papers, 5 invited reviews, 34 conference proceedings, 10 popular articles (in Dutch) and 1 textbook (in Dutch) Total citations: 1819; h-index: 25

PhD theses supervised: 5

Current composition group: 1 graduate student

Recent Membership in National and International Committees:

Member, National Committee on Astroparticle Physics (CAN): 2004-2009

Pieter Dirk Barthel

Education: Free University of Amsterdam

B.Sc. Physics	09 1976
M.Sc. Physics and Astronomy	08 1980
University of Leiden - Ph.D., on thesis: Radio Structure in Quasars	09 1984

Advisors: H. van der Laan, G.K. Miley and R.T. Schilizzi

Positions:

Research Fellow, California Institute of Technology	09 1984 – 09 1987
Senior Research Fellow, California Institute of Technology	09 1987 – 08 1988
Senior Research Fellow, Royal Dutch Academy of Sciences	09 1988 – 08 1993
Assistant Professor, Kapteyn Astronomical Institute, Groningen	09 1993 – 08 1996
Associate Professor, Kapteyn Astronomical Institute, Groningen	09 1996 – 02 2004
Full Professor, Kapteyn Astronomical Institute, Groningen	03 2004 – present

Memberships:
Netherlands Astronomical Society
International Astronomical Union: Commissions 28, 40, 46, 47

Research:
Quasars and Active Galaxies: origin, evolution, interrelation, AGN-starburst symbiosis

Publications:
Authored or co-authored 85 refereed papers, 20 invited reviews, 100 conference papers,

Pictures of the Day, and co-editor of four books: total citations ~3500 (ADS); h-index: 31

PhD students supervised: 8

Current composition group: 2 graduate students, 1 postdoc

Recent Membership in National and International Committees:
Member, European Space/Ground Astronomy Coordination Group (ESA): 1998-2001
Member, FIRST/Herschel Scientific Evaluation Committee (ESA): 1998
Mission Scientist ESA Herschel Space Observatory: 1998- present
Member Science Team Akari (ISAS), chairman/founder Dutch Akari Consortium: 2002- present
Member/chair of eight NWO Evaluation Committees (VENI, VIDI, TopTalent): 2002- present
Member LOFAR Survey Working Group: 2004 - present
Member-at-large ESO Observing Program Committee, chair AGN Panel: 1992 - 1997
Member HST Time Allocation Committee Cycle 8, chair AGN-Physics panel: 1998
Member HST Time Allocation Committee Cycle 11 chair Extragalactic panel: 2001
Chairman High School Astronomy Education Working Group of the Neth. Astron. Soc: 1994 - 2008
Member/co-founder NOVA Minnaert Committee for Public Outreach: 1997 - present
Chairman Astronomy Teaching Committee NOVA: 1999 - 2005
Member Astronomy Teaching Committee NOVA: 2005 - present
Member National Evaluation Committee Physics/Astronomy in secondary education: 2005 - present
National representative ESA Advisory Committee on Education (ACE): 2005 - present
Co-organizer of several international meetings

Ewine Fleur van Dishoeck

Education: University of Leiden

M.Sc. Chemistry (summa cum laude)	15 01 1980
Ph.D. (cum laude) on thesis: Photodissociation and Excitation of Interstellar Molecules	
Advisors: H.J. Habing and A. Dalgarno	19 06 1984

Positions

Junior Fellow, Harvard Society of Fellows	01 07 1984 – 01 07 1987
Visiting Member, Institute for Advanced Study	01 09 1984 – 01 09 1988
Visiting Professor, Princeton University	01 07 1987 – 01 07 1988
Assistant Professor of Cosmochemistry, Caltech	06 09 1988 – 30 04 1990
Senior Lecturer, Univ. of Leiden	01 05 1990 – 31 03 1995
Professor of Molecular Astrophysics, Univ. of Leiden	01 04 1995 – present
External scientific member, Max-Planck Inst fűr Extraterrestrische Physik	01 01 2008 – present

Memberships

Royal Netherlands Academy of Sciences
Foreign Associate, US National Academy of Sciences
Foreign Honorary Member, American Academy of Arts & Sciences
Hollandse Maatschappij der Wetenschappen
Associate member, Royal Astronomical Society, UK
International Astronomical Union
Koninklijke Nederlandse Chemische Vereniging
American Astronomical Society

Other affiliations and honors

Pastoor Schmeits Prize of Dutch Astronomy, 1986; PIONIER Award, NWO, 1990; Maria Goeppert Mayer Award, American Physical Society, 1993; Gold Medal, Royal Dutch Chemical Society, 1994; Tinsley Visiting Professor, University of Texas, 1997; Bishop lecturer, Columbia University, 1998; Distinguished visitor, JILA, University of Colorado, 1999; Miller Visiting Research Professor, University of California, Berkeley, 2000; Spinoza Award, NWO, 2000; Aaronson award and lecture, University of Arizona, 2001; Bourke medal and lectureship, Royal Society of Chemistry UK, 2001; Moore distinguished scholar, California Institute of Technology, 2003; Chemerda lecturer, Penn State, 2005; Cecilia Payne-Gaposchkin lecturer, Harvard, 2005; Physica prize, Netherlands, 2005; Lindsay lecturer , Goddard, 2006; Petrie award, Canada, 2007; Grubb-Parson award lecturer, Durham, 2007; Niels Bohr lecture, Copenhagen, 2008; Spitzer lecturer, Princeton, 2009

Research: Interstellar molecules; star- and planet formation; basic molecular processes; submm/IR
Publications: Authored or co-authored 303 refereed papers, 48 invited review papers, ~300 conference contributions, 25 popular papers, and editor of 2 books; ~13700 citations (ADS); h-index: 61
PhD theses supervised: 28
Current composition group: 4 graduate students, 2 postdocs

Recent Membership in National and International Committees (selection):

Scientific Director NOVA: 2007-present
Co-editor ARA&A: 2010-present
Associate editor ARA&A: 2005-2009
Member, ALMA Board: 2006-present
Member/chair, ALMA Science Advisory Committee: 1999-2005
Chair, European ALMA Science Advisory Committee: 2003-2006
Co-PI, European JWST-MIRI Consortium: 2001-present
Member, Herschel HIFI Science Team: 1997 - present
Chair, IAU working group on Astrochemistry 1999-present
Vice-president, IAU Commission 14: 2009-present
Member, SRON Board: 2000-present
Chair, Science Advisory Committee, Faculty of Sciences, Leiden Univ.: 2003-present
Member, Fachbeirat MPIA Heidelberg: 2002-present
Member, Harvard astronomy visiting committee: 2003-present
Member, SMA advisory committee: 2005-present
co-organizer of numerous international meetings, including Chair SOC of 3 IAU Symposia

Heino Falcke

Education: University of Bonn
Physics Diploma 13 02 1992
Ph.D. (sum cum laude) on thesis: Starved Holes and Active Nuclei - the Central Engine in Galactic Centers", Advisor: Peter L. Biermann 05 07 1994
"Habilitation" and "venia legendi" at the RFW-Universität Bonn, Habilitation thesis "The Silent Majority - Jets and Radio Cores from Weakly Active Black Holes" 15 11 2000

Positions
Research assistant, RFW-Universität Bonn 1992-1994
Postdoc (Max-Planck stipend), MPIfR Bonn, (optical interferometry group, G. Weigelt) 1994-1995
Research associate, Univ. of Maryland (& STScI Baltimore), USA (Prof. A.S. Wilson (†)) 1995-1997
Postdoc, MPIfR Bonn (VLBI group, A. Zensus) 1997-1997
DFG stipend at the RFW-Universität Bonn, MPIfR guest scientist 1997-1999
Visiting professor, Dept. of Astronomy & Steward Observatory, University of Arizona 1999-1999
Scientific staff at the MPIfR Bonn (VLBI group) 2000-2001
Senior scientist at the MPIfR Bonn 2002-2003
Interim professorship, Universität zu Köln 2003-2003
senior scientist LOFAR, ASTRON & Adjunct Professor, University of Nijmegen 2003-2007
Full professor of radio astronomy and astroparticle physics, Radboud Universiteit, Nijmegen 2007-

Memberships International Astronomical Union
Deutsche Physikalische Gesellschaft
Astronomische Gesellschaft

Other affiliations and honors
2000 Ludwig-Biermann-Award, Astronomische Gesellschaft
2006 Akademiepreis (academy award), Berlin-Brandenburgischen Akademie der Wissenschaften (former Preußische Akademie der Wissenschaften)
2006 Visiting Miller Professor, UC Berkeley
2008 European Research Council (ERC) Advanced Grant
2009 Helmholtz lecturer, Humboldt-Universität zu Berlin
2009 Member NASA Lunar Science Institute (NLSI), astrophysics node

Research: theoretical astrophysics, radioastronomy, & astroparticle physics: jets & disks from stellar and supermassive black holes, Galactic Center, low-frequency radio astronomy, radio detection of ultra-high energy Cosmic Rays and neutrinos, radio transients and surveys
Publications: Authored or co-authored 284 articles (142 refereed), edited 5 books, 15 review articles, 4 popular articles, founded Galactic Center Newsletter, 6073 citations (ADS), h-index: 45
PhD theses supervised: 7
Current composition group: 3 graduate students, 5 postdocs, 2 software developers

Recent Memberships in National and International Committees (selection):
Member, science advisory group of the ESF-ESSC on ESA's Exploration programme: 2007
Member, Lunar Exploration Definition Team (LEDT) of ESA's first moon lander
Member, of the International Scientific Advisory Committee/Science Working group
Chair, SKA international SKA Outreach committee: June 2003-Nov. 2004
Co-Chair, EU FP6 network "Scientific Workshops" (within RADIONET I3 proposal): 2004-2007
LOFAR international project scientist
Chair, Committee for Astroparticle Physics in the Netherlands (CAN)
"Key Researcher" and coordinator of NOVA Network 3 (High-Energy Astrophysics): 2007-
Member and NL country representative of the AUGER collaboration
Chairperson, IAU working group "Astronomy on the Moon"
Spokesperson and member, LOPES collaboration
Member, LOFAR Technical Working Group & NL LOFAR consortium
Member and Spokesperson, LOFAR Key-Science Project "Cosmic Rays"
Member, Auger collaboration
Main organizer of four big international workshops, co-organizer/SOC 14 other workshops
58 invited or review talks at conference and workshops

Marijn Franx

Education: University of Leiden

B.Sc. Astronomy	19 05 1981
M.Sc. Astronomy (cum laude)	16 10 1984
Ph.D. Astronomy (cum laude) on thesis: Structure and Kinematics of Elliptical Galaxies Advisors: H.C. van de Hulst, G.D. Illingworth, P.T. de Zeeuw	22 09 1988

Positions:

Junior Fellow, Harvard University	01 10 1988 – 31 06 1991
Hubble Fellow, Harvard University	01 07 1991 – 31 03 1993
Full Professor of Extragalactic Astronomy, Univ. of Groningen	31 03 1993 – 31 03 1998
Full Professor of Extragalactic Astronomy, Univ. of Leiden	01 04 1998 – present

Memberships:
American Astronomical Society
International Astronomical Union
Royal Netherlands Academy of Arts and Sciences (KNAW)

Other affiliations and honors:
co-PI on University of Groningen funded grant Formation and Evolution of Galaxies
Advanced ERC grant

Research:
Formation and evolution of galaxies

Publications: Authored or co-authored 205 refereed papers, including 2 Annual Review papers. Approximately 13700 citations, h-index :71.
PhD students supervised: 13, 5 have been offered Hubble Fellowships
Current composition group: 4 graduate students, 2 postdocs

Recent Membership in National and International Committees:
Member, NWO proposal evaluation committee 2002–2005
Member, NOVA Board 2004–2007
Member, ACS Science Team 1998–2007
Member, Board of Leids Kerkhoven Bosscha Foundation 2003–
Member, VLT-MUSE Science Team 2006–
Member, JWST NIRSPEC Science Team 2004–
Member, JWST Science Working Group 2006–
Chair, ESO-ELT Science Working Group 2006–2009
Member, ESO-ELT Science and Engineering Core Working Group 2006–
Co-PI, ULTRA-VISTA survey
PI, VLT and HST large programs
Co-organizer of several international meetings

Paul Joseph Groot

Education: University of Amsterdam

M.Sc. Physics & Astronomy	27 03 1995
Ph.D. (cum laude) on thesis: Optical variability in compact sources Advisors: J. van Paradijs and R.G.M Rutten	07 12 1999

Positions

CfA Fellow, Harvard-Smithsonian Center for Astrophysics	01 10 1999 – 01 02 2002
Assistant Professor, Radboud University Nijmegen	01 02 2002 – 31 10 2003
Associate Professor, Radboud University Nijmegen	01 11 2003 – 15 10 2006
Full Professor, Radboud University Nijmegen	15 10 2006 – present

Memberships

Royal Netherlands Academy of Sciences, Young Academy (KNAW DJA)
Netherlands Astronomer's Club (NAC)
International Astronomical Union (IAU)
Netherlands Physics Society (NNV)

Other affiliations and honors

NWO VIDI award, 2002
EU Descartes Prize, 2002
Young Academy of the Royal Netherlands Academy of Sciences, 2009

Research: (Ultra) compact binaries; Galactic Surveys, Stellar/short time-scale transients.

Publications

Authored or co-authored 203 publications (90 refereed), 4024 citations (ADS), h-index: 25
PhD theses supervised: 3
Current composition group: 3 graduate students, 1 postdoc

Recent Membership in National and International Committees (selection):

Chair, Department of Astrophysics, Radboud University Nijmegen: 2006 - present
Chair, Netherlands Astronomer's Club (NAC): 2008 - present
Member, Board of NOVA: 2006 - present
Member, Netherlands Committee for Astronomy: 2006 – present
Member, Board of Inst. for Math, Astrophysics and Particle Physics, RU Nijmegen: 2006 – present
Member, NOVA Instrument Steering Committee: 2002 – 2006
Project Scientist & NL CoPI, VLT X-Shooter Spectrograph: 2005 – present
Chair, SOC/LOC First International Workshop on AM CVn stars Nijmegen: 2005
Member, SOC 'Second Internation Workshop on AM CVn stars Cape Town: 2008
Member, NWO VIDI selection committee: 2006-2007
Member, NWO Program Committee WSRT, La Palma & JCMT: 2002 – 2005, 2009 – present

Amina Helmi

Education:

M.Sc. Astronomy: University of La Plata (grade average: 9.91, max. 10) 28 09 1994
Ph.D.: University of Leiden (cum laude) on thesis: The formation of the Galactic Halo
Advisors: P.T. de Zeeuw and S.D.M. White 28 06 2000

Positions

Postdoctoral Fellow, University of La Plata	15 07 2000 – 31 12 2000
Postdoctoral Fellow, Max Planck Inst. for Astrophysics	01 01 2001 – 30 06 2002
NOVA Postdoctoral Fellow, Univ. of Utrecht	01 07 2002 – 31 08 2003
Professor of Dynamics, Structure and Evolution of the Milky Way, Univ. of Groningen	01 09 2003 – present

Memberships

The Young Academy, Royal Netherlands Academy of Sciences
International Astronomical Union

Other affliations and honors

Amelia Earhart Fellowship Award, 1995 and 1997; CJ Kok prize, University of Leiden, 2000; VIDI research grant (Innovation Scheme, NWO) 2003; Christiaan Huygens Prize, 2004; ERC Starting Grant (European Science Foundation) 2009

Research: Structure, evolution and dynamics of Local Group galaxies; dark matter

Publications

Authored or co-authored 61 refereed papers, 1 invited review paper (A&AR), ~40 conference contributions (including invited reviews and talks), 5 popular papers; ~3500 citations (ADS); h-index: 29

PhD theses supervised: 3
Current composition group: 5 graduate students, 2 postdocs

Recent Membership in National and International Committees (selection):

Member, Astronomy Working Group, ESA, 2007 – 2010
Member, ESO/ESA Working Group on the Milky Way, 2007 -2008
Member, ASTRONET European Science Vision working group, panel B (Galaxies)
Member, RAVE Executive Board
Member, ‘Chemical Tagging working group’ (Gaia Research for European Astronomy Training)
Member, Grant Assessment Committee for Astronomy, NWO: 2004-present
Co-organizer of more than ten international meetings, including SOC of 1 IAU JD and 1 IAU Symposium

Michiel Hogerheijde

Education: University of Leiden
M.Sc. Astronomy 23 11 1993
Ph.D. on thesis: The Molecular Environment of Young Stellar Objects
Advisors: E.F. Van Dishoeck and G.A. Blake 10 06 1998

Positions

Miller Research Fellow, University of California at Berkeley	01 08 1998 – 31 07 2001
Bart J. Bok Fellow, University of Arizona	15 08 2001 – 14 08 2003
Assistant professor, Leiden University	01 09 2003 – 31 12 2008
Associate professor, Leiden University	01 01 2009 – present

Memberships
Nederlandse Natuurkundige Vereniging
American Astronomical Society

Other affiliations and honors
C.J. Kok prize, Leiden 1998; Jansky Fellowship, NRAO 2003 (awarded); Clay Fellowship, Harvard-Smithsonian Center for Astrophysics 2003 (awarded)

Research: Interstellar molecules; star- and planet formation; submm/IR; radiative transfer; interferometry

Publications
Authored or co-authored 81 refereed papers, ~ 40 conferences contributions, 2 popular papers; ~1500 citations (ADS); h-index: 24
PhD theses supervised: 3
Current composition group: 2 graduate students, 3 postdocs

Recent Membership in National and International Committees (selection):
Member, ALMA Science Advisory Committee: 2007–present
Member, European ALMA Science Advisory Committee: 2006–present
Member, IRAM Programme Committee: 2007–present
Member/panel chair: ESO Observing Programme Committee: 2005, 2006
Member, ESA ASTRO-F Time Allocation Committee: 2005
Co-organizer of several international meetings

Jan Mathijs van der Hulst

Education: University Groningen M.Sc. Astronomy 23 09 1973
Ph.D. on thesis: The Distribution and Kinematics of Neutral Hydrogen in the Interacting Galaxies NGC 4038/39 and NGC 3031/77
Advisors: R.J. Allen and T.S. van Albada 04 11 1977

Positions

Research associate, National Radio Astronomy Observatory, USA	07 11 1977 – 01 12 1978
Assistant Professor, University of Minnesota	01 12 1978 – 31 05 1982
Senior researcher, Netherlands Foundation for Radio Astronomy	01 06 1982 – 31 05 1988
Associate Professor, University of Groningen	01 06 1988 – 31 03 2001
Full professor Extragalactic Radio Astronomy, University of Groningen	01 04 2001 – present
Visiting scientist, Australia Telescope National Facility	10 01 2002 – 10 07 2002

Memberships
International Astronomical Union
European Astronomical Society
American Astronomical Society
Nederlandse Astronomen Club

Research: Structure, Dynamics and Evolution of Galaxies, HI 21-cm line studies.
Publications: Authored or co-authored 126 refereed papers, ~6462 citations (ADS); h-index: 45
15 invited review papers, ~90 conference contributions, and editor of 1 book;
PhD theses (co)supervised: 17
Current composition group: 4 (shared) graduate students, 1 (shared) postdoc

Recent Membership in National and International Committees (selection)
Scientific Director Kapteyn Astronomical Institute: 2006 – present
Member, Isaac Newton Group of Telescopes Board: 2003 – 2004
Chair, Isaac Newton Group of Telescopes Board: 2004 – 2007
Observing member, ASTRON Board: 1996–2000
Member, ASTRON Board: 2002 – 2004
Chair, ASTRON Board: 2005 – 2007
Chair, European SKA consortium: 2008 – 2009
Member, European SKA consortium: 2010 – present
Member, NWO/EW Advies Commissie Astronomie (ACA): 2005 – 2007
Member, NOVA Board: 2006 - present
Member, Netherlands Committee for Astronomy: 2004 – present (vice chair since 2008)
Member, SKADS Board: 2006 – 2009
Member, PrepSKA Board: 2008 – present
Member, International Science Working Group of the SKA project: 2002 – present
Chair, SKA working group on “Galaxy Evolution”: 2002 – 2004
Member at large, Astronet Roadmap Working Group: 2007 – 2008
Member, Advisory Board Astrophysics Research Institute, John Moores Univ. Liverpool: 2010 – present
PATT La Palma Coordinating Panel: 1997-2000
PATT JCMT International Time Allocation Committee: 1996–2000
PATT ING Time Allocation Committee: 1989 – 1992
ASTRON/EW Program Committee: 1982 – 1988, 1991 – 1993, 1996 – 2000 (Chairman)
ASTRON LOFAR/WSRT Programme Committee: 2008 – present
Secretary “Landelijke Werkgemeenschap Sterrenstelsels” : 1987 – 1997
Chair, “Kamer Sterrenkunde VSNU” : 2003 – 2005
Member, “Nederlands Platform voor de Natuurkunde” : 2003 – 2005
Member, “Discipline overleg Natuurwetenschap en Techniek” : 2003 – 2005
Member, SOC Commission 40 of the IAU: 1988 – 1994
Member, SOC “Island Universes”, international conference at Terschelling: 2005
Organiser, Joint Discussion 1 “Gas Disks in Galaxies” at the IAU General Assembly: 1994
Member, SOC IAU Colloquium 171 “The Low Surface Brightness Universe” : 1998
Chair SOC JENAM 2009 Symp. “The next era in radio astronomy: LOFAR and the pathway to SKA”
CoI, ISO Short Wave Spectrometer: 1989 – 1998

Christoph U. Keller

Education: ETH Zurich, Switzerland

M.Sc. Physics	21 04 1988
Ph.D. (with medal) thesis on: High Resolution Observations of Solar Magnetic Fields	
Advisors: J.O. Stenflo	25 11 1992

Positions

Postdoc, Institute of Astronomy of ETH Zürich, Switzerland	01 12 1992 – 31 12 1993
Research Associate, National Solar Observatory, Tucson, USA	01 01 1994 – 30 06 1995
Associate Astronomer, tenure-track, National Solar Observatory	01 07 1995 – 31 08 1998
Associate Astronomer, tenured, National Solar Observatory	01 09 1998 – 30 06 2005
Adjunct Astronomer, National Solar Observatory, Tucson, USA	01 07 2005 – present
Professor of Experimental Astrophysics, Utrecht University	01 07 2005 – present

Memberships

International Astronomical Union
American Astronomical Society
American Geophysical Union
Dutch Astronomy Society
Swiss Society for Astrophysics and Astronomy
British Interplanetary Society

Other affiliations and honors

Donald E. Billings Award in Astro-Geophysics of the University of Colorado at Boulder, USA, 1992; Award and medal of ETH Zürich, Switzerland, 1993; Ludwig-Biermann-Förderpreis of the Astronomische Gesellschaft, Germany, 1994; Antarctica Service Medal of the United States of America, 1999; AURA Science Award, 2002; Friedrich Wilhelm Bessel award of the Humboldt Foundation, 2003; NASA Tech Brief Award, 2005; VICI Award, NWO, 2006

Research: Solar magnetic fields; exoplanetary systems; astronomical instrumentation; polarimetry

Publications

Authored or co-authored 44 refereed papers, 5 invited review papers, ~140 conference contributions, 1 popular paper, and editor of 1 book; 1849 citations (ADS); h-index: 19
PhD theses supervised: 5
Current composition group: 8 graduate students, 5 postdocs, 3 engineers

Recent Membership in National and International Committees (selection):

Scientific Director, Sterrenkundig Instituut Utrecht: 2009-present
Chair, Scientific Advisory Committee Kiepenheuer Institute for Solar Physics, Freiburg: 2006-present
Member, Scientific Advisory Committee Kiepenheuer Institute for Solar Physics, Freiburg: 2005-present
Member , Kiepenheuer Institute for solar Physics Foundation, Freiburg,: 2008-present
Member, Isaac Newton Group of Telescopes Board, 2008-present
Member, Executive board of the Graduate School of Natural Sciences, Utrecht University: 2009-present
Member, Editorial board of Solar Physics: 2009-present
Member, European Association for Solar Telescopes (EAST): 2007-present
Member, Scientific Committee of the Istituto Ricerche Solari Locarno, Switzerland: 2005-present
Member, Board of the Olga Koningfonds, The Netherlands: 2006-present
Member, ASTRON Board: 2006-2007
co-organizer of numerous international meetings

Michiel van der Klis

Education: University of Amsterdam

M.Sc. Astronomy	06 1979
Ph.D. on thesis: Observational Studies of X-Ray Binary Systems	
Advisors: E.P.J. van den Heuvel and J.A.M. Bleeker	02 1983

Positions

Post-doctoral Fellow, NWO	03 1983 – 08 1984
Research Fellow, European Space Agency (ESA)	09 1984 – 08 1986
Scientific staff member, EXOSAT Observatory, ESA	09 1986 – 12 1988
Associate professor, University of Amsterdam (UvA)	01 1989 – 12 1993
Full professor, University of Amsterdam	12 1993 – present
Director, Astronomical Institute Anton Pannekoek, UvA	09 2005 – present

Memberships

International Astronomical Union
International Committee on Space Research
European Astronomical Society (founding member)
American Astronomical Society
Royal Netherlands Academy of Arts and Sciences
Hollandse Maatschappij der Wetenschappen
Nederlandse Natuurkundige Vereniging
Nederlandse Astronomenclub
Kenniskring Amsterdam

Other affiliations and honors

Bruno Rossi Prize for High-Energy Astrophysics of the American Astronomical Society: 1987
Zeldovitch Award for Astrophysics from Space of the International Committee on
Space Research: 1990
Pastoor Schmeits Prize of Dutch astronomy : 1990
Pionier award, NWO, with F. Verbunt :1991
Miller Visiting Research Professor, University of California at Berkeley : 1998
Spinoza Award, NWO : 2004

Research: Neutron stars and stellar mass black holes; X-ray astronomy.
Publications
Authored or co-authored 392 refereed papers, ~50 invited reviews and ~130 conference, popular and miscellaneous papers. Editor of several conference proceedings and one reference book (w/ Lewin, 2006, 690 pp). Citations 14037 (ADS); h-index: 60.
PhD theses supervised: 22
Current composition group: 6 graduate students, 2 postdocs

Recent Memberships in National and International Committees (selection):

Chair, NOVA board: 2007-
Chair, Netherlands Committee on Astronomy (NCA – National strategy; IAU representative): 2007-.
Rossi X-Ray Timing Explorer Scientific Working Group, NASA.
Science Advisory Committee Institute for Mathematics, Astrophysics and Particle Physics, RUN
Boards of: Leids Kerkhoven-Bosscha Fonds, Jan Hendrik Oort Fonds, Leids Sterrenwacht Fonds, Stichting Jan van Paradijs, Amsterdams Fonds Astronomie
Receiving Editor, New Astronomy
Reviewing Editor, Science Magazine: 1999–2008
Exact Sciences Board (NWO-EW): 2003–2006
Astronomy Working Group (AWG), European Space Agency (ESA): 2002–2005
XMM-Newton Users Group, ESA: 2002–2005
NOVA Instrument Steering Committee: 1998–2005
Principal Investigator, PuMa 2 project (Pulsar Instrumentation for the WSRT): 1996–2004
Coordinator, NOVA Network 3: Compact Objects 1996–2004
Scientific Council, Foundation for Space Research Netherlands (SRON): 1998–2002

Léon V.E. Koopmans

Education: University of Groningen
M.Sc. Astronomy 01 09 1995
Ph.D. (cum laude) on thesis: A Study of Radio-Selected Gravitational Lenses
Advisor: A.G. de Bruyn 07 02 2000

Positions:

CERES Fellow, University of Manchester	01 04 2000 – 31 08 2000
Postdoctoral Fellow, TAPIR, Caltech	01 09 2000 – 30 11 2002
Visiting Fellow, TAPIR, Caltech	01 12 2002 – 01 12 2003
Institute Fellowship, STScI	01 12 2002 – 31 01 2004
Assistant Professor, University of Groningen	01 02 2004 – 31 05 2009
Associate Professor, University of Groningen	01 06 2009 – present

Memberships:
Dutch Astronomical Society
International Astronomical Union
American Astronomical Society (2000-2004)
Vereniging voor Vernieuwingsimpuls Onderzoekers (VENI/VIDI/VICI)
NOVA Key-Researcher

Other affiliations and honors:
Cambridge Institute Fellowship (2002; *declined*);
VIDI career award 2005

Research: Galaxy Structure, Formation & Evolution; Gravitational Lensing and Dynamics; Reionization
Publications:
Authored or co-authored 90 refereed papers, 61 non-refereed publications, 3 popular papers, and editor of 1 IAU proceeding; 3132 citations (ADS); h-index: 31
PhD theses supervised: 6 *(2 graduated in 2009, 2 will graduate in 2010)*; Co-promotor: 2
Current composition group: 4 graduate students, 1 postdoc, 1 programmer

Recent Membership in National and International Committees:
Member, LOFAR EoR Key-Science Management: 2004-present
Member, ASTRON Scientific Advisory Council (SAC): 2008-present
Member, LOFAR Astronomy Research Committee (ARC): 2004-2009
Member, ESO OPC and panel co-chair: 2008-present
Member, IAU commissions 28 (galaxies) and 47 (cosmology): 2006-present
Member, Steering Committee of the FP6 EU RTN “ANGLES”: 2004-2008
Organizer of a 7 international meetings and SOC member/chair of 9 meetings

Alex de Koter

Education: Utrecht University

M.Sc. Astronomy	29 09 1988
Ph.D. on thesis: Studies of the Variability of Luminous Blue Variable Stars	
Advisors: H.J.G.L.M. Lamers and W. Schmutz	13 09 1993

Positions

Visiting Scientist, University Space Research Association, NASA	15 11 1993 – 15 11 1995
Staff Astronomer, Advanced Computer Concepts, NASA	16 11 1995 – 31 08 1997
NWO Post Doctoral Fellow, University of Amsterdam	01 09 1997 – 31 12 1998
Assistant Professor, University of Amsterdam	01 01 1999 – 31 05 2004
Associate Professor, University of Amsterdam	01 06 2004 – present
Adjunct Professor, Utrecht University	01 07 2008 – present

Memberships
International Astronomical Union

Other affiliations and honors
O-star coordinator VLT-FLAMES large programme surveys on massive stars.

Research: Stellar evolution; mass-loss and rotation of stars; quantitative spectroscopy & hydrodynamics of stellar winds; UV/optical/IR

Publications
Authored or co-authored 112 refereed papers, 7 invited review papers, ~70 conference contributions, 2 popular papers, and editor of one books; ~4380 citations (ADS); h-index: 37
PhD theses supervised: 11
Current composition group: 2 (+3 to be appointed) graduate students, 1 postdoc

Recent Membership in National and International Committees (selection):
Chair, NOVA Minnaert Committee: 2004-present
Advisor and coordinator of NOVA Outreach Office
Member, NWO Program Committee EW Free Competition: 2007-2008
Member, ESO Observing Programme Committee (National Representative): 2005
Member, NWO Vernieuwingimpuls VIDI Programme Committee: 2003-2005
Member, NWO Vernieuwingimpuls VENI Programme Committee: 2003
Co-I HIFI Science Team: 2007-present
Ambassador, Network ‘Platform Beta Techniek’: 2007-present
co-organizer and SOC chair/member of several international meetings

Koenraad Honoraat Kuijken

Education: University of Cambridge

B.A. Mathematics (1st class honours)	06-1984
Certificate of Advanced Study in Mathematics (distinction)	06-1985
Ph.D. Astronomy on thesis: The Surface Mass Density of the Galactic Disk. Advisor: G. Gilmore	09-1988

Positions:

Title A Research Fellow, Trinity College, Cambridge	01 09 1988 – 31 08 1995
Research Fellow, Canadian Inst. for Theoretical Astrophysics	01 12 1989 – 31 08 1991
Hubble Fellow, Harvard-Smithsonian Ctr. for Astrophysics	01 09 1991 – 31 08 1994
Associate Professor of Astronomy, Univ. of Groningen	01 09 1994 – 31 05 1999
Full Professor of Astronomy, Univ. of Groningen	01 06 1999 – 31 07 2002
Full Professor of Astronomy, Leiden University	01 08 2002 - present
Scientific Director, Leiden Observatory	01 07 2007 - present

Other affiliations and honors:

Visiting Scientist, Dept. of Theoretical Physics, University of the Basque country
Pastoor Schmeits Prize 1998

Research:

Theory and observations related to dark matter in galaxies and the Universe, using dynamics and gravitational lensing

Publications:

Authored or co-authored 84 refereed papers, 12 invited reviews, and ca.50 conference contributions, miscellaneous and popular papers
Total citations (ADS): 4850. h-index 39.
Current composition group: 10 PhD students supervised (5 in progress)
9 postdoctoral fellows (3 currently)

Membership in National and International Committees:

Dutch National Representative, Panel Chairman, and Interim Chairman,
ESO Observing Programme Committee: 1998–2001
Member, HST Time Allocation Panel: 1998, 2008
Dutch National Representative, ESO Scientific Technical Committee: 2002–2005
Dutch delegate, ESO Council: 2007–
Chair, NL ESO Contact Committee: 2007–
Coordinator, NOVA Research Network 1: 1999–2003
Member, NOVA Instrument Steering Committee: 2002–2007
Member, NOVA Board: 2007–
Member, National Committee for Astronomy: 2007–
Chairman, Lorentz Center Programme Board for Astronomy: 2002–2004
Member, ASTRON board: 2005–2007
Member, NWO AdviesCommissie Astronomie (ACA): 2005–2006
'Foreign' member, FWO-Vlaanderen Programmacommissie E7 (fysica+astronomie): 2006–2009
Member, European Research Council Starting Grants Selection Panel PE9: 2009–
External member, faculty search committees in Gent, Groningen, Bonn
External reviewer, DFG Schwehrpunkt Programm "Formation and Evolution of Galaxies" : 2007
External reviewer, Heidelberg IMPRESS Graduate school: 2009

Søren Schack Larsen

Education: University of Copenhagen
M.Sc. Astronomy 01 09 1996
Ph.D. on thesis: Young Massive Star Clusters in Spiral Galaxies
Advisors: T. Richtler and J. V. Clausen 01 09 1999

Positions

Research Associate, Copenhagen University Astronomical Observatory	01 09 1999 – 31 12 1999
Postdoctoral Researcher, University of California / Lick Observatory	01 01 2000 – 31 12 2002
ESO Fellow, ESO, Garching	01 01 2003 – 30 11 2003
Instrument Scientist, ST-ECF, Garching	01 12 2003 – 30 03 2006
Assistant Professor (UD), University of Utrecht:	01 04 2006 – present

Memberships
American Astronomical Society
International Astronomical Union
Nederlandse Astronomenclub

Research: Formation and evolution of stellar clusters, globular cluster systems, resolved stellar populations, chemical evolution of galaxies.

Publications
Authored or co-authored 63 refereed papers, 3 invited review papers, editor of one book, ~2200 citations (ADS); h-index: 25
PhD theses supervised: 2
Current composition group: 2 graduate students

Recent Membership in National and International Committees:
Member, Time allocation committee for Dutch Island Observatories: 2007 - present
Member, ESO Contact Commission: 2007 - present
Member, board of Olga Koning Fund: 2009 - present

Reynier Frans Peletier

Education: University of Leiden

B.Sc. Mathematics	01 07 1982
B.Sc. Astronomy	25 06 1983
University of Groningen	
M.Sc. Mathematics	24 08 1985
M.Sc. Astronomy	23 09 1985
Ph.D. Astronomy on thesis: Elliptical Galaxies: Structure and Stellar Content. Advisors: T.S. van Albada, E.A. Valentijn and R.L. Davies	29 09 1989

Positions

Postdoctoral Researcher, Harvard-S. Center for Astrophysics	01 10 1989 – 15 08 1991
Postdoctoral Fellow, European Southern Observatory	15 08 1991 – 31 12 1992
Postdoctoral Researcher, U. Groningen and La Palma	01 01 1993 – 30 06 1997
PPARC Advanced Fellow, University of Durham, UK	01 07 1997 – 30 06 1999
Lecturer, University of Nottingham, UK	01 07 1999 – 31 08 2003
UHD (Associate Professor), University of Groningen	01 09 2003 – 30 04 2005
Adjunct Professor, University of Groningen	01 05 2005 – 31 10 2009
Full Professor, University of Groningen	01 11 2009 – present

Memberships

International Astronomical Union
Nederlandse Astronomen Club

Other affiliations and honors

Visiting Researcher, Observatoire de Lyon, 2001-2002
PPARC Advanced Fellow, 1997-2002
PI of La Palma International Time Programme on Dwarf Galaxies, 2005-2006

Research

Formation, structure and stellar populations of galaxies; astronomical instrumentation

Publications

Authored or co-authored 135 refereed papers, 12 invited reviews, 147 conference contributions, miscellaneous and popular papers, and editor of 1 book, 7000citations; h-index: 48
PhD theses supervised: 7
Current composition group: 4 graduate students

Recent Membership in National and International Committees:

Member, ESO Observing Programme Committee: 2002-2005
Member, PATT UKIRT Time Allocation Committee: 2000-2003
Member, Spanish Time Allocation Committee CAT:2009-2012
Panel Member, Hubble Space Telescope TAC: 2002, 2003
Member, Dutch VISIR team: 2002–
Member, NWO-VENI grant committee: 2004-2005
Member, Euro-VO Science Advisory Committee: 2006-2010
Member, several committees in the University of Groningen at several levels.
Organizer or co-organizer of 6 international meetings

Simon Frederik Portegies Zwart

Education: University of Amsterdam
M.Sc. Astronomy 1992
Advisor: Jan van Paradijs
Utrecht University
Ph.D. thesis: Interacting stars 1996
Advisor: F. Verbunt

Positions:

Spinoza fellow, University of Amsterdam	1996 - 1997
JSPS fellow, University of Tokyo, Japan	1997 - 1998
Hubble Fellow; MIT, USA	1998 - 2002
KNAW Fellow, University of Amsterdam	2002 - 2007
Assistant Professor, University of Amsterdam	2007 - 2009
Professor, Leiden University	2009 - present

Memberships:
International Astronomical Union

Research:
Computational Astrophysics

Other affiliations and honors:
VICI, NWO, 2008;
Pastoor Schmeits prize of Dutch Astronomy, 2007
MICA, 2007
Honor Gravity Research Foundation, 2000

Publications:
Authored or co-authored 124 refereed papers, 104 conference contributions, 24 popular papers, and editor of 2 books; 4600 citations (ADS); h-index: 39

PhD theses supervised: 6

Current composition group: 3 graduate students, 3 postdocs, 1 software engineer, 2 programmers

Recent Membership in National and International Committees (selection):
European liaison MICA: 2007-present

Huub Röttgering

Education: University of Leiden

M.Sc. Astronomy	15 06 1988
Ph.D. on thesis: Ultra-Steep Spectrum Radio Sources: Tracers of Distant Galaxies Advisor: G.K. Miley	27 01 1993

Positions

Postdoctoral Fellow, Cambridge University, England	01 02 1993 – 01 02 1995
NWO Postdoctoral Fellow, Leiden University	01 02 1995 – 01 10 1998
Assistant Professor (UD), Leiden University	01 10 1998 – 01 01 2003
Associate Professor (UHD), Leiden University	01 01 2003 – 01 04 2009
Professor of observational cosmology, Leiden University	01 04 2009 – present

Other affiliations and honors
Distinguished guest, Caltech, Pasadena, USA, 2006
Visiting professor, Oxford University, UK 2009

Research
Cosmology, distant (radio) galaxies, clusters of galaxies, active galactic nuclei, optical and radio interferometers.

Publications
Authored or co-authored 208 refereed papers, 25 invited review papers, ~200 conference contributions, editor of 4 books; ~8000 citations (ADS), h-index: 52
PhD theses (co-)supervised: 21
Current composition group: 3 graduate students, 5 postdocs

Recent Membership in National and International Committees (selection):

Member, Science team MID-infrared Interferometric instrument for VLTI (MIDI): 1998 - present
Chair, Dutch Program Committee for WSRT, JCMT and La Palma: 2002 - 2005
Member, Terrestrial Planet Science Advisory Team (TESAT) of ESA's Darwin mission: 2002 - 2008
Member, NASA's Science Working Group for the Terrestrial Planet Finder (TPF): 2000 - 2008
PI, LOFAR surveys: Opening up a new window on the Universe: 2003 – present
PI, DCLA Development and Commissioning of LOFAR for Astronomy: 2003 – present
Chair, NWO selection committee for VENI postdocs: 2003
Observer, Board of ASTRON: 2002 – 2005
Chair, LOFAR Astronomy Research Committee (ARC): 2004 - 2007
Member, LOFAR Research Management Committee (RMC): 2004 - 2007
Member, space science and astronomy review panel of the Academy of Finland: 2005
Member, time allocation panel, Spitzer Space Telescope: 2007
Member ESO Observing Program committee (OPC): 2007 - 2009
Co-I, Near Infrared Spectrograph for Euclid, ESA's Dark Energy Mission: 2008 - present
Member, Science Advisory Committee ASTRON: 2009 – present
Member, selection panel NWO's Rubicon program: 2009 - present
Co-organizer of numerous international meetings

Joop Schaye

Education:

Certificate of advanced study in mathematics, University of Cambridge	16 06 1997
M.Sc. theoretical phycis (cum laude), University of Groningen	27 08 1997
M.Sc. astronomy (cum laude), University of Groningen	29 08 1997
Ph.D., University of Cambridge	
On thesis: Thermal history and metal enrichment of the intergalactic medium.	
Advisor: G. P. Efstathiou	24 10 2000
(degree approved; degree conferred: 13 05 2006)	

Positions

Member, Institute for Advanced Study	01 09 2000 – 31 08 2002
Long-term member, Institute for Advanced Study	01 09 2002 – 28 02 2005
Assistant Professor, Univ. of Leiden	01 03 2005 – 30 06 2007
Associate Professor, Univ. of Leiden	01 07 2007 – present

Honors

Propaedeuse prize (best physics 1st year results), Univ. of Groningen, 1993, Benefector's scholarship, St. John's College, 1996, Isaac Newton Studentship, Univ. of Cambridge, 1997, Kamerlingh Onnes Prize (for best final results in physics), Univ. of Groningen, 1997, Keck fellowship, Institute for Advanced Study, 2000, Long-term membership, Institute for Advanced Study, 2002, Marie Curie Excellence Grant, EU, 2004, VIDI grant, NWO, 2006

Research: galaxy formation, intergalactic medium, cosmology, computational astrophysics

Publications

Authored or co-authored 56 refereed papers, 4 invited review papers, 23 conference contributions; ~3350 citations (ADS); h-index: 30

PhD theses supervised: 2

Current composition group: 5 graduate students, 1 postdoc

Recent Membership in National and International Committees (selection):

Member of the steering committee, Virgo Consortium: 2005-present
Member, LOFAR Epoch of Reionization science team: 2005-present
Member, MUSE science team: 2005-present
PI, OWLS collaboration: 2005-present
PI, Marie Curie Excellence team: 2005-2009
Member, EDGE science team: 2006-2008
NL-representative, Euro-VO Data Center Alliance, Theoretical astrophysics expert group: 2006-present
Member, National research initiative e-science (NWO): 2006
Co-Investigator, MUSE (Multi Unit Spectroscopic Explorer): 2007-present
Member, ISTOS science team: 2007-2008
Chair, Organizing committee, "Computational cosmology": 2007
Member, SOC, IAU symposium 244, "Dark galaxies and lost baryons": 2007
Member, Xenia science team: 2008-2009
Member, SOC, "Galaxies in real life and simulations": 2008
Member, SOC, "Theory in the Virtual Observatory": 2008
Chair, Organizing committee, "The chemical enrichment of the intergalactic medium": 2009
Member, SOC, "Cosmological reionization: 2010

Marco Spaans

Education: University of Leiden

M.Sc. Astronomy	27 08 1991
Ph.D. (cum laude) on thesis: Models of Inhomogeneous Interstellar Clouds	
Advisor: E.F. van Dishoeck	21 09 1995

Positions

Research Fellow, Johns Hopkins University	01 10 1995 – 30 09 1997
Hubble Fellow, Harvard University	01 10 1997 – 30 08 2000
NOVA Fellow, Univ. of Groningen	01 09 2000 – 30 08 2001
Assistant Professor, Univ. of Groningen	01 09 2001 – 30 08 2006
Professor of ISM Physics, Univ. of Groningen	01 01 2008 – present

Memberships

International Astronomical Union

Other affiliations and honors

C.J. Kok Prize (best thesis) of Dutch Astronomy, 1995

Research: Star and planet formation, active galaxies, ISM, proto-galaxies

Publications

Authored or co-authored 74 refereed papers, 3 invited review papers, ~60 conference contributions, 5 popular papers, and chapters in 3 books; ~1612 citations (ADS); h-index: 26

PhD theses supervised: 7

Current composition group: 5 graduate students, 1 postdoc

Recent Membership in National and International Committees (selection):

Co-I, SCUBA-2 and HARP-B JCMT Galactic surveys, 2005-present
Head of ISM group, University of Groningen: 2005-present
Co-I, Herschel guaranteed time program HERCULES: 2008-present
PI , ALMA band 9 R&D: 2008-present
Member, JCMT oversight committee: 2009-present
Co-organizer of 10 international (IAU) meetings

Xander A.G.G.M. Tielens

Education: University of Leiden

M.Sc. Astronomy	1976
Ph.D. on thesis: Physics and Chemistry of Interstellar Dust Advisors: H.J. Habing and L.J. Allamandola	1982

Positions

NRC Associate NASA Ames Research Center	1982 – 1984
Research Associate University of California Berkeley	1984 – 1989
Senior Scientist NASA Ames Research Cente:	1989 – 1997
Senior Scientist SRON	1997 – 2004
Professor of Astrophysics, University of Groningen	1998 – 2005
Senior Scientist NASA Ames Research Center	2005 – 2009
Professor of Astrophysics, University of Leiden	2009 – present

Memberships

American Astronomical Society

Other affiliations and honors

HJ Allan Award NASA Ames Research Center 1988; Pastoor Schmeits Prize of Dutch Astronomy, 1992; HJ Allan Award NASA Ames Research Center 1992; Miller Visiting Research Professor, University of California, Berkeley, 2002; Caroline Herschel fellow STScI 2009; European Reseach Council Advanced Grant 2009; Visiting Professor Chalmers University, Sweden 2010

Research: Interstellar medium, interstellar dust, interstellar molecules, photo dissociation regions, ejecta from asymptotic giant branch stars, infrared spectroscopy

Publications

Authored or co-authored 319 refereed papers with 19,500 citations; (ADS), h-index 79; author of the text book “Physics and Chemistry of the Interstellar Medium (University of Cambridge Press); editor of 4 conference proceedings; 13 invited reviews over the last 5 years

PhD theses supervised 1999-2009: 17

Current composition group: 2 graduate students, 1 postdocs; 6 graduate & 4 postdoc positions pending

Recent Membership in National and International Committees (selection):

Project Scientist, HIFI Heterodyne instrument on board of Herschel Space Observatory : 1997-present
NASA Project Scientist, Stratospheric Observatory for Infrared Astronomy: 2005-2007
Coordinator of “The Molecular Universe EU RTN Network: 2004-2008
Member of the Editorial Board of the Journal (Springer Verlag) “Space Sciences Review”
Editor of the Journal Astrophysics & Space Sciences
Chair or co-Chair of 14 international meetings; Member of SOC of an additional 8 meetings over the last decade

Eline Tolstoy

Education: University of Leiden
M.Sc. Astronomy 08 1990
University of Groningen
Ph.D. thesis: Modellling the Resolved Stellar Populations of Nearby Galaxies
Advisors: A. Saha, P.C. van der Kruit, H. Butcher 10 1995

Positions

Graduate Student Research Assistant, STScI, Baltimore, USA	09 1990 – 09 1995
Postdoctoral Research Assistantship, STScI, Baltimore, USA	10 1995 – 05 1996
ESA Postdoctoral Fellow, ST-ECF, Garching, Germany	06 1996 – 05 1998
ESO Postdoctoral Fellow, ESO, Garching, Germany	06 1998 – 05 2000
Gemini Support Scientist, Oxford University, UK	06 2000 – 07 2001
KNAW Fellow, and member of Faculty, Kapteyn Institute, Univ. of Groningen	07 2001 – 06 2006
Associate Prof, Kapteyn Institute, Univ. of Groningen	07 2006 – present

Affiliations and honors
Pastoor Schmeits Prize of Dutch Astronomy, 2007; NWO VICI grant 2007; Hoorcollegedocent van het jaar 2006 FWN, Groningen; Onderwijsprijs FWN, Groningen 2003; KNAW Fellowship 2001

Research: Imaging and spectroscopy of resolved stellar populations in nearby galaxies, dwarf galaxies, chemical evolution, variable stars

Publications
Authored or co-authored 58 refereed papers, ~10 invited review papers, ~70 conference contributions; ~2600 citations (ADS); h-index: 31
PhD theses supervised: 2
Current composition group: 2 graduate students, 3 postdocs

Recent Membership in National and International Committees (selection):
Member, NOVA Instrument Steering Committee: 2001-2007
Member, NWO VENI committee: 2002-2003
Member, NWO VIDI committee: 2009-present
Member, MICADO science team: 2008-present
Member, HARMONI science team: 2008-present
Member, EVE/OPTIMOS science team: 2009-present
Member, ESO – E-ELT *Science Working Group*: 2006-present
Member, Directors advisory committee, ING, La Palma: 2002-2008
Member, HST TAC, 2007, 2008 (chair of panel)
Member, ESO, time allocation panels: 2002-2004
co-organizer of numerous international meetings, including once Chair SOC, and once chair of LOC

Francîscus Wilhelmus Maria Verbunt

Education: University of Utrecht, University of Amsterdam
M.Sc. 1977
PhD Mass transfer in stellar x-ray sources 07 07 1982

Positions:
Postdoctoral researcher: Institute of Astronomy Cambridge (UK) 01 09 1982 – 30 08 1985
Postdoctoral researcher: MPE Garching 01 09 1985 – 30 09 1989
Professor High Energy Astrophysics Utrecht University 01 10 1989 – present

Memberships
International Astronomical Union

Other affiliations and honors:
Pionier award NWO (with Michiel van der Klis) 1991-1995

Research:
X-ray binaries, radio pulsars, X-rays, History of Astronomy

Publications:
34 conference contributions; 49 popular papers
1 book, 1 booklet (with Govert Schilling)
153 in refereed journals; 44 invited reviews; 7300 citations; h-index: 46

PhD Theses Supervised: 14

Recent membership in National and International Committees:
Member, Nova Board: 2003-4
Member, NWO VENI committee: 2003
Member, Astron PuMa Raad van toezicht: 2003
Member, NWO VIDI committee: 2004
Chairman, XMM TAC X-ray binaties: 2006-2007
Member, Astronomy Grant advisory committee Finnish Academiy of Sciences: 2006
Member, Astron LOFAR Commissioning Advisory Board: 2007
Member, Review Committee Radio Astronomy INAF: 2007
Member, NWO VICI committee: 2007, 2009

Laurentius Bernardus Franciscus Maria Waters

Education: Utrecht University

M.Sc Astronomy	05 1983
Ph.D. (cum laude) in thesis; Infrared studies of mass loss from hot stars	06 11 1987
Advisors: H.J.G.L.M. Lamers and P.S. The	

Positions:

Stipendium Niels Stensen Foundation, Astronomical Institute UvA	11 1987 – 11 1988
Post-doctoral fellow, Center for High Energy Astrophysics, UvA	11 1988 – 07 1989
National Fellowship, CITA University of Western Ontario, London, Canada	07 1989 – 07 1990
Scientist, SRON Laboratory for Space Research Groningen	07 1990 – 06 1992
Fellow, Royal Netherlands Academy of Arts and Sciences, UvA	06 1992 – 06 1997
Associate Professor, University of Amsterdam	07 1997 – 12 2000
Full Professor, University of Amsterdam	01 2001 – present
Full Professor (part-time appointment) Institute for Astronomy, Leuven University	10 1999 – present

Memberships:
Royal Netherlands Academy of Arts and Sciences (KNAW)
International Astronomical Union

Other affiliations, honors:
Pastoor Schmeits Prize of Dutch Astronomy, 1995. Pionier Award, NWO, 1996

Research: star- and planet formation, interstellar medium, late stages of stellar evolution

Publications:
Authored or co-authored 230 papers in refereed journals; 10600 cit. (ADS); h-index: 54

PhD theses supervised: 25
Current composition group: 4 graduate students

Recent memberships in National and International committees (selection):
Chair, Science Advisory Board of the Space Research Organization of the Netherlands (SRON)
Chair, NWO ALW beoordelingscommissie Planeetonderzoek
Chair, Department of Astronomy, Physics and Mathematics, University of Amsterdam
Member, Fachbeirat Max Planck Institut f\"ur Astronomie, Heidelberg
Coordinator, NOVA network 2 "Origin and Evolution of Stars and Planetary Systems"
Member, HIFI science team
Member, MIRI science team
Co-principal investigator, MID- Infrared Instrument (MIDI) for the Very Large Telescope Interferometer
Member, MATISSE science team
Member, executive board of SPHERE
Chair, Dutch SPHERE team
Board member, Adviesraad voor Technische Wetenschappen, Wiskunde, Informatica, Natuur- en Sterrenkunde en Scheikunde (TWINS) of the KNAW.
Member, Nationaal Platform Planeetonderzoek
Member, board of Stichting Beta Plus, University of Amsterdam
Member, board Amsterdams Fonds voor de Astrofysica
Member, board Jan van Paradijs fonds

Ralph Antoine Marie Joseph Wijers

Education: M.Sc. Astronomy with Theoretical Physics (cum laude) 27 01 1987
Ph.D. on thesis: Studies of Accreting and Non-accreting Neutron Stars
Advisors: J.A. van Paradijs and E.P.J. van den Heuvel 19 09 1991

Positions

Compton GRO Fellow, Princeton University Observatory	01 10 1991 – 30 09 1994
Postdoctoral Fellow, Institute of Astronomy, Cambridge	01 10 1994 – 30 09 1997
Royal Society URF, Institute of Astronomy, Cambridge	01 10 1987 – 31 07 1998
Assistant Professor of Astronomy, Stony Brook University	01 08 1998 – 30 06 2002
Adjunct Professor of Astronomy, Stony Brook University	01 07 2002 – 30 06 2007
Professor of High-Energy Astrophysics, Univ. of Amsterdam	01 07 2002 – present

Memberships
Nederlandse Astronomenclub
American Astronomical society
Royal Astronomical Society
Genootschap voor Natuur-, Genees- en Heelkunde
Nederlandse Natuurkundige Vereniging
International Astronomical Union

Other affiliations and honors
Compton GRO Fellowship, 1991; Royal Society University Research Fellowship, 1997; Descartes Prize, EC, 2002; VICI award, NWO, 2004; Advanced Investigator Grant, ERC, 2009

Research: Gamma-ray bursts, high-energy astrophysics, transient

Publications
Authored or co-authored 289 scientific papers, of which 163 refereed, 15 invited reviews,
12 popular papers, and editor of 8 books; ~9200 citations (ADS); h-index: 50
PhD theses supervised: 9
Current composition group: 4 graduate students, 5 postdocs

Recent Membership in National and International Committees (selection):
Editor, Monthly Notices of the Royal Astronomical Society: 2006-present
Editor, New Astronomy Reviews: 2009-present
Co-ordinating editor, New Astronomy Reviews: 2009-present
Member, Astronet Science Vision Panel A: 2006-2007
Member, Astronet Roadmap Panel A: 2007-2008
Member , SRON Board: 2004-present
Member, ASTRON Science Advisory Council: 2008-present
Chair, Astrophysics section, Nederlandse Natuurkundige Vereniging: 2002-present
Chair, LOFAR Astronomy Research Committee: 2007-present
Member, LOFAR International Working Group: 2009-present
Co-PI, LOFAR Transients Key Project, 2003-present
PI, EU Research Training Network on 'Gamma-ray Bursts: An Enigma and a Tool': 2002-2006
Chair, European ALMA Science Advisory Committee: 2003-2006
SOC member and/or chair of 2-3 international meetings per year

Rudi Adam Dirk Wijnands

Education: University of Leiden

M.Sc. Astronomy	20 12 1994
Ph.D. on thesis: Millisecond Phenomena in X-ray binaries	
Advisors: Prof. Dr. Michiel van der Klis	16 02 1999

Positions

Postdoctoral position, Astronomical Institute, University of Amsterdam	16 02 1999 – 31 08 1999
Chandra Fellow, Massachusetts Institute of Technology, USA	01 09 1999 – 31 08 2002
St..Andrews Research and Teaching Fellow, St. Andrews, Scotland	01 09 2002 – 31 09 2003
PPARC Advanced Fellow, St. Andrews, Scotland	01 10 2003 – 31 12 2003
Assistant professor (UD), University of Amsterdam, Amsterdam	01 01 2004 – 31 12 2007
Associate professor (UHD), University of Amsterdam, Amsterdam	01 01 2008 – present

Memberships

International Astronomical Union

Other affiliations and honors

The Andreas Bonn Medal, "Het genootschap ter bevordering van natuuur-, genees- en heelkunde ", 1998
Chandra Fellowship, NASA, USA, 1999
St.Andrews Fellowship, St. Andrews University, Scotland, 2002
PPARC Advanced Fellowship, PPARC, UK, 2003
Bruno Rossi Prize, High-Energy Astrophysics Division of the American Astronomical Society, 2006
ERC Starting grant, European Research Council, 2008

Research: Accreting neutron stars and stellar mass black holes; cooling of accretion-heated neutron stars; X-rays/optical/NIR

Publications

Authored or co-authored 149 refereed papers, 2 invited review papers, ~20 conference contributions, 142 telegrams or circulars, and editor of 1 proceedings; ~5200 cit. (ADS) ; h-index: 37
PhD theses supervised: 2
Current composition group: 3 graduate students, 1 postdoc

Recent Membership in National and International Committees (selection):

Member, "Vrije competitie" selection committee, NWO-EW: 2008-2010
Member, Veni selection committee, NWO-EW: 2010
Member, Astro-E time allocation committee: 1999
Member, Chandra time allocation committee: 2003
Member, XMM-Newton time-allocation committee: 2007-2008
Chair, XMM-Newton time-allocation committee: 2009
Participating member, EC Initial Training Network: Black Hole Universe
Co-organizer of several national and international meetings, including chair of the SOC and the LOC of the 2008 Accreting millisecond X-ray pulsars conference in Amsterdam

Appendix B1: Five key publications 2003-2009

Abraham Achterberg

1. Van der Swaluw, E., Achterberg, A., Gallant, Y.A., Downes, T.P., Keppens, R. 2003: *Interaction of high-velocity pulsars with supernova remnant shells*, A&A, 397, 913
2. Wiersma, J., Achterberg, A., 2004: *Magnetic field generation in relativistic shocks*, A&A, 428, 365
3. Van Marle, A., Langer, N., Achterberg, A. García-Segura, G., 2006: *Forming a constant density medium close to long gamma-ray bursts,* A&A, 460, 105
4. Achterberg, A., Wiersma, J.: 2007, *The Weibel instability in relativistic plasmas I: linear theory*, A&A, 475, 1
5. Schure, K.M., Vink, J., García-Segura, G., Achterberg, A.: 2008: *Jets as diagnostics of the circumstellar medium and the explosion energetic of supernovae: the case of Cassiopeia A*, ApJ, 686, 399

Pieter Dirk Barthel

1. Filho, M.E., Barthel, P.D., Ho, L.C., 2006: *A radio census of nuclear activity in nearby galaxies,* A&A, 451, 71
2. Barthel, P.D., 2006: *Star-forming QSO host galaxies*, A&A. 458, 107
3. Labiano, A., Barthel, P.D., et al., 2007: *GPS radio sources: new optical observations and an updated master list,* A&A, 463, 97
4. Chi, A., Garrett, M.A., Barthel, P.D. 2008: *AGN and starbursts in the HDF-N and HFF: deep, global VLBI observations,* Mem. Soc. Astron. Italia, 79, 1259
5. Evans, A.S., Hines, D.C., Barthel, P.D., et al. 2009: *Molecular gas and the host-galaxy system of the z~0.3 QSO PG1700+518,* Astron.J., 138, 262

Ewine Fleur van Dishoeck

1. Jørgensen, J.K., Schöier, F.L., van Dishoeck, E.F. 2004, *Molecular inventories and chemical evolution of low-mass protostellar envelopes*, A&A, 418, 1021
2. Lahuis, F., van Dishoeck, E. F., Boogert, A. C. A., Pontoppidan, K. M., Blake, G. A.., Dullemond, C. P., Evans, N. J., Hogerheijde, M. R.., Jørgensen, J. K., Kessler-Silacci, J. E.; Knez, C., 2006, *Hot organic molecules toward a young low-mass star: a look at inner disk chemistry*, ApJ (Letters), 636, L145
3. Geers, V. C., Augereau, J.-C., Pontoppidan, K.M., et al., 2006, *c2d Spitzer-IRS spectra of disks around T Tauri stars. II. PAH emission features*, A&A, 459, 545
4. Öberg, K.I., Fuchs, G.W., Awad, Z., Fraser, H.J., Schlemmer, S., van Dishoeck, E.F., Linnartz, H., 2007: *Photodesorption of CO ice*, ApJ (Letters), 662, L23
5. Visser, R., van Dishoeck, E.F., Doty, S.D., Dullemond, C.P., 2009, *The chemical history of molecules in circumstellar disks. I. Ices.*, A&A, 495, 881

Heino Falcke

1. Falcke, H., Körding, E., Markoff, S*, 2004: A scheme to unify low-power accreting black holes - jet-dominated accretion flows and the radio/X-ray correlation.* A&A, 414, 895
2. Falcke, H. et al*. 2005: Detection and imaging of atmospheric radio flashes from cosmic ray air showers,* Nature, 435, 313
3. Bower, G.C., Falcke, H., Herrnstein, R.M., Zhao, J.-H., Goss, W.M., Backer, D.C*.,* 2004: *Detection of the intrinsic size of Sagittarius A* through closure amplitude imaging*, Science, 304, 704
4. The Pierre Auger Collaboration, 2007: *Correlation of the highest-energy cosmic rays with nearby extragalactic objects*, Science, 318, 938
5. Scholten, O., Buitink, S., Bacelar, J., Braun, R., de Bruyn, A. G., Falcke, H., Singh, K., Stappers, B., Strom, R. G., Yahyaoui, R., 2009: *Improved flux limits for neutrinos with energies above* 10^{22} *eV from observations with the Westerbork Synthesis Radio Telescope,* Phys. Rev. Letters, 103, id. 191301

Marijn Franx

1. Franx, M., Labbé, I., Rudnick, G., van Dokkum, P. G., Daddi, E., Förster Schreiber, N. M., Moorwood, A., Rix, H.-W., Röttgering, H., van de Wel, A., van der Werf, P., van Starkenburg, L., 2003: *A significant population of red, near-infrared-selected high-redshift Galaxies,* ApJ (Letters), 587, L79
2. van der Wel, A., Franx, M., van Dokkum, P. G., Rix, H.-W., Illingworth, G. D., d Rosati, P., 2005: *Mass-to-light ratios of field early-type galaxies at z ~ 1 from ultradeep spectroscopy: evidence for mass-dependent evolution,* ApJ, 631, 145
3. van Dokkum, P.G., Franx, M., Kriek, M., Holden, B., Illingworth, G.D., Magee, D., Bouwens, R., Marchesini, D., Quadri, R., Rudnick, G., Taylor, E. N., Toft, S. , 2008*:"Confirmation of the remarkable compactness of massive quiescent galaxies at z ~2.3: early-type galaxies did not form in a simple monolithic collapse*, ApJ (Letters), 677, L5
4. Kriek, M., van der Wel, A., van Dokkum, P.G., Franx, M., Illingworth, G.D., 2008: *The detection of a red sequence of massive field galaxies at z ~2.3 and its evolution to z ~ 0,* ApJ, 682, 896
5. Franx, M., van Dokkum, P. G., Schreiber, N. M. F., Wuyts, S., Labbé, I., Toft, S., 2008: *Structure and star formation in galaxies out to z = 3: evidence for surface density dependent evolution and upsizing,* ApJ, 688, 770

Paul Joseph Groot

1. Groot, P.J., Verbeek, K., et al., 2009: *The UV-excess survey of the northern Galactic plane,* MNRAS, 399, 323
2. Roelofs, G.H.A., Groot, P.J., Benedict, G.F. et al., 2007: *Hubble Space Telescope parallaxes of AM CVn stars and astrophysical consequences*, ApJ, 666, 1174
3. Drew, J.A., Greimel, R., et al., 2005: *The INT photometric H-alpha survey of the northern Galactic plane (IPHAS)* , MNRAS, 362, 753
4. Roelofs, G.H.A., Nelemans, G., Groot, P.J., 2007: *The population of AM CVn stars from the Sloan Digital Sky Survey*, MNRAS, 382, 685
5. Morales-Rueda, L.M, Groot, P.J., et al*.,* 2006: *Short time-scale variability in the faint sky variability survey*, MNRAS, 371, 1681

Amina Helmi

1. Helmi, A., 2004: *Velocity trends in the debris of Sagittarius and the shape of the dark matter halo of our Galaxy,* ApJ, 610, L97
2. Helmi, A., Navarro, J.F., Nordström, B., Holmberg, J., Abadi, M.G., Steinmetz, M., 2006: *Pieces of the puzzle: ancient substructure in the Galactic disc,* MNRAS, 365, 1309
3. Helmi, A., et al., 2006*: A new view of the dwarf spheroidal satellites of the Milky Way from VLT FLAMES: where are the very metal-poor stars?,* ApJ (Letters), 651, L121
4. Smith, M.C., Ruchti, G.R., Helmi, A., et al. 2007: *The RAVE survey: constraining the local Galactic escape speed*, MNRAS, 379, 755
5. De Lucia, G., Helmi, A., 2008: *The Galaxy and its stellar halo: insights on their formation from a hybrid cosmological approach*, MNRAS, 391, 14

Michiel Hogerheijde

1. Qi, C., Wilner, D.J., Calvet, N., Bourke, T.L., Blake, G.A., Hogerheijde, M.R., Ho, P.T.P., Bergin, E. 2006: *CO J = 6-5 observations of TW Hydrae with the SubMillimeter Array*. ApJ, 636, L157
2. Brinch, C., Crapsi, A., Jørgensen, J.K., Hogerheijde, M.R., Hill, T. 2007: *A deeply embedded young protoplanetary disk around L1489 IRS observed by the SubMillimeter Array*. A&A, 475, 915
3. Brinch, C., Hogerheijde, M.R., Richling, S. 2008: *Characterizing the velocity field in hydrodynamical simulations of low-mass star formation using spectral line profiles*. A&A, 489, 607
4. Salter, D.M., Hogerheijde, M.R., Blake, G.A. 2008: *Captured at millimeter wavelengths: a flare from the classical T Tauri star DQ Tauri.* A&A, 492, L21
5. Panić, O., Hogerheijde, M.R., Wilner, D., Qi, C. 2009: *A break in the gas and dust surface density of the disc around the T Tauri star IM Lupi*. A&A, 501, 269

Jan Mathijs van der Hulst

1. Sancisi, R., Fraternali, F., Oosterloo, T.A., van der Hulst, J.M. 2008: *Cold gas accretion in galaxies*, A&A Reviews, 15, 189
2. Zwaan, M.A., van der Hulst, J.M., Briggs, F.H., Verheijen, M.A.W., Ryan-Weber, E.V., 2005: *Reconciling the local galaxy population with damped Lyman α cross-sections and metal abundances,* MNRAS, 364, 1467
3. Noordermeer, E., van der Hulst, J.M., Sancisi, R., Swaters, R.S., van Albada, T.S. 2007: *The mass distribution in early-type disc galaxies: declining rotation curves and correlations with optical properties,* MNRAS, 376, 1513
4. Aragón-Calvo, M.A., van de Weygaert, R., Jones, B.J.T., van der Hulst, J.M., 2007: *Spin alignment of dark matter halos in filaments and walls,* ApJ, 655, 5
5. Oosterloo, T.A., Morganti, R., Sadler, E.M., van der Hulst, T., Serra, P. 2007: *Extended, regular HI structures around early-type galaxies,* A&A, 465, 787

Christoph U. Keller

1. Keller, C.U., Harvey, J.W., Giampapa, M.S. 2003: *SOLIS: an innovative suite of synoptic instruments,* SPIE, 4853, 194
2. Keller, C.U., Schuessler, M., Voegler, A., Zakharov, V. 2004: *On the origin of solar faculae*, ApJ, 607, L59
3. Keller, C.U. 2006,:*Design of a polarimeter for extrasolar planetary systems characterization*, SPIE, 6269, 62690T
4. Ayres, T.R., Plymate, C., Keller, C.U. 2006: *Solar carbon monoxide, thermal profiling, and the abundances of C, O, and their isotopes*, ApJS, 165, 618
5. Harvey, J.W., Branston, D., Henney, C.J., Keller, C.U., SOLIS and GONG Teams, 2007: *Seething horizontal magnetic fields in the quiet solar photosphere,* ApJ, 659, L177

Michiel van der Klis

1. Wijnands, R., van der Klis, M., Homan, J., Chakrabarty, D., Markwardt, C.B., Morgan, E.H., 2003: *Quasi-periodic X-ray brightness fluctuations in an accreting millisecond pulsar*. Nature, 424, 44
2. Casella, P., Altamirano, D., Patruno, A., Wijnands, R., van der Klis, M., 2008: *Discovery of coherent millisecond X-ray pulsations in Aquila X-1,* ApJ (Letters), 674, L41
3. Belloni, T., Homan, J., Casella, P., van der Klis, M., Nespoli, E., et al., 2005: *The evolution of the timing properties of the black-hole transient GX 339-4 during its 2002/2003 outburst,* A&A, 440, 207
4. Altamirano, D., van der Klis, M., Wijnands, R., Cumming, A., 2008: *Millihertz oscillation frequency drift predicts the occurrence of type I X-ray bursts.* ApJ (Letters), 673, L35
5. Boutloukos, S., van der Klis, M., Altamirano, D., Klein-Wolt, M., Wijnands, R., et al, 2006: *Discovery of twin kHz QPOs in the peculiar X-ray binary Circinus X-1*, AJ, 653, 1435

Léon V.E. Koopmans

1. Vegetti, S., Koopmans, L.V.E., 2009. *Bayesian strong gravitational-lens modeling on adaptive grids: objective detection of mass substructure in Galaxies,* MNRAS, 392, 945.
2. Barnabè, M., Koopmans, L.V.E., 2007. *A unifying framework for self-consistent gravitational lensing and stellar dynamics analyses of early-type galaxies,* ApJ, 666, 726
3. Koopmans, L.V.E., Treu, T., Bolton, A.S., Burles, S., Moustakas, L.A. 2006: *The Sloan Lens ACS Survey. III. The structure and formation of early-type Galaxies and their evolution since z~1,* ApJ, 649, 599
4. Koopmans, L.V.E., 2005, *Gravitational imaging of cold dark matter substructures*, MNRAS, 363, 1136
5. Treu, T., Koopmans, L.V.E., 2004: *Massive dark matter halos and evolution of early-type galaxies to z ~1*. ApJ, 611, 739

Alex de Koter

1. Mokiem, M.R., de Koter A., Vink J.S., Puls J., Evans C.J., Smartt S.J., Crowther P.A., Herrero A., Langer N., Lennon D.J., 2007: *The empirical metallicity dependence of the mass-loss rate of O- and early B-type stars,* A&A, 473, 603
2. Vink, J.S., de Koter A., 2005: *On the metallicity dependence of Wolf-Rayet winds*, A&A, 442, 587
3. van Boekel, R., Min, M., Leinert, Ch., Waters, L.B.F.M, Richichi, A., Chesneau, O., Dominik, C., Jaffe W., Dutrey, A., Graser, U., Henning, Th., de Jong, J., Kohler, R., de Koter, A., Lopez, B., Malbet, F., Morel, S., Paresce, F., Perrin, G., Preibisch, Th., Przygodda, F., Scholler, M., Wittkowski, M. 2004, *The building blocks of planets in the terrestrial region of proto-planetary disks*, Nature, 432, 479
4. van Boekel, R., Waters, L.B.F.M., Dominik, C., Bouwman, J., de Koter, A., Dullemond, C.P., Paresce F., 2005: *A 10 micron spectroscopic survey of Herbig Ae star disks: grain growth and crystallization*, A&A, 437, 189
5. Evans, C.J., Smartt, S.J., Lee, J.-K., Lennon, D.J., Kaufer, A., Dufton, P.L., Trundle, C., Herrero, A., Simon-Diaz, S., de Koter, A., Hamann, W.-R., Hendry, M.A., Hunter, I., Irwin, M.J., Korn, A.J., Kudritzki, R.-P., Langer, N., Mokiem, M.R., Najarro, F., Pauldrach, A.W.A., Przybilla, N., Puls J., Ryans, R.S.I., Urbaneja, M.A., Venn, K.A., Villamariz, M.R., 2005: *The VLT-FLAMES survey of massive stars: Observations in the Galactic clusters NGC 3293, NGC 4755 and NGC 6611,* A&A, 437, 467

Koenraad Honoraat Kuijken

1. Romanowsky, A.J., Douglas, N.G., Arnaboldi, M., Kuijken, K., Merrifield, M.R., Napolitano, N.R., Capaccioli, M., Freeman, K. C., 2003: *A Dearth of dark matter in ordinary elliptical galaxies,* Science, 301, 1696
2. de Jong, J.T.A., Kuijken, K., Crotts, A.P.S., Sackett, P.D., Sutherland, W.J., Uglesich, R.R., Baltz, E.A., Cseresnjes, P., Gyuk, G., Widrow, L. M. and the MEGA collaboration, 2004*: First microlensing candidates from the MEGA survey of M 31*, A&A, 417, 461
3. Heymans, C., Van Waerbeke, L., Bacon, D., Berge, J., Bernstein, G., Bertin, E., Bridle, S., Brown, M.L., Clowe, D., Dahle, H., Erben, T., Gray, M., Hetterscheidt, M., Hoekstra, H., Hudelot, P., Jarvis, M., Kuijken, K., Margoniner, V., Massey, R., Mellier, Y., Nakajima, R., Refregier, A., Rhodes, J., Schrabback, T., Wittman, D., 2006: *The Shear Testing Programme - I. Weak lensing analysis of simulated ground-based observations,* MNRAS, 368, 1323.
4. Kuijken, K., 2006: *Shears from shapelets*, A&A, 456, 827
5. Kuijken, K., Siemens, X., Vachaspati, T. 2008: *Microlensing by cosmic strings*, MNRAS, 384, 161

Søren Schack Larsen

1. Larsen, S.S., 2004, *Structure and environment of young stellar clusters in spiral galaxies*, A&A, 416, 537
2. Larsen, S.S., Brodie, J.P., Strader, J., 2005: *Globular clusters in NGC 4365: New K-band imaging and a reassessment of the case for intermediate-age clusters,* A&A, 443, 413
3. Scheepmaker, R.A., Haas, M.R., Gieles, M., Bastian, N., Larsen, S.S., Lamers, H.J.G.L.M., 2007: *ACS imaging of star clusters in M51. I. Identification and radius distribution*, A&A, 469, 925
4. Larsen, S.S., Origlia, L., Brodie, J.P., Gallagher, J.S., 2008, *Anatomy of a young massive star cluster: NGC1569-B*, MNRAS, 383, 263
5. Larsen, S.S., 2009, *The mass function of young star clusters in spiral galaxies*, A&A, 494, 539

Reynier Frans Peletier

1. Cappellari, M., Bacon, R., Bureau, M., Damen, M.C., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Falcón-Barroso, J, Krajnovíc, D., Kuntschner, H., McDermid, R.M., Peletier, R.F., Sarzi, M., van den Bosch, R.C.E., van de Ven, G., 2006: *The SAURON project - IV. The mass-to-light ratio, the virial mass estimator and the Fundamental Plane of elliptical and lenticular galaxies*, MNRAS, 366, 1126
2. Emsellem, E., Cappellari, M., Peletier, R.F., et al., 2004 : *The SAURON project - III. Integral feld absorption line kinematics of 48 elliptical and lenticular galaxies*, MNRAS, 352, 721
3. Balcells, M., Graham, A.W., Domínguez-Palmero, L., Peletier, R.F. 2003: *Galactic bulges from Hubble Space Telescope near-onfrared camera multi-object spectrometer observations: the lack of r1/4 bulges*, ApJ (Letters), 582, L79
4. Peletier, R. F., Falcón-Barroso, J., Bacon, R., Cappellari, M., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Ganda, K., Krajnovíc, D., Kuntschner, H., McDermid, R.M., Sarzi, M., van de Ven, G., 2007: *The SAURON project - XI. Stellar populations from absorption-line strength maps of 24 early-type spirals,* MNRAS, 379, 445
5. Sánchez-Blázquez, P., Peletier, R.F., Jiménez-Vicente, J., Cardiel, N., Cenarro, A.J., Falcón-Barroso, J., Gorgas, F.J., Selam, S., Vazdekis, A., 2006, *Medium-resolution Isaac Newton Telescope library of empirical spectra*, MNRAS, 371, 703

Simon Frederik Portegies Zwart

1. Portegies Zwart, S., and 23 colleagues, 2009. *A multiphysics and multiscale software environment for modeling astrophysical systems,* NewA, 14, 369
2. Belleman, R.G., Bedorf, J., Portegies Zwart, S.F., 2008: *High performance direct gravitational N-body simulations on graphics processing units II: An implementation in CUDA,* NewA, 13, 103
3. Portegies Zwart, S.F., van den Heuvel, E.P.J., 2007: *A runaway collision in a young star cluster as the origin of the brightest supernova*, Nature, 450, 388
4. Grindlay, J., Portegies Zwart, S., McMillan, S., 2006: *Short gamma-ray bursts from binary neutron star mergers in globular clusters,* NatPh, 2, 116
5. Portegies Zwart, S.F., Baumgardt, H., Hut, P., Makino, J., McMillan, S.L.W., 2004: *Formation of massive black holes through runaway collisions in dense young star clusters*, Nature, 428, 724

Huub Röttgering

1. Intema, H.T., van der Tol, S., Cotton, W.D., Cohen, A.S., van Bemmel, I.M., Röttgering, H.J.A., 2009: *Ionospheric calibration of low frequency radio interferometric observations using the peeling scheme. I. Method description and first results*, A&A, 501, 1185
2. Venemans, B.P., Röttgering, H.J.A., Miley, G.K., van Breugel, W.J.M., de Breuck, C., Kurk, J.D., Pentericci, L., Stanford, S.A., Overzier, R.A., Croft, S., Ford, H., 2007: *Proto- clusters associated with z > 2 radio galaxies. I. Characteristics of high redshift protoclusters*, A&A, 461, 823
3. Jaffe, W., Meisenheimer, K., Röttgering, H. J. A., Leinert, C., Richichi, A., Chesneau, O., Fraix-Burnet, D., Glazenborg-Kluttig, A., Granato, G.-L., Graser, U., Heijligers, B., Köhler, R., Malbet, F., Miley, G.K., Paresce, F., Pel, J.-W., Perrin, G., Przygodda, F., Schoeller, M., Sol, H., Waters, L. B. F. M., Weigelt, G., Woillez, J., de Zeeuw, P. T., 2004: *The central dusty torus in the active nucleus of NGC 1068*, Nature, 429, 47
4. Daddi, E., Röttgering, H.J A., Labbé, I., Rudnick, G., Franx, M., Moorwood, A.F.M., Rix, H.W., van der Werf, P.P., van Dokkum, P.G., 2003: *Detection of strong clustering of red K-selected galaxies at 2 < z < 4 in the Hubble Deep Field-South*, ApJ, 588, 50
5. Jarvis, M.J., Wilman, R.J., Röttgering, H.J.A., Binette, L., 2003: *Probing the absorbing haloes around two high-redshift radio galaxies with VLT-UVES*, MNRAS, 338, 263

Joop Schaye

1. Schaye, J., Aguirre, A., Kim, T.-S., Theuns, T., Rauch, M., Sargent, W.L.W., 2003: *Metallicity of the intergalactic medium using pixel statistics. II. The distribution of metals as traced by C IV,* ApJ, 596, 768
2. Schaye, J., 2004: *Star formation thresholds and galaxy edges: why and where*, ApJ, 609, 667
3. Pawlik, A.H., Schaye, J., 2008: *TRAPHIC - Radiative transfer for smoothed particle hydrodynamics simulations,* MNRAS, 389, 651
4. Pawlik, A.H., Schaye, J., van Scherpenzeel, E., 2009: *Keeping the Universe ionized: photoheating and the clumping factor of the high-redshift intergalactic medium*, MNRAS, 394, 1812
5. Schaye, J., Dalla Vecchia C., Booth, C.M., Wiersma, R.P.C., Theuns, T., Haas, M.R., Bertone, S., Duffy, A.R., McCarthy, I.G., van de Voort, F., 2010, *The physics driving the cosmic star formation history,* MNRAS, in press (arXiv:0909.5196)

Marco Spaans

1. Meijerink, R., Spaans, M., 2005, *Diagnostics of irradiated gas in galaxy nuclei. I. A far-ultraviolet and X-ray dominated region code*, A&A, 436, 397
2. Dijkstra, M., Haiman, Z.,Spaans, M., 2006: *Lyα radiation from collapsing proto-galaxies. I. Characteristics of the emergent spectrum*, ApJ, 649, 14
3. Ormel, C.W., Spaans, M., Tielens, A.G.G.M., 2007: *Dust coagulation in proto-planetary disks: porosity matters,* A&A, 461, 215
4. Klessen, R.S., Spaans, M., Jappsen, A.-K., 2007: *The stellar mass spectrum in warm and dusty gas: deviations from Salpeter in the Galactic centre and in circumnuclear starburst regions*, MNRAS, 374, L29
5. Ormel, C.W., Spaans, M., 2008: *Monte Carlo simulation of particle interaction at high dynamic range: advancing beyond the googol*, ApJ, 684, 1291

Xander A.G.G.M. Tielens

1. Wolfire, M., McKee, C.F, Hollenbach, D.J, Tielens, A.G.G.M., 2003: *Neutral phases of the interstellar medium*, ApJ, 587, 278
2. Peeters, E., Spoon, H.W.W., Tielens, A.G.G.M., 2004: *Polycyclic aromatic hydrocarbons as a tracer of star formation?*, ApJ, 613, 986
3. Kemper, F., Vriend, W.J., Tielens, A.G.G.M., 2004: *The absence of crystalline silicates in the diffuse interstellar medium,* ApJ, 609, 826
4. Cazaux, S., Tielens, A.G.G.M., Ceccarelli, C., Castets, A., Wakelam, V., Caux, E., Parise, B., Teyssier, D., 2003: *The hot core around the low-mass protostar IRAS 16293-2422: scoundrels rule!,* ApJ, 593, L51
5. A.G.G.M. Tielens, 2005*, Physics and chemistry of the interstellar medium*, University of Cambridge Press

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2. Cole, A. A., Skillman, E. D., Tolstoy, E. et al., 2007: *Leo A: a late-blooming survivor of the epoch of reionization in the local group*, ApJ (Letters), 659, 17
3. Battaglia, G., Tolstoy, E., et al., 2006: *The DART imaging and CaT survey of the Fornax dwarf spheroidal galaxy*, A&A, 459, 423
4. Tolstoy, E., Irwin, M.J., et al. 2004, *Two distinct ancient components in the Sculptor dwarf spheroidal galaxy: first results from DART*, ApJ (Letters), 617, 119
5. Tolstoy, E., Venn, K.A., et al., 2003: *VLT/UVES Abundances in four nearby Dwarf spheroidal galaxies: II. Implications for understanding galaxy evolution*, AJ, 125, 707

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1. Verbunt, F., Pooley, D., Bassa, C., 2008: *Observational evidence for the origin of X-ray sources in globular clusters,* in IAU Symp.246, Dynamical evolution of dense stellar systems, ed. E. Vesperini, 301
2. Costantini, E., Kaastra, J., Arav, N., Kriss, G.A., Steenbrugge, K.C., Gabel, J.R., Verbunt, F., Behar, E., Gaskell, C.M., Korista, K.T., Proga, D., Kim Quijano, J., Scott, J.E., Klimek, E.S., Hedrick, C.H., 2007: *X-ray/ultraviolet observing campaign of the Markarian 279 active galactic nucleus outflow: a close look at the absorbing/emitting gas with Chandra-LETGS,* A&A, 461, 121
3. van der Sluys, M.V., Verbunt, F., Pols, O.R., 2006: *Modeling the evolution of double white dwarfs*, A&A ,460, 209
4. Bassa, C.G., van Kerkwijk, M.H., Koester, D., Verbunt, F., 2006: *The masses and origin of the millisecond pulsar PSR J1911$-$5958A and its white-dwarf companion,* A&A, 456, 295
5. Werner, N., de Plaa, J, Kaastra, J., Vink, J., Bleeker, J., Tamura, T., Peterson, J., Verbunt, F., 2006: *XMM-Newton spectroscopy of the cluster of galaxies 2A0335+096*, A&A, 449, 475

Laurentius Bernardus Franciscus Maria Waters

1. van Boekel, R., Min, M., Leinert, Ch., Waters, L.B.F.M., Richichi, A.; Chesneau, O., Dominik, C., Jaffe, W., Dutrey, A., Graser, U., Henning, Th., de Jong, J., Köhler, R., de Koter, A., Lopez, B., Malbet, F., Morel, S., Paresce, F., Perrin, G., Preibisch, Th., Przygodda, F., Schöller, M., Wittkowski, M., 2004: *The building blocks of planets within the `terrestrial' region of protoplanetary disks,* Nature, 432, 479
2. van Boekel, R., Min, M., Waters, L.B.F.M., de Koter, A., Dominik, C., van den Ancker, M.E., Bouwman, J., 2005: *A 10 μm spectroscopic survey of Herbig Ae star disks: grain growth and crystallization,* A&A, 437, 189
3. Bouwman, J., de Koter, A., Dominik, C., Waters, L.B.F.M., 2003: *The origin of crystalline silicates in the Herbig Be star HD 100546 and in comet Hale-Bopp*, A&A 401, 577
4. Deroo, P., van Winckel, H., Min, M., Waters, L.B.F.M., Verhoelst, T., Jaffe, W., Morel, S., Paresce, F., Richichi, A., Stee, P., Wittkowski, M., 2006: *Resolving the compact dusty discs around binary post-AGB stars using N-band interferometry,* A&A, 450, 181
5. Acke, B., Min, M., van den Ancker, M. E., Bouwman, J., Ochsendorf, B., Juhasz, A., Waters, L.B.F.M., 2009: *On the interplay between flaring and shadowing in disks around Herbig Ae/Be stars,* A&A, 502, 47

Ralph Antoine Marie Joseph Wijers

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2. Gehrels, N, Wijers, R.A.M.J., et al., 2005: *A short γ-ray burst apparently associated with an elliptical galaxy at redshift z = 0.225,* Nature, 437, 851
3. Péer, A., Ryde, F., Wijers, R.A.M.J, Mészáros, P., Rees, M.J., 2007: *New method of determining the initial size and Lorentz factor of gamma-ray burst fireballs using a thermal emission component*, ApJ (Letters), 664, L1
4. Tanvir, N.R., Wijers, R.A.M.J., et al., 2009: *A gamma-ray burst at redshift z~8.2*, Nature, 461, 1254
5. Van Eerten, H.J., Meliani, Z., Wijers, R.A.M.J., Keppens, R, 2009: *No visible optical variability from a relativistic blast wave encountering a wind termination shock*, MNRAS, 398, L63

Rudi Adam Dirk Wijnands

1. Wijnands R., van der Klis, M., Homan, J., Chakrabarty, D., Markwardt, C.B., Morgan, E.H., 2003, *Quasi-periodic brightness fluctuations in an accreting millisecond pulsar*, Nature, 424, 44
2. Chakrabarty, D., Morgan, E.H., Muno, M.P., Galloway, D. K., Wijnands, R., van der Klis, M., Markwardt, C.B., 2003, *Nuclear-powered millisecond pulsars and the maximum spin frequency of neutron stars*, Nature, 424, 42
3. Altamirano, D., Casella, P., Patruno, A., Wijnands, R., van der Klis, M., 2008: *Intermittent millisecond X-ray pulsations from the neutron star X-ray transient SAX J1748.9-202 in the globular cluster NGC 6440*, ApJ, 647, L45
4. Casella, P., Altamirano, D., Patruno, A., Wijnands, R., van der Klis, M., 2008: *Discovery of coherent millisecond X-ray pulsations in Aquila X-1*, ApJ, 674, L41
5. Cackett, E.M., Wijnands, R., Linares, M., Miller, J.M., Homan, J., Lewin, W.H.G., 2006: *Cooling of the quasi-persistent neutron star X-ray transients KS 1731-260 and MXB 1659-29*, MNRAS, 372, 479

Appendix B2: Top-10 publications for each of the research networks

This Appendix contains the Top-10 publications in the 2003-2009 period for each of the research networks, sorted in three categories:

I. Ten publications that we are proud of. These are not necessarily the most highly cited papers.

II. Ten highest cited papers led by an author from an institute in the Netherlands. These lists are biased toward publications in the earlier years.

III. Ten highly cited papers in international collaborations. This category recognizes the fact that most projects are carried out in (large) international teams in which the lead author can be from a non-Dutch institute.

Network 1

I. Ten papers that we are proud of (alphabetical order):

1. Cappellari, M., Bacon, R., Bureau, M., Damen, M.C., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Falcon-Barroso, J., Krajnovic, D., Kuntschner, H., McDermid, R.M., Peletier, R.F., Sarzi, M., van den Bosch ,R.C.E., van de Ven, G: 2006, *The SAURON project - IV. The mass-to-light ratio, the virial mass estimator and the Fundamental Plane of elliptical and lenticular galaxies*, MNRAS 366, 1126 (247 cit)
2. Franx, M., Labbé, I, Rudnick, G., van Dokkum, P.G., Daddi, E., Förster-Schreiber, N.M., Moorwood, A., Rix, H.W., Röttgering, H., van de Wel, A., van der Werf, P., van Starkenburg, L., 2003: *A significant population of red, near-infrared-selected high-redshift galaxies*, ApJL, 587, L79 (278 cit)
3. Helmi, A., Irwin, M.J., Tolstoy, E., Battaglia, G., Hill, V., Jablonka, P., Venn, K., Shetrone, M., Letarte, B., Arimoto, N., Abel, T., Francois, P., Kaufer, A., Primas, F., Sadakane, K., Szeifert, T., 2006: *A new view of the dwarf spheroidal satellites of the Milky Way from VLT FLAMES: where are the very metal-poor stars?*, ApJL 651, 121 (86 cit)
4. Jaffe, W., Meisenheimer, K., Röttgering, H.J.A., Leinert, C., Richichi, A., Chesneau, O., Fraix-Burnet, D., Glazenborg-Kluttig, A., Granat,, G.L., Graser, U., Heijligers, B., Köhler, R., Malbet, F., Miley, G.K., Paresce, F., Pel, J.W., Perrin, G., Przygodda, F., Schoeller, M., Sol, H., Waters, L.B.F.M., Weigelt, G., Woillez, J., de Zeeuw, P.T., 2004: *The central dusty torus in the active nucleus of NGC 1068*, Nature 429, 47 (153 cit)
5. Koopmans, L.V.E., Treu, T., Bolton, A.S., Burles, S., Moustakas, L.A., 2006: *The Sloan Lens ACS Survey. III. The structure and formation of early-type galaxies and their evolution since z ≈1*, ApJ, 649, 599 (154 cit)
6. Kriek, M., van Dokkum, P.G., Franx, M., Quadri, R., Gawiser,E., Herrera, D., Illingworth, G.D., Labbé, I., Lira, P., Marchesini, D., Rix, H.W., Rudnick, G., Taylor, E.N., Toft, S., Urry, C.M., Wuyts, S., 2006: *Spectroscopic identification of massive galaxies at z ~2.3 with strongly suppressed star formation*, ApJL, 649, L71 (82 cit)
7. Miley, G.K., Overzier, R.A., Tsvetanov, Z.I., Bouwens, R.J., Benítez, N., Blakeslee, J.P., Ford, H.C., Illingworth, G.D., Postman, M., Rosati, P., Clampin, M., Hartig, G.F., Zirm, A.W., Röttgering, H.J.A., Venemans, B.P., Ardila, D.R., Bartko, F., Broadhurst, T.J., Brown, R.A., Burrows, C.J., Cheng, E.S., Cross, N.J.G., De Breuck, C., Feldman, P.D., Franx, M., Golimowski, D.A., Gronwall, C., Infante, L., Martel, A.R., Menanteau, F., Meurer, G.R., Sirianni, M., Kimble, R.A., Krist, J.E., Sparks, W.B., Tran, H.D., White, R.L., Zheng, W., 2004*: A large population of `Lyman-break' galaxies in a protocluster at redshift z ≈ 4.1,* Nature 427, 47 (59 cit)
8. Romanowsky, A.J., Douglas, N.G., Arnaboldi, M., Kuijken, K., Merrifield, M.R., Napolitano, N.R., Capaccioli, M., Freeman, K.C., 2003*: A dearth of dark matter in ordinary elliptical galaxies*, Science, 301, 1696 (199 cit)
9. Schaye, J., Dalla Vecchia, C., 2008:,*On the relation between the Schmidt and Kennicutt-Schmidt star formation laws and its implications for numerical simulations*, MNRAS, 383, 1210 (38 cit)
10. Tolstoy, E., Irwin, M.J., Helmi, A., Battaglia, G., Jablonka, P., Hill, V., Venn, K.A., Shetrone, M.D., Letarte, B., Cole, A.A., Primas, F., Francois, P., Arimoto, N., Sadakane, K., Kaufer, A., Szeifert, T., Abel T., 2004: *Two distinct ancient components in the Sculptor dwarf spheroidal galaxy: first results from the dwarf abundances and radial velocities team*, ApJL 617, L119 (126 cit)

Network 1

II. Most cited papers with NL lead (sorted by citation count):

1. Franx, M., Labbé, I., Rudnick, G., van Dokkum, P.G., Daddi, E., Förster-Schreiber, N.M., Moorwood, A., Rix, H.W., Röttgering, H., van de Wel, A., van der Werf, P., van Starkenburg, L., 2003: *A significant population of red, near-infrared-selected high-redshift galaxies*, ApJL, 587, L79 (278 cit)
2. Cappellari, M., Bacon, R., Bureau, M., Damen, M.C., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Falcon-Barroso, J., Krajnovic, D., Kuntschner, H., McDermid, R.M., Peletier, R.F., Sarzi, M., van den Bosch, R.C.E., van de Ven, G., 2006: *The SAURON project - IV. The mass-to-light ratio, the virial mass estimator and the Fundamental Plane of elliptical and lenticular galaxies*, MNRAS, 366, 1126 (247 cit)
3. Romanowsky, A.J., Douglas, N.G., Arnaboldi, M., Kuijken, K., Merrifield, M.R., Napolitano, N.R., Capaccioli, M., Freeman, K.C., 2003: *A dearth of dark matter in ordinary elliptical galaxies*, Science, 301, 1696 (199 cit)
4. Koopmans, L.V.E., Treu, T., Bolton, A.S., Burles, S., Moustakas, L.A., 2006: *The Sloan Lens ACS Survey. III. The structure and formation of early-type galaxies and their evolution since z ≈1*, ApJ, 649, 599 (154 cit)
5. Tolstoy, E., Venn, K.A., Shetrone, M., Primas, F., Hill V., Kaufer, A., Szeifert, T., 2003: *VLT/UVES abundances in four nearby dwarf spheroidal galaxies. II. Implications for understanding galaxy evolution*, AJ, 125, 707 (157 cit)
6. Jaffe, W., Meisenheimer, K., Röttgering, H.J.A., Leinert, C., Richichi, A., Chesneau, O., Fraix-Burnet, D., Glazenborg-Kluttig, A., Granato, G.L., Graser, U., Heijligers, B., Köhler, R., Malbet, F., Miley, G.K., Paresce, F., Pel, J.W., Perrin, G., Przygodda, F., Schoeller, M., Sol, H., Waters, L.B.F.M., Weigelt, G., Woillez, J., de Zeeuw, P.T., 2004: *The central dusty torus in the active nucleus of NGC 1068*, Nature, 429, 47 (153 cit)
7. Labbé, I., Franx, M., Rudnick, G., Schreiber, N.M.F., Rix, H.W., Moorwood, A., van Dokkum, P.G., van der Werf, P., Röttgering, H., van Starkenburg, L., van de Wel, A., Kuijken, K., Daddi, E., 2003: *Ultradeep near-infrared ISAAC observations of the Hubble Deep Field South: observations, reduction, multicolor catalog, and photometric redshifts*, AJ, 125, 1107 (149 cit)
8. Tolstoy, E., Irwin, M.J., Helmi, A., Battaglia, G., Jablonka, P., Hill, V., Venn, K.A., Shetrone, M.D., Letarte, B., Cole, A.A., Primas, F., Francois, P., Arimoto, N., Sadakane, K., Kaufer, A., Szeifert, T., Abel, T., 2004: *Two distinct ancient components in the Sculptor dwarf spheroidal galaxy: first results from the dwarf abundances and radial velocities team*, ApJL, 617, L119 (126 cit)
9. Kaastra, J.S., Tamura, T., Peterson, J.R., Bleeker, J.A.M., Ferrigno, C., Kahn, S.M., Paerels, F.B.S., Piffaretti, R., Branduardi-Raymont, G., Böhringer, H., 2004: *Spatially resolved X-ray spectroscopy of cooling clusters of galaxies*, A&A, 413, 415 (113 cit)
10. Förster-Schreiber, N.M., van Dokkum, P.G., Franx, M., Labbé, I., Rudnick, G., Daddi, E., Illingworth, G.D., Kriek, M., Moorwood, A.F.M., Rix, H.W., Röttgering, H., Trujillo, I., van der Werf, P., van Starkenburg, L., Wuyts, S., 2004: *A substantial population of red galaxies at z > 2: modeling of the spectral energy distributions of an extended sample*, ApJ, 616, 40 (109 cit)

Network 1

III. Highly cited papers in international collaborations (alphabetical order):

1. Abazajian, K. N., Adelman-McCarthy, J. K., Agueros, M. A., and 202 co-authors, including Brinchmann, J., 2009: *The seventh data release of the Sloan Digital Sky Survey,* ApJS, 182, 543 (171 cit)
2. Bolton, A.S., Burles, S., Koopmans, L.V.E., Treu, T., Moustakas, L.A., 2006:*The Sloan Lens ACS Survey. I. A large spectroscopically selected sample of massive early-type lens g*alaxies, ApJ, 638, 703 (106 cit)
3. Bouwens, R.J., Illingworth, G.D., Blakeslee, J.P., Franx, M., 2006: *Galaxies at z ~ 6: the UV luminosity function and luminosity density from 506 HUDF, HUDF Parallel ACS Field, and GOODS i-dropouts,* ApJ, 653, 53 (190 cit)
4. Emsellem, E., Cappellari, M., Krajnovic, D., van de Ven, G., Bacon, R., Bureau, M., Davies, R.L., de Zeeuw, P.T., Falcon-Barroso, J. Kuntschner, H., McDermid, R., Peletier, R.F., Sarzi, M., 2007: *The SAURON project - IX. A kinematic classification for early-type galaxies*, MNRAS, 379, 401 (92 cit)
5. Heymans, C., Van Waerbeke, L., Bacon, D., Berge, J., Bernstein, G., Bertin, E., Bridle, S., Brown, M. L., Clowe, D., Dahle, H., Erben, T., Gray, M., Hetterscheidt, M., Hoekstra, H., Hudelot, P., Jarvis, M., Kuijken, K., Margoniner, V., Massey, R., Mellier, Y., Nakajima, R., Refregier, A.,Rhodes, J., Schrabback, T., Wittman, D., 2006: *The shear testing programme - I. Weak lensing analysis of simulated ground-based bservations,* MNRAS, 368, 1323 (127 cit)
6. Paumard, T., Genzel, R., Martins, F., Nayakshin, S., Beloborodov, A. M., Levin, Y., Trippe, S., Eisenhauer, F., Ott, T., Gillessen, S., et al. 2006: *The two young star disks in the central parsec of the Galaxy: properties, dynamics, and formation*, ApJ, 643, 1011 (189 cit)
7. Postman, M., Franx, M., Cross, N.J.G., Holden, B., Ford,H.C., Illingworth,G.D., Goto, T., Demarco, R., Rosati, P., Blakeslee, J.P., Tran, K.V., Benítez, N., Clampin, M., Hartig, G.F., Homeier, N., Ardila, D.R., Bartko, F., Bouwens, R.J., Bradley, L.D., Broadhurst, T.J., Brown, R.A., Burrows, C.J., Cheng, E.S., Feldman, P.D., Golimowski, D.A., Gronwall, C., Infante, L., Kimble, R.A., Krist, J.E., Lesser, M.P., Martel, A.R., Mei, S., Menanteau, F., Meurer, G.R., Miley, G.K., Motta, V., Sirianni, M., Sparks, W.B., Tran, H.D., Tsvetanov, Z.I., White, R.L., Zheng, W., 2005: *The morphology-density relation in z ~ 1 clusters*, ApJ, 623, 721 (138 cit)
8. Sanchez-Blazquez, P., Peletier, R.F., Jimenez-Vicente, J., Cardiel, N., Cenarro, A.J., Falcon-Barroso, J., Gorgas, J., Selam, S., Vazdekis, A., 2006:*Medium-resolution Isaac Newton Telescope library of empirical spectra*, MNRAS, 371, 703 (114 cit)
9. van Dokkum, P.G., Franx, M., Kriek, M., Holden, B., Illingworth, G.D., Magee, D., Bouwens, R., Marchesini, D., Quadri, R., Rudnick, G., Taylo,r E.N., Toft, S., 2008:*Confirmation of the remarkable compactness of massive quiescent galaxies at z ~ 2.3: early-type galaxies did not form in a simple monolithic collapse*, ApJL, 677, L5 (77 cit)
10. Venn, K. A., Irwin, M., Shetrone, M. D., Tout, C. A., Hill, V., Tolstoy, E., 2004: *Stellar chemical signatures and hierarchical galaxy formation*, AJ, 128, 1177 (202 cit)

Network 2

I. Ten papers that we are proud of (alphabetical order):

1. van Boekel, R., Min, M., Leinert, Ch., Waters, L. B. F. M., Richichi, A., Chesneau, O., Dominik, C., Jaffe, W., Dutrey, A., Graser, U.. and 13 coauthors, 2004: *The building blocks of planets within the `terrestrial' region of protoplanetary disks,* Nature, 432, 479
2. Jørgensen, J.K., Schöier, F.L., van Dishoeck, E.F. 2004:, *Molecular inventories and chemical evolution of low-mass protostellar envelopes*, A&A, 418, 1021
3. Meijerink, R., Spaans, M., 2005: *Diagnostics of irradiated gas in galaxy nuclei. I. A far-ultraviolet and X-ray dominated region code*, A&A, 436, 397
4. Öberg, K. I., Garrod, R. T., van Dishoeck, E. F., Linnartz, H., 2009: *Formation rates of complex organic molecules in UV irradiated CH_3OH-rich ices. I. Experiments*, A&A, 504, 891
5. Ormel, C.W., Spaans, M., Tielens, A.G.G.M., 2007: *Dust coagulation in protoplanetary disks: porosity matters,* A&A, 461, 215
6. Panić, O., Hogerheijde, M.R., Wilner, D., Qi, C. 2009: *A break in the gas and dust surface density of the disc around the T Tauri star IM Lupi*. A&A, 501, 269
7. Snik, F., Karalidi, T., Keller, C.U., Laan, E., ter Horst, R., Navarro, R. Stam, D., Aas, C., de Vries, J., Oomen, G., Hoogeveen, R., 2008: *SPEX: an in-orbit spectropolarimeter for planetary exploration*, SPIE, 7010, 35
8. Vink, J.S., de Koter A., 2005: *On the metallicity dependence of Wolf-Rayet winds*, A&A, 442, 587
9. Peeters, E., Spoon, H.W.W., Tielens, A.G.G.M., 2004: *Polycyclic aromatic hydrocarbons as a tracer of star formation?*, ApJ, 613, 986
10. Woitke, P., Thi, W.-F., Kamp, I., Hogerheijde, M. R., 2009: *Hot and cool water in Herbig Ae protoplanetary disks. A challenge for Herschel,* A&A, 501, 5

Network 2

II. Most cited papers with NL lead (sorted by citation count):

1. Schöier, F. L., van der Tak, F. F. S., van Dishoeck, E. F., Black, J. H., 2005: *An atomic and molecular database for analysis of submillimetre line observations,* A&A, 432, 369 (161 cit)
2. van Boekel, R., Min, M., Leinert, Ch., Waters, L. B. F. M., Richichi, A., Chesneau, O., Dominik, C., Jaffe, W., Dutrey, A., Graser, U.. and 13 coauthors, 2004: *The building blocks of planets within the `terrestrial' region of protoplanetary disks,* Nature, 432, 479 (113 cit)
3. Tielens A.G.G.M., 2005*: Physics and chemistry of the interstellar medium*, University of Cambridge Press (103 cit)
4. van Boekel, R., Min, M., Waters, L. B. F. M., de Koter, A., Dominik, C., van den Ancker, M. E., Bouwman, J., 2005: *A 10 μm spectroscopic survey of Herbig Ae star disks: grain growth and crystallization,* A&A, 437, 189 (102 cit)
5. Cazaux, S., Tielens, A.G.G.M., Ceccarelli, C., Castets, A., Wakelam, V., Caux, E., Parise, B., Teyssier, D., 2003: *The hot core around the low-mass protostar IRAS 16293-2422: scoundrels rule!,* ApJ, 593, L51 (101 cit)
6. van Boekel, R., Waters, L. B. F. M., Dominik, C., Bouwman, J., de Koter, A., Dullemond, C. P., Paresce, F., 2003: *Grain growth in the inner regions of Herbig Ae/Be star disks*, A&A 400, 21 (96 cit)
7. Dominik, C., Decin, G., 2003: *Age dependence of the Vega phenomenon: theory,* ApJ, 598, 626 (88 cit)
8. van Dishoeck, E.F., 2004: *ISO spectroscopy of gas and dust: from molecular clouds to protoplanetary disks*, ARA&A, 42, 119 (85 cit)
9. Cazaux, S., Tielens, A.G.G.M., 2004: *H_2 formation on grain surfaces,* ApJ, 604, 222 (83 cit)
10. Meijerink, R., Spaans, M., 2005: *Diagnostics of irradiated gas in galaxy nuclei. I. A far-ultraviolet and X-ray dominated region code*, A&A, 436, 397 (77 cit)

Network 2

III. Highly cited papers in international collaborations (alphabetical order):

1. Boogert, A.C.A., Pontoppidan, K.M., Knez, C., Lahuis, F., Kessler-Silacci, J., van Dishoeck, E.F.,and 20 co-authors, 2008: *The c2d Spitzer spectroscopic survey of ices around low-mass young stellar objects. I. H_2O and the 5-8 μm bands*, ApJ, 678, 985 (36 cit)
2. Dullemond, C. P., Dominik C., 2005: *Dust coagulation in protoplanetary disks: A rapid depletion of small grains*, A&A, 434, 971 (165 cit)
3. Evans C.J., Smartt S.J., Lee J.-K., and 22 co-authors including de Koter and Langer, 2005, *The VLT-FLAMES survey of massive stars: observations in the Galactic clusters NGC 3293, NGC 4755 and NGC 6611*, A&A 437, 467 (49 cit)
4. Evans N.J., Allen L.E., Blake G.A., and 16 co-authors including van Dishoeck, 2003: *From molecular cores to planet-forming disks: an SIRTF legacy program*, PASP 115, 965 (200 cit)
5. Evans N. J., Dunham M. M., Jørgensen J. K., Enoch M. L., Merin B., van Dishoeck E. F., and 12 co-authors, 2009: *The Spitzer c2d legacy results: star-formation rates and efficiencies; evolution and lifetimes*, ApJS 181, 321 (56 cit)
6. Kessler-Silacci, J., Augereau J.C., Dullemond C.P., Geers V., Lahuis F., Evans N. J., II., van Dishoeck E.F., Blake G.A., Boogert, A. C., Brown J., Jørgensen J.K., Knez C., Pontoppidan K. M.,2006: *c2d Spitzer IRS spectra of disks around T Tauri stars. I. Silicate emission and grain growth*, ApJ 639, 275 (106 cit)
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8. Meixner, M., K. Gordon, R. Indebetouw, and the SAGE team including Tielens, 2006: *Spitzer survey of the Large Magellanic Cloud: surveying the agents of a galaxy's evolution (SAGE). I. Overview and initial results*, AJ, 132, 2268 (137 cit)
9. Mokiem, M. R., de Koter, A., Evans, C. J., Puls, J., Smartt, S. J., Crowther, P. A., Herrero, A., Langer, N., Lennon, D. J., Najarro, F., Villamariz, M. R., Vink, J. S., 2007: *The VLT-FLAMES survey of massive stars: wind properties and evolution of hot massive stars in the Large Magellanic Cloud*, A&A, 465, 1003 (37 cit)
10. Whitney, B. A., Sewilo, M., Indebetouw, R., and 47 co-authors including Tielens, 2008: *Spitzer Sage survey of the Large Magellanic Cloud. III. Star formation and ~1000 new candidate young stellar objects*, AJ, 136, 18 (42 cit)

Network 3

I. Ten papers that we are proud of (alphabetical order):

1. Hjorth, J., and 26 colleagues including Kaper, van den Heuvel and Wijers, 2003: A very energetic supernova associated with the γ-ray burst of 29 March 2003, Nature, 423, 847
2. Wijnands, R., van der Klis, M., Homan, J., Chakrabarty, D., Markwardt, C.B., Morgan, E.H., 2003: *Quasi-periodic X-ray brightness fluctuations in an accreting millisecond pulsar*, Nature, 424, 44
3. Fender, R.P., Belloni, T.M., Gallo, E., 2004: *Towards a unified model for black hole X-ray binary jets*, MNRAS, 355, 1105
4. Falcke, H., Körding, E., Markoff, S., 2004: *A scheme to unify low-power accreting black holes. Jet-dominated accretion flows and the radio/X-ray correlation,* A&A , 414, 895
5. Portegies Zwart, S. F., Baumgardt, H., Hut, P., Makino, J., McMillan, S. L. W., 2004: *Formation of massive black holes through runaway collisions in dense young star clusters*, Nature, 428, 724
6. Yoon, S.C., Langer, N., 2005: *Evolution of rapidly rotating metal-poor massive stars towards gamma-ray bursts*, A&A, 443, 643
7. Falcke, H., and 75 colleagues, 2005: *Detection and imaging of atmospheric radio flashes from cosmic ray air showers*, Nature, 435, 313
8. Voss, R., Nelemans, G., 2008: *Discovery of the progenitor of the type Ia supernova 2007on*, Nature, 451, 802
9. Tanvir, N.R., and 62 colleagues including Wijers, 2009: *A γ-ray burst at a redshift of z~8.2*, Nature, 461, 1254
10. Helder, E.A., Vink, J., Bassa, C.G., Bamba, A., Bleeker, J.A.M., Funk, S., Ghavamian, P., van der Heyden, K.J., Verbunt, F., Yamazaki, R., 2009: *Measuring the cosmic-ray acceleration efficiency of a supernova remnant*, Science, 325, 719

Network 3

II. Most cited papers with NL lead (sorted by citation count):

1. Fender, R.P., Belloni, T.M., Gallo, E., 2004: *Towards a unified model for black hole X-ray binary jets*, MNRAS 355, 1105 (259 cit)
2. Gallo, E., Fender, R.P., Pooley, G.G., 2003: *A universal radio-X-ray correlation in low/hard state black hole binaries*, MNRAS, 344, 60 (242 cit)
3. Falcke, H., Körding, E., Markoff, S., 2004: *A scheme to unify low-power accreting black holes. Jet-dominated accretion flows and the radio/X-ray correlation*, A&A, 414, 895 (210 cit)
4. Portegies Zwart, S.F., Baumgardt, H., Hut, P., Makino, J., McMillan, S.L.W., 2004: *Formation of massive black holes through runaway collisions in dense young star clusters,* Nature, 428, 724 (200 cit)
5. Fender, R., 2006: *Jets from X-ray binaries*, in: Compact stellar X-ray sources, ed. W. Lewin & M. van der Klis (Cambridge University Press), p. 381 (132 cit)
6. Yoon, S.C., Langer, N., 2005: *Evolution of rapidly rotating metal-poor massive stars towards gamma-ray bursts,* A&A, 443, 643 (130 cit)
7. Fender, R., Belloni, T., 2004: *GRS 1915+105 and the disc-jet coupling in accreting black hole systems*, ARA&A, 42, 317 (115 cit)
8. Fender, R.P., Gallo, E., Jonker, P.G., 2003: *Jet-dominated states: an alternative to advection across black hole event horizons in `quiescent' X-ray binaries*, MNRAS, 343, 99 (114 cit)
9. van der Klis, M., 2006: *Rapid X-ray variability*, in: Compact stellar X-ray sources, ed. W. Lewin & M. van der Klis (Cambridge University Press), 39 (112 cit)
10. Kuulkers, E., den Hartog, P.R., in 't Zand, J.J.M., Verbunt, F.W.M., Harris, W.E., Cocchi, M., 2003: *Photospheric radius expansion X-ray bursts as standard candles*, A&A, 399, 663 (108 cit)

Network 3

III. Highly cited papers in international collaborations (sorted by citation count):

1. Hjorth, J., and 26 colleagues including Kaper, van den Heuvel and Wijers, 2003: *A very energetic supernova associated with the γ-ray burst of 29 March 2003*, Nature, 423, 847 (634 cit)
2. Winkler, C., and 19 colleagues including Hermsen, 2003: *The INTEGRAL mission*, A&A, 411, L1 (410 cit)
3. Heger, A., Fryer, C.L., Woosley, S.E., Langer, N., Hartmann, D.H., 2003: *How massive single stars end their life*, ApJ, 591, 288 (419 cit)
4. Gehrels, N., and 76 colleagues including Wijers, 2005: *A short γ-ray burst apparently associated with an elliptical galaxy at redshift z = 0.225*, Nature, 437, 851 (239 cit)
5. The Pierre Auger Collaboration, and 442 colleagues including Falcke and Hörandel, 2007: *Correlation of the highest-energy cosmic rays with nearby extragalactic objects*, Science, 318, 938 (231 cit)
6. Fruchter, A.S., and 32 colleagues including Wijers, 2006.: *Long γ-ray bursts and core-collapse supernovae have different environments,* Nature, 441, 463 (213 cit)
7. Pian, E., and 44 colleagues including Wijers, 2006: *An optical supernova associated with the X-ray flash XRF 060218*, Nature, 442, 1011 (176 cit)
8. Paumard, T., and 13 colleagues including Levin, 2006: *The two young star disks in the central parsec of the Galaxy: properties, dynamics, and formation*, ApJ, 643, 1011 (175 cit)
9. Barthelmy, S.D., and 30 colleagues including Wijers, 2005: *An origin for short γ-ray bursts unassociated with current star formation*, Nature, 438, 994 (169 cit)
10. Palmer, D.M., and 27 colleagues including Wijers, 2005: *A giant γ-ray flare from the magnetar SGR 1806 – 20*, Nature 434, 1107 (168 cit)

Appendix B3: Publication statistics 2000 – 2009

This appendix lists the number of publications by NOVA astronomers. They are subdivided into the three research networks and are given per year covering the period 2000-2009. They are split into the following types of publications: (1) article in refereed journal; (2) article in a non-refereed medium; (3) PhD theses with a NOVA institute advisor at the universities of Amsterdam, Groningen, Leiden, Utrecht or Nijmegen; and (4) public outreach articles. The output of each of the research networks is of order 100-200 refereed papers and 6-10 PhD theses per year. The category 'non-refereed journals' includes articles in conference proceedings, in journals that have no or a weak refereeing procedure, (chapters in) books and announcements in astronomical telegrams and GRB circular networks, etc. The number of books written by Dutch astronomers is small enough that it is not listed as a separate category. The category 'Instrumentation' includes publications on instrument descriptions and related technical R&D. The category 'other astronomical research' ('other' in the tables) includes publications on astronomical research topics outside the field of the three networks including scientific results on solar physics and history of astronomy. Figures B3.1 through B3.4 provide an overview of the statistics.

Figure B3.1 shows the total number of publications per year over the period 2000 – 2009 and Figure B3.2 presents the numbers for each of the categories per year. The majority of the publications are in refereed and non-refereed journals.

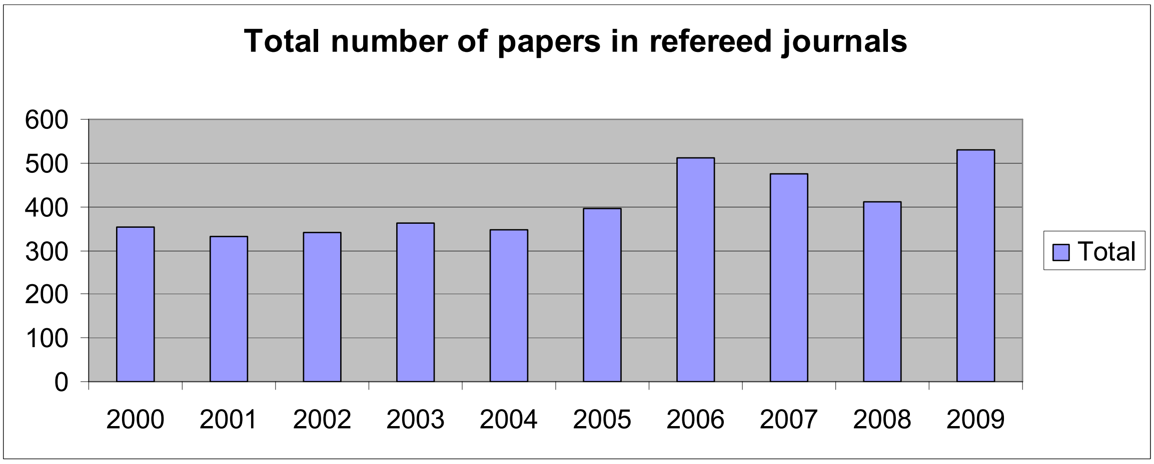


Figure B3.1: *Total number of papers in refereed journals per year over the period 2000-2009.*

The total number of publications in refereed journals in the period 2007-2009 is 28% larger than those in the 2003-2005 period. There is a trend over the last four years (see Fig B3.2) to publish less in conference proceedings.

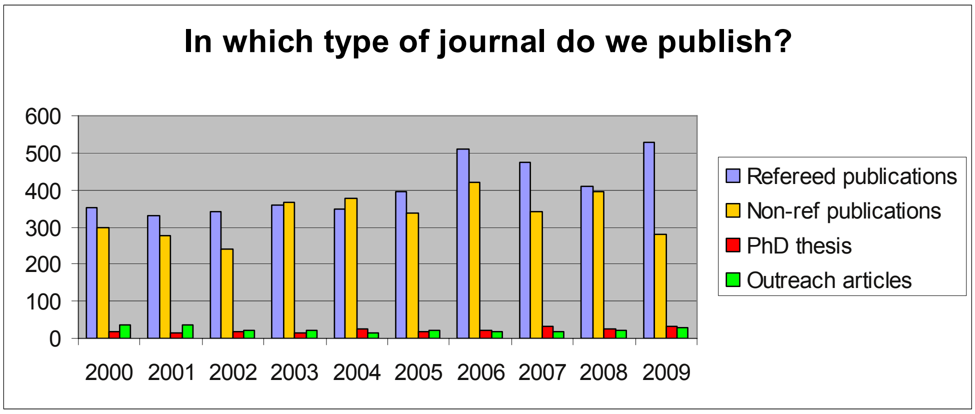


Figure B3.2*: Number of papers per type of publication for the period 2000 – 2009 summed over all research areas. The following types of publications are considered: articles in refereed journals that have a strict refereeing system, articles in non-refereed journals including conference proceedings, PhD theses, and articles in popular science magazines and newspapers ('outreach articles'). Press releases, annual reports and products for educational purposes are not included.*

Fig. B3.3 shows the numbers of publications in refereed journals per year over the period 2000-2009 for each of the research networks, and for the papers related to instrumentation or another area in astronomy. Networks 1 and 3 show a growth in the number of publications between 2003 and 2009 while the publication activity in Network 2 varies over the years. Part of this variation is related to Tielens' absence from the Netherlands in the period 2005-2008.

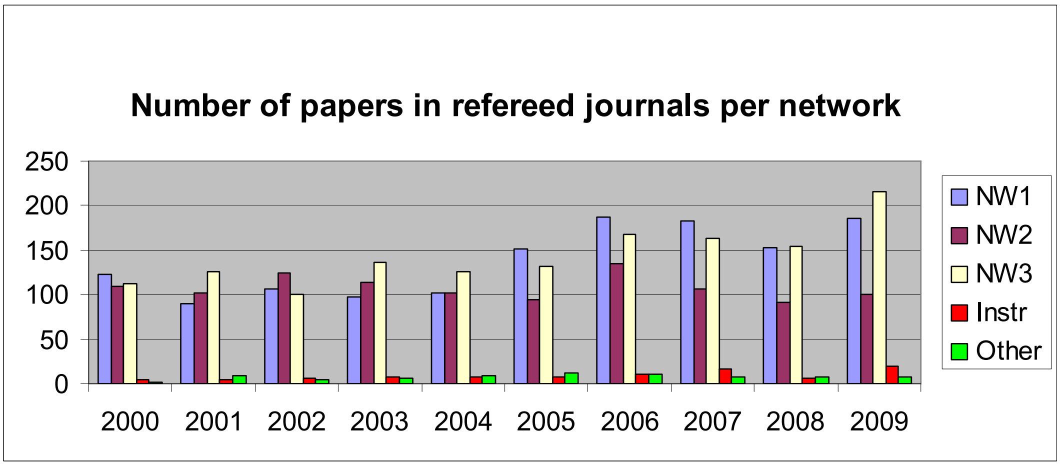


Figure B3.3*: Number of papers in refereed journals per year over the period 2000-2009 per research network. The number of papers in refereed journals for the categories instrumentation and research outside the network domains are also shown.*

Figure B3.4 shows the number of publications in refereed journals over the period 2000-2009 for each of the five university institutes.

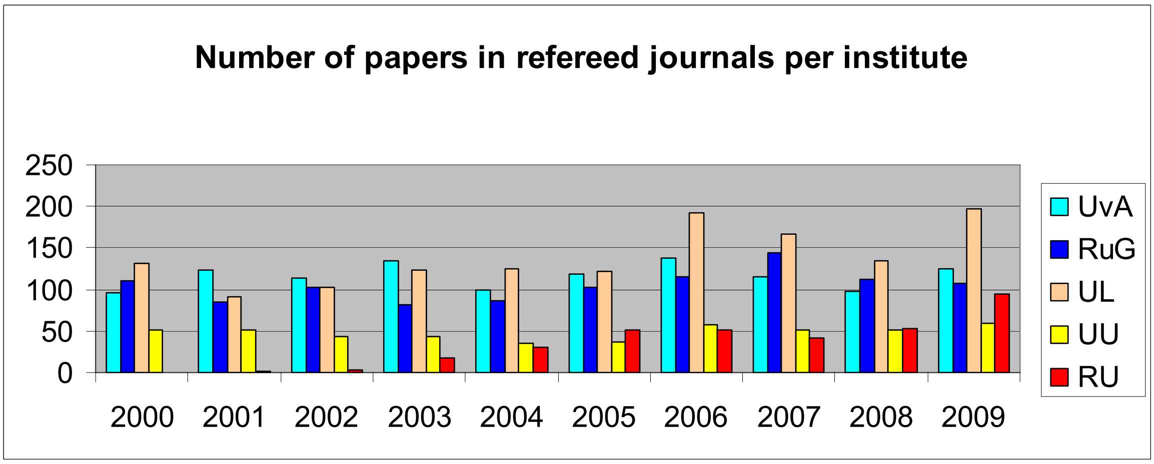


Figure B3.4: *Number of publications in refereed journal per institute per year.*

Table B3.5 lists the number of astronomical publications for NOVA per year for the period 2000 – 2009. The criterion for counting a publication is whether the affiliation of the institute is mentioned in the paper. The top frame provides the total number of publications per year categorized to publication type. Subsequent frames show the same numbers for each of the research networks, and for the categories 'Instrumentation' and 'other research'.

NOVA: all

Type publication	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
Refereed publications	352	332	341	361	347	397	511	476	411	529	***4057***
Non-ref publications	298	278	239	366	379	338	421	340	394	279	***3332***
PhD theses	19	16	19	13	25	19	20	32	24	33	***220***
Outreach articles	37	35	21	21	13	20	17	19	22	30	***235***
TOTAL	***706***	***661***	***620***	***761***	***764***	***774***	***969***	***867***	***851***	***871***	***7844***

NOVA: Network-1

Type publication	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
Refereed publications	123	90	107	98	102	151	187	183	153	185	***1379***
Non-ref publications	81	106	81	86	92	88	76	103	98	65	***876***
PhD theses	8	1	6	5	7	8	5	13	8	13	***74***
Outreach articles	4	8	5	7	1	3	1	1	0	0	***30***
TOTAL	***216***	***205***	***199***	***196***	***202***	***250***	***269***	***300***	***259***	***263***	***2359***

NOVA: Network-2

Type publication	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
Refereed publications	110	102	124	114	102	95	134	107	91	101	***1080***
Non-ref publications	108	64	59	93	86	104	81	44	59	38	***736***
PhD theses	9	5	10	4	9	5	7	7	7	8	***71***
Outreach articles	2	3	3	3	0	1	1	0	1	0	***14***
TOTAL	***229***	***174***	***196***	***214***	***197***	***205***	***223***	***158***	***158***	***147***	***1901***

NOVA: Network-3

Type publication	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
Refereed publications	113	126	100	136	126	131	168	163	154	215	***1432***
Non-ref publications	82	78	86	127	155	115	176	151	169	137	***1276***
PhD theses	1	10	2	4	8	5	7	10	8	8	***63***
Outreach articles	0	3	1	3	1	0	0	1	0	3	***12***
TOTAL	***196***	***217***	***189***	***270***	***290***	***251***	***351***	***325***	***331***	***363***	***2783***

NOVA: Instrumentation

Type publication	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
Refereed publications	5	5	6	7	8	8	11	16	6	20	***92***
Non-ref publications	17	17	9	44	34	26	67	25	35	27	***301***
PhD theses	0	0	0	0	1	0	0	1	1	4	***7***
Outreach articles	3	1	0	1	2	0	1	1	0	1	***10***
TOTAL	***25***	***23***	***15***	***52***	***45***	***34***	***79***	***43***	***42***	***52***	***410***

NOVA: other research

Type publication	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
Refereed publications	1	9	4	6	9	12	11	7	7	8	***74***
Non-ref publications	10	13	4	16	12	5	21	17	33	12	***143***
PhD theses	1	0	1	0	0	1	1	1	0	0	***5***
Outreach articles	28	20	12	7	9	16	14	16	21	26	***169***
TOTAL	***40***	***42***	***21***	***29***	***30***	***34***	***47***	***41***	***61***	***46***	***391***

Table B3.5: Numbers of publications for NOVA for the period 2000 – 2009.

Appendix B4: PhDs in astronomy for the period 2003-2009

The following tables list the PhDs in astronomy awarded by the universities that are federated in NOVA for the period 2003-2009, sorted by university. In total 166 PhDs in astronomy were awarded: 33 at UvA, 43 at RuG, 53 at UL, 28 at UU and 9 at RU.

University of Amsterdam							
Name	**Promotor**	**Start date**	**PhD date**	**Thesis title**	**Duration**	**Current job**	**Current institute**
J. Dewi	van den Heuvel	01/04/1999	28/03/2003	From Be/X-ray binaries to double neutron star systems	3.92	Student Psychology	University of Geneva
A. Bik	Waters co: Kaper	01/05/2000	27/09/2004	The stellar content of high-mass star-forming regions	4.33	Fellow	Max-Planck-Institut für Astronomie
R. van Boekel	Waters co: Pel	01/05/2000	21/10/2004	High spatial resolution infrared studies of proto-planetary disks	4.42	Fellow	Max Planck Institut fur Astronomie
J. Braithwaite	Spruit	nvt externe pr	08/04/2004	Stable and unstable magnetic fields in stars		Fellow / academic	The Argelaender Institute, University of Bonn
C. Dijkstra	Waters	01/07/2000	23/11/2004	Silicates and water ice around evolved stars	4.33	Fellow	SRON, EOS Divisie
M. Klein-Wolt	Van der Klis	01/05/2000	30/09/2004	Black hole X-ray binaries	4.33	Consultant	Altran
A. Lenorzer	Waters co: de Koter / Kaper	01/10/1999	14/01/2004	Near-infrared spectroscopic analysis of hot massive stars	4.25	Researcher / Staff member	IAC
E. Rol	Van den Heuvel co: Kaper	01/01/1999	29/01/2004	The physics of gamma-ray burst afterglows	5.00	Fellow	Universiteit van Amsterdam
S. van Straaten	Van der Klis	01/03/2000	22/04/2004	Timing similarities among accreting neutron stars	4.08	Researcher	Optiver, beurshandelsfirma
E. Gallo	van der Klis	01/09/2001	23/09/2005	Relativistic jets from stellar black holes	4.00	Fellow (Hubble)	MIT Kavli Institute for Astrophysics and Space Research
S. Migliari	van der Klis	01/09/2001	21/09/2005	Disc-jet coupling in neutron star and black holes binaries	4.00	Fellow	University of California, Centre for Astrophysics and Space Sciences
M. Min	Hovenier/Waters	01/04/2001	12/05/2005	Optical properties of circumstellar and cometary grains	4.08	Fellow	Universiteit Utrecht
N.L.J. Cox	Ehrenfreund / Kaper	01/05/2002	09/06/2006	Diffuse interstellar bands and interstellar carbon chemistry in the galaxy and beyond	4.08	Fellow	ESA
A. Gualandris	v.d Heuvel / Kaper	01/09/2002	12/09/2006	Simulating self-gravitation systems on parallel computers	4.00	Fellow	Rochester Institute of Technology
T. Kouwenhoven	Kaper	01/09/2002	19/09/2006	The primordial binary population in the association Sco OB2	4.00	Bairen Researcher	Peking University, Kavli institute
A. van der Meer	van den Heuvel	01/12/2000	09/03/2006	X-ray and optical spectroscopy of high-mass X-ray binaries	5.25	Senior Researcher	ABF Research
M.R. Mokiem	van den Heuvel co:de Koter	01/12/2001	27/04/2006	The physical properties of early-type massive stars	4.33	Consultant	OC&C strategy consultants
A. van der Horst	Wijers	01/09/2003	07/09/2007	Broadband view of blast wave physics. A study of gamma-ray burst afterglows	4.00	Fellow	NASA, Marshall Space Flight Center
H. Koers	Gaemers / Wijers		21/09/2007	The astrophysical Herald. Neutrinos as probes for particle physics and astronomy		Fellow	Universite Libre de Bruxelles
J. Meijer	Waters	01/01/2003	19/09/2007	Theoretical studies of the infrared emission properties of proto-planetary disks	4.67	Researcher	KNMI
R. Schnerr	Henrichs	01/12/2002	07/02/2007	Magnetic fields and mass loss	4.17	Fellow	Stockholm University, Institute for Solar Physics
P. Weltevrede	van der Klis / Stappers	01/12/2002	16/03/2007	The modulation and propagation of the radio emission of pulsars	4.25	Lecturer	University of Manchester
K. Wiersema	Wijers	01/10/2003	13/09/2007	Delving into the dragon's den: the host galaxies of gamma-ray bursts	3.92	Fellow	University of Leicester
D. Altamirano	Van der Klis	15/11/2003	23/04/2008	Different manifestations of accretion onto compact objects	4.42	Fellow	Universiteit van Amsterdam
P. Curran	Wijers	01/10/2004	05/09/2008	Multi-wavelength analyses of gamma-ray bursts: Features of swift GRBs and the blast wave model	3.92	Fellow	University College London, Mullard Space Science Lab
E. Gaburov	Wijers / Sloot co: Portegies Zwart /	01/08/2004	04/11/2008	Stellar collisions in young star clusters	4.25	Fellow	Universiteit Leiden
P. den Hartog	Hermsen co: Van der Klis	01/11/2002	21/05/2008	Non-thermal x-ray emission from anomalous x-ray pulsars	5.50	Visitor Scientist	SRON
D. Paszun	Dominik	01/09/2004	17/10/2008	The collisional evolution of small dust aggregates	4.08	Software engineer	FL Media
G.H. Janssen	van der Klis co: Stappers	15/11/2004	25/03/2009	High precision radio pulsar timing	4.33	Fellow	Jodrell Bank Center for Astrophysics, University of Manchester.
R. Karuppusamy	van der Klis co: Stappers	13/02/2007	13/11/2009	A Study on Giant Radio Pulsars	2.75	Fellow	Max Planck Institute
M. Linares Alegre	van der Klis	01/07/2005	16/09/2009	Accretion states and thermonuclear bursts in neutron star X-ray binaries	4.17	Fellow (Rubicon)	MIT Kavli Institute for Astrophysics and Space Research
A. Patruno	van der Klis co: Wijnands	01/04/2005	09/06/2009	Accreting millisecond X-ray pulsars: from accretion disk to magnetic poles	4.17	Fellow (Veni)	Universiteit van Amsterdam
A. Verhoeff	Waters / Tielens co: Pel	01/05/2005	10/11/2009	Dusty Disks around Young Stars	4.5	Fellow	Astronomical Institute

Appendix B4 PhDs

University of Groningen							
Name	**Promotor**	**Start date**	**PhDdate**	**Thesis title**	**Duration**	**Current job**	**Current institute**
M. Beijersbergen	van der Hulst	01/09/1998	06/01/2003	The galaxy population in the Coma Cluster	4.33	Strategy Consultant	ABN
J. Bernard Salas	Tielens co: Wesselius	15/04/1999	30/09/2003	Physics and chemistry of gas in planetary nebulae	4.42	Research Associate	Cornell University
M.E. Filho	van der Hulst co: Barthel, Ho	01/12/1998	09/05/2003	Nuclear activity in nearby galaxies	4.42	Reseacher	University of Porto, Centro di Astrofisica
A.C. González Garcia	van Albada	15/10/1998	28/03/2003	Elliptical galaxies: merger simulations and the fundamental plane	4.42	Fellow	Instituto de Astrofísica de Canarias
M. Kregel	van der Kruit co: Freeman	01/09/1998	17/11/2003	Structure and kinematics of edge-on galaxy disks	5.17	Project manager /	Ingenieursbureau Oranjewoud B.V.
H.W.W. Spoon	Tielens	01/01/1999	20/10/2003	Mid-infrared spectroscopy of dusty galactic nuclei	4.75	Research Associate	Cornell University
S.M. Cazaux	Tielens co: Spaans	01/11/1999	06/01/2004	Grain surface chemistry in astrophysical objects: from H2 to complex molecules	4.17	Fellow	Rijksuniversiteit Groningen
K. Fathi	van der Kruit co: Peletier	external	17/12/2004	Morphology and dynamics in the Inner regions of spiral galaxies		Assistant Professor	Stockholm University
L.K. Hunt	van der Kruit	external	15/10/2004	Building Galaxies: from low-metallicity compact dwarfs to active galactic nuclei		Research Associate	INAF-Osservatorio Astrofisico di Arcetri
H.R. Klöckner	van der Hulst co: Baan	01/01/1999	19/03/2004	Extragalactic Hydroxyl	5.17	Fellow	University of Oxford
E. Romano-Diaz	van de Weijgaert / Sanders	01/10/1998	08/10/2004	Probing cosmic velocity flows in the Local Universe	6.00	Fellow	University of Kentucky
B.W. Holwerda	van der Kruit / Allen	01/10/2000	17/06/2005	The opacity of spiral galaxy disks	4.67	Fellow	University of Capetown, Astronomy department
J.T.A. de Jong	Kuijken / Crotts / Sackett	01/01/2000	23/09/2005	Microlensing in Andromeda. A search for baryonic dark matter.	5.67	Fellow	Max Planck Institut fur Astronomie
B. Emonts	v.d.Hulst co: Morganti	01/05/2002	24/11/2006	Nearby Radio Galaxies: the interplay of gas, star, formation and active nucleus	4.50	Fellow (Bolton Fellowship)	CSIRO Australia Telescope National Facility (ATNF)
A. Labiano Ortega	Barthel / O`Dea co: Vermeulen	01/10/2001	24/02/2006	Host galaxies and environments of compact extragalactic radio sources	4.33	Fellow (ESA)	European Science Astronomy Centre
E. Noordermeer	van der Hulst / Sancisi / van Albada	01/02/2000	10/03/2006	The distribution of gas, stars, and dark matter in early-type disk galaxies	6.08	Software consultant	Tessella
M.A. Aragon Calvo	van de Weijgaert / van der Hulst	01/10/2002	16/11/2007	Morphology and Dynamics of the Cosmic Web	5.08	Fellow	Johns Hopkins University
G. Battaglia	Tolstoy co: Helmi	15/06/2003	07/09/2007	Chemistry and kinematics of stars in Local Group galaxies	4.25	Fellow	ESO
R. Boomsma	van der.Hulst / Sancisi co: Oosterloo	01/08/2001	26/01/2007	The disk-halo connection in NGC 6946 and NGC 253	5.42	Specialist Thermo	AVEBE U.A.
M.A. Brentjens	de Bruyn	15/03/2002	29/06/2007	Radio polarimetry in 2.5D	5.25	LOFAR Support	ASTRON
F.F.T. Christen	Kuijken / Valentijn	12/09/2000	27/04/2007	OmegaCAM and Gravitional Lensing	6.58		
K. Ganda	Peletier	01/09/2003	14/12/2007	Late-type spiral galaxies : kinematics and stellar populations in their inner regions	4.25	Commercial position	Sykes Enterprises
K. Kovac	v.d.Hulst / Verheijen co: Oosterlo	01/11/2002	19/01/2007	Searching for the lowest mass galaxies: an HI perspective	4.17	Fellow	ETH Hoenggerberg Campus
B. Letarte	Tolstoy / Hill	16/09/2002	30/03/2007	Chemical analysis of the Fornax Dwarf Galaxy	4.50	Fellow / Research	South African Astronomical Observatory (SAAO)
N.M.A. Mohamed	Sanders	01/02/2002	07/09/2007	The simulation of cooling flows in clusters of galaxies	5.58	Research Associate	Helwan University
D.R. Poelman	Spaans	01/09/2003	26/10/2007	Emission characteristics of water in the universe	4.08	Fellow	University of St Andrews
W.E. Schaap	van de.Weijgaert / van Albada	01/09/1997	19/01/2007	DTFE: The Delaunay Tessellation Field Estimator	9.33	Publisher	Wolters-Noordhoff
P.A. Araya Melo	van de Weijgaert	01/10/2002	19/05/2008	Formation and evolution of galaxy clusters in cold dark matter cosmologies	5.58	Fellow	Jacobs University
W.F. Frieswijk	Spaans co: Shipman	01/01/2004	28/03/2008	Early stages of clustered star formation : massive dark clouds throughout the Galaxy	4.17	Fellow	Rijksuniversiteit Groningen
P. Kamphuis	Peletier / van der Kruit	01/01/2004	07/11/2008	The structure and kinematics of halos in disk galaxies	4.83	Fellow	Astronomisches Institut, Ruhr-Universität
J.W. Kooi	Wild / Klapwijk	external	22/12/2008	Advanced receivers for submillimeter and far infrared astronomy		Scientific Research	California Institute for Technology
C.W. Ormel	Tielens / Spaans	01/09/2004	10/10/2008	The early stages of planet formation: how to grow from small to large	4.08	Fellow	Max-Planck-Institut für Astronomie
P. Serra	Trager co: Oosterloo / Morganti	15/01/2004	11/04/2008	Stars, neutral hydrogen and ionised gas in early-type galaxies	4.25	Fellow	ASTRON
M. Barnabe	de Bruin / Koopmans	01/02/2005	27/03/2009	Combined gravitational lensing and stellar dynamics analysis of early type galaxies	4.08	Fellow	KIPAC/Stanford
A. Berciano-Alba	Koopmans / Garrett / de Bruyn	01/12/2004	01/03/2009	Strong gravitational lensing in the radio domain	4.25		
C. Boersma	Tielens / Waters co: Allamandola	01/02/2005	11/12/2009	Infrared emission features: probing the interstellar PAH population and circumstellar environment of Herbig Ae/Be stars	4.83	Fellow	NASA Ames Research Center
J.S. Heiner	van der Kruit / Allen	01/07/2004	06/04/2009	Large-scale photodissociation regions in nearby spiral galaxies	4.75	Fellow	Université Laval
Y.S. Li	Helmi	01/11/2004	30/01/2009	Local Group Galaxies in a Lambda CDM Universe	4.17	Fellow	Rijksuniversiteit Groningen
A.F. Loenen	Spaans / Baan	01/09/2005	23/10/2009	Star formation and the ISM : interactions in the Milky Way and other galaxies	4.08	Fellow	Leiden Observatory
E. Platen	van de Weijgaert / Jones	15/03/2005	13/11/2009	A void perspective of the Cosmic Web	4.67		
G. Sikkema	Peletier / Valentijn	01/09/2003	13/03/2009	The Influence of the Environment on the Evolution of Galaxies	5.50	Fellow	Rijksuniversiteit Groningen
R.M. Thomas	Zaroubi co: Koopman	01/04/2005	20/03/2009	Cosmological Reionization Simulations for LOFAR	3.92	Fellow	CITA
A. Villalobos Coffre	Helmi	01/05/2004	25/05/2009	Simulations of the formation of thick discs in galaxies	5.00	Fellow	Osservatorio Astronomico di Trieste

Leiden University							
Name	**Promotor**	**Start date**	**PhD date**	**Thesis title**	**Duration**	**Current job**	**Current institute**
A.M.S. Gloudemans-Boonman	van Dishoeck co: Doty	01/01/1998	05/03/2003	Spectroscopy of gases around massive young stars	5.17	Researcher	SRON/EOS
J.D. Kurk	Miley co: Rottgering	01/10/1998	22/05/2003	The cluster environment and gaseous halos of distant radio galaxies	4.58	Fellow	MPE Garching
G.M. Muñoz Caro	van Dishoeck co: Schutte	01/11/1998	05/02/2003	From photoprocessing of interstellar ice to amino acids and other organics	4.25	Researcher (permanent position)	Center of Astrobiology, INTA
E.K. Verolme	de Zeeuw	01/04/1999	21/05/2003	Dynamical models of axi-symmetric and tri-axial stellar systems	4.08	Department manager 'Procurement and in-	TNO Defense, Security and Safety (TNO Defensie en Veiligheid)
J.K. Jørgensen	van Dishoeck	01/11/2000	14/10/2004	Tracing the Physical and Chemical Evolution of Low-Mass Protostars	3.92	Assistant Professor	University of copenhagen
K. Kraiberg Knudsen	Franx co: van der Werf	01/05/2000	06/10/2004	Deep Submillimeter Observations of Faint Dusty Galaxies	4.42	Fellow	University of Bonn, Argelander-Institute for Astronomy
D. Krajnovic	de Zeeuw	01/09/2000	12/10/2004	On the nature of early-type galaxies	4.08	Fellow	ESO
I. Labbé	Franx co: van Dokkum	01/04/2000	13/10/2004	Deep Infrared Studies of Massive High Redshift Galaxies	4.50	Fellow (Hubble)	Carnegie observatories
M. Messineo	Habing	01/12/1999	30/06/2004	Late Type Giants in the Inner Galaxy	4.50	Astronomer	Center for imaging science, Rochester Institute of Technology
K.M. Pontoppidan	van Dishoeck	01/11/2000	14/10/2004	Fire and Ice	3.92	Fellow (Hubble)	California Institute of Technology
R. Ruiterkamp	Ehrenfreund	01/10/1999	28/10/2004	Aromatic Molecules in Space: Laboratory Studies and Applications to Astrochemistry	5.00		LIC Soft condensed Matter, Leiden University
F.A. van Broekhuizen	van Dishoeck / Schlemmer co: Fraser	01/10/2000	29/06/2005	A laboratory route to interstellar ice	4.67	Senior Researcher	IVAM, Universiteit van Amsterdam
D. van Delft	Visser / van Lunteren	01/01/2003	10/02/2005	Heike Kamerlingh Onnes, een biografie	4.00	Director / Professor	Museum Boerhaave/Universiteit Leiden
P.B. Lacerda	Habing	01/08/2000	17/02/2005	The shapes and spins of Kuiper Belt objects	4.50	Fellow (Newton)	Queen's University
F.I. Pelupessy	Icke co: van der Werf	01/09/2000	16/03/2005	Numerical studies of the interstellar medium on galactic scales	4.50	Fellow	Universiteit Leiden
M.A. Reuland	Miley co: van Breugel, Röttgering	01/09/1999	24/02/2005	Gas, dust, and star formation in distant radio galaxies	5.42	Manager Pricing complex Risks and	E.ON Energy Trading
E.J. Rijkhorst	Icke co: Mellema	01/09/2001	06/12/2005	Numerical Nebulae	4.25	Research Associate	UCL Centre for Medical Image computing (CMIC)
K.C. Steenbrugge	Schilizzi co: Kaastra		02/02/2005	High-resolution X-Ray spectral diagnostics of Active Galactic Nuclei		Fellow	St Johns college, Oxford
G.M. van de Ven	de Zeeuw	01/10/2001	01/12/2005	Dynamical structure and evolution of stellar systems	4.17	Junior Faculty	Max Planck Institute for Astronomy
B.P. Venemans	Miley co: Röttgering	01/10/2000	27/04/2005	Protoclusters associated with distant radio galaxies	4.50	Fellow	ESO
A. van der Wel	Franx / van Dokkum	01/09/2001	29/09/2005	Setting the scale: photometric and dynamical properties of high-redshift early-type galaxies	4.00	Fellow	Max Planck Institut fur Astronomie
B.J. Jonkheid	van Dishoeck	01/12/2001	28/06/2006	Chemistry in evolving protoplanetary disks	4.50	Fellow	KNMI
I.L. ten Kate	Ehrenfreund/ van Loosdrecht	01/11/2001	26/01/2006	Organics on Mars. Laboratory studies of organic material under simulated martian conditions	4.17	Visiting Assistant Research Scientist	Goddard Space Flight Center, GEST
R. Meijerink	Israel co: Spaans	01/10/2002	08/11/2006	Models of the ISM in Galaxy Centers	4.08	Fellow	Leiden Observatory
R.A. Overzier	Miley co: Rottgering	01/01/2002	30/05/2006	Emergence of cosmic structures around distant radio galaxies and quasars	4.33	Fellow	Max Planck Institut fur Astronomie
S.J. Paardekoper	Paardekoper: Icke co: Mellema	01/09/2002	28/06/2006	Growing and moving planets in disks	3.75	Fellow (STFC)	University of Cambridge
S.E. Bisschop	van Dishoeck co: Linnartz	01/11/2003	08/11/2007	Complex Molecules in the Laboratory and Star Forming Regions	4.00	Fellow	University of copenhagen
V.C. Geers	van Dishoeck	01/02/2003	23/10/2007	Polycyclic Aromatic Hydrocarbons in Disks around Young Solar-type Stars	4.67	Fellow	ETH
S. Hekker	Quirrenbach / Aerts co: Snellen	15/09/2003	18/09/2007	Radial velocity variations in red giant stars:Pulsations, Spots and Planets	4.00	Fellow	Observatory, University of Birmingham
M. Kriek	Franx / van Dokkum	01/10/2003	26/09/2007	The Many Phases of Massive Galaxies	3.92	Fellow (Spitzer)	Princeton University
F. Lahuis	van Dishoeck		09/05/2007	Molecular fingerprints of star formation throughout the Universe - a space-based infrared study		Calibration scientist	SRON
J. Ritzerveld	Icke	01/03/2003	14/02/2007	The Simplicity of Transport. Triangulating the First Light	3.92	Head of Risk Management	LeasePlan NL
L. Snijders	Franx co: v.d.Werf	01/10/2003	28/11/2007	Extreme star formation in starbust galaxies	4.08	Advisor People Development	Nuon Energy
S. Wuyts	Franx co:van Dokkum	01/01/2003	27/09/2007	Red Galaxies at high Redshift	4.67	Fellow	Harvard–Smithsonian Center for Astrophysics
S. Albrecht	Quirrenbach co: Snellen	15/11/2003	17/12/2008	Stars and planets at high spatial and spectral resolution	5.08	Fellow (Rubicon)	Kavli institute of Astrophysics and Space Research, MIT
R. van de Bosch	De Zeeuw	01/04/2004	10/09/2008	Giant elliptical galaxies	4.42	Fellow (McDonald)	McDonald Observatory, The Univesity of Texas at Austin
C. Brinch	Van Dishoeck co: Hogerheijde	01/10/2004	22/10/2008	The evolving velocity field around protostars	4.00	Fellow (Allegro)	Leiden Observatory
T. van Kempen	Van Dishoeck co: Hogerheijde	01/09/2004	09/10/2008	Probing protostars: The physical structure of the gas and dust during low-mass star formation	4.08	Fellow (SMA)	Harvard–Smithsonian Center for Astrophysics
D. Schnitzeler	Miley / De Bruyn co: Katgert	01/09/2003	15/05/2008	Faraday tomography of the galactic ISM with the WSRT	4.67	Fellow	ATNF/CSIRO Marsfield
L. van Starkenburg	Franx co: Van der Werf	01/09/2002	04/12/2008	Dynamics of high redshift disk galaxies	5.00	Informatieanalist	Achmea Zorgverzekering
C. Tasse	Miley co: Röttgering	01/11/2003	31/01/2008	Host galaxies and environment of active galactic nuclei	4.17	Fellow	Observatoire de Meudon
H. Verbraak	Stolte co: Linnartz	01/09/2005	10/09/2008	High resolution infrared spectroscopy of ionic complexes	4.50	Research Engineer	Philips EUV
H.T. Intema	Miley co: Röttgering	01/02/2005	31/07/2009	A sharp view on the low-frequency radio sky	4.42	Fellow (Jansky)	National Astronomy Observatory
D. Lommen	van Dishoeck co: van Langevelde, Wright	15/04/2005	15/04/2009	The first steps of planet formation	4.00	High school teacher	Rijnlands Lyceum
E.R. Micelotta	Israel / Tielens	15/11/2004	15/05/2009	PAH processing in space	4.50		
K.I. Öberg	Van Dishoeck / Linnartz	01/09/2005	31/08/2009	Complex processes in simple ices	3.92	Fellow (Hubble)	Harvard University
O. Panic	Van Dishoeck co: Hogerheijde	15/08/2005	15/08/2009	High angular resolution studies of protoplanetary discs	4.00	Fellow (ALMA)	ESO
A.H. Pawlik	Röttgering co: Schaye	01/05/2005	30/09/2009	Simulating cosmic reionisation	4.33	Fellow	University of Texas
D. Raban	Röttgering co: Jaffe	01/03/2005	28/02/2009	Infrared Interferometric Observations of Dust in the Nuclei of Active Galaxies	3.92	Scientific Researcher	TNO Delft
E.N.C. Taylor	Franx co: Van Dokkum	01/09/2004	31/08/2009	Ten billion years of massive gGalaxies	4.92	Fellow	University of Melbourne
R. Visser	Van Dishoeck	01/09/2005	31/10/2009	Chemical evolution from cores to disks	4.08	Fellow	Leiden Observatory
N. de Vries	Schilizzi co: Snellen, Röttgering	01/09/2005	31/08/2009	The evolution of radio-loud active galactic nuclei	3.92	Fellow	Leiden Observatory
A.-M. Weijmans	De Zeeuw	01/02/2005	31/07/2009	The structure of dark and luminous matter in early-type galaxies	4.42	Fellow (Dunlap)	Dunlap Institute for Astronomy & Astrophysics

Appendix B4 PhDs

Utrecht University

Name	Promotor	Start date	PhD date	Thesis title	Duration	Current job	Current institute
R. Cornelisse	Verbunt co: Heise	01/01/1999	15/01/2003	A wide field view of the population of X-ray bursters in the galaxy	4.00	Fellow (Ramon y Cajal)	Instituto d'Astrofisica de Canarias
F. Hulleman	Verbunt co: van Kerkwijk	01/01/1999	14/04/2003	Anomalous X-ray pulsars at optical and infrared wavelengths	4.25	Webdeveloper	
W.M. Bergmann Tiest	Bleeker co: Hoevers		01/03/2004	Energy resolving power of transition-edge X-ray microcalorimeters		Fellow	Universiteit Utrecht, Physics of man
K.J. van der Heyden	Bleeker		02/02/2004	High-resolution X-ray spectral diagnostics of shell type Supernova Remnants		Fellow	South African Astronomical Observatory
A.G.J. van Leeuwen	Verbunt	01/01/1999	10/05/2004	Radio pulsars	4.27	Staff member	ASTRON, Astronomy group
J. Petrovic	Langer	01/11/2000	27/10/2004	On the evolution of massive close binary systems	3.92	Researcher	NIKHEF
S.C. Yoon	Langer	15/12/2000	22/04/2004	On the evolution of accreting white dwarfs in binary systems	4.00	Senior Researcher	Argelander-Institut für Astronomie der Universität Bonn
N.J. Bastian	Lamers co: Kissler-Patig	01/03/2001	21/04/2005	Studies on the formation, evolution and destruction of massive star clusters	4.08	Advanced Fellow	Cambridge University
P.K. Fung	Kuijpers	01/06/2000	12/09/2005	Pulsars:magnetosphere and radio emission	5.25	Designer	Medicore
D.J. Nickeler	Goedbloed / Fahr co:		10/06/2005	MHD equilibria of astrospheric flows		Scientist	Astronomical Institute of the Academy of Science, Solar Physics Department
C. Wang	Goedbloed	01/09/2001	23/11/2005	Study of plasma channels for use in laser wakefield accelerators	4.17	Associate professor	Hefei University of technology, School of mechanical and automotive engineering
C.G. Bassa	Verbunt / van Kerkwijk	01/01/1993	11/12/2006	Optical studies of compact binaries in globular clusters and the Galactic disk	13.92	Fellow	Jodrell Bank Univ of Manchester
M. Gieles	Lamers co: Portegies Zwart	01/11/2002	20/10/2006	Star Clusters	3.92	UD	Univ. Of Edinburgh
A-J. van Marle	Langer	01/05/2002	03/05/2006	Models for the circumstellar medium of long gamma-ray burst progenitor candidates	4.00	Fellow	Katholieke Universiteit Leuven, Plasma – Astrofysica
M. van der Sluys	Verbunt	01/09/2001	02/05/2006	Formation and evolution of compact binaries	4.67	CITA National Fellow	University of Alberta, Astrophysics group
A.G. de Wijn	Rutten / Keller	01/11/2002	24/11/2006	Dynamics of fine structure in the solar chromosphere	4.00	Fellow	High Altitude Observatory (HAO), University Corporation for Atmospheric Research (UCAR)
A. Bonacic Marinovic	Langer co: Pols	01/10/2003	31/10/2007	Nucleosynthesis and evolution of AGB stars in binary systems	4.00	Epidemic Outbreak Response Modeller	UMC Utrecht
J. Leenaarts	Rutten/ Carlsson/ Keller	15/09/2003	14/09/2007	Numerical simulations of the solar atmosphere	4.00	Fellow	University of Utrecht
J. de Plaa	Bleeker co: Kaastra	01/11/2002	12/02/2007	Enrichment study of hot intra-cluster gas through X-ray spectroscopy	4.25	Fellow	SRON
A.J.Th. Poelarends	Langer	01/01/2003	24/01/2007	Stellar evolution on the borderline of white dwarf and neutron star formation	4.00	Masterstudent theology	Convenant Theological Seminary
J. Wiersma	Achterberg	01/02/2001	29/05/2007	Magnetic Fields inside extremely fast shock waves	5.00	ICT	juridisch bureau
E. Glebbeek	Langer co: Pols / Portegies Zwart	01/06/2004	25/06/2008	Evolution of the remnants of stellar collisions	4.00	Fellow	McMaster University
L. Keek	Langer co: In "t Zand / Méndez	15/11/2004	01/12/2008	Probing thermonuclear burning on accreting neutron stars	4.08	Research Associate	University of Minnesota, School of Physics and Astronomy
N. Werner	Verbunt co: Kaastra	01/06/2004	13/05/2008	X-ray spectroscopy of clusters of galaxies and of the cosmic web	3.92	Fellow	Stanford University, Kavli Institute for Particle Astrophysics and Cosmology (KIPAC)
M. Cantiello	Langer	01/12/2005	06/11/2009	Observational consequences of Unstable Stellar Interiors	3.92	Fellow	Argelander Institut f. Astronomie
M.R. Duvoort	Achterberg / Heise co:van	01/04/2005	02/11/2009	A search for Gamma Ray Burst Neutrinos in AMANDA	4.58		Shell of Kema
R.A. Scheepmaker	Lamers	01/06/2005	16/06/2009	Star clusters in the Whirlpool Galaxy	4.00	Fellow	SRON
F. Snik	Keller	01/07/2005	26/10/2009	Astronomical Polarimetry: new concepts; new instruments; new measurements & observations	4.25	Fellow	Sterrekundig Instituut Universiteit Utrecht

Appendix B4 PhDs

Radboud University Nijmegen							
Name	**Promotor**	**Start date**	**PhD date**	**Thesis title**	**Duration**	**Current position**	**Current institute**
J.B. Moortgat	Kuijpers	01/11/2001	08/05/2006	General relativistic plasma dynamics	4.50	Research Associate	Reservoir Engineering Research Institute (Geophysics research)
J.M. Smits	Kuijpers co: Stappers	01/09/2000	24/10/2006	Properties and geometry of radio pulsar emission	6.08	Research Associate	University of Manchester, School of Physics and Astronomy
E.J.M. van den Besselaar	Groot co: Augusteijn	16/02/2003	27/11/2007	White dwarf-red dwarf binaries in the Galaxy	4.75	Researcher	European Climate Assessment at KNMI
G.H.A. Roelofs	Groot co: Nelemans	01/11/2002	16/04/2007	The AM Canum Venaticorum Stars	4.42	Junior Econoom	Centraal Plan Bureau
S.J. Lafebre	Kuijpers / Falcke	01/11/2006	19/12/2008	From cosmic particle to radio pulse	4.00	Fellow	Penn State University, Physics department
A. Nigl	Falcke / Kuijpers	01/05/2003	22/01/2008	Fast Radio Flashes Observed with LOFAR Prototypes	4.67	Pilot	Lufthansa, Condor
S.J. Buitink	Falcke / Kuijpers	01/11/2004	01/10/2009	Radio emission from cosmic particle cascades	4.92	Fellow	Lawrence Berkeley National Laboratory , University of California
R.A. Hijmering	Groot co: Verhoeve /	01/02/2003	21/12/2009	Distributed read-out imaging device array for astronomical observations in UV/VIS	6.83	Fellow	SRON
H. Hu	Aerts co: Nelemans	01/09/2005	06/10/2009	Backtracking the evolution of subdwarf B stars with asteroseismology	4.08	Fellow	Institute of Astronomy, Cambridge University

Appendix C: Overview of finances

The total expenditures on the university astronomical program amounted to 24.7 M€ in 2009. These funds were used to employ nearly 290 fte researchers, 25 fte support staff, and to carry out an instrumentation program of M€ 5.4. Table C.1 lists the expenditures for each of the university institutes over the period 2003-2009. These numbers include the part of the NOVA-funded program that was carried out at the universities. The line "NOVA" lists the expenditures on the NOVA instrumentation program outside the university institutes, for example the costs of the Optical-IR instrumentation group hosted at ASTRON in Dwingeloo and the ALMA Band-9 activities hosted at SRON in Groningen. Usually costs for buildings, building services and general overhead are not charged to the university departments and are hence are not included in the cost numbers. At the UvA, however, a full cost accounting system has been introduced in the middle of the period causing a jump in the expenditures between 2005 and 2006.

	Total	2003	2004	2005	2006	2007	2008	2009
UvA	**30,360**	3,573	3,181	3,016	5,085	5,109	5,278	5,118
RuG	**32,183**	3,068	3,981	4,766	4,752	4,980	5,293	5,343
UL	**43,799**	5,459	5,229	6,223	6,013	6,366	7,097	7,412
UU	**17,191**	1,785	2,106	2,189	2,719	2,925	2,946	2,520
RU	**6,761**	412	719	962	1,098	999	1,075	1,496
"NOVA"	**19,053**	2,212	1,630	2,334	3,594	2,535	3,927	2,820
Total	**149,347**	**16,509**	**16,847**	**19,490**	**23,261**	**22,914**	**25,617**	**24,709**

***Table C.1**: Expenditures (in k€) on the astronomical research and instrumentation program at the university institutes and through NOVA over the period 2003-2009. NOVA funds spent at the universities are included in the numbers for each of the institutes. The line "NOVA" lists the expenditures on the NOVA instrumentation program outside the university institutes.*

Compared to 2003 the expenditures grew by ~50% for a variety of reasons: (1) inflation and salary increases amounting to 17% between 2003 and 2009 for which the numbers are not corrected; (2) introduction of a full cost accounting system at the UvA in the middle of the period; (3) increase of the numbers of research staff and people working on instrumentation projects between 2003 and 2009 (see Appendix D).

Further details on the expenditures are provided in Sect C.2 of this appendix.

C.1. Revenues

Over the period 2003 – 2009 the entire program was funded by the universities (43%), the NOVA Grant (18%), grants from NWO, KNAW and ERC (total 25%), ESO contracts (6%), and other contractual work including EU network funding (8%). Table C.2 provides a specification for each institute and for NOVA. The total is less than the sum of all institutes and NOVA because the numbers of the institutes already include expenditure of NOVA funds at the universities. For the UvA the NOVA line lists the total amount of NOVA funds this university received from the Ministry of OCW including the UvA share of the interuniversity instrumentation program for which NOVA is responsible.

Summary of expenditures	Total	2003	2004	2005	2006	2007	2008	2009
in k€								
UvA - funding origin	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	**12,391**	1,026	939	990	2,322	2,176	2,449	2,489
NOVA	**7,711**	1,065	1,065	1,065	1,065	1,084	1,154	1,213
NWO/KNAW/ERC	**8,788**	1,270	881	843	1,507	1,646	1,345	1,296
EU + other contracts	**1,470**	212	296	118	191	203	330	120
Total UvA	**30,360**	**3,573**	**3,181**	**3,016**	**5,085**	**5,109**	**5,278**	**5,118**
RuG - funding origin	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	**17,280**	1,815	2,413	2,713	2,511	2,612	2,604	2,612
NOVA	**6,896**	592	785	955	1,045	989	1,017	1,513
NWO/KNAW/ERC	**4,953**	310	490	630	713	869	1,013	928
EU + other contracts	**3,054**	351	293	468	483	509	659	291
Total RuG	**32,183**	**3,068**	**3,981**	**4,766**	**4,752**	**4,980**	**5,293**	**5,343**
UL - funding origin	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	**21,390**	2,946	2,708	2,601	2,892	3,111	3,445	3,687
NOVA	**7,540**	965	1,010	1,006	1,106	1,104	989	1,360
NWO/KNAW/ERC	**10,937**	1,220	1,147	1,844	1,424	1,333	2,050	1,919
EU + other contracts	**3,932**	328	364	772	591	818	613	446
Total UL	**43,799**	**5,459**	**5,229**	**6,223**	**6,013**	**6,366**	**7,097**	**7,412**
UU - funding origin	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	**9,426**	1,072	1,053	1,528	1,725	1,553	1,456	1,039
NOVA	**2,562**	410	538	244	412	428	215	314
NWO/KNAW/ERC	**3,718**	245	425	325	425	645	873	779
EU + other contracts	**1,484**	57	90	92	157	300	402	387
Total UU	**17,191**	**1,785**	**2,106**	**2,189**	**2,719**	**2,925**	**2,946**	**2,520**
RU - funding origin	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	**3,192**	242	314	378	559	537	519	643
NOVA	**1,067**	0	0	236	294	157	90	290
NWO/KNAW/ERC	**2,502**	170	405	348	245	305	466	563
EU + other contracts	**0**	0	0	0	0	0	0	0
Total RU	**6,761**	**412**	**719**	**962**	**1,098**	**999**	**1,075**	**1,496**
All institutes - funding origin	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	63,680	7,101	7,428	8,210	10,009	9,988	10,473	10,470
NOVA	25,775	3,032	3,398	3,505	3,922	3,763	3,466	4,690
NWO/KNAW/ERC	30,898	3,215	3,348	3,990	4,314	4,798	5,747	5,485
EU + other	9,940	948	1,043	1,450	1,422	1,830	2,003	1,244
Total	**130,293**	**14,297**	**15,217**	**17,155**	**19,667**	**20,379**	**21,690**	**21,889**
NOVA - funding origin	**Total**	**2,003**	**2,004**	**2,005**	**2,006**	**2,007**	**2,008**	**2,009**
Universities	**511**	0	0	0	0	81	205	225
NOVA grant	**27,148**	2,173	1,607	4,778	5,420	4,721	3,931	4,517
NWO	**6,427**	2,980	2,515	305	300	0	212	115
ESO	**9,528**	0	765	581	1,620	1,047	2,959	2,556
EU	**712**	0	0	84	68	335	59	166
Other	**1,014**	91	141	92	107	195	232	156
Total NOVA	**45,340**	**5,244**	**5,028**	**5,840**	**7,515**	**6,379**	**7,598**	**7,735**
Institutes + NOVA	**Total**	**2,003**	**2,004**	**2,005**	**2,006**	**2,007**	**2,008**	**2,009**
Universities	**63,680**	7,101	7,428	8,210	10,009	9,988	10,473	10,470
NOVA grant	**27,148**	2,173	1,607	4,778	5,420	4,721	3,931	4,517
NWO / KNAW / ERC	**37,325**	6,195	5,863	4,295	4,614	4,798	5,959	5,600
ESO	**9,528**	0	765	581	1,620	1,047	2,959	2,556
EU + other	**11,666**	1,039	1,184	1,626	1,597	2,360	2,294	1,566
Total	**149,347**	**16,509**	**16,847**	**19,490**	**23,261**	**22,914**	**25,617**	**24,709**

***Table C.2**: Origin of funding for each of the university institutes and NOVA over the period 2003 – 2009 including the origin of the funding. The total university + NOVA is listed in the bottom frame.*

C.2. NOVA program: expenditures and revenues 2003-2009

The NOVA Grant from the Ministry of OCW amounted to 4.2 M€ per year over the period 2003 – 2006. From 2007 onwards the allocation has increased to 4.8 M€ per year in 2009.

Table C.3 summarizes the research and instrumentation program administrated by NOVA and the corresponding expenditures over the period 2003-2009. The research program, the NOVA office and the outreach activities were paid for 100% from the NOVA Grant. The revenues are listed in Table C.4 according to their expenditure. The NOVA grant also serves as cash flow buffer to cope with strict spending schedules that are required by several external grants. Therefore the spending of the NOVA grant does for follow the annual payment schedule.

NOVA expenditures (in k€)	**Total**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Research program								
Overlap positions	**5,764**	850	1,036	705	1,206	792	600	576
Network research projects	**6,959**	1,287	974	835	1,064	977	812	1,010
Science support	**380**							380
Workshop and visitors	**399**	28	79	27	110	52	57	47
Total research program	**13,503**	**2,164**	**2,089**	**1,567**	**2,380**	**1,820**	**1,469**	**2,013**
Office, outreach								
Office	**1,357**	184	163	156	182	198	229	245
NIC	**629**	92	90	60	104	39	125	119
Total Office and outreach	**1,986**	**276**	**253**	**216**	**286**	**237**	**354**	**364**
Instrumentation projects								
ALMA Band-9 R&D	**125**	125						
ALMA Band-9 prototype	**4,164**	404	805	796	1,229	803	127	
ALMA Band-9 production	**4,283**					59	2,201	2,023
ALMA R&D upgrade	**431**				182	174	30	45
ALMA ALLEGRO	**254**				24	71	75	84
CHAMP+	**628**	34	212	37	140	12	193	
Subtotal ALMA projects	**9,885**	**563**	**1,017**	**833**	**1,575**	**1,119**	**2,626**	**2,152**
VLTI: NEVEC, MIDI; study fringe strac	**623**	326	116	161				20
VLTI: Matisse	**141**							141
VLT: Sinfoni	**869**	305	73	316	106	66	3	
VLT: X-Shooter	**2,286**		50	356	836	856	188	
VLT: MUSE + ASSIST	**1,442**	24	15	239	42	338	318	466
VLT: Sphere-Zimpol	**556**	28	11				150	367
VST: OmegaCAM/CEN	**1,448**	285	157		378	281	347	
E-ELT: Phase-A studies	**1,128**						517	611
Subtotal ESO: Op-IR	**8,493**	**968**	**422**	**1,072**	**1,362**	**1,541**	**1,523**	**1,605**
JWST: MIRI cold optical bench	**7,273**	906	1,027	1,309	1,382	1,231	927	491
Gaia photometric software	**217**		37				39	141
Subtotal space projects	**7,490**	**906**	**1,064**	**1,309**	**1,382**	**1,231**	**966**	**632**
WSRT: PuMa II	**843**	95	86	601	61			
LOFAR DCLA	**1,074**			92	294	175	152	361
Laboratory Astrophysics/Matri^{2}ces	**765**	153	26	92	111	106	115	162
DOT	**219**	42	42	45	45	45		
S^{5}T	**150**						40	110
Amuse	**109**							109
New initiatives/seed funding	**823**	77	29	13	19	105	353	227
Subtotal other projects	**3,983**	**367**	**183**	**843**	**530**	**431**	**660**	**969**
	0							
Total instrumentation	**29,851**	**2,804**	**2,686**	**4,057**	**4,849**	**4,322**	**5,775**	**5,358**
TOTAL NOVA-funded program	**45,340**	**5,244**	**5,028**	**5,840**	**7,515**	**6,379**	**7,598**	**7,735**

***Table C.3**: NOVA-funded program and the corresponding expenditures over the period 2003-2009. The figures are in k€.*

Origin funding NOVA program	Total	2003	2004	2005	2006	2007	2008	2009
Universities	**511**					81	205	225
NOVA grant	**27,148**	2,173	1,607	4,778	5,420	4,721	3,931	4,517
NWO	**6,427**	2,980	2,515	305	300		212	115
ESO	**9,528**		765	581	1,620	1,047	2,959	2,556
European Union	**712**			84	68	335	59	166
Other	**1,014**	91	141	92	107	195	232	156
Total revenues (in k€)	**45,340**	**5,244**	**5,028**	**5,840**	**7,515**	**6,379**	**7,598**	**7,735**

Table C.4*: Origin of the funding of the research and instrumentation program administrated by NOVA. Figures are in k€. Revenues are listed according to their expenditures.*

C.3. NOVA program for 2010-2013

An overview of the research and instrumentation program administrated by NOVA for the period 2010-2013 is provided in Table C5. The total budget amounts to 42.9 M€. The revenues consist of the following components: (1) NOVA Grant of 20.2 M€, (2) cash carry-over on the NOVA bank account at the start of 2010 of 6.9 M€; (3) ESO payments amounting to 7.8 M€ (mainly for ALMA Band-9 production), (4) SRON contribution to the network research program of 0.4 M€, (5) final NWO payment of 0.8 M€ for the MIRI project, (6) EU and other revenues of 0.8 M€, (7) ESFRI grant for E-ELT instrumentation of 4.0 M€, and additional funds still to be earned for the Optical-IR instrumentation group of 2.0 M€.

The expenditures include (1) 13.1 M€ on the research program, (2) 27.2 M€ on the instrumentation program including the ESO funded work on the ALMA receivers, (3) 2.1 M€ on the NOVA office and the outreach program, and (4) a reserve fund of 0.5 M€ to guarantee social benefits for staff working on the ALMA and Optical-IR instrumentation projects in case they are unable to find a new job at the time that their project is completed. This fund will grow in 2010-2013 through contributions from the projects concerned.

Staff expenditure for NOVA positions at the universities will be reimbursed on the basis of notional cost figures differentiated by rank as specified in Table C6. These figures are based on the actual staff costs per 1st January 2010. Each year they will be adjusted to the actual staff cost figures for that year if NOVA receives financial compensation for inflation (which is current practice since 2007). In addition each NOVA research position comes with a bench/travel fee of 15 k€ per year for a professor position, 12 k€ per year for a faculty position at UHD or UD level or for a postdoc position, and 9 k€ per year for a PhD (AIO) position. For the instrumentation projects the NOVA allocation for bench and travel is determined on a case by case basis depending on the needs for the project.

NOVA staff will be appointed at the universities according to local employment conditions. It is assumed that universities, through their local procedures, will cover possible costs when temporary research staff is unable to find a new job immediately after completion of their term. For the ALMA hardware projects and the NOVA Optical-IR instrumentation group, part of the project budget is reserved by NOVA to cover costs in case staff working on these projects call on social arrangements when they are unable to find a new job after the project is completed. A similar arrangement under NOVA responsibility is in place for the staff working at the NIC.

Reimbursements of costs for staff working on the NOVA program outside the universities federated in NOVA are according to the contractual arrangements that describe the collaboration between NOVA and the other party.

NOVA expenditures (in k€)	Total	2010	2011	2012	2013
RESEARCH PROGRAM					
Overlap positions	**1,868**	**661**	**606**	**376**	**225**
Network research funding					
Formation and evolution of galaxies	**2,287**	706	689	611	281
Formation of stars and planetary systems	**2,673**	876	729	605	463
Black holes, neutron stars, white dwarfs	**2,291**	777	679	478	356
Cross network research projects	**870**	267	201	201	201
Science Support	**1,570**	488	443	352	288
Miscelleneous research projects	**130**	30	30	30	40
Total network research funding	**9,822**	**3,144**	**2,771**	**2,278**	**1,629**
Workshops & Visitors	**263**	83	60	60	60
New initiatives	**1,144**	144	200	500	300
TOTAL RESEARCH PROGRAM	**13,097**	**4,032**	**3,637**	**3,214**	**2,215**
INSTRUMENTATION PROGRAM	**Total**	**2010**	**2011**	**2012**	**2013**
Optical-IR instrumentation	**10,120**	2,395	2,475	2,620	2,630
ALMA Band-9 production	**9,134**	3,166	2,200	1,059	2,709
ALMA ALLEGRO	**464**	201	123	71	69
ALMA technical R&D	**473**	233	166	75	0
MIRI	**700**	341	144	113	103
Gaia	**283**	151	82	50	0
LOFAR-DCLA	**1,427**	859	460	108	0
MUSE	**244**	75	74	74	22
MUSE-ASSIST	**648**	634	7	7	0
S^5T	**229**	160	55	13	0
AMUSE	**417**	265	152	0	0
$MATRI^2CES$	**296**	173	69	44	9
Seed funding / Miscelleneous projects	**230**	120	110	0	0
Contingency for specific projects	**715**	80	30	390	215
General contingency and new initiatives	**1,745**	245	600	600	300
EC funded small projects	**95**	66	15	15	0
TOTAL INSTRUMENTATION	**27,221**	**9,163**	**6,763**	**5,238**	**6,057**
OFFICE and OUTREACH					
NOVA Office	**1,160**	355	255	275	275
Outreach	**908**	351	218	176	163
Reservations for social fund for staff	**517**	0	0	150	367
Total Office and Outreach	**2,585**	**706**	**474**	**601**	**805**
TOTAL NOVA funded program	**42,904**	**13,901**	**10,873**	**9,053**	**9,076**

Table C.5: *NOVA-funded program and the corresponding expenditures over the period 2010-2013. The figures are in k€.*

Annual staff costs in k€ Rank	Scale	Salary per 1 Jan 2010	Muntiplication factor	Gross salary in k€	Bench-travel in k€	Total in k€
HL	16 - 9	85,704	1.3973	119.754	15.0	134.754
UHD	14 - 5	63,852	1.4131	90.229	12.0	102.229
UD	12 - 6	54,516	1.4237	77.614	12.0	89.614
Postdoc	11 - 6	46,464	1.4362	66.732	12.0	78.732
PhD students				41.297	9.0	50.297
OBP/Proj.manager	11 - 6	46,464	1.4362	66.732		66.732
OBP/Soft.engineer	11 - 6	46,464	1.4362	66.732		66.732
Junior project scientist	10 - 8	39,780	1.4407	57.311		57.311
OBP/Technician	9 - 8	41,064	1.4401	59.136		59.136
OBP/adm support	7 - 5	28,548	1.4432	41.200		41.200
OBP/management assistant	8 - 9	35,724	1.4427	51.489		
OBP/Director	15 - 9	83,486	1.4019	117.039		117.039

***Table C6**: Summary of the budget guidelines for the NOVA reimbursement of staff costs at the universities. The staff cost figures (in k€) are applicable for 2010 and will be adjusted for inflation each year on a best-effort basis.*

APPENDIX D: Overview of Staffing

D1. NOVA and its university institutes

In 2009 the university astronomical community in the Netherlands consisted of 288.4 research staff, of which 59.1 had permanent or tenure-track positions and 229.3 had temporary positions. Support staff amounted to 28.2 fte including the NOVA Office and the NOVA Information Center. Furthermore NOVA has an optical-IR instrumentation group of 9.4 people. Table D1.1 provides an overview of the development of the research staff over the period 2003-2009, and the distribution of staff over the categories tenured, postdoc,

NOVA research staff numbers							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	49.9	54.3	58.7	61.3	61.6	61.3	59.1
Postdoc	39.5	37.9	48.6	50.3	50.0	54.1	54.4
PhD	90.7	97.7	112.5	128.3	132.5	134.4	139.5
Instrumentation	16.0	18.0	22.5	26.4	29.2	30.8	35.4
Total research	**196.1**	**207.9**	**242.3**	**266.3**	**273.3**	**280.6**	**288.4**
Support staff	23.9	24.1	24.4	24.9	25.6	25.5	28.2
Op-IR instr						8.8	9.4
Research in Network 1: evolution of galaxies							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	20.3	24.6	25.5	26.3	27.2	27.0	25.7
Postdoc	16.4	11.9	15.1	16.9	16.9	20.6	22.2
PhD	36.1	41.5	46.8	54.4	55.9	59.5	56.0
Total research	**72.7**	**78.0**	**87.3**	**97.6**	**100.0**	**107.0**	**103.9**
Research in Network 2: formation of stars and planetary systems							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	10.8	11.3	12.9	12.7	12.2	12.9	13.2
Postdoc	16.5	15.8	17.9	11.3	9.6	8.6	10.1
PhD	27.0	27.5	27.8	29.0	32.8	34.1	35.9
Total research	**54.3**	**54.6**	**58.6**	**52.9**	**54.6**	**55.6**	**59.2**
Research in Network 3: astrophysics of compact objects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	14.3	14.1	13.9	16.1	16.4	17.5	17.3
Postdoc	6.5	9.4	15.2	21.3	22.3	21.4	19.1
PhD	24.7	27.5	35.5	41.9	41.0	37.6	42.7
Total research	**45.5**	**51.0**	**64.6**	**79.3**	**79.8**	**76.5**	**79.0**
Instrumentation							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	3.0	3.0	5.0	5.0	4.8	3.0	2.0
Postdoc	0.1	0.8	0.3	0.0	0.0	0.7	1.5
PhD	2.0	1.0	1.4	2.0	1.5	1.1	1.3
Instrumentation	16.0	18.0	22.2	25.1	27.6	28.3	32.3
Total research	**21.1**	**22.7**	**28.9**	**32.1**	**33.9**	**33.1**	**37.1**

Table D1.1: *Staffing at the university astronomical institutes in the Netherlands federated under NOVA in fte without any* adjustments for the fraction of *their time that people spend on research. The top frame lists the total numbers for the institute, the other frames list staff numbers assigned to networks and instrumentation as indicated.*

PhD student, and staff working on scientific instrumentation. The tenured staff consists of full professors, associate professors (UHD), and assistant professors (often on tenure-track positions). 'Instrumentation' denotes temporary or semi-permanent staff working on instrumentation projects (mainly postdoctoral fellows with training in technical physics or scientific programmers). The staff numbers for administrative and computer support, institute/program managers and financial control are listed together under 'support staff'. The staff numbers denoted as 'Op-IR instr' refer to the optical-IR instrumentation group hosted at ASTRON for which NOVA took over responsibility from 1st January 2008 onwards. The numbers are in full time equivalents. This means that staff that started or terminated their job during the year, or staff with a part-time employment are also not counted, except when they are paid by the university, and then for that fraction.

Table D1.1 lists the numbers of the different categories of scientific staff at each of the university institutes. These numbers are in full time equivalents (fte) without taking into account the fraction of time people spend on research (see caption Table D1.1). Staff that started or terminated their job during the year, or staff with a part-time employment, are counted for the fraction of time they had their position.

Table D1.1 includes all research staff with an employment contract or a bursary through one of the universities. Postdocs and PhD students are also counted if they work at the university institute through external fellowships or funding through ASTRON or SRON. Some staff members employed by one university also have adjunct professor positions of typically 0.5-1 day per week at another university; they are counted and assigned to the universities according to the fraction of the salary paid by each university. Emeriti who are still active researchers and visitors who have no employment relation with the university are not included in the numbers. ASTRON and SRON research staff members that have special relations with a university (zero or joint appointments, special professorships) and often spend one day per week at the university institute are also not counted.

The table provides the staff numbers for NOVA as a whole and for the three research networks. About 95% of the research staff works in one or more research networks with little variation over the years, if people working on instrumentation projects are not taken into account. A few staff members and their PhD students work in research areas that are not covered by the three research networks, for example in history of astronomy (at UL). The numbers of people working in the area of solar physics (at UU) are included in the numbers for Network-2.

The research staff at the university astronomical institutes grew by nearly one-third from 197 fte in 2003 to 289 fte in 2009. The number of tenured staff varied between 50 and 62 with fluctuations mostly due to staff turnover. Major research grants obtained in 2003-2009 provided the resources to hire the increasing numbers of PhD students and postdocs.

The total number of staff working in the Network 1 area shows an increase of nearly 50% between 2003 and 2009, especially in the number of postdoc and PhD positions. The number of staff in Network 2 is more or less constant over the years. The number of staff working in the Network 3 area shows an increase of ~80% between 2003 and 2009, again mostly in the number of postdoc and PhD positions.

Figure D1.1 shows the origin of funding for the research staff positions (including the people working on instrumentation projects) with its variation over the period 2003-2009. The corresponding numbers are presented in Table D1.2. The resources for funding of the research staff are the direct funding from the universities (40%), the NOVA Grant (22%), research grants from various NWO programs, KNAW, collaborations with ASTRON and SRON (29%), research grants from the EU and ERC (7%), and researchers paid from other external sources (2%). The percentages are for 2009. The fraction of research funding through external grants from mainly NWO varies from 22% in 2003 to 29% in 2006-2009.

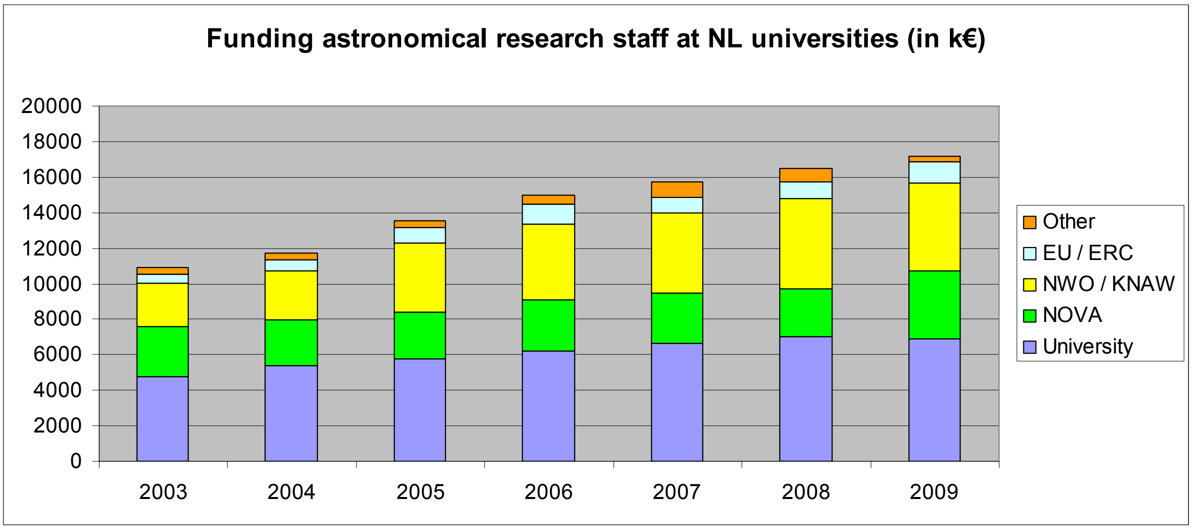


***Figure D1.1**: The origin of funding of the university astronomical research staff in the Netherlands over the period 2003-2009 in units of k€.*

The staff costs are calculated using notional cost figures differentiated by rank as explained in Appendix D, § 3. Between 2003 and 2009 salary costs of university personnel in the Netherlands increased by ~16%. The numbers in Fig. D1.1 and Table D1.2 have not been corrected for corrected for inflation and general increases of staff costs (for instance on social security).

Funding Research staff	2003	2004	2005	2006	2007	2008	2009
University	4756	5420	5782	6213	6627	7053	6916
NOVA	2855	2553	2624	2856	2832	2689	3806
NWO / KNAW	2432	2718	3864	4308	4535	5042	4971
EU / ERC	465	667	894	1110	879	925	1149
Other	420	338	387	491	839	774	326
Total (in k€)	**10929**	**11696**	**13551**	**14978**	**15712**	**16482**	**17168**

Table D1.2: *The origin of funding of the university astronomical research staff in the Netherlands over the period 2003-2009 in units of 'then' k€. Figure D1.1 is based on the numbers in this table.*

Figures D1.2 – D1.4 show the staff numbers for each of the three research networks over the period 2003-2009 with the distribution over the five universities.

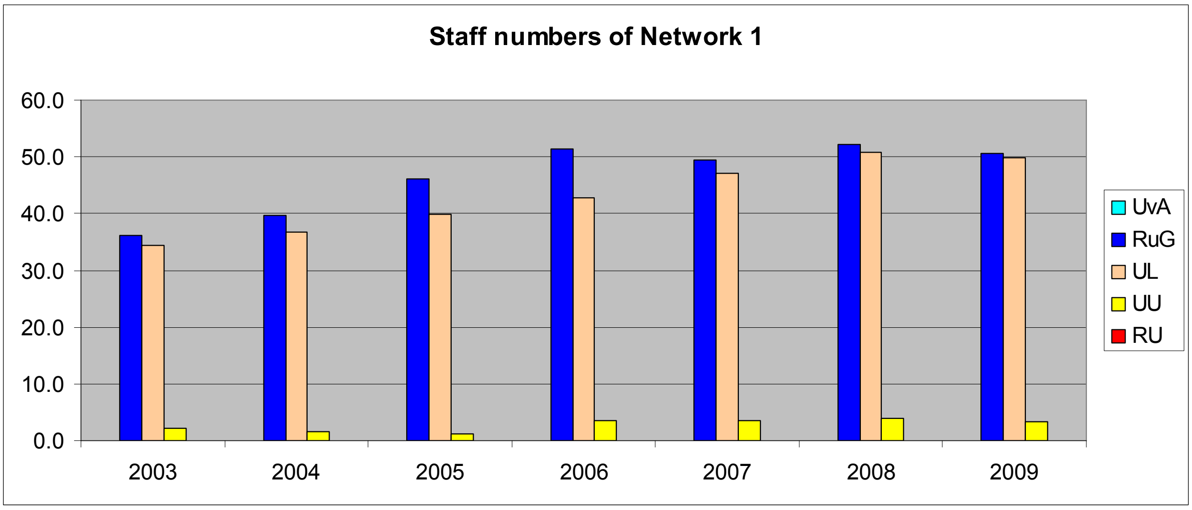


Figure D1.2: *Number of research staff (summed over all categories) working in the field of Network 1 and their distribution over the five universities.*

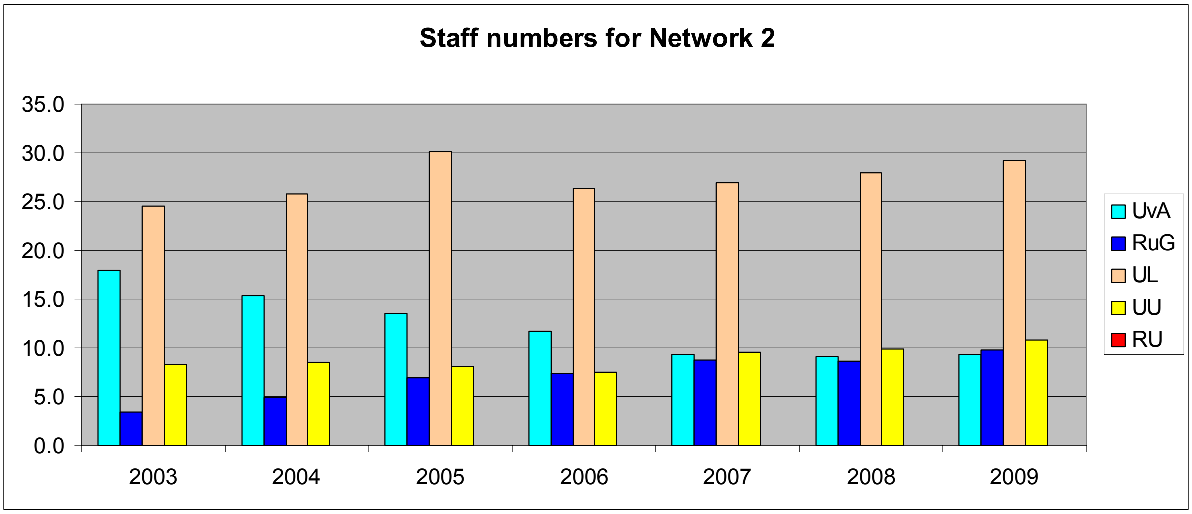


Figure D1.3: *Number of research staff (summed over all categories) working in the field of Network 2 and their distribution over the five universities.*

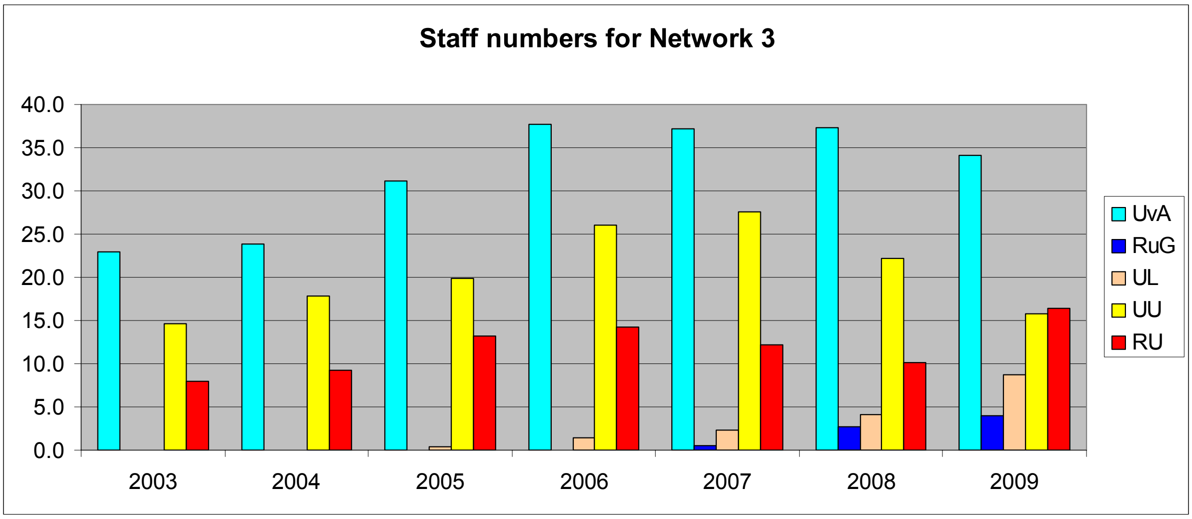


Figure D1.4: *Number of research staff (summed over all categories) working in the field of Network 3 and their distribution over the five universities.*

D2. Staffing at the Astronomical Institute Anton Pannekoek of UvA

In 2009 the Astronomical Institute Anton Pannekoek (API) of the Universiteit van Amsterdam consisted of 45.4 research staff of which 10.6 had permanent or tenure track positions and 34.9 had temporary positions. Table D2.1 provides an overview of the development of the research staff at API over the period 2003-2009, and the distribution of staff over the categories tenured, postdoc, PhD student, and staff working on scientific instrumentation (see § D1 for a specification of the categories). The table provides the staff numbers for the institute as a whole, for the two main research areas in which staff at the institute is working, and for staff working on instrumentation projects at the UvA. Total staff numbers (top frame) show relatively modest variations (not counting staff appointed to work on instrumentation projects).

Astronomy at Universiteit van Amsterdam							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	11.1	11.7	10.4	11.5	10.6	10.4	10.6
Postdoc	9.2	8.7	11.8	12.6	12.6	14.2	11.3
PhD students	20.5	18.8	22.3	25.2	23.4	21.8	21.6
Instrumentation	0.0	0.0	0.5	1.6	1.6	1.9	2.0
Total research	**40.9**	**39.3**	**45.1**	**50.9**	**48.1**	**48.3**	**45.4**
Support staff	3.9	3.8	3.8	3.7	3.3	3.6	3.7
NIC Office	1.1	1.0	0.8	0.7	0.9	1.1	1.5
Research in Network 2: formation of stars and planetary systems							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	3.0	3.9	3.4	4.4	4.3	4.2	4.2
Postdoc	4.9	4.0	3.8	1.8	1.0	1.0	0.9
PhD students	10.0	7.5	6.3	5.4	4.0	3.9	4.3
Total research	**18.0**	**15.4**	**13.5**	**11.7**	**9.3**	**9.1**	**9.4**
Research in Network 3: astrophysics of compact objects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	8.1	7.9	7.0	7.1	6.3	6.2	6.4
Postdoc	4.3	4.8	8.1	10.8	11.6	13.2	10.4
PhD students	10.5	11.3	16.0	19.8	19.4	17.9	17.4
Total research	**22.9**	**23.9**	**31.1**	**37.7**	**37.2**	**37.3**	**34.1**
Staff working on instrumentation projects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Postdoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PhD students	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Instrumentation	0.0	0.0	0.5	1.6	1.6	1.9	2.0
Total research	**0.0**	**0.0**	**0.5**	**1.6**	**1.6**	**1.9**	**2.0**

Table D2.1: *Staffing at the Astronomical Institute Anton Pannekoek (API) in fte without any adjustments for the fraction of their time that people spend on research. The top frame lists the total numbers for the institute, the other frames list staff numbers assigned to networks and instrumentation as indicated.*

The staff working in the Network 3 area shows an increase of ~50% between 2003 and 2009 with a growth of ~90% in the number of postdoc and PhD positions. Tenured staff in this area was extremely successful in obtaining major research grants from various NWO and EU programs.

The staff working in Network 2 declined by over 40% between 2003 and 2009 with a reduction of postdoc and PhD staff numbers. These numbers are projected (funding in place) to rise again in the near future.

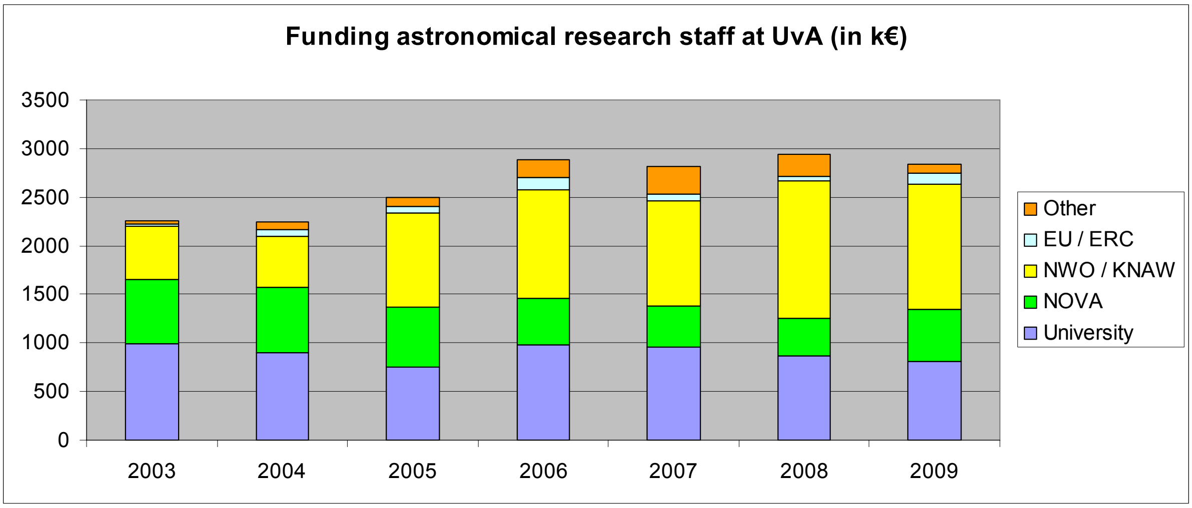


***Figure D2.1**: The origin of funding of the research staff at API over the period 2003-2009 in units of k€.*

Figure D2.1 shows the origin of funding for the research staff positions at API with its variation over the period 2003-2009. The corresponding numbers are presented in Table D2.2. The three main resources for funding of the research staff are direct funding from the university (29%) and the NOVA Grant (19%), research grants from various NWO programs, KNAW, and collaborations with ASTRON and SRON (45%), research grants from the EU and ERC (4%) and other sources (3%). The percentages are for 2009. The fraction of research funding through external grants, mainly from NWO, increased from 24% in 2003 to 46% in 2009.

Funding Research staff	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	989	898	750	981	963	870	812
NOVA	662	679	620	475	417	384	534
NWO / KNAW	551	526	971	1125	1086	1417	1289
EU / ERC	20	60	60	124	69	40	115
Other	38	85	97	183	284	226	87
Total (in k€)	**2260**	**2248**	**2498**	**2887**	**2818**	**2936**	**2837**

Table D2.2: *The origin of funding of the research staff at API over the period 2003-2009 in units of k€. Figure D2.1 is based on the numbers in this table.*

D3. Staffing at the Kapteyn Institute of the University of Groningen

In 2009 the Kapteyn Institute of the University of Groningen consisted of 85.0 research staff of which 16.1 had permanent or tenure track positions, and 68.9 had temporary positions. Table D3.1 provides an overview of the development of the research staff at the Kapteyn Institute over the period 2003-2009, and the distribution of staff over the categories tenured, postdoc, PhD student, and staff working on scientific instrumentation (see § D1 for a specification of the categories). The table provides the staff numbers for the institute as a whole, for the three NOVA research networks, and for people working on instrumentation projects.

Astronomy at Kapteyn Institute at University of Groningen

Staff category	2003	2004	2005	2006	2007	2008	2009
Tenured staff	12.3	16.1	18.4	17.5	16.6	17.2	16.1
Postdoc	7.9	5.1	8.0	8.3	6.8	6.8	7.2
PhD students	13.2	17.2	18.7	19.9	17.9	15.0	11.5
PhD bursary	8.3	8.1	12.4	18.0	20.6	25.7	30.6
Instrumentation	8.1	10.8	13.6	15.3	16.8	17.5	19.7
Total research	**49.8**	**57.4**	**71.0**	**79.1**	**78.7**	**82.2**	**85.0**
Support staff	7.2	7.2	7.6	7.2	7.2	6.7	7.4

Research in Network 1: evolution of galaxies

Staff category	2003	2004	2005	2006	2007	2008	2009
Tenured staff	9.3	13.1	13.4	13.3	13.3	13.2	12.1
Postdoc	7.9	5.1	8.0	8.3	6.3	6.1	6.4
PhD students	10.7	13.9	13.3	13.1	11.5	11.3	9.0
PhD bursary	8.3	7.6	11.4	16.7	18.3	21.6	23.1
Total research	**36.2**	**39.7**	**46.2**	**51.4**	**49.4**	**52.2**	**50.6**

Research in Network 2: formation of stars and planetary systems

Staff category	2003	2004	2005	2006	2007	2008	2009
Tenured staff	2.0	2.0	2.0	1.2	1.0	2.0	2.0
Postdoc	0.0	0.0	0.0	0.0	0.5	0.8	0.8
PhD students	1.5	2.3	3.9	4.9	5.2	3.6	2.4
PhD bursary	0.0	0.5	1.0	1.3	2.1	2.3	4.6
Total research	**3.5**	**4.8**	**6.9**	**7.4**	**8.8**	**8.7**	**9.8**

Research in Network 3: astrophysics of compact objects

Staff category	2003	2004	2005	2006	2007	2008	2009
Tenured staff	0.0	0.0	0.0	0.0	0.3	1.0	1.0
Postdoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PhD students	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PhD bursary	0.0	0.0	0.0	0.0	0.2	1.8	2.9
Total research	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**2.8**	**3.9**

Staff working on instrumentation projects

Staff category	2003	2004	2005	2006	2007	2008	2009
Tenured staff	1.0	1.0	3.0	3.0	2.0	1.0	1.0
Postdoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PhD students	1.0	1.0	1.4	2.0	1.2	0.1	0.0
PhD bursary	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Instrumentation	8.1	10.8	13.6	15.3	16.8	17.5	19.7
Total research	**10.1**	**12.8**	**18.0**	**20.3**	**20.0**	**18.5**	**20.7**

Table D3.1: *Staffing at the Kapteyn Institute of the University of Groningen in fte without any adjustments for the fraction of their time that people spend on research. The top frame lists the total numbers for the institute, the other frames list staff numbers assigned to networks and instrumentation as indicated.*

The RuG is the only university in the Netherlands with an astronomy department that had a dual system for their relationship with PhD students: through regular employment (indicated as PhD students) and through studentships (PhD bursary). The top frame of Table D3.1 lists the total numbers for the two categories. A major fraction of the increase of the number of PhD students/bursaries occurred because the studentship policy allowed hiring more people with the same amount of funds.

The research in NOVA Network 1 is by far the largest research area for the Kapteyn institute (between 80-85% of the people, not counting the instrumentation projects). The numbers show an increase of over 40% between 2003 and 2009, mostly in the number of PhD positions. The staff working in Network 2 more than doubled between 2003 and 2009. The numbers of staff working on instrumentation projects are relatively large because of the ALMA Band-9 receivers, OmegaCEN, and software development for the LOFAR reionization project that occurs at the RuG.

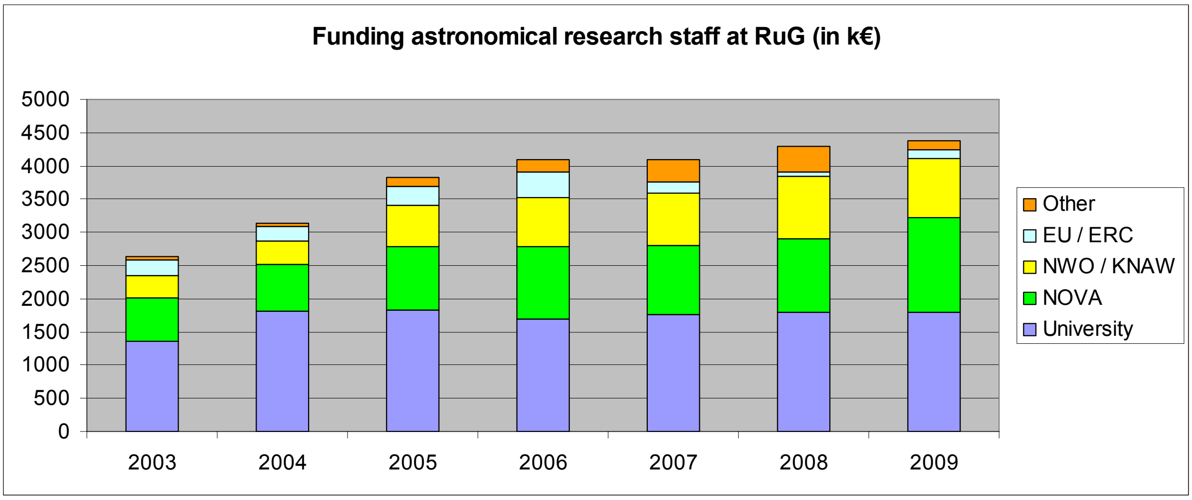


Figure D3.1*: The origin of funding of the research staff at Kapteyn Institute over the period 2003-2009 in units of k€.*

Figure D3.1 shows the origin of funding for the research staff positions at the Kapteyn Institute with its variation over the period 2003-2009. The corresponding numbers are presented in Table D3.2. The three main funding sources are direct funding from the university (41%) and the NOVA Grant (33%), research grants from various NWO programs, KNAW, and collaborations with ASTRON and SRON (20%), research grants from the EU and ERC (3%) and other sources (3%). The percentages are for 2009. The fraction of research funding through external grants from mainly NWO increased from 12% in 2003 to 20% in 2009.

Funding Research staff	2003	2004	2005	2006	2007	2008	2009
University	1365	1807	1830	1702	1762	1798	1792
NOVA	655	702	958	1082	1045	1103	1437
NWO / KNAW	328	359	616	731	789	940	878
EU / ERC	245	217	292	396	164	74	139
Other	36	48	129	189	341	379	137
Total (in k€)	**2628**	**3132**	**3825**	**4101**	**4101**	**4295**	**4383**

Table D3.2: *The origin of funding of the research staff at Kapteyn Institute over the period 2003-2009 in units of k€. Figure D3.1 is based on the numbers in this table.*

D4. Staffing at Leiden Observatory of Leiden University

In 2009 Leiden Observatory at Leiden University consisted of 104.2 research staff of which 21.3 had permanent or tenure track positions, and 82.9 had temporary positions. Table D4.1 provides an overview of the development of the research staff over the period 2003-2009, and the distribution of staff over the categories tenured, postdoc, PhD student, and staff working on scientific instrumentation (see § D1 for a specification of the categories). The table provides the staff numbers for the institute as a whole, and for the three research networks, and for the people working on instrumentation projects. Over the years the fraction of research staff working in Networks 1 and 2 decreased from slightly over 90% in 2003 to 80% in 2009 (not counting for staff appointed to work on instrumentation projects). The research areas outside the two main streams in Leiden include a growing interest in the astrophysics of compact objects (Network 3), computational astrophysics and history of astronomy. The latter topic is outside this evaluation.

Astronomy at University Leiden							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	17.3	17.3	20.0	20.1	21.2	20.4	21.3
Postdoc	16.7	16.3	19.0	16.3	16.6	24.0	26.6
PhD students	29.6	32.3	35.3	38.3	43.8	46.2	48.1
Instrumentation	6.9	6.2	7.1	5.8	6.6	7.8	8.3
Total research	**70.4**	**72.1**	**81.4**	**80.4**	**88.2**	**98.4**	**104.2**
Support staff	7.0	7.0	7.0	7.3	7.6	7.6	7.2
Research in Network 1: evolution of galaxies							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	10.5	11.0	11.5	12.0	12.9	12.7	12.6
Postdoc	7.8	6.8	7.1	7.9	9.6	13.5	14.8
PhD students	16.1	19.0	21.3	22.8	24.6	24.6	22.5
Total research	**34.3**	**36.8**	**39.9**	**42.7**	**47.1**	**50.8**	**49.9**
Research in Network 2: formation of stars and planetary systems							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	4.3	3.9	5.5	4.8	4.5	4.7	5.0
Postdoc	8.8	8.8	11.6	7.1	5.3	5.9	6.6
PhD students	11.5	13.2	13.0	14.5	17.1	17.5	17.6
Total research	**24.5**	**25.8**	**30.1**	**26.4**	**26.9**	**28.0**	**29.2**
Research in Network 3: astrophysics of compact objects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	0.0	0.0	0.4	1.0	1.0	1.0	1.7
Postdoc	0.0	0.0	0.0	0.5	0.7	2.1	3.7
PhD students	0.0	0.0	0.0	0.0	0.7	1.0	3.3
Total research	**0.0**	**0.0**	**0.4**	**1.5**	**2.3**	**4.1**	**8.7**
Staff working on instrumentation projects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	1.0	1.0	1.0	1.0	1.8	1.0	1.0
Postdoc	0.1	0.8	0.3	0.0	0.0	0.7	1.0
PhD students	1.0	0.0	0.0	0.0	0.3	1.0	1.0
Instrumentation	6.9	6.2	7.1	5.8	6.5	6.8	7.6
Total research	**9.0**	**7.9**	**8.3**	**6.8**	**8.5**	**9.5**	**10.6**

***Table D4.1**: Staffing at Leiden Observatory in fte without any adjustments for the fraction of their time that people spend on research. The top frame lists the total numbers for the institute, the other frames list staff numbers assigned to networks and instrumentation as indicated.*

The number of staff working in the Network 1 area shows an increase of over 50% between 2003 and 2009, mostly in the number of postdoc and PhD positions. Tenured staff in that area was extremely successful in obtaining major research grants from various NWO, ERC and EU programs.

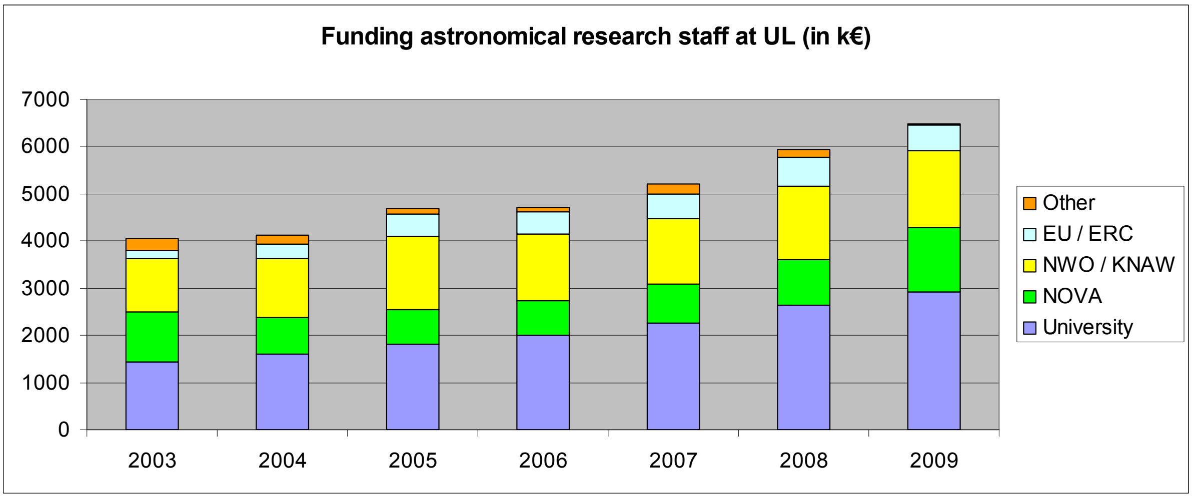


Figure D4.1: *The origin of funding of the research staff at Leiden Observatory over the period 2003-2009 in units of k€.*

Figure D4.1 shows the origin of funding for the research staff at Leiden Observatory with its variation over the period 2003-2009. The corresponding numbers are presented in Table D4.2. The three main funding sources are direct funding from the university (45%) and the NOVA Grant (21%), research grants from various NWO programs, KNAW, and collaborations with ASTRON and SRON (25%), research grants from the EU and ERC (8%), and other sources (1%). The percentages are for 2009. The fraction of research funding through external grants from mainly NWO varies from 28% in 2003 to 25% in 2009, with a peak of 33% in 2005.

The increase of funding from the university is remarkable. This reflects the Leiden university policy to provide additional funds to research groups that receive major external grants.

Funding Research staff	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	1443	1603	1817	2010	2256	2638	2924
NOVA	1066	766	735	723	826	969	1368
NWO / KNAW	1126	1249	1546	1405	1386	1561	1635
EU / ERC	150	330	472	484	531	602	524
Other	269	170	125	81	212	161	36
Total (in k€)	**4053**	**4118**	**4695**	**4703**	**5211**	**5932**	**6487**

Table D4.2: *The origin of funding of the research staff at Leiden Observatory over the period 2003-2009 in units of k€. Figure D4.1 is based on the numbers in this table.*

D5. Staffing at the Astronomical Institute of Utrecht University

In 2009 the Astronomical Institute (SIU) of Utrecht University consisted of 34.9 research staff of which 7.0 had permanent or tenure track positions, and 27.9 had temporary positions. Table D5.1 provides an overview of the development of the research staff over the period 2003-2009, and the distribution of staff over the categories tenured, postdoc, PhD student, and staff working on scientific instrumentation (see § D1 for a specification of the categories). The table provides the staff numbers for the institute as a whole, for the three research networks, and for the people working on instrumentation projects. The numbers of staff working in the area of solar physics are included in the numbers for Network 2. The number of staff working in Networks 1 and 2 nearly doubled from 2003 to 2009.

Astronomy at Utrecht University							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	7.2	7.2	8.0	9.5	9.5	9.0	7.0
Postdoc	5.8	6.5	5.9	9.6	10.9	7.0	5.5
PhD students	13.1	15.2	16.4	19.0	21.4	22.0	19.4
Instrumentation	1.0	1.0	1.0	2.4	2.8	2.2	3.0
Total research	**27.1**	**29.9**	**31.3**	**40.4**	**44.6**	**40.2**	**34.9**
Support staff	3.0	3.0	3.0	3.0	3.0	3.0	3.6
Visiting fellows			0.6	0.5	0.5	1.8	0.5
Research in Network 3: astrophysics of compact objects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	4.2	4.2	4.5	5.2	5.1	5.0	4.0
Postdoc	2.3	3.4	3.3	6.6	7.0	4.0	1.2
PhD students	8.1	10.3	12.2	14.2	15.5	13.1	10.7
Total research	**14.6**	**17.9**	**19.9**	**26.0**	**27.6**	**22.2**	**15.8**
Research Network 2: formation of stars and planetary systems; solar physics							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	1.5	1.5	2.0	2.3	2.3	2.0	2.0
Postdoc	2.8	3.1	2.6	2.3	2.8	1.0	1.8
PhD students	4.0	4.0	3.5	2.9	4.4	6.8	7.0
Total research	**8.3**	**8.5**	**8.1**	**7.5**	**9.5**	**9.8**	**10.8**
Research in Network 1: evolution of galaxies							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	0.5	0.5	0.5	1.0	1.0	1.0	1.0
Postdoc	0.7	0.0	0.0	0.7	1.0	1.0	1.0
PhD students	1.0	1.0	0.8	1.8	1.5	2.0	1.4
Total research	**2.2**	**1.5**	**1.3**	**3.5**	**3.5**	**4.0**	**3.4**
Instrumentation projects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	1.0	1.0	1.0	1.0	1.0	1.0	0.0
Postdoc	0.0	0.0	0.0	0.0	0.0	0.0	0.5
PhD students	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Instrumentation	1.0	1.0	1.0	2.4	2.8	2.2	3.0
Total research	**2.0**	**2.0**	**2.0**	**3.4**	**3.8**	**3.2**	**3.8**

Table D5.1*: Staffing at the Astronomical Institute in Utrecht in fte without any adjustments for the fraction of their time that people spend on research. The top frame lists the total numbers for the institute, the other frames list staff numbers assigned to networks and instrumentation as indicated.*

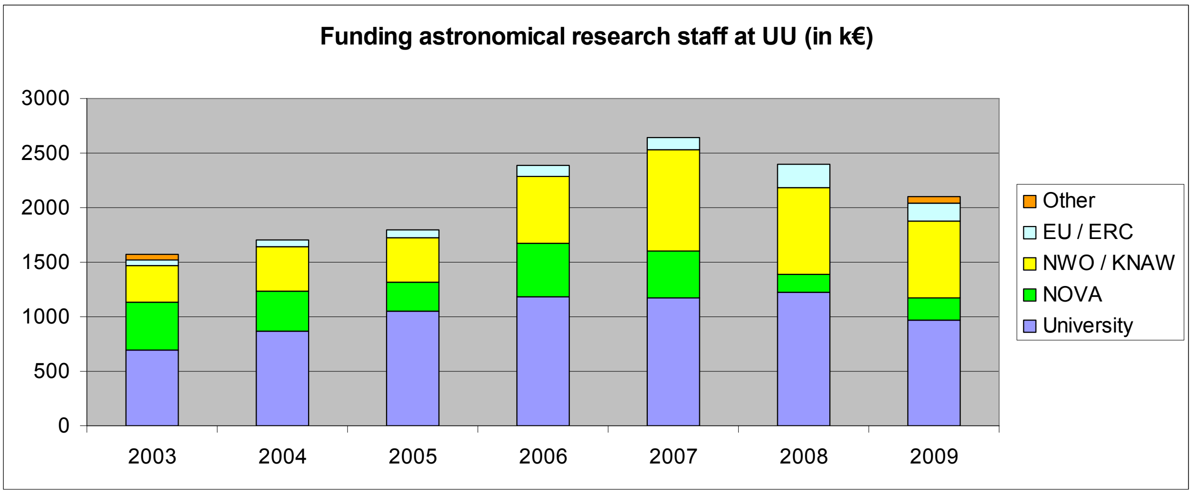


Figure D5.1*: The origin of funding of the research staff at SIU over the period 2003-2009 in units of k€.*

Figure D5.1 shows the origin of funding for the research staff at SIU with its variation over the period 2003-2009. The corresponding numbers are presented in Table D5.2. The main funding sources are direct funding from the university (46%) and the NOVA Grant (10%), research grants from various NWO programs, KNAW, and collaborations with ASTRON and SRON (33%), research grants from the EU and ERC (8%) and other sources (3%). The percentages are for 2009. The fraction of research funding through external grants from mainly NWO varied from 22% in 2003 to 33% in 2009 with a peak of 35% in 2007.

Funding Research staff	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	696	863	1047	1181	1176	1220	970
NOVA	438	376	271	493	424	171	209
NWO / KNAW	338	401	410	608	926	797	699
EU / ERC	50	60	70	106	116	208	160
Other	45	0	0	0	0	7	67
Total (in k€)	**1567**	**1700**	**1797**	**2388**	**2642**	**2403**	**2105**

Table D5.2: *The origin of funding of the research staff at SIU over the period 2003-2009 in units of k€. Figure D5.1 is based on the numbers in this table.*

D6. Staffing at the Department of Astrophysics of the Radboud University in Nijmegen
In 2009 the Department of Astrophysics at the Radboud University in Nijmegen consisted of 18.9 research staff of which 4.2 had permanent or tenure track positions, and 14.7 had temporary positions. Table D6.1 provides an overview of the development of the research staff at Department of Astrophysics in Nijmegen over the period 2003-2009, and the distribution of staff over the categories tenured, postdoc, PhD student, and staff working on scientific instrumentation (see § D1 for a specification of the categories). The table provides the staff numbers for the institute as a whole. In Nijmegen all research staff works in the area of Network 3. The number of research staff more than doubled between 2003 and 2009 with some fluctuations in the number of postdoc and PhD positions related to the start and completion of individual appointments. Tenured staff doubled over the period.

Astronomy at Radboud University Nijmegen							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	2.0	2.0	2.0	2.8	3.7	4.3	4.2
Postdoc	0.0	1.3	3.8	3.5	3.1	2.0	3.8
PhD students	6.0	6.0	7.3	7.9	5.4	3.9	8.4
Instrumentation	0.0	0.0	0.3	1.3	1.5	1.5	2.4
Total research	**8.0**	**9.2**	**13.5**	**15.4**	**13.7**	**11.6**	**18.9**
Support staff	0.0	0.4	0.5	1.0	1.5	1.5	2.1
Research in Network 3: astrophysics of compact objects							
Staff category	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Tenured staff	2.0	2.0	2.0	2.8	3.7	4.3	4.2
Postdoc	0.0	1.3	3.8	3.5	3.1	2.0	3.8
PhD students	6.0	6.0	7.3	7.9	5.4	3.9	8.4
Instrumentation	0.0	0.0	0.3	1.3	1.5	1.5	2.4
Total research	**8.0**	**9.2**	**13.5**	**15.4**	**13.7**	**11.6**	**18.9**

Table D6.1: *Staffing at the Department of Astrophysics in Nijmegen in fte without any adjustments for the fraction of their time that people spend on research. The top frame lists the total numbers for the institute, the other frames list staff numbers assigned to networks and instrumentation as indicated.*

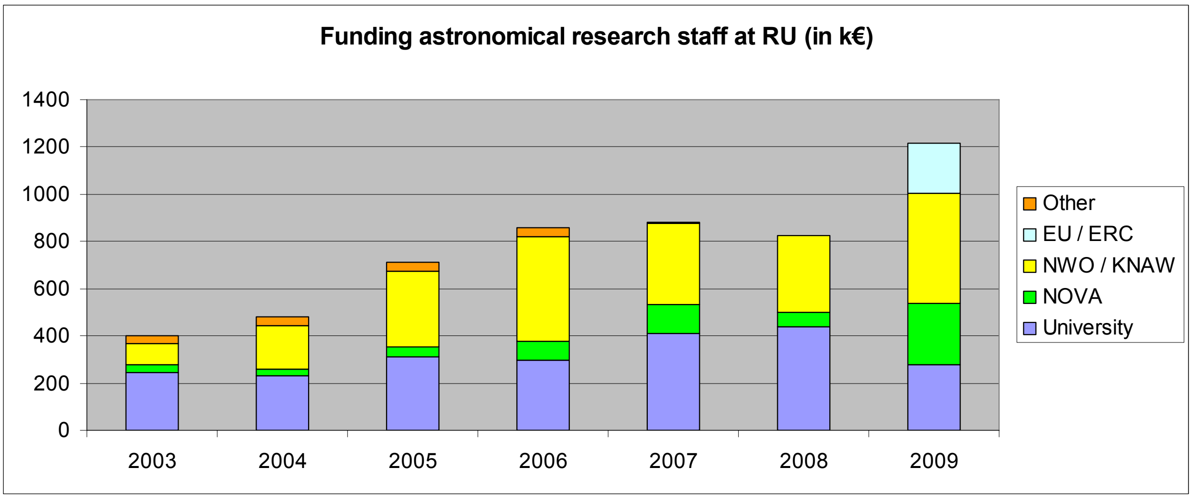


Figure D6.1: *The origin of funding of the research staff at the Department of Astrophysics in Nijmegen over the period 2003-2009 in units of k€.*

Figure D6.1 shows the origin of funding for the research staff position at the Astronomical Department in Nijmegen with its variation over the period 2003-2009. The corresponding numbers are presented in Table D6.2. The resources for funding of the research staff are direct funding from the university (23%) and the NOVA Grant (21%), research grants from various NWO programs, KNAW, and collaborations with ASTRON and SRON (39%), and research grants from the EU and ERC (17%). The percentages are for 2009. The fraction of research funding through NWO varied from 22% in 2003 to 39% in 2009 with a peak of 51% in 2006.

Funding Research staff	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
University	244	231	313	297	412	436	279
NOVA	35	30	40	82	119	62	257
NWO / KNAW	89	183	321	439	347	327	470
EU / ERC	0	0	0	0	0	0	211
Other	32	36	37	38	3	0	0
Total (in k€)	**400**	**480**	**711**	**857**	**881**	**826**	**1216**

Table D6.2: *The origin of funding of the research staff at the Department of Astrophysics in Nijmegen over the period 2003-2009 in units of k€. Figure D6.1 is based on the numbers in this table.*

Appendix E: research highlights 2003-2009

E1. Network 1: Formation and evolution of galaxies: from high redshift to the present

The question how galaxies formed and evolved is one of the most fundamental problems in current-day astronomy. Most of what we know about the Universe comes from light emitted in galaxies. Before stars or planets can be made, the galaxies have to form in which these objects reside. The study of galaxy formation and evolution has progressed greatly in the last decade due to spectacular advances in observational facilities and improved theoretical modeling. Observationally, galaxies can now be traced to a redshift of 7 and above (corresponding to ages less than 5% of the current age of the Universe). Theoretically, processes can be probed in great detail in very large volumes, allowing the study of rare, bright objects but also the low-mass precursors of normal galaxies in the nearby Universe. NOVA astronomers have played key roles in the study of galaxy formation and evolution, using observational facilities like the ESO-VLT, the Hubble Space Telescope (HST), and additional observatories, and have been making important contributions to the interpretation and modeling of these results.

E1.1. Network 1 science highlights 2003-2009

Discovery of a population of massive evolved galaxies at high redshift

Labbé (PhD), Kriek (PhD), Franx and collaborators discovered a new population of galaxies at redshifts between 1.5 and 3.5. The galaxies were found through very deep near-IR imaging with the VLT and are selected by their very red near-IR colors. They are too faint to be selected or studied at (observer's) optical wavelengths, and they contribute more than half of the mass density of massive galaxies in the Universe. Follow-up spectroscopy showed that many of these galaxies have quiescent populations, i.e., they do not form stars any more, already at a redshift of 2.7 (!), whereas others are forming stars at very high rates. NICMOS imaging with the HST revealed that the quiescent galaxies are ultra-compact: they are smaller by a factor of 5 than nearby galaxies of the same stellar mass. These results have significantly changed our understanding of galaxy evolution.

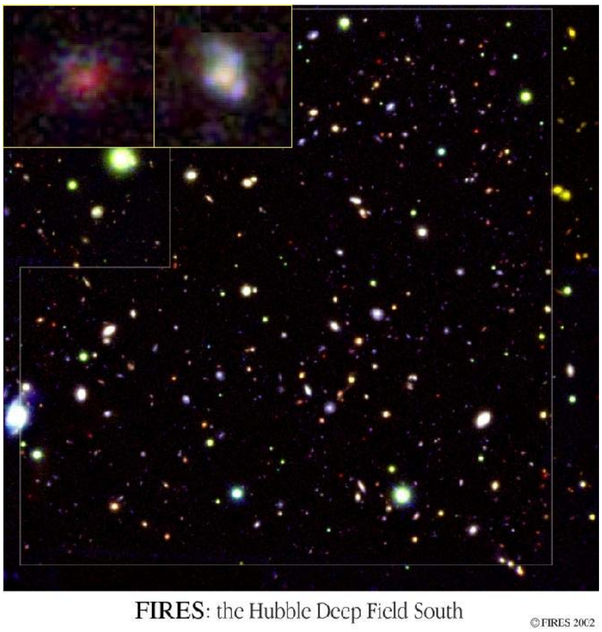


***Figure 1**:* The most sensitive near-infrared image of the sky until recently. The figure shows a three-color composite image of the Hubble Deep Field South observed with the ISAAC instrument at the ESO VLT (100 hr exposure) and with the HST-WFPC2-camera. The image is a combination of one HST exposure (in the I-filter at 0.814 µm; here rendered as blue) and two ISAAC exposures (Js; 1.24 µm; green and Ks; 2.16 µm; red). The image unveiled a large number of distant red galaxies, which emitted their light 11 billion years ago. Most of these galaxies stopped forming stars a long time ago. The inset at the upper left shows one of these red galaxies. For comparison, the right inset shows a blue galaxy which is still forming stars in rudimentary spiral arms at the same distance (From: Franx and the FIRES team, based on Labbé et al. 2003, ApJ, 591, L95; 2005, ApJ, 624, L81).

Gravitational-lens imaging of the mass structure of galaxies

Koopmans, Barnabe (PhD), Vegetti (PhD), Czoske and their US collaborators started a major survey in 2003 to search for galaxy-scale strong gravitational lenses: the Sloan Lens ACS (SLACS) Survey. By combining spectroscopy from the SDSS and imaging follow-up with HST, they discovered nearly 100 new lens systems, half of the total currently known population. By combining these studies with stellar dynamics measurements from large ground-based telescopes (e.g. VLT, Keck) the group showed that massive early-type galaxies have a remarkably homologous and isothermal structure and that the tilt in the Fundamental Plane for high-mass galaxies is caused by an increased dark matter fraction inside their effective radius. Weak lensing studies have extended some of these remarkable results to much larger radii, well into their dark matter halos. The sample is currently being studied for indications of the presence of cold dark-matter mass substructure, with first encouraging results.

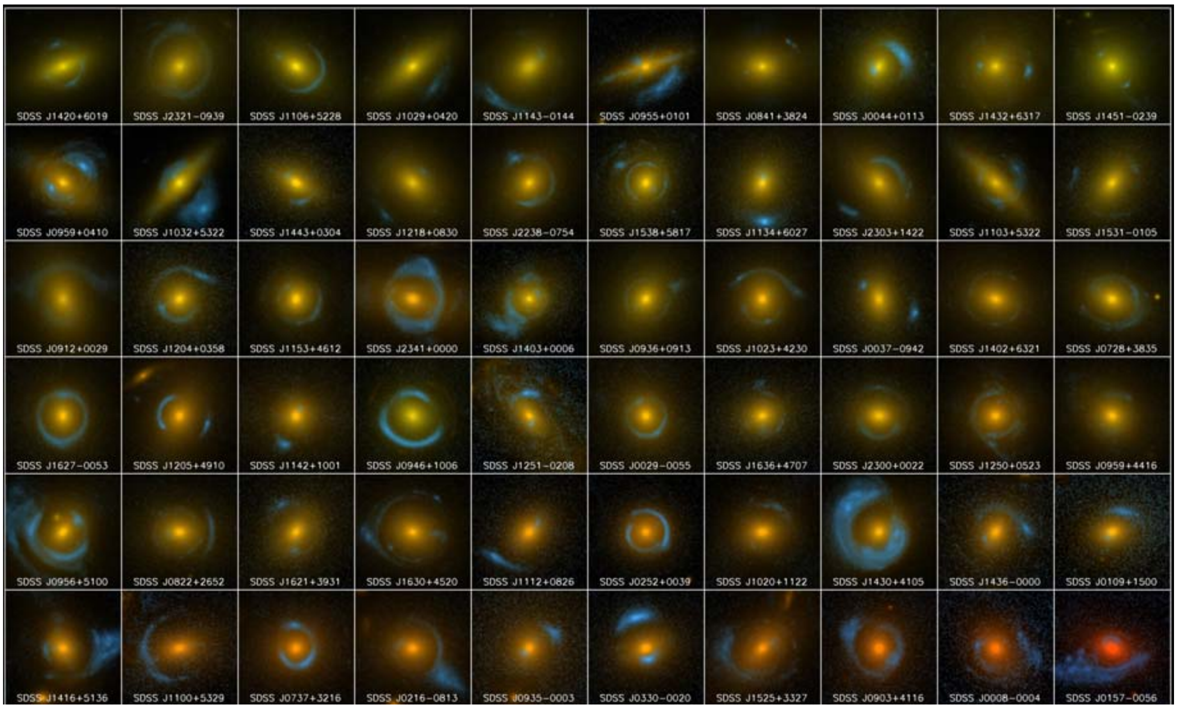


***Figure 2**: A color-enhanced mosaic of Hubble Space Telescope images of gravitational-lens galaxies discovered by the SLACS survey. In each case, the massive foreground galaxy is seen in yellow to red, and the distorted features of the more distant background galaxy are seen in blue. The images are arranged from upper left in order of increasing distance of the foreground galaxy from Earth (from: Bolton, Burles, Koopmans et al., 2008, ApJ, 682, 964).*

The cosmos in a computer

Schaye initiated the OverWhelmingly Large Simulations (OWLS) project. With Booth, Dalla Vecchia, Haas (PhD), Pawlik (PhD), and others he investigated the physics of galaxy formation using more than fifty large, cosmological simulations. The parameters of the model are systematically varied to determine which physical processes are dominant. Galaxies form stars in a self-regulated fashion at a rate controlled by the balance between, on the one hand, feedback from massive stars and black holes and, on the other hand, gas cooling and accretion. Paradoxically, the cosmic star formation rate is highly insensitive to the assumed star formation law. This can be understood in terms of self-regulation: if the star formation efficiency is changed, then galaxies adjust their gas fractions so as to achieve the same rate of production of massive stars. The inclusion of photon-heating strongly reduces the clumpiness of intergalactic gas, which resolves the discrepancy between the observed rate of star formation and the rate required to keep the Universe ionized.

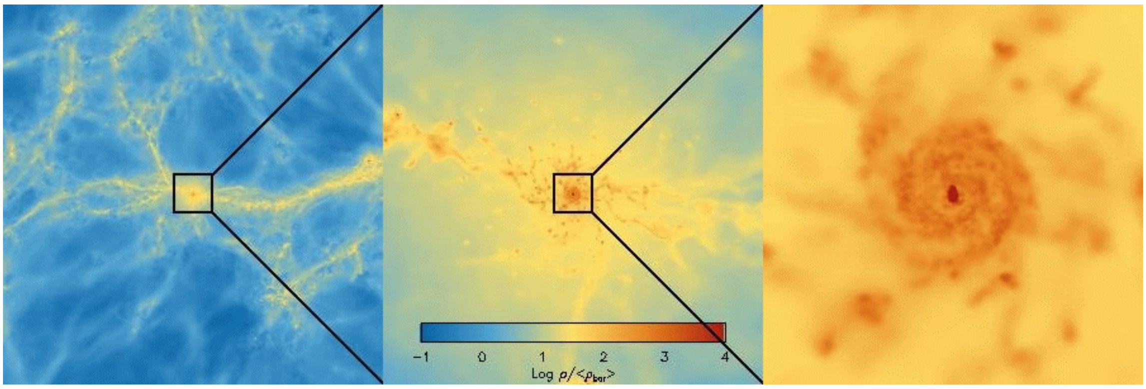


***Figure 3**: Zoom into a 10^{12} solar mass halo at redshift z=2 in the reference OWLS run. From left to right, the images are 10, 1 and 0.1 comoving Mpc/h on a side. All slices are 1 comoving Mpc/h thick. Note that the first image shows only a fraction of the total simulation volume, which is cubic and 25 comoving Mpc/h on a side. The color coding shows the projected gas density, $log^{10}(\rho/<\rho>)$, and the color scale ranges from <1 to 4. The coordinate axes are rotated to show the galaxy face-on. This halo is the tenth most massive in the simulation. About half of the haloes in this mass range host extended disc galaxies, while the other half have highly disturbed morphologies due to ongoing mergers (from: Schaye et al. 2010, MNRAS, 402, 1536).*

Dwarf galaxies: full of surprises

Battaglia (PhD), Starkenburg (PhD), Helmi, Tolstoy, and collaborators studied the stellar populations, dynamics and evolution of dwarf galaxies in the Local Group. Surprisingly, even these small galaxies appear to have had a surprisingly complex early evolution. The wide-field photometric and low resolution spectroscopic surveys carried out by the team reveal multiple components with different spatial distributions, kinematics and metallicities. Although these dwarf galaxies have on average low metallicities, a strong lack of stars with metallicities below [Fe/H] = -3 became apparent, in contrast with our Milky Way halo. New high-resolution studies by the team however have unveiled a few very metal poor stars, indicating that these stars were disguised by the limitations of traditional analysis techniques.

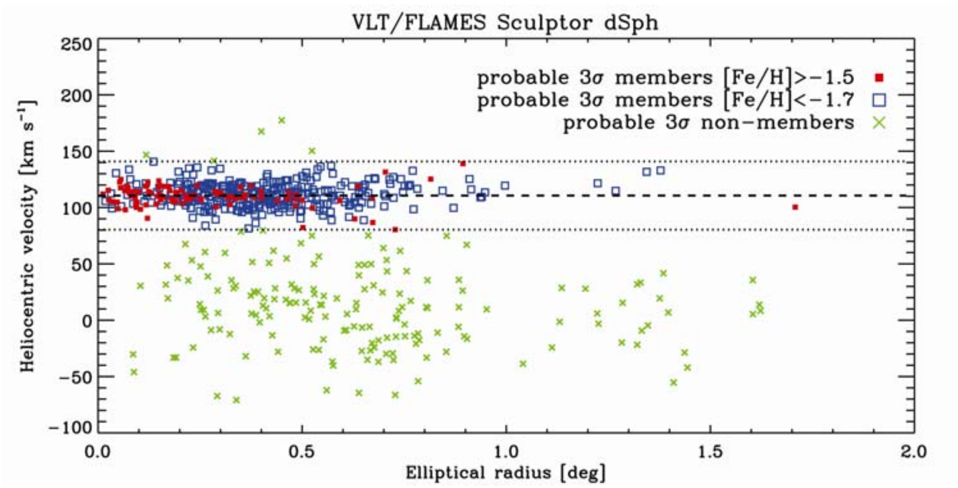


***Figure 4**: The Sculptor dwarf spheroidal galaxy has two components with distinctly different spatial distribution, kinematics and metallicities. The 'metal-rich' component (red, [Fe/H]>-1.7) is cold and centrally concentrated, while the 'metal-poor' (blue, [Fe/H]<-1.7) stars are more extended and show hotter kinematics. Green objects are likely foreground sources. This decomposition in a bulge and a halo bears close resemblance to larger galaxies, but was until this discovery unexpected for objects that are a factor of 10,000 fainter than the Milky Way (based on: Tolstoy et al. 2004, ApJ, 617, L119; Battaglia et al. 2008, ApJ, 681, L13).*

High redshift radio galaxies and the origin of clusters of galaxies

High-redshift radio galaxies ($2<z<5$) are unique laboratories for studying the formation and evolution of massive galaxies and rich clusters at $z>2$. Miley, Röttgering, Kurk (PhD), Venemans (PhD), Overzier (PhD) and collaborators have extensively used the VLT to show that such galaxies are often embedded in overdense structures of star-forming galaxies, with properties expected of protoclusters. Subsequent follow-up work has constrained their properties, including the ages and masses of protocluster galaxies. Their study of the 'Spiderweb Galaxy' (z=2.2) provides the prime example of a forming brightest cluster galaxy and its associated proto-cluster. The associated 3 Mpc-sized structure of galaxies has a derived mass $>2\times10^{14}$ M_o. The central galaxy has a mass of $\sim10^{12}$ M_o (from its Spitzer IR spectrum), among the largest known. It is surrounded by a giant Ly alpha halo and embedded in dense hot ionized gas with an ordered magnetic field. HST images show that the Spiderweb galaxy contains tens of satellite galaxies presumably merging into a massive galaxy. These galaxies are embedded in a halo of diffuse ultraviolet intergalactic light, consistent with young stars also being formed in an extended region around the massive galaxy.

SAURON's view of early type galaxies

A team led by de Zeeuw, Davies (Oxford) and Bacon (Lyon) involving researchers from Leiden and Groningen carried out a representative survey of nearby early-type galaxies and spiral bulges (bulges project led by Peletier) with SAURON, a panoramic integral-field spectrograph custom-built for the 4.2m WHT. The SAURON maps reveal a fascinating diversity of properties, allowing, e.g., the replacement of the traditional classification in E and S0 galaxies by a kinematic classification in slow and fast rotators. The former are nearly all E galaxies, are mildly triaxial,

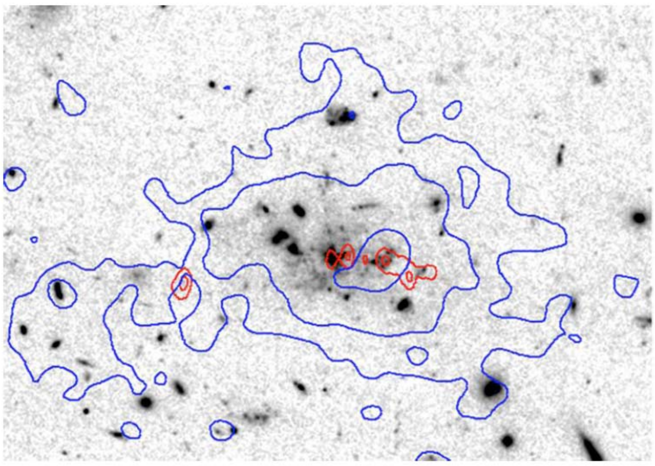


***Figure 5**: Deep HST image of the "Spiderweb Galaxy" at the center of a protocluster at z=2.2, showing VLT Ly-α contours (blue) and VLA 8 GHz radio contours (red) superimposed on the composite HST-ACS image The Ly-α gaseous nebula (~200 kpc) is comparable in size with local cD galaxies (from: Miley et al. 2006, ApJ, 650, L29).*

and have little or no ongoing star formation. The latter are a mix of E's and S0's, are nearly oblate and contain an embedded stellar disk, and often have a metallicity distribution which is more flattened than the stellar light. Combination with Spitzer images of PAH emission, UV images from GALEX, as well as X-ray, HI and CO maps all demonstrate that 15% of the 48 representative early-type objects show signs of star formation in the past 2 Gyr, strongly indicating that minor mergers continue to be important. The slow rotators often contain a kinematically decoupled core; comparison with triaxial dynamical models shows that in many cases these are not distinct components but are caused by the presence of extended counter-rotating disks. The net rotation observed is nearly zero over the bulk of the object, but is not exactly cancelled in the central region, leading to what appears to be a rapidly rotating separate core.

Other highlights

Further examples of science highlights from Network 1 are described in § 5, as they are closely related to the NOVA instrumentation program: they represent the NW1 'harvest' of the investments in instrumentation. Thus, van der Werf (co-)led a study with SINFONI to study the nuclear velocity field of molecular gas in Centaurus A, accurately measuring the black hole mass; Röttgering led the national effort to develop astronomical software for LOFAR (the DCLA project), resulting in the first 30-75 MHz maps with multiple stations; at OmegaCEN the data flow system developed for OmegaCAM was used in the analysis of the faint dwarf population in the ACS Coma cluster survey; and Jaffe led a study of the circumnuclear mid-IR emission of nearby AGNs using the VLTI instrument MIDI, revealing for the first time the dusty torus on pc scales.

E2. Network 2: Formation and evolution of stars and planetary systems

The origin of stars and planetary systems, and of the Sun and the solar system, is a central theme in modern astrophysics. Over the past decade it has become clear that planetary systems orbiting other stars are common; however, systems similar to our own, with terrestrial planets near the star (in the habitable zone) and gas-giants further out, have still not been found. What is the origin of this large diversity in planetary architectures? Much of it was likely set in the early phases of protoplanetary disk evolution when gas was still present in the disk. Network 2 researchers have fully exploited new observational opportunities at VLT, VLTI, Spitzer, JCMT, APEX and SMA of both the gas and dust components to be at the forefront of this rapidly developing field.

Stars form in the cold, dense regions of interstellar space, where clouds become unstable against the pull of gravity. In the center of such a collapsing cloud a protostar is rapidly formed, surrounded by a disk of gas and dust. The disk funnels material from the cloud to the growing star, and later on plays an essential role in the process of planet formation. Planets may form initially through sticking of small dust particles in the disk; once they have grown to kilometer size, gravity takes over and planets can form. Network 2 researchers have developed innovative modeling techniques to tackle the many orders of magnitudes in scales involved in these processes which complicate numerical simulations.

The formation and early evolution of massive stars is much less well understood, due to the much shorter timescales involved and the larger distances. The strong radiation field developed by massive protostars very early on causes a qualitatively different evolution compared to solar type stars. For instance, it is unclear if the formation of the most massive stars in galaxies is through the gravitational collapse of a single cloud core. Stellar winds play a pivotal role in the later stages, when they drive stellar evolution and return enriched material to the interstellar medium. Collaborative Network 2 and 3 projects have led to pioneering observations and models of the most massive stars in low metallicity environments.

Throughout the evolutionary stages, gas and dust undergo different degrees of modification by the prevalent ultraviolet radiation fields, energetic particles, strong shocks and gas-grain interactions, which cycle one compound to another. The ubiquitous Polycyclic Aromatic Hydrocarbons can now be observed throughout the Universe and their full diagnostic power is starting to be explored. In cold cores and proto-planetary disks, ices grow on top of the refractory dust, and chemical reactions within the ice can form new, more complex molecules that evaporate once the dust grains drift closer to the young star. Dust particles grow, settle, crystallize and are chemically modified as their temperature rises. This increase in chemical complexity may be at the basis of the development of life in planetary systems, and can be put into the context of the evolution of our own solar system. Over the last decade, Network 2 researchers have provided a firm astrophysical basis for a quantitative determination of crucial chemical building blocks throughout low-mass (proto-)planetary system evolution.

E2.1. Network 2 science highlights 2003-2009

The composition of the building blocks of planetary systems in the "terrestrial" regions of proto-planetary disks

Silicate grains in interstellar clouds are largely amorphous. In contrast, spatially unresolved mid-IR spectra of proto-planetary disks show abundant crystalline silicates that must have been formed in the disk. The Amsterdam group led by Waters has been a pioneer and leader in this field since their discovery with ISO-SWS in 1996. Similarly, solar system comets, believed to be primitive bodies that represent the composition of pristine material at the time the solar system was formed, also show crystalline silicates. In order to understand their origin and possible relation to the process of planet and comet formation, it is important to determine their spatial distribution. Van Boekel (NOVA PhD), Waters, Dominik, de Koter and collaborators used the MIDI instrument at the VLTI to image the spatial distribution of amorphous and crystalline silicates in disks surrounding intermediate mass pre-main-sequence stars (Fig. 6). These unique observations showed for the first time that most of the crystalline silicates are concentrated in the innermost few AU from the star, due to thermal annealing of amorphous grains and gas-phase condensation. There are however also disks with abundant crystalline silicates at larger distances from the star. These grains must have been transported there by radial mixing or been produced locally e.g. by shocks, thus providing a unique probe of the physical processes.

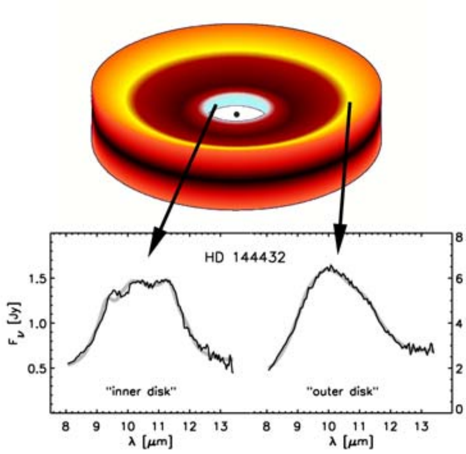


***Figure 6**: MIDI observations of the silicate emission band near 10 μm in a proto-planetary disk. The top panel contains a (flared) protoplanetary disk model by Dullemond & Dominik (2004, A&A, 421, 1075). The bottom left panel shows the spectrum of the inner disk and the right panel of the outer disk. The presence of crystalline silicates can be inferred from the narrow peaks at 9.3, 10.5 and 11.3 μm. The broader underlying emission band is due to amorphous silicates (from: van Boekel et al. 2004, Nature, 432, 479).*

First look at organic chemistry in the planet-forming zones of disks

Observations of the gas-phase chemistry in the inner disk were thought to be impossible with current instrumentation due to their low spectral and spatial resolution. The detection of strong absorption of organic molecules by Lahuis (PhD), van Dishoeck, Pontoppidan (former NOVA PhD) and the 'Cores to Disks' (c2d) Spitzer-IRS team therefore came as a surprise (Fig. 7). Analysis of the Spitzer and complementary data shows temperatures of several hundred K and abundances three orders of magnitude higher than in the surrounding cloud. The most plausible origin of this hot gas is in the inner (<6 AU radius) region, viewed in a near-edge-on geometry. These data provided the first look at organic chemistry in the planet-forming zones of disks, an area that was fully opened up two years later with the detection of the same molecules and water in emission toward many more disks by c2d and other groups. The IRS 46 data form just one

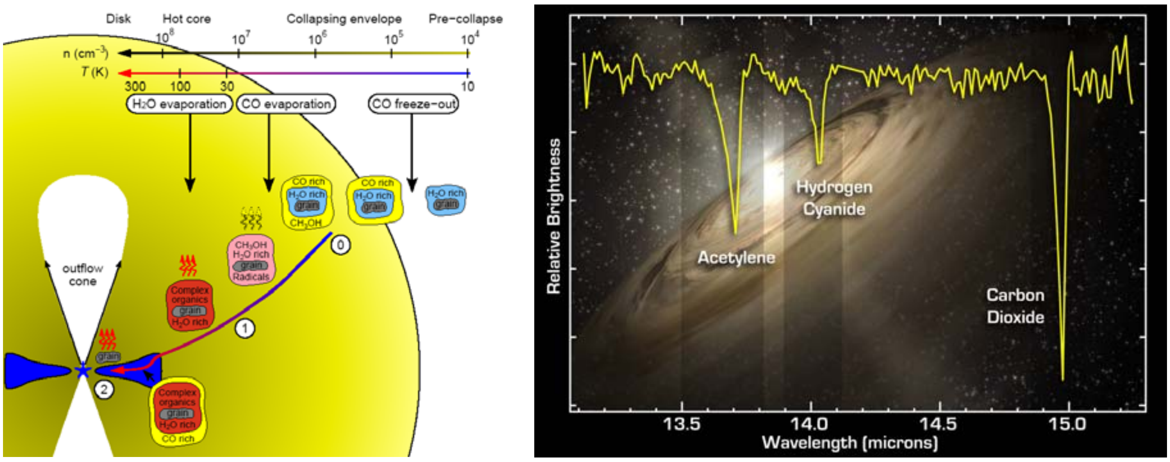


Figure 7: *Left panel: Cartoon representation of the evolution of material from the prestellar core stage through the collapsing envelope (size <0.05 pc) into a proto- planetary disk. The formation of zeroth- and first-generation organic molecules in the ices is indicated with 0 and 1, and second-generation molecules in the hot-core region with 2. Once material enters the disk, it will rapidly move to the cold mid-plane where additional freeze-out and grain surface chemistry occur. All ices evaporate inside the (species-dependent) sublimation radius ('snow line') (from: Herbst & van Dishoeck 2009, ARA&A, 47, 427, based on Visser et al. 2009, A&A, 495, 881).*
Right panel: Discovery of hot organic molecules in the planet-forming zones of disks. The normalized Spitzer-IRS spectra show ro-vibrational absorption of C_2H_2, HCN and CO_2 along the line of sight toward the young stellar object IRS 46 in Ophiuchus (typical absorption depths 10-20%). The line of sight toward this source passes through the inner few AU of the inclined disk. The shape of the bands provides a measure of the temperature. The spectra are superposed on an artist impression of a disk (from: Lahuis et al. 2006, ApJ, 636, L145).

highlight of the large c2d-IRS survey of several hundred young stellar objects (co-)led by van Dishoeck probing the evolution of gas and dust from the embedded to the T Tauri phase. This program provided the first complete inventory of ices toward low-mass protostars as well as surveys of PAHs and silicates (probing grain growth and crystallization) in disks around young stars down to the brown dwarf limit.

Journey from core to disk: producing complex organic molecules on the way

The huge physical and chemical changes from the initial collapse of a molecular cloud to the formation of a protoplanetary disk have been modeled by Visser (PhD), van Dishoeck, Hogerheijde and co-workers in 2D for the first time. The interplay between gas, solids (including ices), the radiation field of the central star and cosmic rays results in a fascinating time dependent chemistry and different histories of molecules in disks which can eventually be related to cometary abundances (Fig. 7, left panel). Understanding and quantifying these changes requires laboratory simulations of the basic processes. Öberg (PhD), Bisschop (NOVA PhD), Linnartz, van Dishoeck and collaborators have used new experimental set-ups funded by NOVA to show that photo-desorption of ices is much more effective than previously thought and that hydrogenation of CO and other simple species to molecules as complex as C_2H_5OH (alcohol) is efficient, even at temperatures as low as 10 K.

Growing planets: from dust to pebbles

The initial phases of planet formation are characterized by the growth of dust particles from sub-micron to millimeter and centimeter size (as evidenced by observations of, e.g., Lommen (NOVA PhD) and collaborators). This growth is governed by van der Waals forces that allow grains to stick efficiently when collisional speeds are low, as is usually the case in gas-rich proto-planetary disks. As grains grow they also settle to the mid-plane, which speeds up their growth rate. Several important steps in the direction of a robust implementation of growth and fragmentation in models for protoplanetary disks have been established by Ormel (PhD), Paszun (PhD), Spaans, Dominik, and Tielens. The outcomes of laboratory experiments that measure the sticking forces between particles under different conditions are well explained by theory (Paszun and Dominik), and recipes have been developed for easy and fast implementation into numerical simulations of disk evolution. Ormel improved the ability of Monte-Carlo methods for dust aggregation computations to handle cases where the particle distribution spans orders-of-magnitude in size (Fig. 8). An approximation was introduced – the grouping method – in which the less important (small) particles are considered as one unit, sharing the same structural parameters. The new method is particularly well suited to tackle runaway coagulation models or population balance models (including fragmentation).

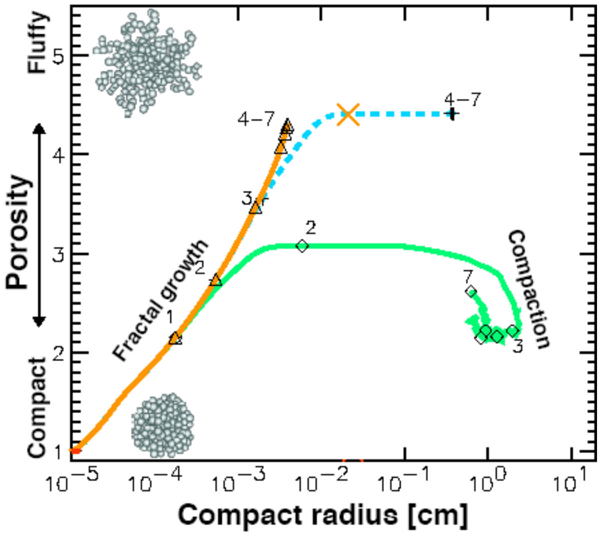


Figure 8*: Evolution of the porosity of dust aggregates with particle size during the growth process in a protoplanetary disk. Under all realistic conditions, the initial growth follows a curve for fractal growth, given by the orange curve. Depending on the strength of turbulence, relative velocities will at some grain size exceed the threshold for compaction and either lead to a saturation of the porosity growth (blue curve) or even turn the trend around and decrease the porosity (figure adapted from: Ormel et al. 2009, A&A, 502, 845).*

Measuring the size of Polycyclic Aromatic Hydrocarbons

As a class, large PAHs are the most abundant complex organic species in the Universe, locking up some 10% of the elemental carbon. Their spectral characteristics - broad bands at 3.3, 6.2, 7.7, 11.2 and 12.7 μm - dominate the mid-IR emission of almost all objects, ranging from photodissociation regions, planetary nebulae, diffuse clouds and protoplanetary disks to the general interstellar medium of galaxies. PAHs dominate the heating of neutral gas through the photoelectric effect and the charge balance of atomic and molecular gas. Tielens and collaborators carried out a systematic study of the properties of PAHs over the last decade based on ISO-SWS and Spitzer data. Yet despite their importance, the precise molecular identification of these species has remained elusive. Boersma (PhD) and Tielens, in collaboration with colleagues at NASA Ames, have studied the far-infrared emission characteristics of PAHs. This is the domain of the so-called drumhead modes where the entire molecule vibrates in unison (Fig. 9, left). The results show that the frequency of these modes is a good measure of the size of the emitting species (Fig. 9, right). Herschel will search, for the first time, this frequency regime for these modes and, if detected, will provide a direct measure of the size of interstellar PAHs.

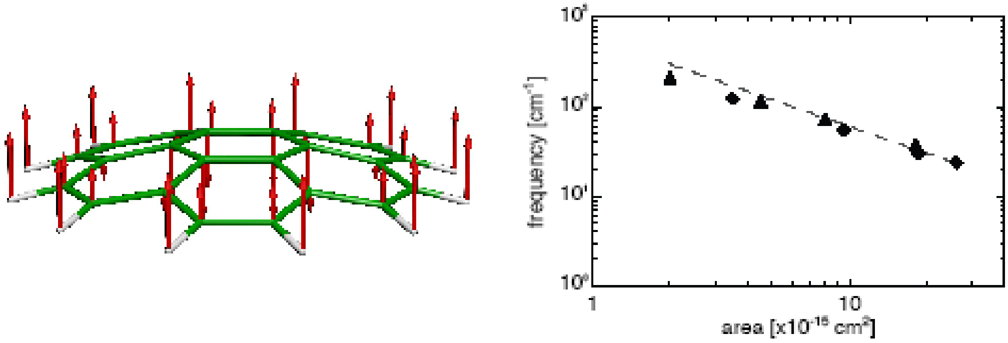


***Figure 9**: Left: A schematic illustrating the lowest frequency mode of the coronene molecule ($C_{24}H_{12}$). In this drumhead mode, all atoms move in a concerted motion. Right: The frequency of the drumhead mode as a function of the area of the PAH taken from the NASA Ames data base and calculated using quantum chemistry. The triangles and diamonds indicate species of the pyrene-like and coronene-like families, respectively. Sizes of the molecular species are in the range of 16 to 130 C-atoms that is thought to dominate the interstellar PAH family. The dashed line indicates the frequencies expected for an unclamped drum with a rigidity characteristic of PAHs (from: Boersma 2009, PhD thesis).*

Disks in gas and dust: getting the full picture

Protoplanetary disks are routinely studied through the thermal emission from their dust content at infrared wavelengths. However, dust only makes up 1% of their mass, and only interferometric observations at (sub)millimeter wavelengths can reveal the structure and dynamics of the gas, which makes up 99% of the disk's mass. Panić, Hogerheijde and collaborators observed the disk around the young star IM Lup in the CO J=2-1 line (Fig. 10), and found that its gas disk extends well beyond 400 AU from the star – as previously deduced from dust continuum imaging - as far out as 900 AU. However, this outer disk is much more tenuous than the inner disk. Panić et al. hypothesize that this is due to the inward migration of dust particles, leaving the gas subject to partial photodissociation by stellar radiation. These observations highlight the importance of getting the full picture of disks, by tracing both the dust and the gas, as is being done by Hogerheijde and collaborators for a much larger sample of T Tauri and Herbig Ae disks.

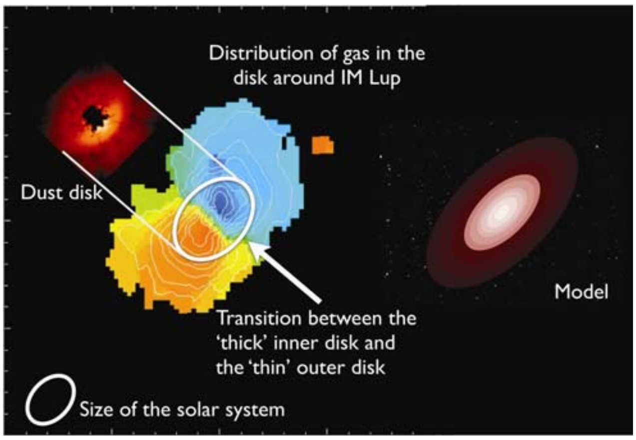


***Figure 10**: Cold CO gas in the protoplanetary disk around the young star IM Lup, observed with the SubMillimeter Array. The gas disk extends to 900 AU, much further than the 400 AU previously inferred from scattered light imaging of the dust particles in this disk. Around 400 AU, however, the surface density in the disk must drop significantly to fit the available observations. (from: Panić et al. 2009, A&A, 501, 269).*

First detection of the secondary transit of a hot Jupiter at optical wavelengths

Exoplanetary transits are a powerful way to obtain information about the physical properties of an exoplanet and its atmosphere. The CoRoT satellite has provided transit lightcurves at optical wavelengths with unprecedented accuracy. This allowed Snellen, de Mooij (PhD) and Albrecht (PhD) to measure for the first time the secondary transit of the "hot Jupiter" orbiting CoRoT-1b

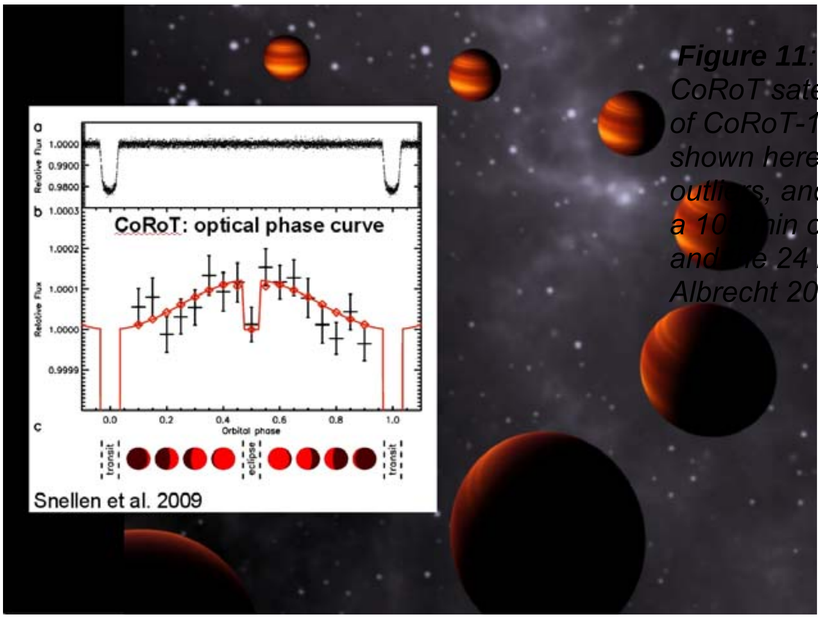


***Figure 11**: The photometric data from the CoRoT satellite covering 36 planetary orbits of CoRoT-1b. The phase folded light curve is shown here, after the rejection of >3 σ outliers, and corrections for perturbations on a 10[illegible] min orbital time scale of the satellite, and the 24 hr day (from: Snellen, de Mooij & Albrecht 2009, Nature, 459, 543f).*

(Fig. 11). The light variation of the system is consistent with the planet dayside hemisphere rotating into view, being eclipsed by the star, and rotating out of view again. The integrated flux from the dayside is 1.2×10^{-4} of that of the parent star, while the night side is consistent with being entirely black. This means that the phase variation is just as we see it for the interior planets in our own solar system. More generally, Snellen and his group have pushed ground-based photometric observations to such accuracy that detections of transits are no longer restricted to space.

Mass loss from massive stars at low metallicity: toward the first generations of stars
Mass loss from the most massive stars in galaxies is an important property that determines the outcome of stellar evolution and the enrichment of the interstellar medium with stellar ejecta. Knowing the mass loss as a function of basic stellar parameters such as luminosity, mass, rotation and metallicity is relevant for e.g. the evolution of the first generations of stars and the origin of gamma ray bursts. In the local universe, the metallicity dependence of mass loss from massive stars can be probed up to metallicities that are 10-50 times lower than in our galaxy. Mokiem (PhD), de Koter and collaborators including Langer, using an innovative approach for

spectral analysis of their VLT large program survey, determined the mass-loss rates for Galactic and Magellanic Clouds stars providing empirical evidence for reduced wind intensities at decreased metallicities and showing for the first time that the wind intensities of stars in the LMC are intermediate to those in the Galaxy and SMC. The empirical relation between mass loss and metallicity agrees with predictions made by de Koter, Vink and collaborators, although a systematic offset of about a factor of two is present, perhaps arising from clumping of material in the winds.

Other highlights: Cazaux (PhD) and Spaans quantified the formation of H_2 and HD on dust grains produced by the first generation of stars. The cooling from these molecules is an important factor in facilitating the formation of lower mass stars and making the transition from Population III to II stars. Min (VENI) and collaborators calculated the optical properties of complex, chemically inhomogeneous fluffy aggregates and concluded that their infrared spectra are not distinguishable from those of much smaller compact grains. Kamp and collaborators developed a new generation of protoplanetary disk models which treat the gas temperature and the resulting enhanced flaring self-consistently. With Hogerheijde, she analyzed the H_2O abundance and line emission in disks in preparation of Herschel observations.

E3. Network-3: The astrophysics of black holes, neutron stars and white dwarfs

The main astrophysical setting of NOVA Network 3 is the astrophysics of compact objects. Alternative terms are the 'Extreme Universe' or 'High Energy Astrophysics', which are closely related. The scientific challenge that Network 3 has set itself is to understand the formation, evolution, physics, and products of compact objects: black holes, neutron stars and white dwarfs.

Compact objects are, with the exception of supermassive black holes in galactic centers, the end products of stellar evolution. They represent the densest concentration of matter in the Universe, with the most exotic equations of state, and the deepest potential wells. Formation and evolution of these objects are inevitably linked to violent processes, such as supernova explosions or gamma-ray bursts. As a consequence of their nature compact objects are broad-band emitters and often manifest themselves as sources of the highest energy radiation, non-thermal emission, the most energetic particles, gravitational waves and the shortest timescale variations. They are the natural sites to study the physics of extreme gravity, extremely high magnetic fields and plasma jets, accretion and efficient particle acceleration. Most commonly, but not exclusively, compact objects are found in binary systems, where, due to mass transfer, they are made 'visible' to the rest of the Universe and hence stellar and binary evolution is an important aspect as well.

As often in astrophysics all these issues are intimately linked. For example, understanding the neutrino, cosmic ray, or gravitational wave production in the Galaxy requires one to understand the physics of compact objects, their formation and population, as well as the physical processes associated with them. On the other hand, to make a full census of compact objects, one needs to understand the emission mechanisms and appearance of compact objects at the various stages of their evolution.

Hence, while Network 3 focuses on compact objects, the physics of the objects requires it to be truly broadband, utilizing the entire accessible wavelength range from radio, through infrared and optical, to X-and gamma-rays and even ultra-high-energy cosmic rays, neutrinos and gravitational waves. Moreover it employs a wide range of techniques, from theoretical to observational and experimental, making it a very lively and cross-disciplinary enterprise.

E3.1. Network-3 highlights 2003-2009

Unifying black holes of all masses: the fundamental plane of black hole activity

Since the discovery of the so-called 'microquasars', i.e., stellar mass black holes with relativistic jets, astronomers had hoped to eventually arrive at a unified picture of black hole activity that links black holes of all masses and accretion states. The big advantage of stellar mass black holes with respect to supermassive ones is that they show variability and major state changes on time scales a million times faster than the black holes in active galactic nuclei (AGN). Could the Galactic stellar black holes therefore help to understand the widely different appearances of their massive siblings at cosmological distances? While the focus of the community had been mainly on disk states (radiatively efficient versus inefficient), the work by Falcke, Fender, & Markoff showed that the contribution of jets to the spectral energy distribution and appearance of black holes is crucial at all levels of accretion, directly linked to the various accretion states ('jet-disk coupling/jet-disk symbiosis'). Interestingly the appearance scales in a simple, predictable way with accretion rate and mass. This realization allows one to link the various states of X-ray binaries (e.g., high-soft versus low-hard states) to certain jet states (e.g., variable and relativistic versus steady and slow) and then further map this to different types of AGN (e.g., quasars/ Seyferts versus radio galaxies/Low-Luminosity AGN). Quantitatively this could be expressed as a 'fundamental plane of black hole activity', where the radio and X-ray emission (of low-state black holes) follows a well-defined correlation as a function of mass and accretion rate across X-ray binaries and AGN.

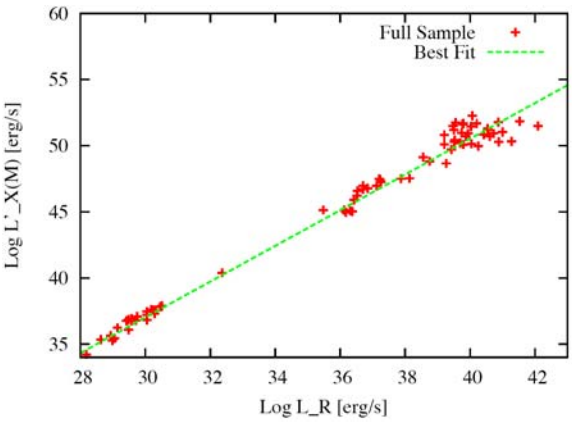


***Figure 12**: Fundamental plane of black hole activity. Plotted is the mass-corrected X-ray luminosity of low-state black holes versus their radio luminosity. At the bottom left low-state X-ray binaries are plotted. At the top right one has LLAGN and Liners, FRI radio galaxies, and beaming-corrected BL Lacs. The scatter is 0.4 dex (from Falcke, Körding, Markoff 2004, A&A, 414, 895; Körding et al. 2006, A&A, 456, 439).*

Conspicuously absent in Fig.12 are black holes in between supermassive and stellar ones, the so-called intermediate-mass black holes. These black holes of hundreds to thousands of solar masses have been claimed to exist, based on the finding of ultra-luminous X-ray sources (ULXs) that seemingly require super-stellar Eddington masses. Numerous candidates exist, but their formation remains a mystery, since single stars are not expected to reach such high masses and then collapse into a black hole. Portegies Zwart provided an interesting solution for the formation problem – at least for the heavier ones. He pointed out that the very bright ULX in M82 resides in a dense cluster, while other, less dense clusters do not harbor a ULX. Numerical simulations show that in the case of dense clusters massive stars will eventually rapidly sink to the center and aggregate to form a ~1000 solar mass black hole, while for less dense clusters the time scale of dynamical friction is too long and no black hole forms.

Gamma-ray bursts: making stellar black holes and probing high redshifts
The formation of stellar mass black holes is by no means a resolved issue. An important clue was found during the NOVA Phase-2 when Dutch astronomers using Beppo-SAX linked the mysterious long Gamma-ray bursts (GRB) to supernova explosions and hence the likely formation of stellar mass black holes. In 2003 a large collaboration involving Wijers, Wiersema (PhD), and Starling found unambiguous signatures of optical lines from a type Ic supernova in the optical afterglows. From an extensive analysis of GRB and SN locations in host galaxies,

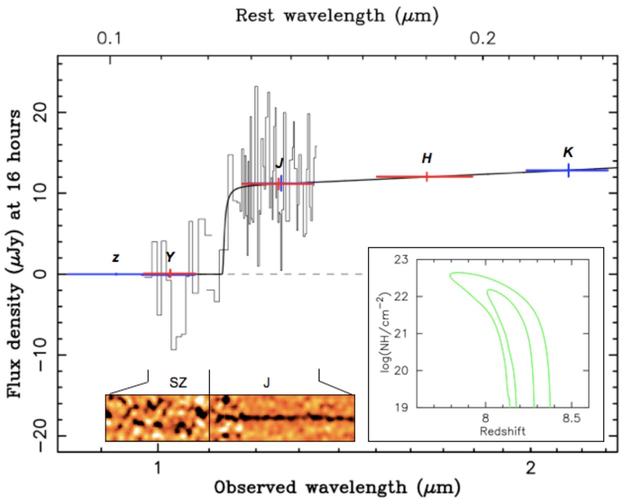


***Figure 13**: The VLT spectrum of the afterglow of GRB090423, with photometric data and a fit for the redshift and hydrogen column superposed the left inset shows the 2D spectrum and the right inset shows the confidence contours of the redshift-H column fit (from: Tanvir et al, 2009, Nature, 461, 1254).*

they also found that GRBs prefer relatively brighter and more metal-poor regions of hosts, and these hosts are more likely small and irregular, again linking GRBs to the most massive, and possibly metal poor, stars. At the same time the group of Langer and Yoon (PhD) had already started to develop evolutionary models of very massive stars including rotation, in which they were able to show that low-metallicity, highly spinning massive stars are likely progenitors for such long gamma-ray bursts. Detailed physical modeling of the afterglows of GRBs (Wijers, Van der Horst, Van Eerten) further supported this connection between GRBs and massive stars by showing that these often come from blast waves propagating in fossil stellar winds.

The theoretical and observational link between star formation and subsequent black hole formation in the Universe to GRBs then makes it possible to use high-redshift GRBs as probes of the evolution of star formation environments and the global universe via spectroscopy of the afterglows. Such investigations confirm that GRBs prefer environments that are poor in metals and have very low dust extinction. Recently this line of investigation culminated in the finding of a GRB at z~8.3 (Fig. 13), which allows study of these processes in an early phase of the Universe.

New views on and with ultra-high energy cosmic rays

The explosive events that lead to the formation of black holes and neutron stars have as another important consequence the acceleration of highly energetic particles or cosmic rays. This was shown in HST and Chandra observations of the shocks in the supernova remnant RCW 86 by Helder (PhD), Vink and collaborators (Fig.14). Here the proper motion of the shock as well as gas temperatures could be measured in great detail with XMM Newton, showing that a significant fraction (>50%) of the kinetic shock energy is dissipated in an unseen component. The energy drain is naturally explained by cosmic ray acceleration, confirming that supernova shocks are indeed remarkably efficient cosmic ray accelerators.

This naturally leads to the desire of observing cosmic rays directly, a topic that did not resonate strongly in the Netherlands until recently. It became, however, acute through the preparations for LOFAR. Falcke & Gorham, based on a new theoretical approach, had predicted that radio emission from Ultra-High Energy Cosmic Rays (UHECRs) should be detectable and that LOFAR should become a sensitive UHECR detector. Using the first LOFAR prototype antennas, the group of Falcke and Hörandel indeed discovered the predicted radio emission. As a consequence several groups around the world now work on radio-detection methods of UHECRs

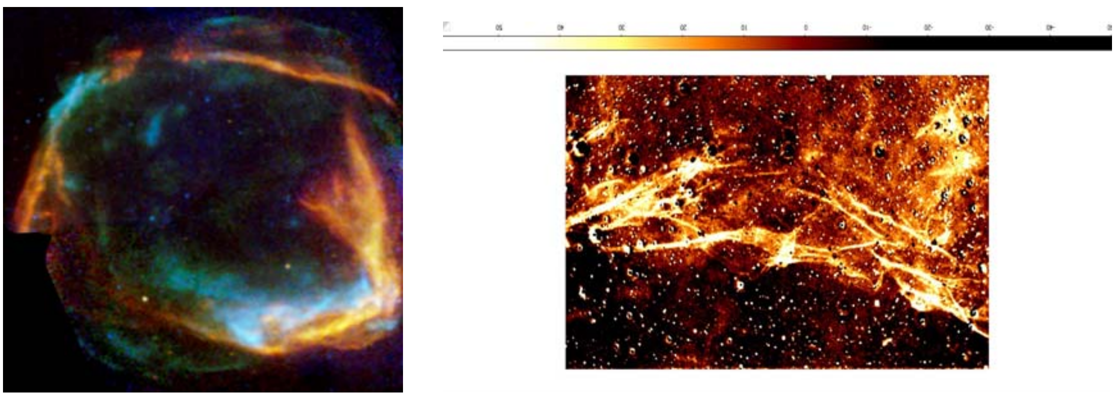


Figure 14*: The northeast shock (right, Hα) of the supernova remnant RCW 86 (left, VLT/FORS2+XMM Newton), where the X-ray emission is dominated by synchrotron radiation from ultra-relativistic electrons. The post shock temperature is much lower than expected from the measured shock velocity, thus indicating cooling through efficient cosmic ray acceleration (from: Helder et al, 2009, Science, 325, 719).*

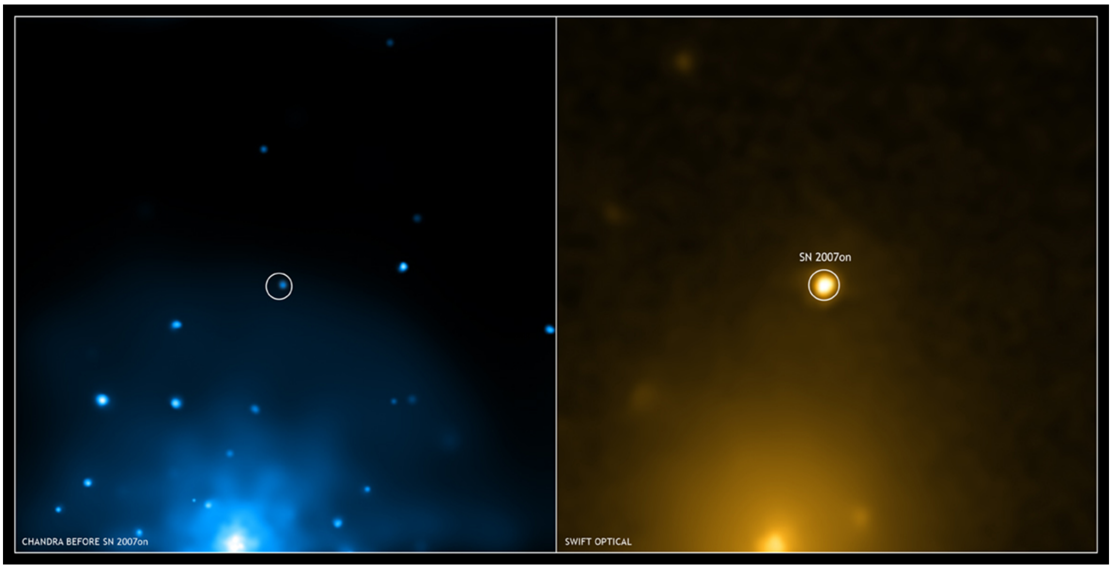


***Figure 15**: Optical image of supernova 2007on (right) and Chandra image taken four years earlier, showing the likely progenitor (image NASA/CXC/MPE, after Voss & Nelemans, 2008, Nature, 451, 802).*

and the NL groups started to participate in the Pierre Auger Observatory, the world's largest UHECR experiment. The experiment found the so-called GZK cut-off and an anisotropic arrival direction of the highest energy cosmic rays. Interestingly, the strongest anisotropy is in the direction of the bright, nearby radio galaxy Cen A. This hosts a powerful jet from a supermassive black hole, thus linking cosmic ray research back to the other NW3 and NW1 themes.

Type Ia supernovae: what is it that explodes?

Of course, supernovae are not only vital for cosmic rays, but they also play a prominent as cosmological probes and standard candles if they occur as so-called Supernova type Ia, where presumably a white dwarf disintegrates completely. However, despite the importance of SNe Ia as the sources of most of the iron ever made and as prime witnesses of the accelerated expansion of the Universe, it is still unclear what actually triggers this explosion. A new way to address this question of the progenitors of SNe Ia is to directly detect them in pre-supernova images. The first likely progenitor was found in Chandra images (Fig. 15) taken four years before the explosion of supernova 2007on in NGC 1404 (Nelemans) which is consistent with the white dwarf hypothesis. Efforts now continue to build a statistical sample.

Signals from strong field gravity: accreting neutron stars and black holes, and radio pulsars

Essentially all the power output from compact objects is generated close to the surface or event horizon. Energy sources are the accretion flow, gravitational collapse, or the spin of the object. Hence, a major question is how the various power generating mechanisms work on the smallest scales. The only concrete hope to ever directly image this region would be in the supermassive black hole in the Galactic center. For all other Galactic black holes one has to rely on either spectroscopic (Verbunt) or timing signals (van der Klis, Wijnands). Here accreting neutron stars provide important laboratories to understand the inner workings around compact objects. The exterior space-time of neutron stars and black holes is similar in many respects and general relativistic phenomena are expected in neutron star accretion. In 2006, results on the accreting neutron star Circinus X-1 obtained by Boutloukos (PhD) and van der Klis confirmed a key prediction made earlier by a general relativistic model for kHz QPOs (Fig. 16).

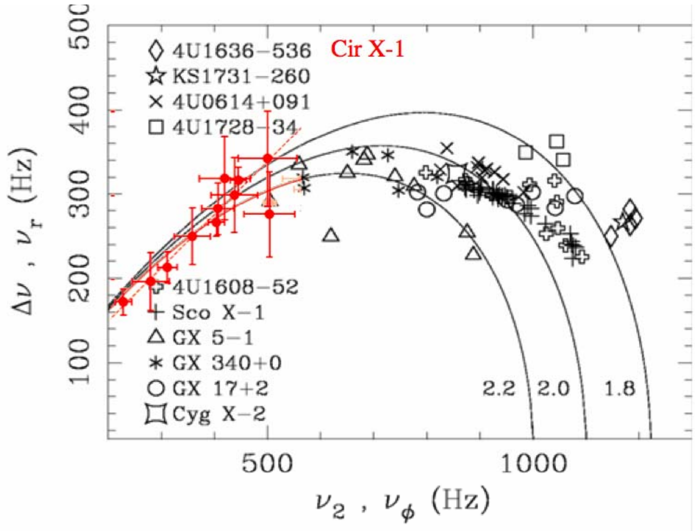


***Figure 16**: Circinus X-1 observations (red) populate for the first time the ascending branch of the radial epicyclic vs. orbital frequency relation predicted by the relativistic precession model for kHz QPOs by Boutloukos et al. 2006, ApJ, 635, 1435 (original figure (black) after Stella and Vietri 1998, Phys Ref. Lett. 82, 17).*

In 2003 Wijnands and van der Klis with MIT and NASA collaborators found a Rosetta stone for addressing these questions, when in addition to periodic pulsations also kHz QPOs were detected likely from the disk/neutron star boundary layer, and burst oscillations from thermonuclear X-ray bursts, all in the same source, the original accreting millisecond pulsar they had found in 1998. This allowed them to relate all three phenomena and to link them to the spin of the neutron star. In 2008, in another source, Watts et al. demonstrated strict phase coherence between the accretion and the thermonuclear pulsations, clinching the link between these two phenomena.

Recently, a collaboration involving van Leeuwen and Hessels observed an accreting neutron star turning on as a millisecond radio pulsar several years after it had stopped accreting, which directly confirmed the viability of that step in existing evolutionary scenario for these objects and the link between them.

Other highlights

Apart from these few selected highlights, there are many other results that deserve to be mentioned. This includes the precise measurement of close white dwarf-white dwarf binaries (Groot, Nelemans) that produce gravitational wave signals guaranteed to be detectable with LISA and hence have been selected as LISA verification sources; the first detection of the Warm-Hot Intergalactic Medium through X-ray spectroscopy (Kaastra, Vink, using techniques originally developed for X-ray binaries); the best upper-limit of the cosmic flux of super-GZK neutrinos using radio observations of the moon (Falcke); and the discovery of the intermittent accreting millisecond pulsars (Altamirano, Casella, Wijnands, van der Klis).

Appendix F: Description of the NOVA instrumentation program for 2003-2013

F1. Instrumentation program 2003-2009

Table F1 summarizes the NOVA-funded instrumentation projects in the 2003-2009 period. This table also shows the NOVA financial contribution to these projects including the external funds (shown as fraction of the total financial contribution). NOVA has the final responsibility for all projects listed in the table with the exceptions of LOFAR DCLA (shared responsibility of several university institutes, ASTRON and NOVA) and the DOT (UU responsibility). This responsibility implies monitoring progress of the projects through the NOVA ISC and the NOVA Executive Director, taking corrective measures through the NOVA Board and Directorate, and where required provide contingency funds or seek for additional external funding.

In-kind staff contributions from the universities, ASTRON and SRON to the projects are not included in the cost figures. NOVA's policy is that national leadership of the instrumentation project must come from tenured university astronomers without any financial compensation from NOVA for the time spent on project tasks. The larger projects carried out with international partners required considerable (in-kind) time for coordination, progress monitoring and meeting of the ESO or ESA requirements for project milestone reviews. LOFAR-DCLA showed similar time overhead demands for university astronomers working together with ASTRON in structuring the science program and organizing the transition of LOFAR into an international project. For the larger projects NOVA provided some financial support through appointments of (part-time) project managers.

Note that the cost numbers in Table F1 do not necessarily reflect total NOVA contributions to each of the projects. This holds in particular for projects that started before 2003 or those that continue beyond 2009. The financial contributions from NOVA to each project have been spent

Instrumentation projects	Costs	External
ALMA		
ALMA Band-9 R&D	125	0%
ALMA Band-9 prototype	4,164	100%
ALMA Band-9 production	4,283	100%
ALMA R&D upgrade	431	18%
ALMA ALLEGRO	254	0%
CHAMP+	628	100%
Subtotal ALMA projects	**9,885**	
Other projects		
WSRT: PuMa II	843	0%
LOFAR DCLA	1,074	a
Laboratory Astrophysics/Matri^{2}ces	765	a
DOT	219	a
S^{5}T	150	a
Amuse	109	0%
New initiatives/seed funding	823	0%
Subtotal other projects	**3,983**	

Instrumentation projects	Costs	External
ESO: VLT, VLTI, VST		
VLTI: NEVEC, MIDI	623	3%
VLTI: Matisse	141	0%
VLT: Sinfoni	869	0%
VLT: X-Shooter	2,286	41%
VLT: MUSE + ASSIST	1,442	5%
VLT: Sphere-Zimpol	556	20%
VST: OmegaCAM/CEN	1,448	0%
E-ELT: Phase-A studies	1,128	15%
Subtotal ESO: Op-IR instrum.	**8,493**	
Space projects		
JWST: MIRI cold optical bench	7,273	76%
Gaia photometric software	217	a
Subtotal space projects	**7,490**	
Total instrumentation projects	**29,851**	

***Table F1**: NOVA investments in instrumentation projects for the period 2003-2009. The numbers (in k€) show the financial contributions of NOVA including external funds from mainly NWO and ESO. The percentages are the fractions of the total NOVA contribution to each project that are funded from external revenues. In-kind staff contributions to projects from the universities, ASTRON and SRON are not included in the figures. Projects indicated with 'a' received significant external funding as well but these revenues were administrated outside NOVA and are not included in the project costs listed in the table.*

on hiring staff at the universities, from ASTRON, SRON, TNO and occasionally from industry, on purchase of hardware and test equipment, on facilities needed for instrument integration and testing, and on travel and meetings.

F1.1. Completed instruments for the VLT, VLTI and VST
In 2003-2009 NOVA and its international collaborators completed three instrument projects for ESO: MIDI for the VLTI, and SINFONI and X-Shooter for the VLT. A fourth instrument, OmegaCAM for the VST was also completed but is waiting for completion of the telescope.

MIDI (MID-infrared Interferometer; NOVA contribution of k€ 680 to the instrument and k€ 200 to the VLTI infrastructure, NL-PI Waters) is the first two-element beam combiner for the 10 μm range, built for the VLTI. It allows coherent beam combination at a spatial resolution in the range of 10-20 milliarcseconds and a spectral resolution between 30 and 230. The instrument was built by a German/Dutch/French consortium led by the MPIA in Heidelberg, with PI Leinert. The Dutch hardware contribution to MIDI was provided by NOVA and ASTRON and was in two main areas: (a) the cold optical bench, and (b) instrument control and data analysis software (led from NL by Jaffe). The scientific capabilities were successfully demonstrated during a first science run in June 2003. Regular observations by astronomers from the ESO community started in April 2004. As a common user instrument, MIDI made optical interferometry available as 'standard' observing technique for a wide class of astronomers. The guaranteed time resulted in two Nature papers with Dutch first authors, on protoplanetary disks (see Appendix E, § 2.1) and active galactic nuclei. Furthermore, observations with MIDI by the ESO community have led to ~70 papers in refereed journals (with 26% co-authors from the Netherlands) and ~184 papers in conference proceedings and non-refereed journals (with 25% co-authors from the Netherlands).

NEVEC was the NOVA-ESO Expertise Centre for the VLTI, active in 2000-2004 (NL-PI Quirrenbach). The NOVA contribution amounted to k€ 1240, of which k€ ~400 was spent on the development of data calibration software for MIDI, and later also exploited by other VLTI instruments, like AMBER. It provided (1) instrument models, data reduction and calibration techniques to ESO for optical interferometry with emphasis on observations of faint objects; (2) concepts for second generation VLTI instruments including PRIMA; (3) education in optical interferometry. Most NEVEC activities occurred before 2003. The NEVEC concept triggered similar initiatives in other countries including France and Germany. With the departure of Quirrenbach NOVA decided not to continue the involvement in PRIMA and to end the NEVEC activities. Guaranteed time awarded by ESO in exchange for the NEVEC investment is on the VLTI auxiliary telescopes to be used (in 2010-2012) after the upgrade of the VLTI system initiated for PRIMA.

SINFONI (Spectrograph for Integral Field Observations in the Near-Infrared; NOVA contribution of k€ 1135 including 5 yr research support for early science harvest, NL-PI van der Werf) is a collaboration between ESO, MPE and NOVA. It combines a cryogenic near-IR (J, H and K-bands) integral field spectrograph (spectral resolution R~3000) with an adaptive optics unit. A laser guide-star facility enables nearly diffraction-limited imaging over the whole sky. The combination of adaptive optics and integral field spectroscopy in the near-IR allows fully spectrally multiplexed imaging at a spatial resolution equal to the HST optical resolution (three times better in both dimensions in K-band) and vastly more sensitive in K-band. Contrary to most other integral field spectrographs, SINFONI is cryogenic and thus allows full K-band capability. NOVA had a key role in the design and production of the spectrograph camera with the upgraded 2048^2 detector for SINFONI. The camera was successfully completed and delivered to ESO in early 2004. In parallel NOVA performed the following feasibilities studies related to SINFONI: (a) performance analysis and optimalization of Laser Guide Star adaptive optics; (b) reconstruction of the adaptive optics corrected point-spread-function based on SINFONI wavefront sensor data.

In exchange for its contribution, NOVA received 18.5 nights of guaranteed observing time.
The time was used for observations with SINFONI of starburst galaxies, Centaurus A, high-z

galaxies and ULIRGs. So far this resulted in five papers in refereed journals led by authors from the Netherlands and in four (3 Dutch and 1 German) PhD theses; another Dutch thesis will follow in 2010. In addition, NOVA astronomers gained significant amounts of open time (more than 50 nights in total) on SINFONI, for galactic as well as extragalactic projects. So far observations with SINFONI resulted in 76 science papers in refereed journals (12% with co-authors from the Netherlands) and 127 papers in conference proceedings and non-refereed journals (20% with co-authors from the Netherlands).

The SINFONI observations of Centaurus A by Van der Werf, De Zeeuw, Cappellari, Reunanen (NOVA PD), Neumayer and Rix (MPIA) and Davies (MPE). demonstrate the power of adaptive optics in combination with an efficient integral field spectrograph (Fig F1). The ionized gas species (Br-γ, [Fe II], [Si VI]) show a rotational pattern that is increasingly overlaid by non-rotational motion for higher excitation lines in the direction of Cen A's radio jet. The H_2 emission lines on the other hand show regular rotation and no distortion due to the jet and can thus be used as a tracer to model the mass of the black hole in the central ±1.5". The gas kinematics are best modeled through a tilted-ring model that describes the warped gas disk. The black hole mass is $4.5{\times}10^7$ Mo based on a kinematically hot disk model where the velocity dispersion is included through the Jeans equation. The same dataset was used for an independent measurement of the black hole mass with stellar kinematics, using the CO band at 2.3 μm. Remarkably, the stars are found to counter-rotate with respect to the gas. Using axisymmetric three-integral models, the best-fitting value for the black hole mass is $5.5{\times}10^7$ $M_{\odot}$, in excellent agreement with the determination from the gas kinematics. This provides one of the cleanest gas-versus-stars comparisons of black hole mass determination.

OmegaCAM (NOVA contribution of M€ 3.3 up to end 2009, including OmegaCEN, NL-PI Kuijken) is the wide-field camera for the VLT Survey Telescope (VST). Its focal plane contains a

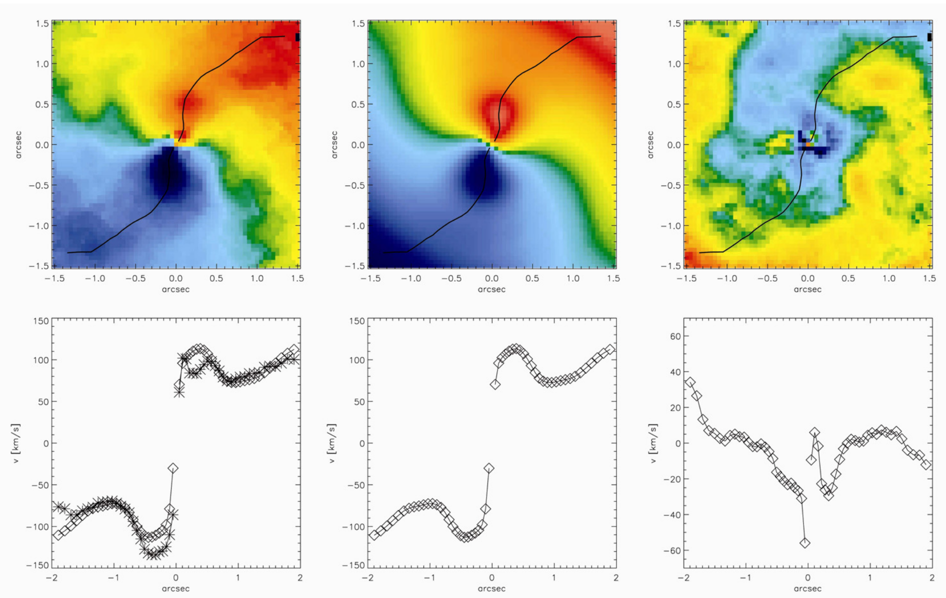


***Figure F1**: Velocity field of molecular gas in the central parsecs of Cen A derived from the H_2 2.12 μm line observed with SINFONI (left panel, top). The central panel (top) shows the velocity field of the best-fitting dynamical model, with a black hole mass of 4.5 x 10^7 Mo. The velocity residual (data-model) is shown in the right panel. The velocity curves in the bottom panels are extracted along the line of nodes (overplotted on the velocity maps), and represent the peak velocity curves. The diamonds correspond to the model velocity curve, while the crosses correspond to the data. In the velocity residual map, note the remarkable bisymmetric pattern close to the nucleus, which may indicate further warping, or gas flow inwards toward the black hole (from: Neumayer et al. 2007, ApJ, 671, 1329).*

1x1 degree, fully corrected field of view, which is tiled with 32 2048x4096 pixel CCD detectors for a total of about 16,000 x 16,000 pixels – a quarter of a giga-pixel. The camera and telescope are designed specifically for good image quality, and the detector array will sample the excellent seeing on Paranal well with 0.2 arcsec per pixel. The total cost of the instrument is of the order of 6 M€. NOVA leads the project, and contributed about one-third of the funding. Other partners are Munich, Göttingen and Bonn in Germany, Padua and Naples in Italy, and ESO who developed the detector and cooling systems. The key NOVA deliverable to the project was the development of the data processing software that will run in ESO's data flow system. Building on this experience, a data center for OmegaCAM, named OmegaCEN, was set up in Groningen led by Valentijn in order to support scientific use of OmegaCAM in the form of calibration and archiving, data processing and expertise. OmegaCAM was completed and delivered to ESO in 2006, where it awaits shipping to Paranal for installation on the VST. Unfortunately the telescope project was hit by a series of delays, and at the time of writing it appears that the telescope will not be ready to accept the camera before summer 2010. OmegaCAM and the VST are expected to have an operational lifetime of at least 10 years. The NOVA guaranteed time share is about four weeks of VST time per year, over the lifetime of the instrument. Several major programs are ready to go: the largest of these is KiDS, the kilo-degree survey, which was approved as a public survey by ESO and will take over 400 nights of observing time. Together with its partner project VIKING on VISTA it will image 1500 square degrees of extragalactic sky in nine bands, from u to K. It is designed to yield high-fidelity measurements of gravitational shear and photometric redshifts, enabling a detailed mapping of the total matter distribution around galaxies, groups and clusters, as well as population studies of galaxies as a function of environment. Other large projects in which the Netherlands has a prominent role are VPHAS+, a galactic plane survey (including Hα); Omega-WHITE, a survey for variable stars; and OmegaTRANS, a survey for planet transit events.

OmegaCEN is the datacenter for wide-field imaging and the expertise center for astronomical information technology located at the Kapteyn Institute (RuG) consisting of about 15 scientists. It is coordinator of Astro-WISE, which is a EU-funded unique advanced survey information system for astronomy. The system allows distributed production and research analysis of large volumes of astronomical wide field imaging data across countries. Geographically-spread survey teams collaborate in this single virtual research environment which is also connected to the Virtual Observatory. The research activities of OmegaCEN have resulted in ~15 science papers in refereed journals and over 30 papers in conference proceedings and non-refereed journals in 2003-2009. Astronomical IT research highlights include the areas of extreme data lineage, database-query-driven visualization and merging of grid systems. The astronomical research performed with Astro-WISE in Europe ranges from gravitational weak lensing to ultra-compact stellar binaries. OmegaCEN's own astronomical research focus is on galaxy evolution: in the Coma cluster using the HST/ACS Coma Legacy Survey, in nearby superclusters and field using a WFI survey, and of large volumes of the nearby universe using UKIDSS/SDSS catalogs.

X-Shooter (NOVA contribution of M€ 2.3, NL-PI Kaper) is the first second-generation instrument for the VLT available for the astronomical community from October 1st, 2009 onwards. It is one of the most powerful optical and near-IR medium-resolution spectrograph in the world, with unprecedented continuous wavelength coverage from 294 to 2487 nm in one shot. The X-Shooter consortium members are from Denmark, France, Italy, The Netherlands and ESO. The concept of X-Shooter was defined with one single main goal in mind: the highest possible throughput for a point source at a resolution which is just sky limited in about an hour of exposure over the broadest possible wavelength range, without compromising throughput at the atmospheric UV cutoff. The moderate size of X-Shooter is, as opposed to most existing or planned VLT instruments, compatible with implementation at the Cassegrain focus. NOVA in collaboration with ASTRON designed and delivered the near-IR spectrometric arm of X-Shooter. For its first semester on the telescope ESO received over 150 proposals for observing time on X-Shooter resulting in an oversubscription of a factor of eight. The X-Shooter guaranteed time program totals 156 nights spread over a period of three years. The NL X-Shooter GTO program

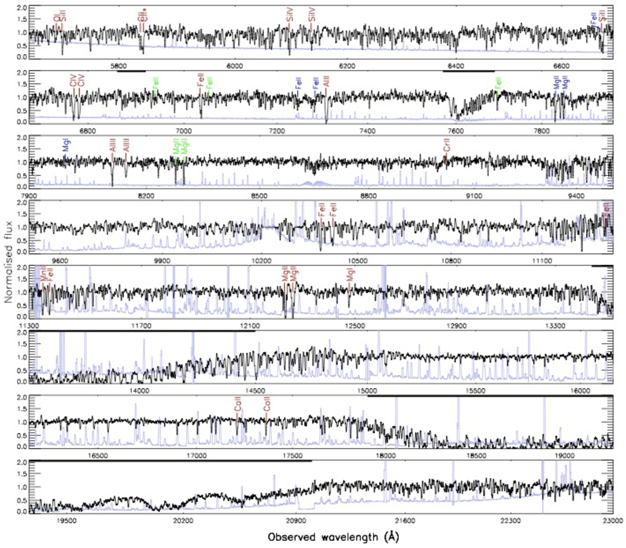


***Fig. F2**: VLT/X-shooter spectrum of the afterglow of GRB090313 covering the range from 570 – 2300 μm in one shot. The UVB part of the spectrum was strongly affected by stray light from the Moon and is not shown. The redshift of the GRB host galaxy is z = 3.4; several absorption lines are indicated. Two intervening systems at z = 1.8 and z = 2.0 are also identified. The suppressions around 1.35 and 1.9 μm are due to the Earth's atmosphere. The light blue trace indicates the flux uncertainty as a function of wavelength.*

(43 nights) is defined in consultation with the Dutch astronomical community. More than 20 NL GTO programs are scheduled, covering topics ranging from the study of brown-dwarf atmospheres, (ultra-)compact binaries, the most massive stars in the Local Group, star clusters, gamma-ray bursts, distant lensed galaxies to the optical identification of high-*z* radio sources to be identified with LOFAR. The strategy is to execute "seed" programs in GTO time that allow for the preparation of normal programs in GO time, as well as some large programs (some in collaboration with the international partners, e.g. the X-Shooter GRB program) leading to break-through science. During commissioning time of the instrument a spectrum was taken from a GRB afterglow (Fig. F2).

F1.2. PuMa for the WSRT

PuMa II (NOVA contribution of M€ 1.3, NL-PI van der Klis) is the collective name for a series of modules which made the radio pulsar capabilities in the Netherlands state-of-the-art in 2005. The project was led by Van der Klis and Stappers. The main improvements compared to the already exciting PuMa I instrument were to use deacceleration techniques to obtain improved pulsar timing as well as the enhanced ability to find tight binary systems with large accelerations, to provide the hardware and software infrastructure to enable coherent de-dispersion to become the normal mode of operation for pulsar observations made with the WSRT, to double the overall bandwidth (up to the maximum delivered by the WSRT) available for pulsar observations and to at least quadruple the bandwidth available for coherent dedispersion analysis. The instrument was completed and delivered to WSRT by the end of 2005. So far observations with the PuMa II modules have resulted in ~25 scientific papers in refereed journals (the majority having co-authors from the Netherlands), seven PhD theses based on PuMa observations and ~10 papers in non-refereed journals (with a similar percentage of 30-100% Dutch co-authors). The new instrument has allowed discovery of the first ever radio pulsar with the WSRT by Janssen and collaborators. PuMa II made some of the highest precision pulsar timing measurements in the world (Laziridis) and will be a vital component of the European Pulsar timing array project which aims to detect low frequency gravitational waves (e.g. Hobbs and collaborators). The knowledge gained with PuMa II is now being used to develop software algorithms for pulsar discovery and timing observations with LOFAR.

F1.3. Instrumentation for ALMA

ALMA is a collaboration between Europe, North America and East Asia with participation by Chile to build an aperture synthesis telescope consisting of at least 66 antennas at the 5000m altitude Chajnantor plateau in northern Chile. When complete, ALMA will observe in frequency bands between 30 and 950 GHz, with a maximum baseline of up to 14 km, offering unprecedented sensitivity and spatial resolution at (sub)millimeter wavelengths. First science observations with a limited number of ALMA antennas are expected to start in late 2011; the entire observatory will be complete in 2013. The main Dutch contribution to ALMA (total investment of ~1 M€ from NOVA and ~15 M€ from ESO, NL-PIs Wild and Hogerheijde) is the receiver cartridge for Band-9 (atmospheric window between 610 and 720 GHz). The work was undertaken in a consortium of NOVA, SRON and TU Delft. The project started as a conceptual design and technology demonstration project in 1999-2003 (building on HIFI expertise), followed by a full design and production of eight prototypes in 2003-2007, and is now in its production phase running from 2007-2012. As of February 2010, thirty-one Band-9 cartridges were produced, tested, and formally delivered to ESO. NOVA's primary motivation to undertake this project was the drive for the scientific use of ALMA at its highest frequencies to probe the physical conditions in the densest regions of proto-planetary disks around newly formed stars and in star-forming molecular clouds in our own and other galaxies out to the highest redshifts. To maximize the science return from ALMA, a node of the European ALMA Regional Center has been established in the Netherlands led by Hogerheijde: ALLEGRO (ALMA Local Expertise GROup). When ALMA becomes fully operational, ALLEGRO will offer general face-to-face user support for novice users, and expert support in the areas of high-frequency observing, imaging of wide fields and with high dynamic range, and the use of advanced science analysis tools.

Within the Netherlands, a collaboration of NOVA, the RuG, SRON, and the Kavli Institute of Nanoscience in Delft developed heterodyne receivers for ALMA to operate at frequencies between 602 and 720 GHz. The work is done under a contract between ESO and NOVA. As the highest frequency band in the baseline project, the Band-9 receivers will provide the observatory's highest spatial resolutions and probe higher temperature scales to complement observations in the lower-frequency bands (between 84 and 500 GHz). A dedicated production team of ~12 people lead by NOVA and based at RuG/SRON in Groningen is producing and testing 66 Band-9 receiver cartridges between 2007 and 2012. The group is managed by Jackson until end 2009, and by Jager from the start of 2010 onwards. By mid February 2010 28 cartridges were produced and accepted by ESO. This work package is fully funded by ESO on a fixed price basis amounting to 12.5 M€ of which 4.3 M€ is already spent in 2007-2009 and 8.2 M€ is available for the years 2010-2012.

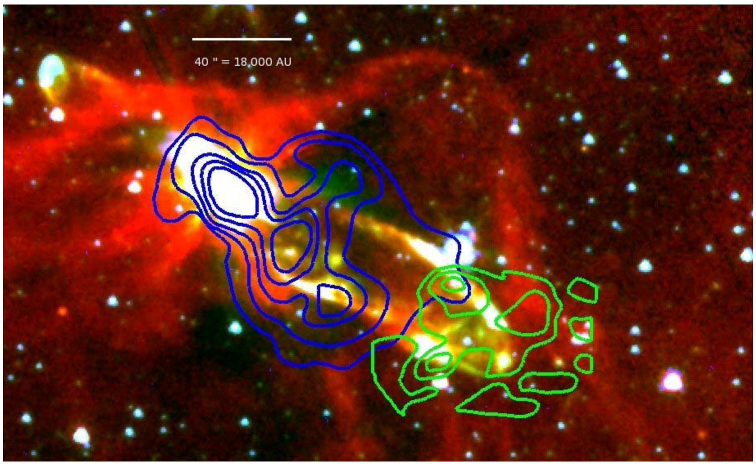
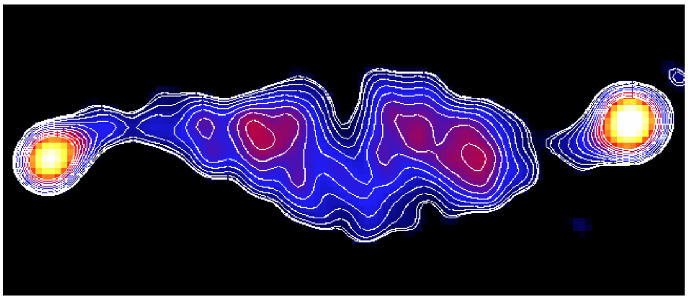


Figure F3: *Spitzer three color (3.6 (blue), 4.5 (green) and 8 μm (red)) image of the HH 46 low-mass protostar with the contours of integrated CO J=6-5 emission (blue/dark) observed with APEX-CHAMP+ overlaid. The [C I] 2-1 emission (green/light) is detected weakly on source but peaks further down at the tip of the outflow where the UV photons produced in the fast bow shock are hard enough to dissociate CO. Analysis of the line profiles shows that the emission consists both of accelerated swept-up gas along the outflow as well as quiescent, photon-heated gas surrounding the outflow cavity walls (from: van Kempen et al. 2009, A&A, 503, 601).*

The technology developed for the ALMA Band-9 receivers is already in use on the CHAMP+ receiver on APEX from mid-2007 resulting in several successful guaranteed time programs and publications (see Fig. F3). CHAMP+ is the first submillimeter heterodyne array camera, consisting of 2x7 pixels in the 650/850 GHz atmospheric windows observed simultaneously. Through interaction with TU Delft and SRON there are continued improvements in the devices, and the development of new technologies such as Kinetic Inductance Detectors (KIDs) may in the future lead to much larger format arrays.

F1.4. NOVA contribution to the mid-IR spectrometer on JWST
The James Webb Space Telescope (JWST), the successor of the HST, will be a passively-cooled telescope in an orbit around the Sun-Earth second Lagrange point, with a lifetime of at least five years. It will have a ~6m primary mirror. The Mid-InfraRed Instrument MIRI will be one of its four instruments. MIRI will be three orders of magnitude more sensitive than any existing ground-based telescope in the 5-30 μm range, a large part of which (>50%) is completely blocked by atmospheric features from the ground. The MIRI instrument, constructed as a joint US-Europe effort, consists of a camera and an integral field spectrometer that will operate in the 5–28.8 μm wavelength range. For optimum performance, the entire instrument will be cooled to 7 K by a MIRI-dedicated cooling system consisting of cryo-coolers. The Dutch contribution to MIRI is the spectrometer main optics (SMO) unit. The Dutch contribution is led by NOVA (NL-PI van Dishoeck, deputy-PI Brandl). The NOVA-ASTRON optical group has lead the optical and mechanical design of the instrument, the end-to-end modeling, the prototyping, construction and testing, and will provide post-delivery engineering support. TNO, together with PeI, have provided key input on the optical design in the early phases of the project. The delivery of the SMO flight model hardware to RAL (UK) was in August 2008 and the gratings were completed in February 2009. The verification model has been successfully tested in the RAL cryo-chamber in 2008 and flight model testing and calibration will take place in late 2010. Planning of the MIRI guaranteed time program has started, with Dutch scientists having leading roles in the protostars, circumstellar disks, exoplanets and high-redshift galaxies themes. The Dutch contribution to MIRI amounted to ~10 M€, with 5.8 M€ from a NWO-Groot grant, 1.6 M€ from NOVA, and in-kind contributions from ASTRON, SRON, and university staff.

F1.5. LOFAR for astronomy
LOFAR, the Low Frequency Array, is a next-generation low frequency radio telescope that will observe in the frequency range of 10 to 240 MHz. The Dutch part of the array will be finished in 2010 and will comprise of 36 stations distributed over an area of diameter of 100 km. In addition, at least eight stations will be built in a number of European countries (Germany, UK, Sweden, and France). The design of LOFAR has been driven by four Key Science Projects (KSPs): (i) the epoch of reionisation, (ii) deep extragalactic surveys, (iii) transient sources and pulsars, and (iv) high energy cosmic rays. The NOVA funded project '*The Development and Commissioning of LOFAR for Astronomy (DCLA)*' (NL-PI Röttgering) consists of the



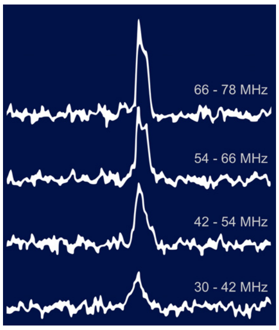


***Figure F4**: (Left) 170 MHz LOFAR image (angular resolution of 10 arcsec) of the powerful radio source 3C61.1, taken with a 20 station LOFAR. This nearby large radio galaxy measures 3 arcmin on the sky corresponding to 600 kpc at z=0.186). (Right) Pulse profiles of the pulsar B1919+21 observed with LOFAR as a function of frequency (from Röttgering et al., in preparation).*

development of essential capabilities and commissioning tasks to enable the four key astronomical projects to accomplish their goals and at the same time provide a first version of general LOFAR user software.

F1.6. Laboratory astrophysics
The Sackler Laboratory for Astrophysics, led by Linnartz, is one of the few places worldwide where experimental physics research dedicated to interstellar matter is strongly embedded within an astronomy department. The laboratory comprises seven experiments – five solid state experiments (SURFRESIDE, CRYOPAD, MATRI^{2}CES, CESSS, HV-setup, of which the first three have been primarily financed by NOVA) and two gas-phase setups (LEXUS, SPIRAS),. SURFRESIDE (SURFace REactions SImulation Device) is designed to study chemical reactions on surfaces. It combines ultra-high vacuum surface science techniques at 10^{-10} Torr (comparable to the densities in protoplanetary disks) with an effusive atomic H source which bombards the ice. Analysis of the reaction products occurs *in situ* by infrared spectroscopy and, after heating, by a quadrupole mass spectrometer. SURFRESIDE became operational in 2006 and is currently being extended with a second beam line.

The objective of the CRYOgenic Photoproduct Analysis Device (CRYOPAD) is to analyze the products obtained by photochemical and thermal reactions in interstellar ice analogs. Ices deposited on a cold (10-100 K) substrate are irradiated with a UV hydrogen discharge lamp and products are analyzed with the same techniques as for SURFRESIDE. CRYOPAD has been operational since 2005 and used heavily by NOVA PhD Öberg (now Hubble fellow at Harvard). Both experiments produce data that are needed in the interpretation of infrared and millimeter observations of ices and gases in hot cores and disks around young stars. About 54 refereed papers and a dozen conference proceedings have been published by the Sackler Laboratory in 2003-2009 (see bi-annual report). One highlight is the formation of water on grains, highly relevant for the interpretation of Herschel-HIFI data. Laboratory studies by Ioppolo (PhD), Linnartz, van Dishoeck and co-workers confirmed that H_2O can be produced by H bombardment of O_2 ice at 15 K, a route proposed by Tielens 25 yr ago but never tested experimentally. The precise pathways have been quantified through modeling by Cuppen.

F2. Instrumentation program for 2010-2013, with forward look to 2020
This appendix provides an overview of NOVA's instrumentation program funded through Phase-3 of the top-research grant that runs from 1st January 2009 until 31 December 2013. Some projects already started in previous phases and others are expected to continue beyond 2013. Furthermore it describes the NOVA strategy for participation in the E-ELT instrumentation program with a forward look up to 2020.

Preparation of the Phase-3 program occurred in 2007. In May of that year NOVA received 15 proposals for instrumentation projects in response to a call for proposals that was issued to the entire astronomical community in the Netherlands. All proposals were presented to the community at an open national instrumentation day held on 4 July 2007. The proposals, together with their referee reports and response by the applicants on the referee reports, were reviewed by the Network Key Researchers (KRs) on their scientific merit and their justification within the national astronomy program. The KRs agreed on a motivated ranking of proposals. The proposals were also reviewed by the NOVA Instrument Steering Committee (ISC) on their technical feasibility, financial aspects, project management and risks. At their meeting the ISC was informed about the recommendations of the KRs including the rating on the scientific priorities of the proposals. The ISC provided the NOVA Board and Directorate with their findings on the issues they addressed. Final decisions were taken by the NOVA Board at their meeting in November 2007. In total 11 proposals were granted and an additional proposal was supported through the seed funding program (see Table C5 in Appendix C for overview, and description of the projects in the following sections). Five projects received approval for an early start in 2008. As in previous phases of the NOVA program, the focus is on providing instruments for the ESO facilities, including VLT, VLTI, ALMA and the planned E-ELT, in collaboration with international partners.

F2.1. Instrument Steering Committee
Progress on the NOVA instrument projects are reviewed twice a year by the Instrument Steering Committee (ISC) on behalf of the NOVA Board. The ISC addresses all aspects of the instrumentation projects, including overall quality, progress, achievement of milestones, use of manpower and financial resources, and project risks. It reports on these matters to the NOVA Board and Directorate and recommends actions where necessary. The ISC also reviews the need to release contingency funds when projects call on such a demand and recommends to the NOVA Board and Directorate on the release of such funds and/or on other measures to keep projects within their budgets. Requests for seed funding are reviewed by the ISC before the NOVA Board and Directorate decide whether they will be granted. The ISC also played a key role in reviewing the technical and managerial aspects of the instrument projects which constitute the present Phase-3 instrumentation program.

The ISC meets normally in September and March, about 3-4 weeks before the Board meetings. The ISC chair attends the Board meetings as an observer and reports orally on ISC matters. In addition, the Board receives a written report of the ISC meetings including its findings and recommendations. The composition of the ISC is listed in Appendix A1.

Each project PI provides the ISC with a written progress report to be submitted two weeks before the ISC meeting. The report has to address a number of pre-defined issues. At the request of the ISC chair a project PI will report orally at the ISC meeting and will be questioned by the ISC.

F2.3. NOVA Optical IR group and preparation for the E-ELT era

F2.3.1. NOVA Optical-IR instrumentation group
From the 1st January 2008 onwards NOVA took over the Optical-IR instrumentation group of ASTRON. This development occurred after the decision by ASTRON and NWO to concentrate future ASTRON activities on radio astronomy. The group consists of ten experienced people with expertise ranging from optical, mechanical, and cryogenic design, system engineering, CNC and optical production capabilities, instrument integration, and verification. Over the last decade this group carried out the optical-IR instrumentation projects for which NOVA had final responsibility towards ESO, ESA, and international partners.

Current arrangements between NOVA, ASTRON, and NWO concerning the Optical-IR instrumentation group are concluded in a contract that covers the period 2008-2011. In January 2010 the NOVA Board decided to seek an extension of the contract for a period of 5 to 7 years to ensure that NOVA has sufficient experienced staff to take on a leading role in an E-ELT instrumentation project. NOVA has final responsibility for the work program of the group and has financial liability and accountability, ASTRON hosts the group and the infrastructural facilities at their building in Dwingeloo, and NWO employs the staff. ASTRON also provides laboratory instruments, test facilities, and software packages for design and measurement.

On the longer term NOVA will move the Optical-IR instrumentation group to the campus of one of the universities that participates in NOVA. At the moment Utrecht is an attractive choice since co-location with both the university and SRON would allow for strategic collaboration in sensor technology and instrument development, and to share (investments in) expensive laboratory infrastructure and equipment. To allow for a move in 2015-2018 – at the time when the first work packages on an E-ELT instrument will be finished – NOVA intends to hire and appoint any new staff members of the Optical-IR group in the coming years through the universities with temporary arrangements for secondment of these people to the ASTRON location to efficiently integrate the existing and new staff of the Optical-IR group. The move of the group is necessary to further strengthen the interactions between the science and instrumentation programs of NOVA and the need to be much more closely connected to technical R&D needed for future instruments to push the frontiers of observational parameter space. Once the E-ELT is in existence, the telescope collecting area is fixed and therefore innovation must come from smart instrumentation.

In the near term, the Optical-IR group will undertake the work packages on SPHERE-Zimpol and Matisse which are of major Dutch astronomical interest and for which NOVA has contractual obligations towards ESO and international partners,. It is involved in the hardware part of four Phase-A studies on E-ELT instruments, and carries out some technical R&D for future instrumentation. From 2011 onwards the group is expected to take on the Phase-B work for one E-ELT instrument with ongoing R&D for a second E-ELT instrument. Head of the group is Navarro. ASTRON provides in-kind systems engineering support through Venema.

F2.3.2. E-ELT program and funding

NOVA leads the national efforts on the E-ELT participation. The projects are undertaken in collaboration with ASTRON, SRON, technical universities, TNO, and several industrial partners. The Netherlands currently participates in four Phase-A studies (out of the 8 studies selected by ESO) and will reduce the number of instruments in which it participates to one instrument with a leading role (with the aim to be the PI of the international consortium) and one other instrument in a partner role. The down-selection is likely to occur in 2010-2011 when ESO decides on the go ahead for the E-ELT and its first generation instrument suite.

In November 2008 the Ministry of OCW and NWO allocated a grant of 18.8 M€ to NOVA and its national partners for work on E-ELT instrumentation projects. The (instrumentation for the) E-ELT was one of the five projects that got national funding out of eight ESFRI projects that were identified as Dutch priorities by the national roadmap committee for large scale research facilities. The grant includes 8.8 M€ for conceptual and preliminary design studies, Phase A and B, and technology development, and 10 M€ for participation in the final design and construction of one instrument. The latter part is conditional to ESO's decision to approve the construction of the E-ELT and to select instruments in which NOVA has a partnership. Payment is spread over the period 2009-2018.

For the period 2010-2013 the budget allocation for the Optical-IR group amounts to ~10 M€. The expenditures include staff costs for the Optical-IR group that will grow from 10 fte in 2010 to 14 fte in 2013 (assuming approval of the E-ELT by ESO Council and Dutch PI role in one instrument consortium). In addition, it contains staff costs for ~4.5 fte in 2013 to support the PI of the E-ELT project, industrial involvement, and travel and material costs. NOVA will cover 3 M€ of these costs from its current budget for Phase-3, the ESFRI grant will pay for 4 M€, and the remaining 2 M€ still has to be earned.

F2.4. Second generation instruments for the VLT and VLTI

The Netherlands, through NOVA and the university astronomical institutes, contribute to three second generation instruments: MUSE and SPHERE for the VLT, and Matisse for the VLTI. The work on MUSE is executed at Leiden Observatory, and the work on the other two projects is done at the Optical-IR instrumentation group.

F2.4.1. MUSE and ASSIST

MUSE, the Multi Unit Spectroscopic Explorer, is a second-generation panoramic integral-field spectrograph for the VLT, developed by an F-NL-D-CH consortium led by CRAL at Lyon and expected to begin operations in 2012. The instrument consists of 24 combined identical integral-field spectrograph units, covering simultaneously the spectral range 480 - 930 nm. MUSE will have two modes of operation, both of which are explicitly designed to exploit a complex multi-laser guide star (LGS) Adaptive Optics (AO) system, called GALACSI (Ground Atmospheric Layer Adaptive Corrector for Spectroscopic Imaging). GALACSI is envisioned as part of the approved VLT AO Facility (AOF), at the heart of which is the development of a Deformable Secondary Mirror (DSM) for the VLT. An important element to ESO's DSM development (and therefore also to MUSE) is ASSIST: Adaptive Secondary Setup and Instrument STimulator. ASSIST has been developed and will be assembled at Leiden Observatory under NOVA responsibility. This facility will act as the primary test-bench for ESO's DSM development, used for verifying control algorithms and hardware, functional validation of AO-Facility instruments (GALACSI and GRAAL), and ensuring the DSM operates at specification before being deployed at the VLT. The core of ASSIST is a support infrastructure to integrate the DSM in a compact and stable test setup. A Nasmyth rotator simulator will be provided for attaching the two AO systems, while ASSIST will be fed by a star simulator and turbulence generator for realistic performance measurements of both the DSM as well as the AO system under test. An on-axis high-speed interferometer will be used for additional testing of the functional operation of the DSM. ASSIST will be delivered to ESO in mid-2011 and integrated with the DSM, for testing, as soon as the DSM has been delivered, which is currently expected by end-2011.

F2.4.1.1. International partners and collaborations

The MUSE consortium (PI Bacon, CRAL) consists of 7 core institutes: Astrophysikalisches Institut Potsdam (AIP); Centre de Recherche Astronomique de Lyon (CRAL); ESO; Leiden Observatory (through NOVA); Eidgenössische Technische Hochschule (ETH), Zürich; Laboratoire d'Astrophysique Observatoire Midi-Pyrénées (LAOMP), Toulouse; and the University of Göttingen.

F2.4.1.2. Science case

The primary mode of MUSE has a wide (1 x 1 arcmin) field of view, which will be used for conducting uniquely sensitive deep-field surveys, with the key goal of understanding the progenitor population of present-day 'normal' galaxies. Through a series of nested surveys of different area and depth, MUSE will detect Lyman-alpha emission from large numbers of proto-galaxies up to redshift z ~ 6. The deepest exposures will reveal emission from the gas around galaxies, enabling the study of gas flowing into and out of galaxies. At low redshifts MUSE will allow detailed two-dimensional mapping of the kinematics and stellar populations of a variety of galaxies. The second mode of MUSE aims to provide the unique capability of near-diffraction limited spatial resolution at optical wavelengths over a large 7.5 x 7.5 arcsec field. This will be used for a variety of science goals, including monitoring solar system bodies, studying the complex emission regions of Active Galactic Nuclei (AGN), and studying young stellar objects.

Implicit in the MUSE project is the development of new enabling technologies that will have an impact on future extremely large telescope facilities. The modular structure of the instrument provides a model for future research-industry partnerships. The integrated role of a multi-laser adaptive optics facility, which will certainly be part of future instrument developments, highlights the challenges in designing, building and managing such complex systems. The development of the DSM itself presents significant challenges both in manufacturing and, more importantly, in system control.

F2.4.1.3. Impact/context NL situation

NOVA's involvement in the MUSE instrument is many-fold, distributed across three inter-related areas of the MUSE project:

1. The MUSE spectrograph scientific impact: participating in the MUSE science team and Guaranteed Time Observation (GTO) allocation, and providing key operations-based deliverables.
2. The Interface Control Document: controls all aspects of interfacing MUSE with the GALACSI AO system and VLT AO Facility. This also involves the development of tools required for optimal use of the AO system for scientific use.
3. The ASSIST test-bench: facility for testing and integrating the ESO DSM and AO-Facility instruments.

The NOVA participation in items 1 and 2 is provided through Franx, Schaye, and Stuik with support of Serre who is appointed as technical postdoc on the MUSE project. He is responsible for the development of the operation and calibration plan for MUSE, its exposure time calculator, and he will also participate in the development of the Point Spread Function (PSF) reconstruction and the interface between MUSE and GALACSI. The NOVA funding for the MUSE project amounts to k€ 453, of which the 5 yr postdoc position for Serre is a major part. In-kind staff effort of NOVA astronomers (~5 staff years over 2002-2012) is additional.

F2.4.1.4. Technical concept and requirements for ASSIST

ASSIST is an on-going NOVA commitment to ESO started in Phase-2. The project is part of the Adaptive Optics Facility program at ESO aiming at upgrading the 4th unit (UT4) of the VLT into an adaptive telescope. It will include a new 2nd generation M2-unit hosting a Deformable Secondary Mirror, two AO modules feeding the instruments Hawk-I and MUSE (called GRAAL and GALACSI respectively) and four Launch Telescopes mounted on the telescope center piece providing four laser beams for the wavefront sensing by the AO modules. In order to test the whole system in Europe, NOVA designed (2007-2009) and will manufacture and test (2010-2011) the ASSIST Test Bench to provide mechanical and optical interfaces to the DSM and the AO modules GRAAL and GALACSI. A source module will feed this optical setup and provide turbulence altered images of the natural and artificial (LGS) star sources. This will allow a full testing and characterization of the AO modules and DSM in Europe before delivery to Paranal.

The project is led by Stuik. Kenworthy took on the role as 'scientific friend of the project' from early 2010 onwards when he arrived in the Netherlands. Total cost of the project amounts to k€ 1944 (2004-2011) including work by Stuik on the early definition of the MUSE project and definition of the interface between instrument and telescope and specification of the required conceptual tests. The funding is made available by NOVA (k€ 1348), Leiden Observatory (k€ 165 plus test equipment and infrastructure), ESO (k€ 100 plus additional hardware) and the EU funded OPTICON network (k€ 331).

F2.4.2. SPHERE-ZIMPOL

SPHERE (Spectro-Polarimetric Exoplanet Research) is one of the four second-generation VLT instruments under development. The SPHERE instrument consists of an extreme Adaptive Optics system and three science arms: ZIMPOL, the imaging polarimeter; IRDIS, the near-IR imaging and slit spectrograph; and IFS, the near-IR integral-field unit. SPHERE will push the capabilities of the VLT to its limits, and the survey nature of its routine observations differs from that of other VLT common user instruments. In order to make full use of the potential of SPHERE, intimate knowledge of calibration and data-reduction techniques will be required.

PI of the international SPHERE consortium is Beuzit (LAOG, Grenoble), and the project manager is Puget. The Dutch contribution focuses on ZIMPOL, the Zürich Imaging Polarimeter. This science arm is designed and constructed in close collaboration with the group at ETH Zurich, and led by Schmid. The Dutch effort is led by Waters (also member of the international SPHERE executive board), and the national project manager is Pragt (NOVA Optical-IR group).

F2.4.2.1. International partners

The SPHERE Consortium consists of 12 members from institutes located in France, Italy, Swiss, Germany and the Netherlands. In addition ESO contributes to the project including provision of hardware components. The Consortium partners are Institut National des Sciences de l'Univers du Centre National de la Recherche Scientifique (INSU/CNRS), acting on behalf of its laboratories: Laboratoire d'Astrophysique de Grenoble (LAOG), Laboratoire d'Astrophysique de Marseille (LAM), Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique, Observatoire de Paris (LESIA), Laboratoire Universitaire d'Astrophysique de Nice (LUAN); Max Planck Institute for Astronomy (MPIA); Istituto Nazionale di Astrofisica (INAF), with activity coordinated by the Osservatorio Astronomico di Padova; Eidgenössische Technische

Hochschule Zürich (ETH); Observatoire de Genève (OG); NOVA, representing the involvement of the University of Amsterdam, Utrecht University and its Optical-IR group; Office National d'Etudes et de Recherches Aérospatiales (ONERA).

F2.4.2.2. Science case

The search for exo-planets has developed into one of the main goals of astronomy. Most of the 400 exo-planets discovered to date have been found using indirect detection methods which provide little information on the planet itself, apart from its mass or size, and some orbital parameters. In addition, these methods have generally little sensitivity to exoplanets that are in orbits as wide as those of the giant planets in our own Solar System. To get information on a planet's physical parameters, such as temperature and pressure, chemical composition and atmospheric structure, which provide key information on planet formation and evolution, direct detection of radiation from the planet is required. This method also enables the detection and study of planets in systems like our own Solar System. It thus covers a parameter space that is complementary to that of the radial velocity method, and is important in view of searches for terrestrial-type exoplanets.

SPHERE aims at the direct detection and characterization of Extra-solar Giant Planets (EGPs). The instrument is based on two detection strategies: one is optimized to detect the polarized, reflected light of old, cold EGPs, and the other is optimized to detect the thermal radiation of young, hot EGPs.

Almost all young, low-mass stars appear to have an accretion disk through which matter flows towards the central star. After the accretion stops, a disk of gas and dust remains, that slowly dissipates. There is growing evidence that these disks are the sites of ongoing planet formation. Imaging and imaging polarimetry of proto-planetary disks reveals important information about its structure and of the composition of the dust in the disk surface layers. Both are strongly affected by the process of planet formation. SPHERE has the capability to image the disks to a distance of 0.1 arcsec from the star, which is much better than current instrumentation is able to provide. SPHERE on the VLT will be a very sensitive instrument to detect and image exo-zodiacal emission in nearby stars, as well as standard debris disks in stars further away from the Sun.

The GTO exoplanet program will focus on establishing the frequency of gas giant exoplanets as a function of stellar mass and age. Other topics will be proto-planetary disks and evolved stars. The Consortium will spend ~200 GTO nights on exoplanet searches using the near-IR arms of SPHERE (IRDIS and IFS), 20-25 nights on exoplanet searches using ZIMPOL and ~20 nights on studies of proto-planetary disks.

F2.4.2.3. Impact/context NL situation

In the Netherlands Waters (UvA) is the national PI, and Pragt (Optical-IR group) is the national project manager. The optical design work is done by Rigal and the mechanical design and thermal analyses by Roelfsema, both Optical-IR group. The national science team consists of Waters, de Koter, Dominik, Hovenier, Jeffers, Keller, Min, Snellen, Stam, and Tolstoy.

Together with the Swiss the Netherlands will design and build the imaging polarimeter arm of SPHERE named ZIMPOL. SPHERE passed successfully its Final Design Review conducted by ESO in December 2008. Procurement and manufacturing of hardware components for SPHERE-Zimpol was in full swing in 2009 with integration starting in the fall. Delivery of the NL hardware components to LAOG is scheduled for September 2010. Commissioning of the full SPHERE instrument at the VLT is planned for March 2012.

Total costs of the Dutch contribution to the projects amount to k€ 1730, with the following contributions: NOVA (k€ 1030), UvA (k€ 200), NWO-M grant (k€ 400 k€) and in-kind support of

ASTRON (100 k€). In-kind staff effort of NOVA astronomers (~3 staff years over 2004-2011) is additional.

F2.4.3. MATISSE

MATISSE (Multi AperTure Mid-Infrared SpectroScope Experiment) is one of the three second generation instruments for ESO's Very Large Telescope Interferometer (VLTI). It is designed to become the ultimate mid-IR instrument that can be operated at the VLTI and the first instrument to use the full power of the four-telescope VLTI. It represents a major technical and scientific advance over the current instruments, MIDI and AMBER. Its spatial resolution will be 3 milliarcsec, the size of a Euro coin at a distance of 1000 km. Dutch astronomers at Leiden, Amsterdam, Groningen and Nijmegen will use MATISSE to study at this resolution dust and gas structures of Active Galactic Nuclei (AGNs), planet-forming regions around stars, and dust shells around young and old stars. Direct emission from extrasolar planets may also be detected. The instrument had its preliminary design review conducted by ESO in November 2009 that resulted in several action items including more detailed specifications of the instrument performance and further evaluations of the instrument– telescope interface requirements. The instrument will become available for astronomical observations in 2014.

F2.4.3.1. International partners

MATISSE is an international collaboration of various institutes in France, Germany and the Netherlands. The international project PI is Lopez (Observatoire de la Côte d'Azur, Nice, France), and the project manager is Antonelli. Other consortium partners are MPIA at Heidelberg, MPIfR at Bonn, NOVA, and Kiel University.

F2.4.3.2. Science case

MATISSE will address new questions due to its capability to allow detailed imaging in multiple bands at mid-IR wavelengths. The mid-IR is particularly suited to studies of dust and molecules in disks and winds surrounding stars, including protostars and AGNs because the temperatures of these regions are typically ~200-1000 K, where emission peaks in the mid-IR. These materials have characteristic absorption and emission lines in the mid-IR: cool H_2 at 9, 12 and 17 µm, HII as Brackett alpha at 4.05 µm (plus many lines of the higher series) and lines of other ionized species such as [Ne II], [Ar III], [SIV], [SIII] [FeIII], CO gas and ice at ~4.7 µm, PAHs at 3.3, 8.6, 11.3 µm, and many dust minerals, like (crystalline) silicates and SiC in the N-band. Two science cases of MATISSE have particular interest from astronomers in the Netherlands:

Protoplanetary disks: Circumstellar disks evolve from a gas-dominated state (mainly traced by millimeter interferometers), to so-called 'debris disks' with large solid bodies, where a minor amount of small dust grains is produced by collisions of larger bodies, such as planetesimals. Proto-planetary disks have now been imaged from the optical/near-IR to the millimeter wavelength range around low-mass young stars (T Tauri stars), intermediate-mass young stars (Herbig Ae/Be stars), and possibly around massive young stars. The innermost several AU of disks, where planet formation is expected to occur, can only be marginally investigated so far with single telescopes and the limited VLTI facilities MIDI or AMBER. This will remain the case until ALMA will be in operation with its longest baselines (~2013), and high resolution mid-IR images become available with MATISSE (~2014). With the 10-20 milliarcsecond spatial resolution achievable with VLTI in the 8-13 µm atmospheric window, MATISSE will be the ideal instrument to study the inner 10-20 AU of disks, where mid-infrared continuum radiation of hot dust is the dominant emission.

Formation of High-Mass stars: for several reasons, progress in the understanding of high-mass star formation has lagged behind that of low-mass stars. Young high-mass stars are relatively rare in our Galaxy and tend to be more distant, well beyond 1 kpc, while many low-mass YSOs are found at 100-300 pc. Furthermore, massive stars predominantly form in very opaque and highly-clustered environments and their pre-main-sequence phases are deeply embedded within the accreting envelope. The early phases of massive star formation are hidden to current optical and near-infrared cameras because of the high extinction. Observations in the mid-infrared are far more suitable, since the optical depth drops strongly toward longer wavelengths, while emitted energy increases strongly in the mid-IR. Thus high-resolution interferometric mid-IR observations are best suited to investigate massive star formation.

F2.4.3.3. Impact/context NL situation
The Netherlands will provide the Cold Optical Bench (COB) for MATISSE, building on the expertise gained on the contribution to MIDI. The design and fabrication will be done by the Optical-IR instrumentation group. The national project PI is Jaffe. The required total staff effort to design, build and test the COB is of order 20 staff years. Project costs for the Netherlands are M€ 2.5 with contributions from NOVA (M€ ~2.1, mainly staff effort) and NWO (k€ 450). In addition international partners and ESO will contribute ~k€ 800 to the hardware costs of the COB.

F2.5. Phase A studies on instrumentation for the E-ELT
In 2008 NOVA signed up to participate in four Phase-A studies for instrument concepts for the E-ELT. All these studies are done in collaboration with partners in Europe. The typical lead time for each of the studies is 15-20 months. The studies on METIS and MICADO were completed in autumn 2009 and reviewed in November and December, respectively, by expert teams set up by ESO. Both studies received very good review reports. The Phase-A studies on EPICS and OPTIMOS-EVE will be completed in early 2010. NOVA expenditures on these studies (mainly staff effort) amounted to ~1 M€ each for METIS and Optimos-EVE, and ~0.5 M€ for MICADO and EPICS. These costs are part of the figures given in § F2.3.2.

Below is a brief description of each of the instrument concepts.

F2.5.1. METIS – mid-IR imager and spectrograph
METIS, the Mid-infrared ELT Imager and Spectrograph, covers the mid-IR L, M, and N bands (from 3 μm to 14 μm), a wider coverage may be considered, depending on the transparency of the atmosphere at the chosen E-ELT location. It will provide high angular resolution imaging (6.5 times higher than the JWST), coronography, and medium resolution (R~3,000) long slit

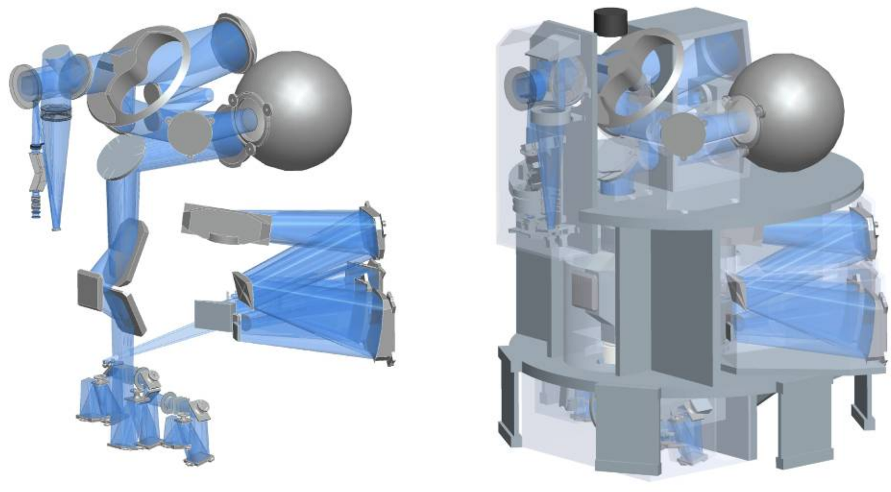


***Figure F.2**: Outline of the optical system inside the METIS cryostat. Left: the telescope beam enters at the top left. The common fore-optics, including the chopper and derotator, is the central, vertical structure. The imager is at the bottom and the IFU spectrograph to the center right. The big sphere is part of the calibration unit. Right: the same optical system, now integrated within the backbone structure.*

and high resolution (R~100,000) IFU spectroscopy, with a sensitivity comparable to that of JWST-MIRI at the same spectral resolution. It is ideally suited to study a wide range of scientific topics, especially in regions with large obscuration. The key science drivers are (1) proto-planetary disks and the formation of planets, (2) physical and chemical properties of exoplanets, (3) formation history of the solar system, (4) growth of super-massive black holes, and (5) morphologies and stellar dynamics of high-z galaxies. Additional areas in which METIS promises breakthrough discoveries are: the Martian atmosphere, properties of low mass brown dwarfs, the formation of massive stars, the Galactic center, evolved stars and their circumstellar environments, IMF and disk survival studies in starburst clusters, and high-z Gamma-Ray Bursts as cosmological probes. Altogether, METIS on the E-ELT will provide an excellent synergy with JWST-MIRI and ALMA.

The METIS consortium is an international team, which consists of the international PI Brandl, project manager Molster and project engineer Venema, all in the Netherlands. The consortium partners are MPIA (co-I and instrument scientist Lenzen), CEA Saclay (Co-I Pantin), KU Leuven (Co-I Blommaert) and UK-ATC (co-I Glasse). The consortium has vast experience in infrared instrumentation from projects like IRAS, ISO-SWS, TIMMI2, VISIR, Spitzer-IRS, NAOS/CONICA, MICHELLE, HERSCHEL-PACS & HIFI, MIDI and JWST-MIRI. The METIS technical team in the Netherlands consists of staff of the Optical-IR group and instrumentalists at Leiden Observatory.

NOVA's future contributions to METIS will include the design and construction of the IFU spectrometers and the fore optics, provision of the international PI (Brandl) supported by dedicated staff, and final instrument integration and testing (see also § F2.3.2 in this appendix).

F2.5.2. MICADO – wide field imager

MICADO is a near-infrared (1-2.5 μm) imager for the E-ELT. It samples the focal plane at 2-4 milli-arcsecond resolution and so is suitable for diffraction-limited imaging. It will cover a field of at least 30 arcsec. The science case includes diverse topics including the environment of the central black hole in our own Galaxy, resolved stellar populations in Local Group galaxies and beyond, and high-redshift galaxies. It takes advantage of the combination of high spatial resolution with great sensitivity of the E-ELT. MICADO is a potential first-light instrument.

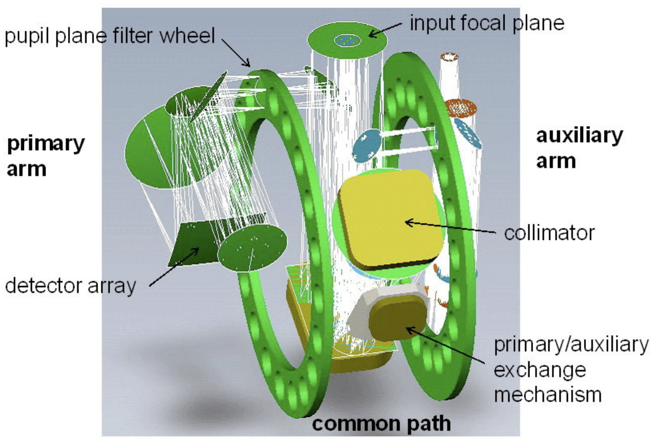


***Figure F.3**: Open design of MICADO with the optical paths in white.*

Dutch interest centers on the study of galaxy formation using the spatial resolving power and sensitivity of MICADO. This includes (i) the imaging of very distant galaxies, which are very faint and small, and whose light is redshifted to the infrared wavelengths; (ii) studying the resolved stellar populations of nearby galaxies, affording a detailed view of the star formation history that cannot be attained from integrated light spectra; and (iii) measuring the internal kinematics of stars in Local Group galaxies in order to derive the orbit structure and hence the dark matter content of these galaxies.

MICADO is a German-Italian-Dutch consortium led by Genzel (MPE) with involvement from USM, MPIA, INAF-Padua, and NOVA. Kuijken (NOVA, Leiden) is the Dutch PI and co-I in the international consortium. In the Phase-A study the main Dutch involvement centers on design work, particularly mechanical and cryogenic, and on design of the data flow software. It builds on expertise developed for the Sinfoni 2K camera and the near-IR arm for X-Shooter (both on the VLT) and for the data-flow and -reduction software for OmegaCAM (on the VST).

NOVA's future contributions to MICADO will include the design of mechanical and cryogenic components, and design and implementation of the data flow software (see also § F2.3.2 in this appendix).

F2.5.3. EPICS – exoplanet finder

EPICS will directly image and characterize exoplanets at visible and near-infrared wavelengths by combining extreme adaptive optics with coronagraphic imaging, imaging spectroscopy and polarimetry. It will characterize extrasolar gas giants that have been discovered by indirect methods, detect and characterize mature cold gas giants like Jupiter at orbital distances between ~5 and 15 AU in the solar neighborhood (< ~20 pc), young gas giants in star forming regions, and Neptune-like planets as well as massive rocky planets (super-Earths) around nearby stars (< ~10 pc). The ultimate goal of EPICS is to detect and characterize exoplanets with liquid water in the habitable zones of stars. Polarimetry can characterize exoplanets in much more detail than any other technique.

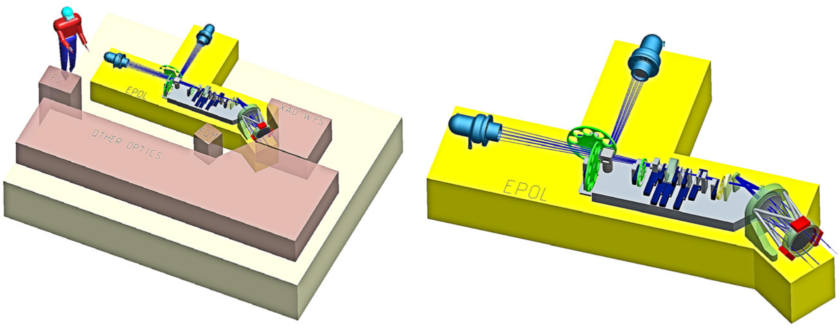


***Figure F.4**: EPOL design as of December 2009. The figure on the left shows the overall EPICS instrument, and the figure on the right shows EPOL itself with the light from the telescope coming from the lower right, passing the 2-mirror coronagraph, the polarimetry components, and finally a polarizing cube beamsplitter and two cameras to simultaneously measure two orthogonal polarization states.*

The EPICS Phase-A started in 2007 and includes setting technical specifications for the telescope design and feedback to the science working group conducting the E-ELT Design Reference Missions. NOVA (co-PI Keller) and ETH Zurich (co-PI Schmid) are responsible for the investigation and conceptual design study of an imaging polarimeter, EPOL (EPICS POLarimeter), one of the two focal plane instruments fed by the common extreme adaptive optics system. Work packages carried out in the Netherlands include contributions to the science case (Keller, Snik, Waters and Stam), system engineering (Venema) and instrument design (Optical-IR instrumentation group).

EPOL will search for faint point-like polarization flux features on top of a much stronger, unpolarized halo due the central star. The polarimetric sensitivity of EPOL of 10^{-5} combined with the extreme adaptive optics and the coronagraph will provide contrast ratios of 10^{-9} and beyond. To achieve this contrast EPOL observations have to be carried out in such a way that systematic effects due to the telescope and adaptive optics can be compensated (subtracted) with differential techniques. These extremely sensitive polarization measurements are therefore accomplished with a cascade of differential techniques. Furthermore, the detected polarization signals must be calibrated absolutely in polarized intensity and direction on the sky, which requires additional instrument and telescope calibration procedures.

The Phase-A study for EPICS is carried out in an international consortium consisting of ESO (international PI M. Kasper) and institutions from six European countries: the Netherlands (NOVA), Germany (MPIA), France (LESIA, LAOG, LAM), the United Kingdom (Oxford), Italy (Padova), and Switzerland (ETH). NOVA and ETH together are responsible for the polarimetry part of the instrument. Keller (NOVA, Utrecht) is the Dutch PI and co-I in the international consortium. The EPICS team greatly benefits from its experience with SPHERE, the precursor instrument for the VLT that is currently being built by many of the EPICS consortia members.

NOVA's future contributions to EPICS will include further technical R&D, and may in a few years time include the design and construction of the imaging polarimeter (see also § F2.3.2 in this appendix).

F2.5.4. OPTIMOS-EVE - Optical to infrared multi-object spectrograph
OPTIMOS-EVE is an optical to near-IR (310-1800 nm) spectrograph for the E-ELT at medium spectral resolutions of R=5000, 15,000 and 30,000 with high multiplexing capabilities of 240 fully-deployable single objects fibers (0.9" diameter), 30 medium sized deployable IFU units (1.8"x3.0", 52 fibers each) and one large fixed IFU (13.5"x7.8", 1560 fibers). It reaches an instrument efficiency of 45% and works in natural seeing or with ground-layer adaptive optics. The field of view is 7'x7' (10'x10' with some vignetting). OPTIMOS-EVE will be the one-stop solution for all optical-near-infrared spectroscopy on the E-ELT with capabilities that are not provided by JWST. The science case includes three key drivers for the E-ELT: (i) the resolved stellar populations in the Local Universe, (ii) the formation of the earliest galaxies and the end of the epoch of reionization and (iii) the possibility to detect extra*galactic* planets. In addition, the science team (with NL members Groot, Kaper, Koopmans, Stam, and Tolstoy) has prepared science cases on galactic haloes at high redshift, lensed galaxies, IGM tomography, redshift surveys, transients, star formation, gaseous exoplanets, and trans-Neptunian objects, testament to the versatile nature of OPTIMOS-EVE. It is expected to be a workhorse instrument on the E-ELT and can be used to exploit the scientific potential of the E-ELT directly from the start.

The OPTIMOS-EVE Phase A has been concluded at the end of February 2010 (review in late March 2010). The instrument has been designed to comply with the top-level requirements as derived from the science case. The consortium consists of three main partners: the Netherlands (NOVA, PI Kaper), France (GEPI, PI Hammer) and the UK (RAL, PI Dalton), with substantial and crucial contributions from Denmark (Copenhagen) and Italy (INAF-Brera and INAF-Trieste). The consortium is based on the successful VLT X-Shooter and FLAMES instrument projects with the addition of the UK-RAL group and their strong experience in fiber positioners and detectors. During the Phase-A study, the Netherlands was responsible for overall project management and the spectrometer design. OPTIMOS-EVE is planned for a start in 2018, coincident with the start of the E-ELT itself.

NOVA's future contributions to OPTIMOS-EVE will include the design and construction of the spectrometer, provision of one of the three international project PI's (Kaper), and overall management of the international consortium (see also § F3.2 in this appendix).

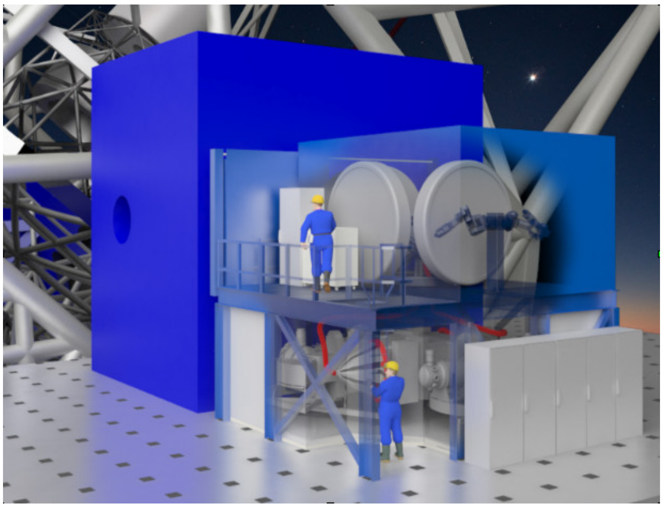


***Figure F.5**: Artist impression of the multi-object optical to near-infrared spectrograph OPTIMOS-EVE at one of the focal stations of the E-ELT.*

F2.6. Atacama Large Millimeter/Submillimeter Array (ALMA)

ALMA will revolutionize astronomy at (sub)millimeter wavelengths and will have a major impact on many areas of astronomical research. On the hardware side NOVA is responsible for the delivery of the high-frequency ALMA Band-9 receivers (see § F1.3 of the Appendix). To maximize the science return from ALMA, a node of the European ALMA Regional Center has been established in the Netherlands: ALLEGRO (ALMA Local Expertise GROup). When ALMA becomes fully operational, ALLEGRO will offer general face-to-face user support for novice users, and expert support in the areas of high-frequency observing, imaging of wide fields and with high dynamic range, and the use of advanced science analysis tools. The NOVA-funded start-up activities of ALLEGRO aim to consolidate the necessary expertise, to participate in the commissioning of ALMA, and to provide user-support during the early science phase of 2011–2013 when ALMA will still be rapidly developing and the frontier of (sub)millimeter astronomy is quickly expanding. Parallel to the ALLEGRO efforts, an instrumentation R&D program will develop state-of-the-art receiver technology for future ALMA upgrades. Some of this technology can be field-tested and used for astronomy at the APEX telescope. In 2009 the ALMA project underwent a 'phase transition' with the first (provisional) acceptance of antennas by the project, the transportation of the first 3 antennas from the Operations Support Facility (OSF) to the Array Operations Site (AOS), and the establishment of three-element interferometry by late 2009.

F2.6.1. International partners and collaborations

ALMA is constructed jointly by Europe, North America, and East Asia. The ALMA Regional Centers (ARCs) form the interface between the ALMA project and its users in each of the three continents. In Europe the ARC consists of a core at ESO and a network of seven nodes. ALLEGRO is one of the nodes, in addition to Manchester, Onsala, Bonn/Cologne/Bochum, Grenoble, Bologna and Czech Republic. Each of the nodes is responsible for general face-to-face user support for the community and specialist help in a number of well defined expertise areas. The ALMA technical R&D efforts are carried out in collaboration with partners in France (IRAM, LERMA), Germany (MPIfR in Bonn, KOSMA), Spain (Centro Astronómico de Yebes), Sweden (OSO, Chalmers), and the USA (Caltech, NRAO). Part of the development work will be closely connected to EU FP7 funded activities within RadioNet.

F2.6.2. Science case and prospects
ALMA is scheduled to start full operation in 2013, but in 2011 early science observations will commence with 16 of the ultimate 66 antennas. This will allow Dutch astronomers to start addressing a number of the questions that ALMA can answer. These include:

- The first stages of star formation: how does star formation commence, and how are the circumstellar disks formed around growing stars from which planets later condense?
- Transitional disks: originally, circumstellar disks around young stars are rich in gas and fine dust. How do they evolve toward planetary systems? How is the gas and dust cleared out? How do newly formed planets create wakes in the disks?
- The Initial Mass Function (IMF) of stars: does the distribution of stellar masses across the Milky Way find its origin in the substructure inside cluster-forming interstellar clouds?
- Star forming galaxies: earlier in the Universe's history, galaxies formed stars at a rate as much as 100 times that seen today in the Milky Way. How do the dynamics of the gas inside these galaxies compare to local regions of active star formation?
- Local Ultra-Luminous InfraRed Galaxies: What are the properties of the dense and warm gas inside nearby ULIRGs? How are these related to their enormous energy output?
- Ionized carbon and CO in high-redshift galaxies: ALMA can uniquely detect and image the emission of gas in high-redshift galaxies. What will the kinematics of the gas in these primitive environments tell us about their dynamics and masses?
- Comets: ALMA can probe the gas composition of a wide range of comets passing by the Earth. What does their diversity and (in)homogeneity tell us about the conditions early in the history of the Solar System?

Astronomers in the Netherlands are active in all of these areas. There is strong synergy between ALMA and other instruments with significant Dutch involvement like the VLT, Herschel, JWST, and E-ELT.

In the ALMA early science phase, Dutch astronomers start to investigate these questions. Even when ALMA has reached its full size however, further development of submillimeter receivers is required to fully explore these topics. The NOVA technical R&D program for ALMA aims at developing mixers with increased sensitivity and suppressing noise from the atmosphere, in particular at the highest ALMA frequencies.

F2.6.3. Impact/context NL situation
ALLEGRO is coordinated by Hogerheijde and supervised by a steering committee consisting of Barthel, Oosterloo, van Langevelde, van Dishoeck, Roelfsema, and Tilanus. The technical R&D activities are coordinated by Spaans and supervised by a steering committee consisting of Baryshev, Boland, Helmich and Hogerheijde. The main benefits of the ALLEGRO and ALMA technical R&D activities for Dutch astronomy include (i) face-to-face user support by ALLEGRO for novice and expert users, based at Leiden Observatory; (ii) world-leading expertise at ALLEGRO on a number of observational applications that serve the needs of Dutch astronomers, such as observing at the Band-9 frequencies (602–720 GHz) where ALMA is pushed to its ultimate performance; (iii) support by ALLEGRO for Dutch astronomers during the critical early science phase when ALMA generates its first data but little is known about the instrumental properties and pipeline software tools are not yet available; (iv) continuation of the leading position in submillimeter receiver design by the ALMA technical R&D program with significant improvements of submillimeter receiver sensitivities for ALMA.

Funding for ALLEGRO from NOVA amounts to k€ 717 over the period 2005-2012. In addition NWO Physical Sciences agreed in 2009 to provide structural support ramping up from funding of 1 fte in 2009 to 5 fte from 2012 onwards, subject to periodic review.

The NOVA budget available for ALMA technical R&D is k€ 911 over the period 2004-2013 including an EU contribution of k€ 89. In addition SRON provides in-kind staff support and laboratory facilities and test equipment.

F2.6.4. Technical concept and requirements

ALLEGRO is part of the European ALMA Regional Center and as such is part of the ALMA project. It will develop observing and calibration strategies for the ALMA Band-9 receiver and deliver these to the international ALMA project. ALLEGRO will also participate in the on-site commissioning of ALMA, with a focus on Band-9 (commissioning postdoc). Finally, ALLEGRO will facilitate access to science-analysis tools developed by the community, but which are currently not intuitive to use and which are difficult to interface with each other and with ALMA data.

The ALMA R&D project will develop innovative technology for a 2nd generation ALMA receiver to significantly improve the sensitivity and therefore the observing efficiency for the two highest frequency atmospheric windows (Band-9 and Band-10). It is planned to demonstrate the new findings on APEX. Emphasis will be on the development of 'sideband-separating' mixers which are capable of suppressing the (unwanted) noise from one of the observational sidebands. For comparison, a 10% improvement in sensitivity can be regarded equivalent to adding five antennas to the ALMA array. Another potential improvement is the development of new SIS junction technology in collaboration with TU Delft using a different tunnel-barrier material. The project aims to demonstrate the improved performance of a sideband separating (2SB) mixer design in a receiver cartridge, and at the telescope, before the end of 2012. This is in line with the current thinking within the ALMA project, which is starting to explore possible future development needs and upgrade paths during the operations phase beyond 2012. Also, the 2SB mixers are the baseline technology for ALMA band 3-8 receivers already, allowing a potential upgrade of band-9 to the 2SB scheme without system wide modifications.

F2.7. Participation in space missions

F2.7.1. JWST-MIRI

With the main hardware delivered (see § F1.4 of the Appendix), the Dutch emphasis shifted to analysis of ground-testing and calibration data, development of data-reduction software, and preparation of in-flight calibration and commissioning plans. Planning of the MIRI guaranteed time program has started, with Dutch scientists having leading roles in the protostars, circumstellar disks, exo-planets and high-redshift galaxies themes.

F.2.7.1.1. Scientific interest in the Netherlands

Owing to the successes of IRAS and ISO, and more recently the Spitzer Space Telescope and VLT-VISIR, there is widespread interest and expertise in mid-infrared observations within the Dutch astronomical community, both in imaging and spectroscopy. This ranges from studies of cosmology and high-redshift galaxies (Franx, Röttgering, Miley, Spaans), active galactic nuclei (Barthel, Jaffe), starbursts (van der Werf, Brandl) and nearby galaxies (Israel) to observations of late-type stars (Tielens, Waters), the formation of massive (Kaper, de Koter, van der Tak, van Langevelde) and low-mass (Hogerheijde, van Dishoeck) young stars in our own Galaxy as well as the proto-planetary disks surrounding them (Waters, van Dishoeck, Dominik, Kamp, Lahuis) to icy Solar System objects (Hogerheijde) and exoplanetary atmospheres (Waters, Snellen). The project is led by van Dishoeck and Brandl, who, together with Kamp, Waters and van der Werf, are members of the European MIRI science team which defines the guaranteed time program.

MIRI will make key contributions to science themes ranging from ‘first light' in the Universe to the assembly of galaxies, the birth of stars and proto-planetary disks, and the evolution of exoplanetary systems and the organic material contained within them. Specific projects of interest to Dutch astronomers include: (1) The distant Universe: MIRI will be critical to identify the youngest objects in the Universe, including the first sources of light after recombination, and distinguish them from objects that have a longer history of star formation. (2) Obscured star formation and AGNs: MIRI is essential to observe the luminosity as well as diagnostic PAH features and fine-structure lines from starburst galaxies and obscured AGNs. Extreme starbursts in high redshift galaxies may be responsible for much of the stellar populations of present-day galaxies. Milder bursts may occur later in the evolution as a result of mergers, perhaps leading to the formation of AGNs. During these episodes, galaxies evolve rapidly in stellar and gas content, in spectro-photometric properties, in metallicity, in luminosity, and often also in morphology. Such starbursts are totally dust-enshrouded and emit most their energy in the mid-infrared, making MIRI key to their study. MIRI will also detect the important rest-frame 2μm region (at z>2), which is dominated by an evolved stellar population with mean age >50-100 Myr that cannot be isolated at shorter wavelengths, but which would trace previous episodes of star formation. (3) Deeply-embedded protostars: MIRI, in combination with ALMA, will be particularly powerful to provide insight into the physical processes in the deeply-embedded protostellar phase when the star is still being assembled through accretion of material from the circumstellar disk and when fragmentation into binary or multiple systems can occur. (4) Evolution of proto-planetary disks and exoplanetary systems: MIRI will contribute hugely to our understanding of the processes by which disks turn into planets. Indeed, the first few Myr of disk evolution may well be responsible for the wide variety of observed exoplanetary systems. Spatially resolved images with MIRI and ALMA down to ~10 AU or less will allow dust growth and settling, as well as the relative settling of the dust versus the gas to be determined as a function of radius and thus the onset of planetesimal formation. Comparison of MIRI spectra of disks with each other and with spectra from Kuiper Belt objects and distant comets allow changes in mineralogy and the raw materials for life (water, hydrocarbons, PAHs) to be traced down to planet-forming zones. The main ingredient for building giant gaseous planets, H_2, can only be traced in the mid-IR. (5) Exoplanetary atmospheres: Exciting new Spitzer data of transiting giant planets show the potential of mid-IR data to probe exoplanetary atmospheric composition and processes. MIRI will likely be the only instrument capable of pushing these studies down to the (super)-Earth regime. The spatial resolution and sensitivity of MIRI will also allow direct detection of Jupiter-like giant planets in wide (> 5 AU) orbits around the nearest stars and characterization of their atmospheres.

F2.7.1.2. International partners and collaborations

The MIRI instrument is designed and built by a joint US/European consortium. The scientific oversight occurs through the MIRI Science Team, led by G. Rieke and G. Wright, including Brandl as instrument scientist. On the U.S. side, JPL is the lead institute for MIRI, whereas Goddard has the prime responsibility for the integration of all instruments. JPL has procured and delivered the detectors with the associated electronics, software and testing. The European consortium is led by the UK (PI G. Wright), with Germany, France, The Netherlands, Belgium, Spain, Switzerland, Ireland, Denmark, and Sweden as partners. Europe will design and build the entire camera/spectrometer unit.

F2.7.1.3. Impact/context NL situation

The Dutch contribution to MIRI is led by NOVA (PI van Dishoeck; deputy-PI Brandl; PM Jager). The hardware has been built at ASTRON, with TNO as sub-contractor for the optical design, and SRON as consultant. Strong technical and space instrumentation expertise has been contributed by NOVA astronomers Pel, Brandl, and de Graauw. The Optical-IR instrumentation group has lead the optical and mechanical design of the instrument, the end-to-end modeling, the proto-typing, construction and testing, and will provide post-delivery engineering support. TNO, together with Pel, have provided key input on the optical design in the early phases.

The main benefits for Dutch astronomers are (i) ensuring that JWST-MIRI will have a proper spectrometer with the desired capabilities; (ii) obtaining a fraction of the JWST guaranteed time; (iii) gaining intimate knowledge of the instrument and its data reduction, essential as a head start for subsequent open-time proposals; (iv) maintaining unique mid-infrared technical expertise in the Netherlands and (v) providing an essential scientific complement to other Dutch projects in the same time frame, in particular ALMA, VLT/VLTI, Herschel, and the E-ELT. Participation in MIRI is also on the scientific and technology path necessary to achieve the next mid- or far-infrared (space) mission. In particular, it has positioned the Netherlands very well to have a lead role in the E-ELT METIS project, which involves largely the same European partners as MIRI.

In 2010-2013 NOVA will fund 1 fte project scientist and a part-time postdoc to participate in the instrument tests in Europe (test procedures, execution, data analysis, calibration products, commissioning plans, calibration plans) and development of data reduction software (framework, data reduction algorithms, calibration and science analysis tools), with a focus on the IFU spectrometer. The scientist will be located at SRON-Groningen, to benefit from the SRON expertise on software development for the ISO and Herschel missions.

F2.7.2. Gaia: a three-dimensional map of the Milky Way

F2.7.2.1. Summary

Gaia is an ESA cornerstone mission scheduled for launch in 2012. Gaia will provide a stereoscopic census of our Galaxy through the measurement of high accuracy astrometry, radial velocities and multi-color photometry. Over the course of its five year mission it will measure parallaxes and proper motions for every object in the sky brighter than magnitude 20, amounting to about 1 billion stars, galaxies, quasars and Solar System objects. Gaia will achieve an astrometric accuracy of 12–25 μas, depending on color, at 15th magnitude and 100–300 μas at 20th magnitude. Multi-color photometry will be obtained for all objects by means of low-resolution spectro-photometry at wavelengths between 330 and 1000 nm. In addition radial velocities with a precision of 1–15 km/s will be measured for all objects to 17th magnitude, thus complementing the astrometry to provide full six-dimensional phase space information for the brighter sources. Gaia will achieve the complete all-sky survey to its limiting magnitude via real-time on board detection.

The main aims of the NOVA project are to

1. design, develop, and deliver the Dutch contribution to the European Gaia Data Processing and Analysis Consortium (DPAC);
2. ensure strong Dutch participation in the scientific exploitation of the Gaia catalogue;
3. develop and maintain in the Netherlands scientific and technical expertise with complex data processing systems for large astronomical surveys, in order to ensure a future Dutch role in such surveys.

F2.7.2.2. Scientific interest in the Netherlands

The primary scientific aim of the mission is to map the structure of the Galaxy and unravel its formation history. Current cosmological models envisage the formation of large galaxies through the merging of smaller structures. There is a long tradition in the Netherlands in this area (Helmi, Brown). However the science case for Gaia is much broader as illustrated by the studies that will be carried out with the Gaia data: the nature and distribution of dark matter (Helmi); the link between dwarf galaxies and the stellar content of the halos of giant galaxies in the local group (Tolstoy, Helmi, Trager); fundamental stellar parameters and binaries (Pols, Nelemans, Portegies Zwart, Levin, Trager); and the formation of stars, star clusters, and planets (Kaper, Brown, Portegies Zwart, Snellen).

Deciphering the assembly history of our Galaxy requires a detailed mapping of the structure, dynamics, chemical composition, and age distribution of its stellar populations.
Ideally one would like to 'tag' individual stars to each of the progenitor building blocks of the Galaxy. The Gaia mission is designed to provide the required fundamental data in the form of

distances (through parallax), space velocities (through proper motions and radial velocities), and astrophysical characterization (through multi-color photometry) for massive numbers of stars throughout most of the Galaxy. Additional scientific products include fundamental stellar data across the Hertzsprung-Russell diagram, unique samples of variable stars of nearly all types (including key cosmological distance calibrators), detection and orbital classification of tens of thousands of extra-solar planetary systems, a comprehensive survey of objects ranging from huge numbers of minor bodies in our Solar System, through galaxies in the nearby Universe, to some 500,000 distant quasars. Gaia will also provide a number of stringent tests of general relativity.

F2.7.2.3. International partners and collaborations

The Gaia spacecraft and scientific payload are built by the industrial company EADS-Astrium and the data processing will be undertaken by the scientific community in Europe which has organized itself into the Gaia DPAC. The data processing activities will be structured around nine 'coordination units' and six data processing centers. The Dutch contribution forms part of the photometric coordination unit, which is responsible for the design, development and operation of the photometric processing pipeline for DPAC. The partners in this coordination unit are groups in the UK, Spain, and Italy. Brown is member of the Gaia science team.

F2.7.2.4. Impact/context NL situation

The Dutch contribution to DPAC is led by NOVA (PI Brown) and the project is carried out by groups in Leiden (photometric instrument algorithms) and Groningen (ground-based preparations). The main benefits for Dutch astronomers are (1) the detailed knowledge of the scientific instruments and the data that will be delivered by Gaia will provide significant advantages in the science exploitation of the final Gaia catalogue and any intermediate data releases, both in terms of time and quality; (2) expertise will be built up regarding the setting up of a very large and complex data processing system, including the development of a complex calibration pipeline. This expertise can be transferred to other large ground or space-based observing programs or facilities in which the Netherlands is involved; and (3) experience with a complex and highly demanding astronomical survey mission employing a large focal plane detector array can be exploited to ensure a prominent Dutch role in technically similar future space missions such as EUCLID and PLATO.

Expenditures on the Gaia project amount to k€ 1224 over the period 2004-2012 with funding provided by NOVA (k€ 513), NWO (k€ 365) and by an EU network grant (k€ 346). In addition universities, especially Leiden, provided in-kind staff support.

F2.8. LOFAR for Astronomy

As described in § F1.5 of this Appendix the NOVA contribution to the project is '*The Development and Commissioning of LOFAR for Astronomy (DCLA)'* consisting of the development of essential software capabilities and commissioning tasks to enable the 4 key astronomical projects to accomplish their goals and at the same time the provision of a first version of general LOFAR user software.

F2.8.1. Scientific interest in the Netherlands

The science potential of LOFAR is an excellent match to the expertise and scientific interests of a large fraction of the Dutch astronomical community. The University of Groningen has long been the world leader in the field of radio spectroscopy and is leading LOFAR studies of the Epoch of Reionization (de Bruyn (PI), Koopmans, Zaroubi). At Leiden University astronomers have successfully conducted radio surveys with the WSRT for more than three decades, and pursued numerous follow-up programs to study galaxy and cluster evolution. The LOFAR survey project is led by Röttgering (PI), Miley, and Snellen, together with Barthel (Groningen) and Morganti (ASTRON). The University of Amsterdam hosts top research groups in (transient) gamma-ray bursts and pulsars, has successfully exploited the Pulsar Machine-2 (PUMA-2) on the WSRT, and is now in charge of the LOFAR Transient Key Project (Wijers (PI), Fender, Stappers). The group at the Radboud University in Nijmegen has extensive expertise in plasma astrophysics and coherent emission processes. It is now leading the study of high energetic cosmic rays with LOFAR (Hörandel (PI), Falcke, Kuijpers). The NOVA project is led by Röttgering and managed by Wise.

The design of LOFAR has been driven by four astrophysical applications that fit excellently with the expertise and scientific interest of the four participating Dutch university astronomy groups. These key LOFAR drivers are

- Epoch of reionization: One of the most exciting applications of LOFAR will be the study of the as yet unobserved epoch in the history of the Universe when the bulk of the gas in the Universe made the transition from neutral to ionized. Key questions that LOFAR will address include (i) what is the redshift and spatial distribution of heated and still cold gas during that epoch, and (ii) what is the nature of the first objects heating and ionizing the cold gas?
- Deep extragalactic surveys: Deep LOFAR surveys will provide unique catalogues of radio sources for investigating several fundamental questions in astrophysics, including the formation of massive black holes, galaxies, and clusters of galaxies. Because the LOFAR surveys will probe unexplored parameter space, it is likely that new phenomena will be discovered.
- Transient Sources: LOFAR's large instantaneous beam will make it uniquely suited to efficiently monitor a large fraction of the sky, allowing sensitive unbiased surveys of many classes of radio sources, including gamma-ray bursts, Galactic black-hole/neutron-star systems, and exoplanets.
- Cosmic Rays: LOFAR has the capacity to measure the composition and energy of high-energy cosmic rays at energies between 10^{15} - $10^{20.5}$ eV. Together with its high directional accuracy, LOFAR studies will be very important for our understanding of both the source origin and the acceleration processes of these particles.

F2.8.2. International partners and collaborations

Although LOFAR initially started as a Dutch project, it has now become an international project. In all the four original Dutch key projects, there are in total more than 150 foreign-based astronomers involved. Two new international key projects have been set up, one related to magnetism in the Universe (PI Zensus, MPIfR, Bonn, Germany) and one to solar studies (PI Mann, AIP, Potsdam, Germany). Further LOFAR stations on a European scale are currently being pursued by a number of European countries, including Germany, UK, Sweden, Poland, France, Austria, Italy and Spain and it is expected that in addition to the 36 stations distributed over the Netherlands at least 8 European stations will be operational in 2010.

F2.8.3. Impact/context NL situation

LOFAR will fulfill an important strategic function in Dutch astronomy. First, as a largely Dutch telescope of world-class, LOFAR will be a search engine for several international mega-facilities (like Fermi, OmegaCAM and ALMA) in which the Netherlands is only a financially minor (<5%) partner. Second, LOFAR will exploit the technical expertise in radio astronomy that the Netherlands has built up during the past half century and provide a visible platform for securing a prominent role in the next international large radio facility, the Square Kilometer Array (SKA). Third, as a world-class astronomical facility in the Netherlands, LOFAR will provide astronomy with a unique tool for education, outreach and political visibility.

Expenditures on the LOFAR-DCLA project amounted to k€ 5200 over the period 2005-2011 with funding contributions from NOVA (k€ 2468), NWO grants (k€ 1772) and the Northern Provinces of the Netherlands (k€ 960). In addition universities and ASTRON contributed in-kind staff support and several NOVA astronomers used part of their VENI, VIDI or VICI grants to hire temporary staff to work on software development and analyses and calibration of early LOFAR data. ASTRON provided the LOFAR-DCLA project manager (Wise).

F2.8.4. Technical concept and requirements
LOFAR's revolutionary design makes use of phased array technology that gives the critical advantage of delivering an affordable telescope with the needed large effective aperture. LOFAR will have low frequency antennas optimized for the 30 - 80 MHz range and high frequency antennas which have their maximum sensitivity between 115 and 240 MHz. These antennas are grouped together in 'stations'. The electric signals from the antennas are digitized and appropriate delays applied so that station beams on the sky can be formed. In the standard observing mode up to eight beams are available simultaneously. 36 stations will be spread in and around the province of Drenthe, with maximum baselines of 100 km and will have a 10 Gb/s connection to the IBM Blue/Gene supercomputer, named Stella, in Groningen. The eight additional European stations will have distances of up to 700 km from the LOFAR core, increasing the angular resolution by almost an order of magnitude.

The design and construction of LOFAR, as a general sensor array, is funded from the national Dutch BSIK subsidy (M€ 52), the contribution (M€ 22) of the three Northern Dutch provinces through SNN (Samenwerkingsverband Noord Nederland), from in-kind contributions of ASTRON, and from investments of partners with an interest outside astronomy. The project entitled the Development and Commissioning of LOFAR for Astronomy (DCLA) was subsequently initiated to enable LOFAR to perform its astronomical science. The DCLA project consists of two main elements:

1. Commissioning and Optimization: Every new large facility undergoes a commissioning process in which the facility is optimized for the intended scientific goals. This requires close interaction between scientists and engineers over a prolonged period. LOFAR commissioning will be particularly important and time-consuming because of (i) the novel calibration procedures, (ii) the high dynamic range needed to attain some of the scientific goals, and (iii) the large range of required exposure times, ranging from nanoseconds for cosmic rays to months for the EOR observations. Basic questions that will need to be addressed concern the acceptable and optimal observing conditions for achieving each of the astronomical goals.

2. Enabling LOFAR for Astronomy: Enabling LOFAR to carry out each of the four key projects requires a set of capabilities to be developed. They include the development of observing modes and procedures, detection algorithms, and software pipelines. For the EOR project, the main challenge is to produce a software pipeline that is capable of producing high dynamic range maps out of a Petabyte of data. For the transient project, a software system is needed that is capable of detecting and characterizing transient radio sources from a large data stream of images and UV data. The goal of the survey project is to create an extensive catalogue of up to 10^8 sources at a range of frequencies for which extensive software tools need to be developed. The cosmic rays need to be detected by cross correlating data from nano-second sampled time series taken at the antenna level. For this a pipeline is needed capable of detecting, cataloguing, and characterizing the cosmic rays.

F2.9. AMUSE

F2.9.1. Summary
AMUSE (Astrophysical MUltipurpose Software Environment) is a software instrument for astrophysical multi-scale and multi-domain simulations. The project was started in May 2009. It will combine existing codes from four different domains (Gravitational Dynamics, Stellar Evolution, Hydrodynamics and Radiative Transfer) into one self-consistent software framework. Target applications are simulations of compound objects with widely differing length scales and physical regimes. The AMUSE software is developed at the Leiden Observatory by a small core

team of 4 scientists (post-doc, software engineer and scientific programmers) in collaboration with the Dutch computational-astrophysics community.

F2.9.2. Scientific interest in the Netherlands

The proposed project will play an important role in focusing theoretical and computational astrophysics in the Netherlands. Researchers from all five universities: Portegies Zwart, Groot, Icke, Kaper, Levin, Nelemans, Pols, Spaans, Tolstoy, and van den Weijgaert. The development of the framework requires regular communication between the parties, and collaboration on a large scale. However, in applying the framework to large-scale astrophysical simulations researchers can maintain their own individual projects without having to share resources or being forced to collaborate on individual projects. Although large-scale collaboration will be encouraged, it is not required for making this project a success. A virtual organization of Dutch computational astrophysics is of crucial importance for the future of theoretical and computational astrophysics in the Netherlands. The unique diversity of computer languages and numerical techniques within the framework enables astronomers and apprentices to actively participate in research with AMUSE without having to ascend the steep learning curve of other large software projects.

The Universe is a multi-physics environment, in which Newton's laws, radiative processes, nuclear reactions, and hydrodynamical effects interact mutually. Generally astrophysical problems span many orders of magnitude in time scales and length scales involved. For example in the Galaxy the smallest scales, of the order of 10^4 meter and 10^{-10} year are coupled to the largest scales of the order of the system's size (10^{20} m) and age (10^{10} year). Small isolated environments within the Galaxy, like planetary disks or close binary stars, also involve a broad range of physical phenomena. While observational astronomy fills important gaps in our knowledge by harvesting ever-wider spectral coverage with continuously increasing resolution and sensitivity, our theoretical understanding lags behind dramatically and continues to lose distance.

Computational astronomy is situated between observations and theory. The calculations generally cover a wider range of physical phenomena, whereas purely theoretical studies are often tailored to a relatively limited range of spectral coverage. On the other hand, extensive calculations can support observational astronomy by mimicking observations, interpretation, and by studying parameter spaces. They can elucidate complex consequences of physical theories. But extensive computer simulations in order to deepen our knowledge of the physics require large programming efforts and a good fundamental understanding of the underlying physics.

F2.9.3. International partners and collaborations

The PI and co-PIs participate actively in an international network of numerically oriented astronomers. They are members of larger collaborations like the starlab team (see http://sns.ias.edu/starlab.html), the MODEST consortium (see http://manybody.org), and MUSE (see http://muse.li). These endeavors are world-wide, which is also reflected in the list of foreign experts with a direct interest and advisory role in this project. It is envisioned to couple the instrument to the Meta Institute for Computational Astrophysics (MICA, http://www.physics.drexel.edu/mica/index.php/Main_Page).

The excellent national computer facilities and advanced grid infrastructure, developed as part of the DAS-3 project in which the UvA, VU, TU Delft, and Leiden University collaborate, are unique in the world. The DAS-3 is a novel wide-area cluster computer across the Netherlands with light paths between sites providing extremely high-speed networking. Other computer resources are provided by the collaboration between Amsterdam, RIT, and Heidelberg.

F2.9.4. Impact/context NL situation
The proposed framework is unique for computational astrophysics in the Netherlands. The efforts are led by Portegies Zwart (PI), Spaans (co-PI). AMUSE will fulfill an important strategic function in Dutch computational astrophysics, as expertise from all the astronomy departments in the Netherlands will be used. A successful framework will also open up new roads to larger and more complicated software developments. AMUSE will provide computer scientists and astrophysicists with a unique environment for education at the MSc level and further research. The expertise that we will build is unique and can bring the Netherlands computational astrophysics internationally to the forefront. The budget for the AMUSE project for the period 2009-2011 amounts to k€ 526 with all funding provided by NOVA.

F2.9.5. Technical concept and requirements
AMUSE's revolutionary design makes use of a high level scripting language (Python) to realize the communication between the application domains, which are written in low-level compiled languages. The technical innovation mainly comes from the development of a general purpose interface between astronomical (and other) domain-specific applications. Other technical challenges lay in the organization of the numerical framework, the embedding within a grid environment and the use of special-purpose hardware in combination with machine-specific applications. The unit conversions between modules and the generalization of input and output will require an innovative and flexible approach to the framework, but by no means poses a technical challenge. The most technically challenging aspect is related to the inter-module communication of large data sets. The transfer of large volumes of data cannot be done efficiently through the top Python layer, but such information has in some way to tunnel from one domain to another. At this point the project team does not have yet a solution ready for this, but emphasize that this only becomes important if they perform simulations of astrophysical systems where the specific domains are not well separated.

F2.10. S^5T: Small Synoptic Second Solar Spectrum Telescope

F2.10.1. Summary
The Small Synoptic Second Solar Spectrum Telescope (S^5T) will study the temporal variation of the weak turbulent magnetic field that covers the entire solar surface but is invisible to traditional magnetic field measuring instruments. While this turbulent field is weak compared to magnetic fields in sunspots, the total magnetic flux emerging through the solar surface in the turbulent field is orders of magnitude larger than the amount of flux emerging in sunspots, even at the peak of the solar activity cycle. Understanding the origin and dynamics of this turbulent field and its interaction with the sunspot cycle is not only important to solve the enigma of the 11-year solar cycle and the variations of the Sun’s energy output that ultimately affect life on Earth, but it is also crucial for our understanding of magneto-hydrodynamic turbulence in an astrophysical plasma with applications to much larger scales, such as the galactic magnetic field whose origin has also not yet been established.

By measuring the linear polarization parallel and close to the solar limb as a function of wavelength, the properties of the weak, turbulent field can be deduced via the Hanle effect, even without spatially resolving the characteristic length scales of this field. Daily measurements with high sensitivity and accuracy with the same instrument during at least one solar cycle (11 years) in combination with advanced radiative MHD numerical simulations will reveal the nature of the ubiquitous weak magnetic field and its relation to the strong fields observed with traditional methods.

The key component of the S^5T is the theta cell, which converts linear polarization with an azimuthally (or radial) symmetry in the focal plane into a uniform linear polarization pattern, which in turn can be analyzed by a regular polarimeter. This allows for a 'one-shot' observation of the entire solar limb polarization by channeling all the relevant light through the theta cell, the precision polarimeter, and finally into a fiber- (bundle-) fed spectrometer, which integrates the signal from the entire limb into a single spectrum. Therefore there is no need for a large-aperture telescope to achieve the required signal-to-noise ratio for highly sensitive spectro-polarimetry. A variety of calibration routines ensure the required polarimetric accuracy and stability.

F2.20.2. Scientific interest in the Netherlands
The S^5T will study a basic astrophysical process, the generation of magnetic fields by the turbulent motion of a plasma. In the case of the Sun, convection drives the plasma motions. Because of the small scale of the S^5T project, the full instrument development will occur within the Netherlands. Design, construction, assembly and testing will take place at the Astronomical Institute in Utrecht. The project is of a size and duration that PhD students can get hands-on experience with the entire project cycle. The S^5T is scientifically supported by the institutes in Utrecht (Keller (PI), Snik (co-PI), Vögler, Achterberg) and Amsterdam (Spruit) and technically by Utrecht University and the Optical-IR Instrumentation Group.

Polarimetric observations of the Sun during the last few decades provided a large amount of information about the nature of solar magnetism. The Zeeman effect in suitable spectral lines is the primary workhorse to derive the magnitude and the direction of the average magnetic flux within a given spatial resolution element on the Sun. Yet, as the longitudinal Zeeman effect is linear in average magnetic field strength, it is virtually blind to weak magnetic fields, particularly to those with a turbulent (mixed-polarity) topology within the spatial resolution element. Therefore, one has to resort to other polarization effects in the solar atmosphere to diagnose the weak magnetic field, which is expected to be ubiquitous on the Sun. Next to the transverse Zeeman effect, the other main process to linearly polarize a spectral line is by coherent large-angle scattering. Such scattering polarization is observed near the limb of the Sun. The scattering polarization can be (partly) destroyed by magnetic fields. This effect is called the Hanle effect and constitutes a sensitive diagnostic for weak magnetic fields. Moreover, the Hanle depolarization only depends on the absolute vertical magnetic field strength and therefore the Hanle effect can also diagnose fields with opposite polarities within a resolution element.

The linearly-polarized spectrum observed several arcseconds inside the limb of the Sun in regions free of strong magnetic fields is called the Second Solar Spectrum, because of the lack of similarity with the intensity spectrum. This by itself implies that a large amount of information about physical processes in the solar atmosphere is hidden in this Second Solar Spectrum. It is a challenge to extract and disentangle all this information, even more so because of the small degrees of polarization which are observed in the Second Solar spectrum: from 1% down to 10^{-4} of the intensity.

The following science questions will be addressed by the S^5T by accurately measuring the Second Solar Spectrum for the duration of a solar cycle:

- What is the origin of the weak, turbulent magnetic field in the solar photosphere: the global dynamo or local dynamo action by the granulation?
- What is the magnetic flux budget of the Sun and how does it change in time?
- How and where are different spectral lines formed?

F2.10.3. International partners and collaborations
The instrument will be commissioned at the existing SOLIS synoptic facility at Kitt Peak, Arizona, USA, and will be operated there for at least ten years by the US National Solar Observatory (NSO). Harvey at NSO is a Co-I. Institutes around the world have expressed their interest in the project and scientists working on turbulent magnetic fields and polarized-light generation are eagerly awaiting the first data.

F2.10.4. Technical concept and requirements
The goal of the S^5T is to deliver daily observations of the Second Solar Spectrum from 420-465 nm, with a polarimetric sensitivity of 10^{-5} and a polarimetric stability of 1%, for more than 10 years. A compact instrument design is obtained by the use of a theta cell. This allows for integration over the entire solar limb, thereby reducing the need for a large aperture to yield the large photon flux required for precision spectro-polarimetry. The S^5T telescope with its 5 cm objective lens is fully optimized for its polarization properties and feeds the polarimeter, which is based on a rapidly switching liquid crystal retarder. After the polarimetric analysis, the light is fed into a spectrometer by means of a fiber bundle. The 8192x96 pixel line scan camera at the focal plane of the spectrograph can be operated with full binning in the spatial direction, which integrates the signal from the entire limb into a single spectrum. Calibration procedures guarantee the long-term stability of the instrument. Funding for this project is provided by NOVA (k€ 339) and UU (k€ 60).

F2.11. MATRI^{2}CES

F2.11.1. Summary
MATRI^{2}CES – Mass Analytical Tool of Reactions in Interstellar ICES – is a new setup at the Sackler Laboratory for Astrophysics at Leiden Observatory with the aim to characterize reaction schemes in inter- and circumstellar ice analogues. It will be capable of studying laser-desorbed ice particles mass selectively in an interaction-free environment by combining proton transfer mass spectrometry and time-of-flight detection. MATRI^{2}CES will be worldwide unique and is expected to exceed the sensitivity of regular techniques – RAIRS and TPD - by several orders of magnitude. The setup will offer the possibility to study reaction products in situ and on line under conditions as typical for inter- and circumstellar matter (ICSM) yielding rate constants that put a quantitative basis to interstellar surface chemistry. The latter is necessary to interpret observational data and will link gas-phase and solid-state astrochemical processes. The focus of MATRI^{2}CES will be on the solid-state astrochemical formation of complex molecules in space.

F2.11.2. Scientific interest in the Netherlands
The results obtained with MATRI^{2}CES are important to interpret Dutch observational programs and ongoing research within the Netherlands on complex molecules in space (Cazaux, Cuppen, Dominik, Helmich, Hogerheijde, Kamp, Spaans, van der Tak, Tielens, van Dishoeck, Waters). The project is led by Linnartz. In particular, a large fraction of the Herschel-HIFI guaranteed time program is devoted to spectral surveys of young stellar objects, whose spectra are expected to be full of lines of complex organic molecules. Complementary ground-based programs on submillimeter telescopes like JCMT and IRAM 30-m are already in progress. Such surveys form the basis for future ALMA line surveys of these regions in which the Netherlands are heavily involved. Currently, interpretation of these data is limited to providing an inventory of species in different regions. The more fundamental questions of how these molecules are formed, why they are seen only under specific conditions, and what the limits to molecular complexity are can only be addressed if complementary laboratory data become available.
In recent years, following astronomical observations (e.g. ISO, Spitzer, JCMT), laboratory studies and astrochemical models, it has become clear that icy dust grains play a key role in the formation of more complex molecules.

The goal of MATRI^{2}CES is to quantitatively characterize such reaction schemes in full dependence of relevant parameters, such as temperature, ice composition and morphology, UV irradiation and/or atom-bombardment. For this, ices are grown under fully controlled laboratory conditions and subsequently processed by UV light and/or atom beams. A special ablation scheme is used to bring ice particles into the gas phase, which are monitored by a state-of-the-art time-of-flight detection scheme. The setup allows an in situ and online detection of molecules produced in the ice and with a sensitivity that is known to be very high.

Since the measurements are performed time-dependent it will be possible to derive reaction rates for specific reaction channels and moreover to determine formation ratios. Implementation of these results in a matrix of physical dependencies (temperature, flux, mixing ratios, etc.) and combining the outcome with, for example, Monte Carlo simulations extends the conclusions far beyond typical laboratory timescales and allows a resolution of chemical processes in space, in which both gas-phase and solid-state astrochemical processes are involved.

F2.11.3. International partners and collaborations
Interstellar ices are currently a hot topic. There is much interest in quantitative results from observers, modelers and laboratory astrophysicists/chemists. The Sackler Laboratory for Astrophysics is member of an EU network application LASSIE (Laboratory Astrophysics Surface Science In Europe) in which all leading European laboratory groups are involved. Good contacts exist towards the groups of McCoustra (Heriot-Watt University, UK), Price (UCL, UK), Lemaire (Paris Observatory, F), Palumbo (Catania Observatory, I), Hornekaer (Aarhus, DK), Henning (MPIA Heidelberg, D), and Fraser (Strathclyde University, UK) which is reflected in active collaborations and common projects. The research in the laboratory is strongly guided by the need of observers and modelers, which includes the HIFI guaranteed time consortium (in particular Tielens, Ceccarelli, Schilke), Herbst (Ohio, USA) and infrared observers (Pontoppidan, Boogert, Blake at Caltech, USA), in addition to Dutch observers.

F2.11.4. Impact/context NL situation
MATRI^{2}CES is being constructed in the Sackler Laboratory for Astrophysics (PI Linnartz) with help of the local instrument machine shop, which has considerable experience in constructing ultra-high vacuum setups. Scientific-technical expertise is furthermore provided within ongoing collaborations with the Laser Centre at the Free University in Amsterdam and the FOM Institute for Plasma Physics in Nieuwegein. The main return to the Dutch community is the ability to analyze and interpret data from a variety of high-profile new observational facilities in much more depth than possible otherwise. Several collaborations within NOVA Network-2 exist to realize this goal. The NOVA funding for this project amounts to k€ 458. Additional funding is secured from various resources including Leiden Observatory and the Sackler foundation.

F2.11.5. Technical concept and requirements
The central unit of MATRI^{2}CES is an ultra-high vacuum chamber in which ices are grown with mono-layer precision and thermal processing, photo-processing and atom bombardment are used to initiate reactions. At this stage the ice is monitored spectroscopically using a Fourier-transform infrared spectrometer. A pulsed laser is used for soft ablation of the ice and to lift ice molecules (both precursors and reaction products, including radicals) into the gas phase. These molecules are picked up by a pulsed molecular-beam expansion that is generated by expanding helium through a special piezo valve in a separately pumped beam chamber. The seeded beam enters the ionization chamber in which the ice molecules are ionized either by regular electron impact ionization or by proton transfer reactions. Electrostatic optics are used to guide the ions into the detection chamber which consists of a commercial time-of-flight mass system. A special trigger scheme is used for time gated detection.

F2.12. Seed funding projects
The NOVA instrumentation program also includes a funding line to explore new opportunities that might develop towards full instrumentation projects in the future. Proposals that get funded should fulfill several criteria including (1) a challenging science goal that fits within the strategic plan for astronomy in the Netherlands, (2) technical and managerial feasibility, (3) perspective on an attractive Dutch role (like PI or co-PI), and (4) the PI has to be affiliated to one of the astronomical institutes participating in NOVA.

Two seed funding projects are already approved which are described below. The seed funding line also provides a financial contribution to pay for the membership of the European SKA

Consortium (ESKAC) to allow university astronomers in the Netherlands to participate in the organization and design studies of the next generation observing facility for radio astronomy, the Square Kilometer Array (SKA).

F2.12.1. Auger-Radio

The project (PI Falcke) aim is to deploy detectors at the Pierre Auger Observatory (PAO) in Argentina for radio detection of high-energy cosmic rays. The detectors utilize very short timescale radio-frequency emissions from cosmic ray air showers to measure the direction, energy, and composition of cosmic rays as they interact in the atmosphere. The Auger project will make heavy use of the very detailed studies of radio emission properties to be obtained with LOFAR and concentrates on the energy range 10^{18} - 10^{20} eV not well covered by LOFAR. The radio technique offers a highly promising detection method which can, with high precision and lifetime, supplement or replace existing cosmic ray techniques such as water Cherenkov tanks and fluorescence telescopes, with the ability to instrument huge areas in a cost-effective manner.

The nature and origin of ultra-high energy cosmic rays (UHECRs) is a major question in high-energy astrophysics today. What are the physical processes that accelerate atomic nuclei beyond energies of 10^{19} eV, many orders of magnitudes above the best accelerators at CERN and how are they related to the known sources commonly studied in radio, X-ray and gamma-ray emission? This can finally be addressed by the PAO collaboration. The PAO covers an unprecedented effective area of 3000 km^2 and has achieved a major breakthrough in showing that UHECR are in fact extragalactic, anisotropically distributed and pointing back to their sources at the very highest energies. A new technique, using digital low-frequency radio antennas, has the potential to extend Auger even further and to determine the nature of these particles (e.g. distinguish between protons, iron nuclei, photons, and neutrinos). The seed funding amounting to 100 k€ will be used to develop a first prototype of a smart, low-power antenna that can be mass-produced and installed in the Auger observatory over a large area. Further funding comes from Falcke’s ERC grant and international partners.

F2.12.1.1. Scientific interest in the Netherlands

Astroparticle physics is a newly emerging field combining the questions and skills of astronomer and particle physicists alike. The astronomy community is currently building the LOFAR radio telescope which is also able to measure UHECRs. At the same time particle physicists and astronomers in the Netherlands jointly participated in the PAO project, which has just become operational and is the leading UHECR observatory in the world. Through LOFAR the radio technique for detecting UHECR has been pioneered by NL researchers led by Falcke who have now taken the lead to establish this technique at the AUGER site as well. In addition the project allows cross-calibration between the Auger observatory and the LOFAR UHECR experiment.

The Auger Radio project is a collaboration between astronomers at the universities of Nijmegen, Groningen, Amsterdam, and Utrecht, the NWO institute ASTRON, and particle physicists at the universities of Groningen and Nijmegen and the NWO/FOM institute NIKHEF (Nijmegen/ Amsterdam), as well as members of the Auger collaboration. The NOVA contribution will be matched by a FOM-funded postdoc position at Nijmegen. The goal of the development is a self-sufficient, solar-powered, self-triggering prototype antenna for later mass production. The antenna will operate in the frequency range from ~30-80 MHz and have a broad acceptance. The electronics requires buffering, smart triggering, and interference rejection on the antenna level. There needs to be wireless communication, synchronization and trigger coincidence detection between different antennas. Low-power consumption requires a high level of integration of all electronic components.

F2.12.2. Cherenkov Telescope Array (CTA)

CTA is a planned European TeV gamma-ray telescope based on imaging Cherenkov light induced from gamma-rays entering the Earth’s atmosphere. CTA will be a natural successor to the highly successful European Cherenkov telescopes H.E.S.S. and MAGIC. These are proprietary telescopes, but CTA will have a significant fraction of its observing time open to all astronomers. Currently it is envisioned to build an array both in the Southern and Northern Hemisphere. CTA will have a sensitivity that is an order magnitude better than the existing telescopes. The main gain in sensitivity is due to a significant increase in the number of telescopes employed in the array, as many as 40 small and large ones. The large telescopes (20m class) are optimized to detect faint Cherenkov light caused by low energy gamma-rays (< 100 GeV), whereas many 6 and 12 meter class telescopes will be placed such that the array captures a large part of the sky in order to optimize the number of high energy photons. The actual effective area of the telescope is determined by the sky coverage, the atmosphere acting as the primary detector. At high photon energies the sky coverage is important as sources are usually photon starved.

The idea for a European effort to build a large Cherenkov array started in 2005. Since then, many European countries have already started participating in the design studies for CTA, currently funded by national funding agencies, but with good prospects for future EU funding. In addition Japan, South Africa and Armenia have joined the CTA consortium. An active exchange of ideas and collaboration takes place with the United States, who are currently studying a similar Cherenkov Array called AEGIS.

The Netherlands is not a full partner in CTA, but UvA (Markoff) and UU (Vink) are signatories to the MoU and are members of the CTA Consortium Board. The NOVA seed funding (k€ 15 in 2009-2010) allows Markoff and Vink to participate in the CTA consortium meetings. Markoff leads the multi-wavelength sub-task of the Physics Work Package and Vink participates in the Physics Work Package, which defines the CTA design goals and optimization, such as trade offs between sensitivity at high and low gamma-ray energies.

Appendix G: participation in EU networks 2003-2009

The university institutes and NOVA participated in the EU networks in the period 2003-2009 as listed in the table below. The selection is limited to network activities. Therefore individual EU mobility and research grants and ERC research grants are not included.

Partner	Name	Start	End	Project title
NOVA,UU,UL	OPTICON-FP6	1-Jan-04	31-Dec-08	Optical-Infrared coordination network for astronomy
NOVA,UU	OPTICON-FP7	1-Jan-09	31-Dec-12	Optical-Infrared coordination network for astronomy
UvA	GAMMA-RAY BURSTS	1-Sep-02	31-Aug-06	Gamma-ray bursts: an enigma and a tool
UvA	Descartes Prize 2002	1-Jan-03	31-Dec-05	European collaboration in gamma-ray astronomy
UvA	ASTRONS	1-Dec-06	30-Nov-10	Astrophysics of neutron stars
UvA	BLACK HOLE UNIVERSE	1-Oct-08	30-Sep-12	Multiwavelength studies of galactic black holes
RuG	SISCO	1-Oct-02	30-Sep-06	Spectroscopic and imaging surveys for cosmology
RuG	ANGLES	1-Apr-04	31-Mar-08	Astrophysics network for galaxy lensing studies
RuG,UL	MOLECULAR UNIVERSE	1-Oct-04	30-Sep-08	The molecular universe: an interdisciplinary program on physics and chemistry of molecules in space
RuG,UL	SKADS	1-Jul-05	31-Dec-09	Square Kilometre Array design studies
RuG	EUROVO-DCA	1-Sep-06	31-Dec-08	The European virtual observatory data centre alliance
RuG	MCCT-SKADS	1-Jan-07	31-Dec-09	Marie Curie conferences and training courses on SKA design studies
RuG	EUROVO-AIDA	1-Feb-08	31-Jul-10	Euro-VO astronomical infrastructure for data access
RuG	PREPSKA	1-Apr-08	31-Mar-11	A preparatory phase proposal for the square kilometre array
RuG	EGEE-III	1-May-08	30-Apr-10	Enabling grids for e-science III
UL	EURO 3D	1-Jul-02	31-Dec-05	Promoting 3d spectroscopy in Europe
UL	PLANETS	1-Nov-02	31-Oct-06	The origin of planetary systems
UL	EARA - EST	1-Sep-04	31-Aug-08	Early stage training in astrophysics
UL	ELT DESIGN STUDY	1-Jan-05	30-Jun-09	Technology development program towards a E-ELT
UL	ELSA	1-Oct-06	30-Sep-10	European leadership in space astrometry
UL	DUEL	1-Jan-07	31-Dec-10	Dark Universe with extragalactic lensing
UL	EVALSO	1-Jan-08	31-Dec-10	Enabling virtual access to Latin-american southern observatories
UL	ELIXIR	1-Dec-08	30-Nov-12	Early universe exploration with NIRSPEC
UL	CosmoComp	1-Dec-09	30-Nov-13	Pan-European training in computational cosmology: modelling cosmic structures
UU	INTAS Solar Photosphere	1-Jul-01	31-Dec-05	High-Resolution Physics of the Solar Photosphere
UU	ESMN-II	1-Nov-02	1-Nov-06	European solar magnetism network
UU	EU USO-SP	1-Feb-06	31-Jan-10	USO-SP international graduate school for solar physics
UU	EU Solaire	1-Jun-07	31-May-11	Solar atmospheric and interplanetary research
UU	EU EST	1-Feb-08	31-Jan-11	Large aperture European solar telescope

Citations and impact of Dutch astronomy

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1 Introduction

The aim of this study is to make a bibliometric comparison of the performance of research astronomers in the *Netherlands Research School for Astronomy* (NOVA) with astronomers elsewhere. This is complementary to similar studies as undertaken by the *Center for Science and Technology Studies* (CWTS), but has the specific feature of using the *NASA Astrophysics Data System* (ADS)[1] and possibilities offered by it. We will use various indices for bibliometric performance for a sample of Dutch (NOVA) astronomers to compare to samples of astronomers worldwide, from the United States in general and from American top-institutes.

Secondly, we will consider the results of the *'Nederlands Observatorium van Wetenschap en Technologie'* (NOWT), the Netherlands Observatory of Science and Technology, which regularly publishes a report *'Science and Technology Indicators'*[2]. We will try and reproduce those results using publication lists from institutions in the Netherlands, again using ADS, and examine and discuss the conclusions and indications from these reports.

2 NASA Abstract Database Service

We investigate here first the reliability of the NASA *Astrophysics Data System* (ADS) for citation analysis in order to address questions about bibliometric performance. Briefly, the ADS is a database for astronomical publications; it provides scanned versions of articles in astronomy and astrophysics in almost all relevant journals, going back to the earliest volumes (in relevant cases well into the nineteenth century), and of papers in proceedings and observatory annals. For papers published since journals started electronic subscriptions the user is linked to the journal sites. Also ADS provides for each article a list of papers that have been cited and of papers that cite that particular publication. In principle ADS is a complementary database to the *Science Citation Index* used for NOWT. Also it can easily order papers of a particular author or group of authors by the number of citations and normalised counts or normalised citations[3], etc. The ADS is a unique facility, available free of charge, made available and maintained by NASA with public funds.

There have been a few investigations into the use of ADS for bibliometric studies. Helmut Abt[4] concludes that the correspondence is good. His abstract reads: *"From a comparison of 1000+ references to 20 papers in four fields of astronomy (solar, stellar, nebular, galaxy), we found that the citation counts in Science Citation Index (SCI) and Astronomical Data System (ADS) agree for 85% of the citations. ADS gives 15% more citation counts than SCI. SCI has more citations among physics and chemistry journals, while ADS includes more from conferences. Each one misses less than 1% of the citations."* More specific to the determination of impact ratios, van der Kruit[5] found that studies based on ADS reproduce the results of studies by the CWTS very well and ADS reliably provides information to perform bibliometric studies.

3 The performance of NOVA astronomers

We use the ADS to investigate the distribution of various publication and citation scores of NOVA astronomers. To this end we used a sample comprising all staff members of the NOVA institutes in the 2003 – 2009 periodand three comparison samples. A list of NOVA researchers was provided by Wilfried Boland, executive director of NOVA; this is the same list as has been used by the CWTS in its recent bibliometric study of NOVA. We will designate this list as the 'NOVA-list'. We also used a list of 'key-researchers' of NOVA, which is of course a selection from the NOVA list itself.

The first random comparison sample has been taken from the membership directory of the International Astronomical Union (IAU)[6]. Only 'active members' were considered. After every selected member his/her membership number n was updated by adding 25. If no name was found the next number was taken, etc. This resulted in a list of order 400 astronomers. We then ignored names that had major difficulties in unique identification in the ADS, such as 'Li' among Chinese astronomers; this applied to about half the sample we had selected. The procedure was repeated for the American Astronomical Society (AAS; taking every 50th member)[7] to produce the second comparison sample. Here we only selected 'full members'. As a final sample a subselection of the AAS was constructed by considering only the faculty of the top 15 institutes of the US. These institutes follow from a study by A.L. Kinney[8]. Note that this selection uses citation scores and therefore this sample contains astronomers with high citation scores that often work in areas of astrophysics with high citation rates. The samples comprised 79 (NOVA), 177 (TopUS), 172 (AAS) and 193 (IAU) astronomers (the list of key-researchers has 26 persons).

From the ADS we found for each person the number of publications (in a refereed journal), first-author publications, normalised[9] publications and first-author papers, and to all these sets of publications a sorted list of the number of citations and normalised citations. We also noted the year of the first (refereed) publication. From this we calculated various properties such as (normalised) citations per paper, Hirsch-index[10], (normalised) citations and (normalised) publication per paper and per year (since that of the first publication).

It is well-known that the h-index of a person increases with time, and for comparison between individuals therefore sometimes the index is divided by the number of years that the person concerned has been active in research. This assumes (usually incorrectly) that one's h-index

[1] The American and European websites of ADS are `http://adsabs.harvard.edu` and `http://esoads.eso.org`.

[2] This study is commissioned by the *Ministery of Education, Culture and Science* (OCW) and performed jointly by the *Center for Science and Technology Studies* (CWTS) of Leiden University and the *Maastricht Economic and social Research and training centre on Innovation and Technoly* (MERIT) of Maastricht University.

[3] Normalised counts/citations are numbers of publications/citations where each paper is counted with a weight that is the inverse of the number of authors.

[4] A Comparison of the citation counts in the Science Citation Index and the Nasa Astronomical Data System (2004); `http://www.garfield.library.upenn.edu/papers/helmutabtorgstratastronv6y2004.html`.

[5] Citation analysis and the NASA Astrophysics Data System (2005), `http://www.astro.rug.nl/~vdkruit/jea3/homepage/ads.pdf`.

[6] Starting with www.iau.org/administration/membership/individual/186; membership numbers run from 186 to 9605.

[7] Starting at members.aas.org/directory/public_directory/member_details.cfm?ID=10000; AAS membership numbers run from 10,000 to 36,000.

[8] The institutes are listed in Appendix A.

[9] This normalisation is done by dividing the score for each paper by the number of authors. For example, a paper with five authors would contribute 0.2 to the normalised number of papers of each author. The same is done for normalised citations.

[10] J.E. Hirsch, Proc. Nat. Acad. Sci. 102(46), 16569 (2005); the value h of the h-index is defined such that the person involved is a (co-)author of h papers that have been cited more than h times.

	NOVA	TopUS	AAS	IAU	NOVA-kr
Number of people in sample	79	177	172	193	26
Number of papers	90	94	26	58	123
Number of first-author papers	21	22	8	19	23
Normalised number of papers	26	25	7	20	33
Number of normalised first-author papers	11	10	3	9	13
Number of citations	3325	4175	544	1042	4558
Number of first-author citation	795	971	112	256	1166
Number of normalised citations	704	929	86	271	1213
h-index	31	34	12	17	39
First-author h-index	13	14	4	8	14
Normalised h-index	14	16	5	9	16
First-author normalised h-index	9	10	3	6	10
Citations per paper	36	43	21	18	38
Citations per first-author paper	39	39	13	15	45
Normalised citations per normalised paper	33	35	17	14	37
Papers per year	3.9	3.3	1.6	1.9	5.6
Citations per year	131	141	34	34	229
Normalised papers per year	1.1	0.9	0.4	0.7	1.5
Normalised citations per year	34	33	6	10	57
First-author papers per year	0.9	0.9	0.5	0.6	1.2
First-author citations per year	40	33	8	9	59
Number of publishing years	25	30	18	30	22

Table 1: Medians of the various distributions of publication and citation scores for the samples of NOVA, topUS (15 top US institutions) tenured staff , AAS and IAU members and NOVA 'key-researchers. The distributions (except for NOVA-kr) are shown as histograms in Figures 1-21.

increases linearly with time. A more serious shortcoming is that it is not always calibrated between disciplines or (sub-)fields of scientific research, where very different publication and citation cultures may prevail. We will in this report use samples that give an idea of what a typical h-index is for an astronomical researcher. Another important effect is that of the number of authors on a paper. E.g. persons contributing to highly cited papers presenting a new instrument or survey all get the credit of an additional point on their h-index.[11] Therefore we also calculated h-indices using normalised citations. Furthermore, we also produced statistics using only papers on which the researchers involved are first author.

Figures 1–21 show representations of the performance of astronomers. Every figure shows in the bottom panels the histogram of astronomers of the TopUS, AAS and IAU samples. The second panel from the top shows the same property for the Dutch (NOVA) staff members and the top panel compares the distributions of all samples (NOVA – solid line, TopUS – dashed line, AAS – dashed-dotted line. IAU – dashed-three dotted line). We collect the median values of the various distributions in Table 1.

Before discussion the results we want to stress that in comparing the various samples it should be kept in mind that the selections are different for different samples. The NOVA and TopUS samples are active, tenured staff members and are selected in a comparable manner. But the AAS and IAU samples have been chosen at random from membership lists and will contain in addition postdocs and other non-tenured astronomers, retired astronomers and persons that are associated with astronomical research but to a large extent perform technical or other support functions. So, although the NOVA and TopUS samples are suitable for a direct comparison, the AAS and IAU samples can be expected on the grounds of their composition to score lower

[11] E.g., the Sloan Digital Sky Survey data release papers have well over a hundred authors and receive hundreds of citations. Such a paper will contribute one extra point to the h-index of all authors.

in bibliometric studies. They are useful, however, in finding out average (typical) values for astronomers of parameters such as the h-index.

It is easily seen from Figures 1 and 2 that the number of papers produced by NOVA astronomers is clearly higher than that of astronomers in the random samples and comparable to the astronomers in the top US institutions. However, it could be that that NOVA and TopUS astronomers have on average a different number of co-authors to their papers. This can be estimated from the ratio between the total and normalised number of papers. For NOVA, TopUS and AAS this is between 3.5 and 4, but for the IAU it is more like 2.9. In Figures 3 and 4 we see that the normalised number of papers for the IAU sample is more similar to NOVA and TopUS, but the AAS sample is not. IAU astronomers publish fewer papers, apparently with fewer co-authors than in the US and the Netherlands.

The AAS sample gives surprising results. This sample performs at a similar or lower level than that for IAU membership. The cause must be that there apparently are among the 'active' AAS members many astronomers that have not published very many papers. In fig. 2 we see that for the AAS astronomers about 45% have fewer than 20 refereed papers. This may seem surprising. However, a random check by hand, selecting only those members whose names start with 'Blo..', 'Men..' en 'Scha..' resulted in 14 out of 36 (39%) having 20 refereed papers or less and 9 (25%) more having between 21 and 40 papers. The number of papers per year is similar to that of the IAU sample. It is an effect of age (see Table 1): AAS astronomers have published on average for fewer years than the other samples. There appears no such difference between the NOVA and AAS samples; the NOVA astronomer on average publishes more papers per year. In fact, the average number of years that an astronomer has been publishing is 29 for NOVA and TopUS and 30 for IAU, but only 18 for the AAS sample (Figure 21). It does not have much to do with people publishing papers with many authors on them. The number of normalised papers per year is 0.9 (NOVA), 0.9 (TopUS), 0.4 (AAS) and 0.7 (IAU), so there appears to be less production in the AAS sample per astronomer. This was not found in a related older paper[12].

From Figures 5-7 we see that the number of citations and related parameters for NOVA astronomers is much higher than that of the IAU and AAS samples. One can also imagine that the distribution of citations per paper differs between the samples. We therefore show the the citations per paper in Figures 12-14 and the h-index (Figures 8-11). We also compare the citations received per year (Figures 15-20). All these figures show that the number of citations to papers by NOVA astronomers is significantly higher than that in the samples randomly selected randomly from the IAU and AAS membership lists. We noted already that this comparison is not entirely fair, as the NOVA-sample consists exclusively of tenured, active researchers.

The comparison of NOVA researchers to the faculty of the top-15 institutes in the USA, however, is between two samples that are selected similarly and the two samples are directly suited to look for differences in bibliometric performance. It is obvious from Table 1 that the NOVA sample performs as good or almost as good as the TopUS astronomers. Note that the number of publishing years is less for the NOVA sample than for the TopUS astronomers, indicating a smaller average age of Dutch tenured staff. Indeed recently (to a large extent due to the NOVA funding from the Bonus-incentives Scheme) a large number of new hires have been made, often replacing retiring staff on so-called 'overlap' positions. The set of key-researchers does even better, but these are of course selected from the most senior astronomers (none of them has an h-index below 20) and this sample should not be compared directly with the TopUS staff.

[12] *"A comparison of astronomy in fifteen member countries of the Organisation for Economic Co-operation and Development"*, P.C. van der Kruit, Scientometrics 31, 155-172 (1994), and *" The astronomical community in the Netherlands"* Quart. J. R.A.S. 35, 409 (1995). Available at www.astro.rug.nl/∼vdkruit/jea3/homepage/oecd.pdf and www.rug.nl/∼vdkruit/jea3/homepage/qjras.pdf.

Summarising:

We find that the NOVA researchers perform much better among bibliometric measures than samples drawn from IAU or AAS membership lists. More suitable for a comparison is with the (tenured) staff of the top-15 US institutions and there the outcokme is that NOVA staff performs in these respects as good or almost as good as that of American top instiutes.

4 The published NOWT results

Every three years the level of Dutch research and development is compared to that of other OESO countries. This is done in the *Nederlands Observatorium van Wetenschap en Technologie* (NOWT), the *Netherlands Observatory of Science and Technology*, which regularly publishes a report *Science and Technology Indicators*. This study is commissioned by the *Ministery of Education, Culture and Science* (OCW) and performed jointly by the *Center for Science and Technology Studies* (CWTS) of Leiden University and the *Maastricht Economic and social Research and training centre on Innovation and Technoly* (MERIT) of Maastricht University.

The NOWT makes use of several indicators. One of the most important ones is the number of citations to papers in refereed journals normalised by the number of citations that the average articles from the same years receive. This parameter is called the *impact ratio* and it indicates whether an article receives more citations (impact ratio > 1) or less (impact ratio < 1) than the average paper worldwide in the same discipline and published in the same year. This is used as an important indication of the quality, visibility and impact of scientific disciplines and the years preceding the report. Usually the window of the years of publication of the papers and the citations is 3 or 4 years prior to that of the NOWT study.

Between the reports of 2005 and 2008 the impact ratio of Dutch astronomy as a whole dropped from 1.25[13] to 1.19 according to NOWT. In the following we will investigate the reasons of this drop and whether this conclusion is robust. This will be done by analysing the citation patterns of articles with authors from the institutes that make up the *Netherlands Research School for Astronomy* (NOVA), using as a tool the *NASA Astrophysics Data System* (ADS).

We will examine first the results published by NOWT. We note first that between the reports there is an important difference in the focus of the studies; the 2005 report paid special attention to the workforce in R&D, whereas the focus of 2008 was budgets. Within the area of bibliometric parameters there is also a difference in emphasis between subsequent NOWT reports.

When we look at the impact ratios, we see that in the 2008 NOWT this is presented as the *total impact ratio* of the universities[14] as well as separate scores for the five universities and of the institutes of ASTRON and SRON.[15] The contributions of ASTRON and SRON are not all purely astronomical, but it is not a priori clear how NOWT treats this. Another thing that is striking in the 2008 report is that NIKHEF (NWO/FOM institute for high energy physics), Rijnhuizen (NWO/FOM institute for plasma physics) and KNMI (meteorology) are considered to produce astronomical publications. This may very well be unjustified; in any case we usually do not regard the staff of these institutes as part of the Dutch astronomical community. Certainly they are not part of the NOVA federation of institutes. Where the Rijnhuizen and KNMI effects

[13] Or 1.27; NOWT gives different results in their tables 4.6 and 4.7 of the 2005 report

[14] This is the impact ratio of 1.19 mentioned as the result for astronomy 2008.

[15] The *Netherlands Foundation for Research in Astronomy* ASTRON and the *Foundation for Space Research in the Netherlands* SRON are funded by the *Netherlands Organisation for Scientific Research* (NWO) primarily as technological organisations; they have institutes in respectively Dwingeloo and Utrecht/Groningen primarily for the design and construction of scientific instruments and the operation of observing facilities. Although there definitely is also related astronomical research, the staff of these institutes are not part of NOVA, which is a federation of astronomical institutes at universities. On the other hand, most astronomers employed by ASTRON and SRON have additional parttime or unpaid affiliations with NOVA institutes.

year	impact	Univ.
2008	1.19	Y
2005	1.25	
2003	1.29	
2000	1.30	Y
1998	1.07	

Table 2: Impact ratios for Dutch astronomy from NOWT reports. The last column indicates whether or not the number applies solely for the institutes at the universities

are small and probably negligible (19 and 10 papers respectively), the NIKHEF contribution is considerable (118 articles or of order 10%).

In the 2005 report the only number reported is an impact ratio for Dutch astronomy as a whole, being either 1.25 (Table 4.6) or 1.27 (Table 4.7). This raises some uncertainties. It is for example not clear whether or not this includes publications from the ASTRON and SRON institutes[16]. And the question is if it also includes NIKHEF, Rijnhuizen and the KNMI?

Going back further in time to the 2003 report, we see that in that report the total impact ratio of Dutch astronomy is 1.29. This 2003 NOWT also provides the impact ratios of the different institutions separately. In this report the impact ratio of astronomy at the universities is equal to the total impact ratio (1.29). It is interesting to see that in 2003 the contributions from ASTRON and SRON are not split into different disciplines and therefore one would assume that they are considered to be completely astronomical.

Table 2 shows the results retrieved from the NOWT reports back to 1998. From this table we see that the impact ratio in 1998 is lower than the current one; however, only two years later the highest impact ratio of the last decade is reported. So there are fluctuations on very short timescales that are unlikely to reflect significant variations in productivity, quality or relevance of Dutch astronomal research. Also, in 2000 and 2008 a total number for the universities only (essentially the NOVA federation) is given, e.g. not including ASTRON, SRON and other possible non-academic institutes.

The astronomy group at the Radboud Universiteit Nijmegen (RU) is new and included in the NOWT report for the first time in 2008. If we look at the impact ratio cited in the report of 2008 we see that their impact according to the NOWT is low (impact ratio = 1.03) compared to the other universities. They produce a much lower quantity of articles which reduces their contribution to the total number. In fact the impact ratio for the universities excluding RU would be 1.20.

These results produced in the NOWT reports suggest that the difference in impact ratio between 2005 and 2008 is within the normal scatter caused by natural fluctuations as well as inconsist methods of calculating the actual number for the whole of Dutch astronomy; the same must hold for the impact ratios of individual institutes.

5 The NOWT studies repeated using ADS

ADS has a query form where articles can be selected according to author, set of authors, words in title or abstract, journal, year of publication, etc. It also has an unsupported query form to search by affiliation, which we will use below. Since this is an unsupported feature of the database services, it is important to establish the trustworthiness of this type of query. To investigate the reliability of ADS we have obtained all the articles of the Kapteyn Astronomical Institute as well as those of the Sterrewacht Leiden and compared them to the Annual reports

[16] It is true that separate results are given for ASTRON as an institute.

of these institutes for the years 1998, 2000, 2003, 2004, 2005 and 2006. From this we find that ADS can be used as a reliable source back to the year 2000. Before 2000 entries for the major journals *Astrophysical Journal* and *Astronomical Journal* do not list affiliation consistently in ADS.

From the comparison of the Kapteyn Institute it became clear that persons with a cross-affiliation are often identified with their main affiliation only. Therefore in ADS roughly 15% of articles listed in the Annual reports are not attributed to the Kapteyn Institute since their authors have an unpaid-appointment with Groningen University in addition to their main affiliation (often ASTRON or SRON) and are solely affiliated with their main institutions in ADS. This problem should also affect the ratios presented in the NOWT reports, but is irrelevant for the impact ratio of Dutch astronomy as a whole. Another mismatch between the lists retrieved from ADS and the Annual Reports is caused by authors who recently have been relocated to a different institute. These authors are often affiliated with their new institutes while much of the work for the article concerned was done at their previous location. Fortunately, this behaviour seems to produce a similar number of additional articles as missing ones when compared to the annual reports. Of course, the actual affiliation mentioned on the papers corresponds to that found in the ADS listing and not to the Annual Reports. Even though there are cases where the affiliation mentioned on the paper is incorrect, these cases seem to be rare and they would most likely not be corrected by CWTS.

We therefore conclude that back until the year 2000, the affiliation search of ADS can be used to construct correct publication lists of the Dutch institutes. This period (2000-2008) also covers the period of the so-called *Dieptestrategie*[17]

We have obtained from ADS lists of all refereed articles, which are affiliated to one of the Dutch institutes, plus the number of citations to that article received up to December 2008. The number of citations of a paper here is the number of references to that article in *all* bibliographic publications, refereed as well as the unrefereed. We have calculated the impact ratios of the institutes by normalising these counts by average citation rates of papers in the same years of publication and with the same citation window. We have done that in several ways.

First, we determined impact ratios by taking only those Dutch publications that appeared in one of the four major astronomical journals and normalised these with the average number of citations of all papers in these journals published in the same years. The journals are *Astrophysical Journal, Astronomical Journal, Monthly Notices of the Royal Astronomical Society* and *Astronomy and Astrophysics*. Secondly, we did the same excercise, but now included in addition the astronomical publications in *Science* and *Nature*. Even though the number of articles in these latter journals is low, their impact is generally extremely high. Thirdly, we include two smaller journals (namely *Astronomische Nachrichten* and *New Astronomy Reviews*) in order to see whether the addition of such journals severely affects the impact ratios. Fourthly, we calculated the citation rates for the total of all refereed Journals in ADS as listed in `http://adsabs.harvard.edu/abs_doc/refereed.html`. In this case of 'all journals' the numbers involved are so large that ADS can only handle one month at the time. Therefore it is very time-consuming to calculate the normalisation factor. We have solved this by taking only the first and last two months into consideration. This assumes that the number of citations per article declines linearly throughout the period considered.

To make a comparison to the NOWT results, we finally used a citation window equal to that of the publication years, as is done in the CWTS and NOWT studies. We used again all refereed journals. Such a citation window is uncomfortably small since a publication on the last day of the window would never obtain citations no matter what its eventual impact is. However, the

[17]The *'Bonus-incentives Scheme'*, in which NOVA has been recognized as a top-research school in 1998 and receives additional funding since then.

Method	2000-2002	2000-2003	2003-2005	2003-2006
4 Major journals	1.22(873)	1.21(1193)	1.27(970)	1.27(1399)
6 Major journals	1.23(889)	1.24(1219)	1.31(1182)	1.31(1428)
8 Journals	1.27(893)	1.27(1238)	1.31(1024)	1.31(1490)
All refereed journals	1.87(986)	1.89(1376)	2.00(1182)	2.00(1721)
Citation window	1.81(986)	1.78(1376)	1.93(1182)	1.87(1721)
All NL	1.74(1285)	1.71(1830)	1.86(1578)	1.80(2261)
NOWT		1.27(1807)		1.19(1311/1407*))

Table 3: Impact ratios (Number of publications) for the different methods described in the text for the periods 2000-2002, 2000-2003, 2003-2005, 2003-2006 (always last year inclusive). In the top part, the impact ratios are the summed results of the Dutch universities together and the citation window extends to (and including) 2008. In the bottom part the publication and citation windows are the same. The first row is for the universities together and the second one all Dutch publications. The NOWT impact ratios in the bottom line are for all Dutch publications for 2000-2003 and for the universities only for 2003-2006.
*)The publication output is given as a percentage of the total output in table 4.6 of the 2008 NOWT report. The individual results of the universities amount to a higher total than the percentage of total output given in this table.

normalisation should be affected in the same way and thus differences should be small as long as the sample is large. In ADS such a window must be set by hand.

We determined all these results for a two 3-year periods (2000-2002 and 2003-2005) as well as two 4-year periods (2000-2003 and 2003-2006) to see whether such changes in the time window are of any influence on the impact ratios.

Detailed results as obtained from the ADS are presented in Tables 6-9 at the end of the report. These tables present the impact ratios for all institutes as well as the overall results for the universities and for all astronomical institutes. Table 6 shows the results as obtained from the NOWT reports and Tables 5-9 the results as obtained from ADS.

The impact ratios and total numbers of publications found using the various normalisations described above are collected in Table 3. It shows that, according to the data obtained with ADS, the impact of the Dutch articles is *increasing* instead of decreasing. This trend is seen in all the different methods that were used to process the ADS data. This is different from the NOWT results and we will try to find out why this is so.

First note that for the period 2003-2006 the number of publications that NOWT uses is already comparable to those in the four major journals. In total ADS has found many more publications from authors at the Dutch universities (1721) than NOWT has for all of Dutch astronomy (1311 or 1407). The situation is is different for the period 2000-2003, where NOWT and ADS find comparable numbers (1807 versus 1830). In any case, the results for 2003-2006 in the NOWT is derived from fewer publications than in reality have been published by all Dutch astronomers. Note that inclusion of the non-academic institutes in the sample would only have an effect if their workers would pre-dominantly publish outside the four major journals. However, this is not the case, which can be seen by comparing the number of publications for ASTRON and SRON in Tables 5 and 8. This shows that also these institutes publish mostly in the four major journals.

Another remarkable feature in Table 3 is the high impact ratios obtained when considering all refereed journals in ADS. This is purely caused by the fact that the bulk of the Dutch astronomical publications are in the major journals, in papers which receive many more citations than publications in other journals. Since the Dutch astronomical publications mostly appear in the major journals the average number of citations per article does not change much when one includes less important journals, while the average number of citations per article of the field is severely lowered by the inclusion of smaller journals. The CWTS solves this in their studies by also calculating the impact ratio with respect to the actual journal citation rates rather than that of the field. This could be done in ADS also, but is less straightforward to implement.

When we consider the number of publications of NIKHEF we find a large difference between NOWT and the number of articles found in ADS. The 2008 NOWT states 118 articles whereas ADS produces 11 articles for all refereed journals. This is caused by the fact that articles in the journal *Physical Review D* are always considered to be astrophysical by the ISI *Web of Knowledge* (WoK) whereas ADS splits articles in this journal into astronomy articles and physics articles. Interestingly the WoK considers all these articles also to be physics articles. A quick glance at the articles in question shows that the majority of these articles are related to the decay or branching of elementary particles. It is questionable whether such articles should be considered astrophysical.

ADS finds more publications (in 2003-2006) than NOWT. We also found that comparing to annual reports even ADS is still missing publications from the university institutes due to double affiliations. This should not be a problem when all Dutch insttiutes are considered since in general such publications then would be found. Still, there appears a clear underrepresentation of papers in refereed journals in the NOWT data. At the same time all impact scores are higher when determined with the use of ADS. We believe that the ADS results (both the values of the impact ratios themselves as the trend with time) are robust and a better determination of the actual situation than the NOWT results.

It is also interesting to see that the choice of citations window does not affect the trend observed in the impact ratio. However, a citation window that coincides with the publication window does significantly lower the impact ratio, as would be expected.

When comparing the number of citations found per article, we find that articles in ADS consistently gain more citations with respect to the same articles in the WoK. This is caused by the fact that the WoK does not count citations to the article when the reference is made with a pre-print identifier. In a society where the use of pre-print archives becomes more and more common, one can expect this lack of citations in the WoK to become increasingly important. Also this effect is most likely more pronounced in the NOWT reports because of the short citation windows.

Summarizing:
From a citation analysis through the use of ADS we conclude that the impact ratio of Dutch astronomical publications is actually rising. This trend seems to be firm over several methods of calculating the impact ratio and is opposite to what is reported in the NOWT reports. This difference is most likely caused by a better separation of astronomy and physics in ADS than in the WoK. ADS probably finds more citations in conference proceedings, while the inclusion of citations to articles with their pre-print identifier could also help explain the difference (especially since the citation windows in the reports are short). Differences in the actual selection process between the different NOWT reports seem to be present and contributing to the differences between ADS and the NOWT report.

6 Figures and tables

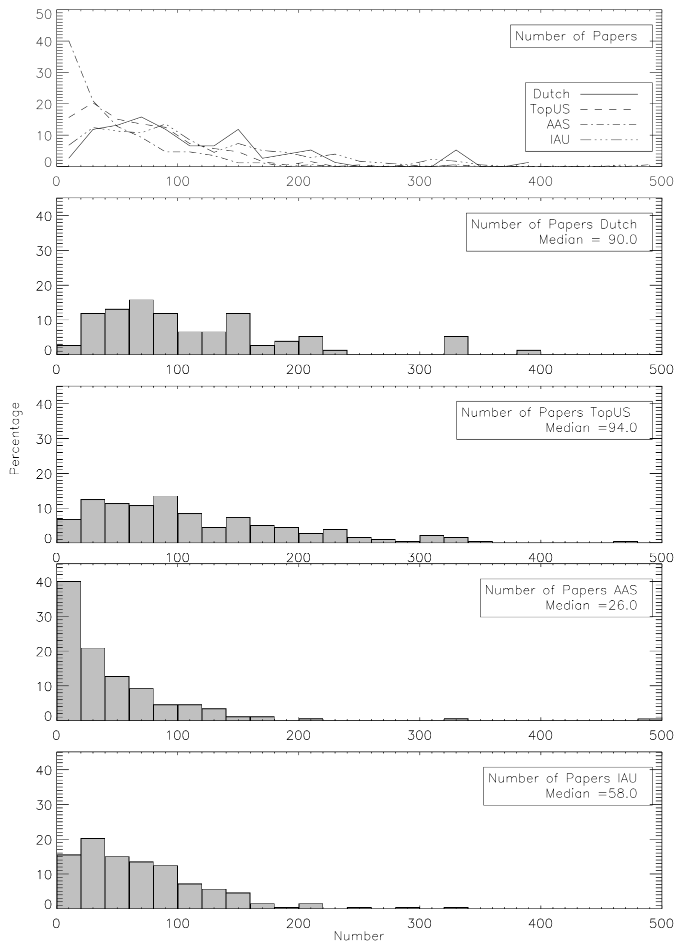


Figure 1: Histograms and a plot of the percentage of authors (y-axis) that has a certain number of papers (x-axis). From top to bottom: (1) The Dutch (solid line) ,the TopUS (dashed line), random AAS (dot-dashed line) and random IAU (three-dotted-dashed line) samples. (2) Histogram of the distribution of the Dutch sample. (2) Histogram of the distribution of the TopUS sample. (3) Histogram of the distribution of the AAS sample. (4) Histogram of the distribution of the IAU sample.

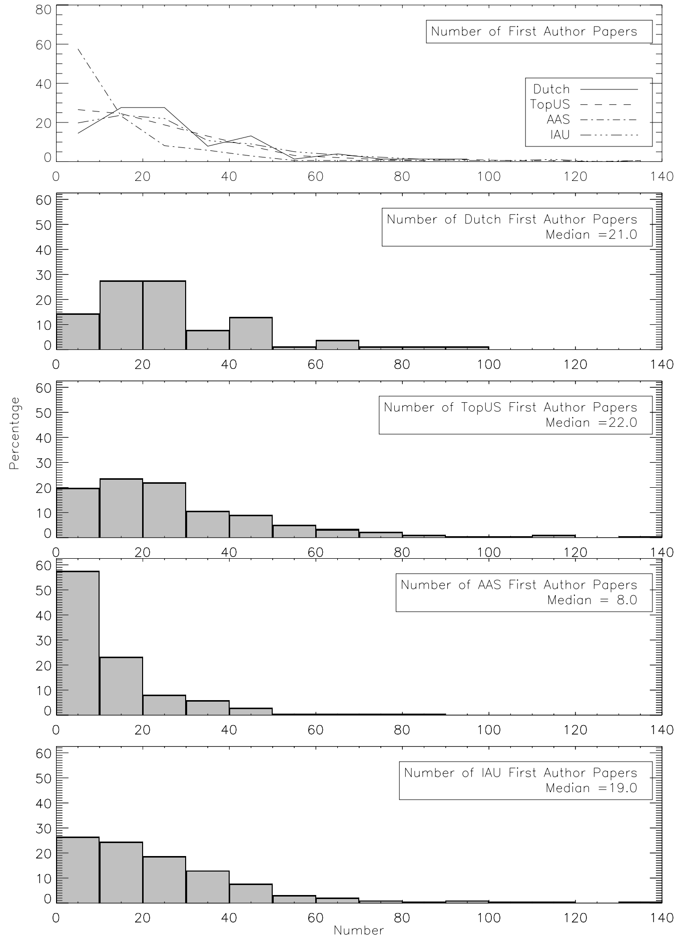


Figure 2: As Figure 1 but now only first author papers are considered.

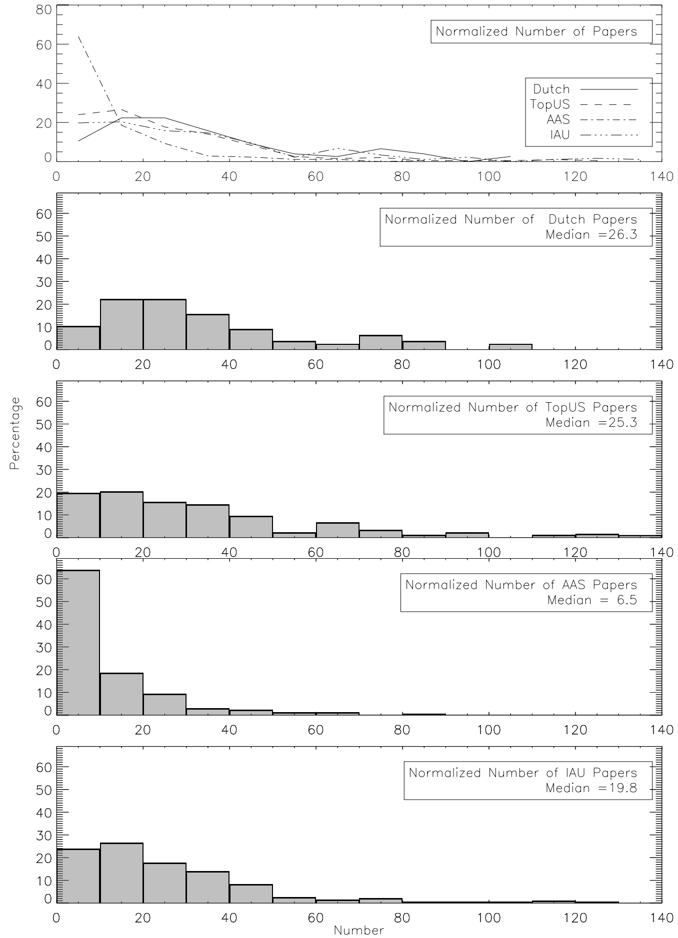


Figure 3: As Figure 1 but now the papers are normalised to the number of authors.

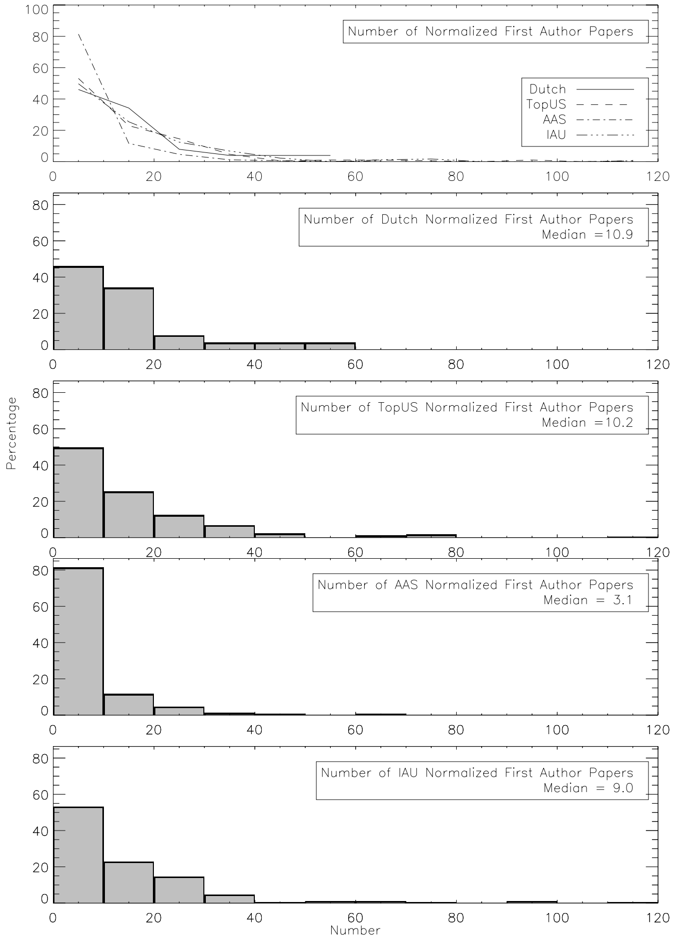


Figure 4: As Figure 2 but now the papers are normalised to the number of authors.

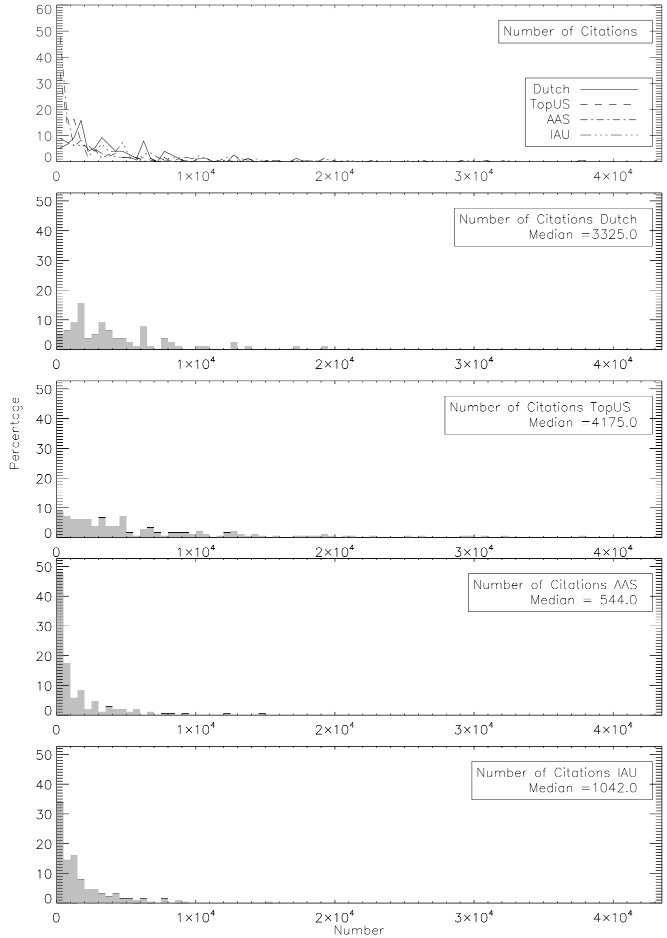


Figure 5: As Figure 1 but now for the citations received.

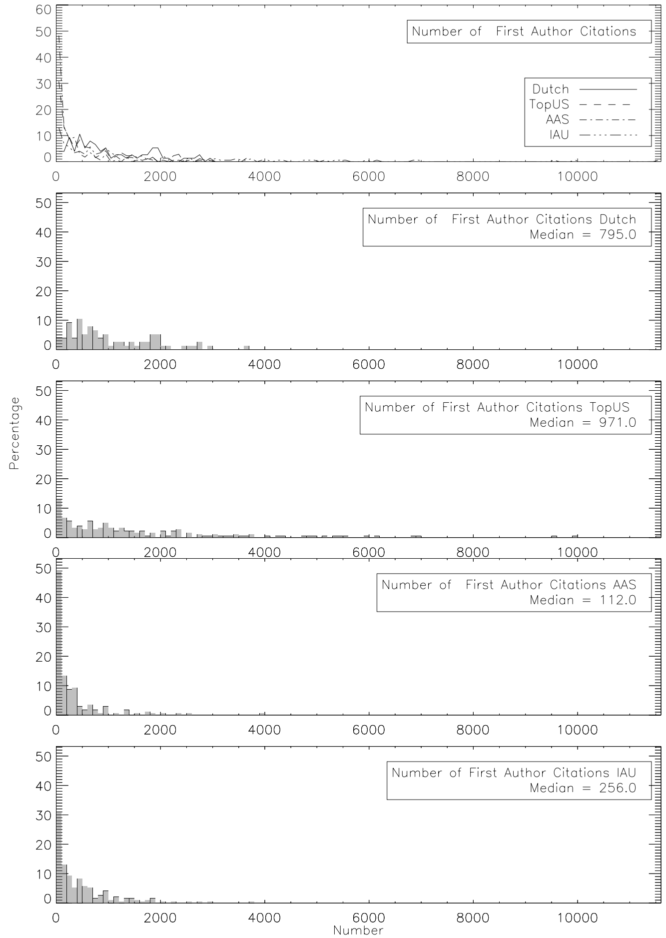


Figure 6: As Figure 5 but now only first author papers are considered.

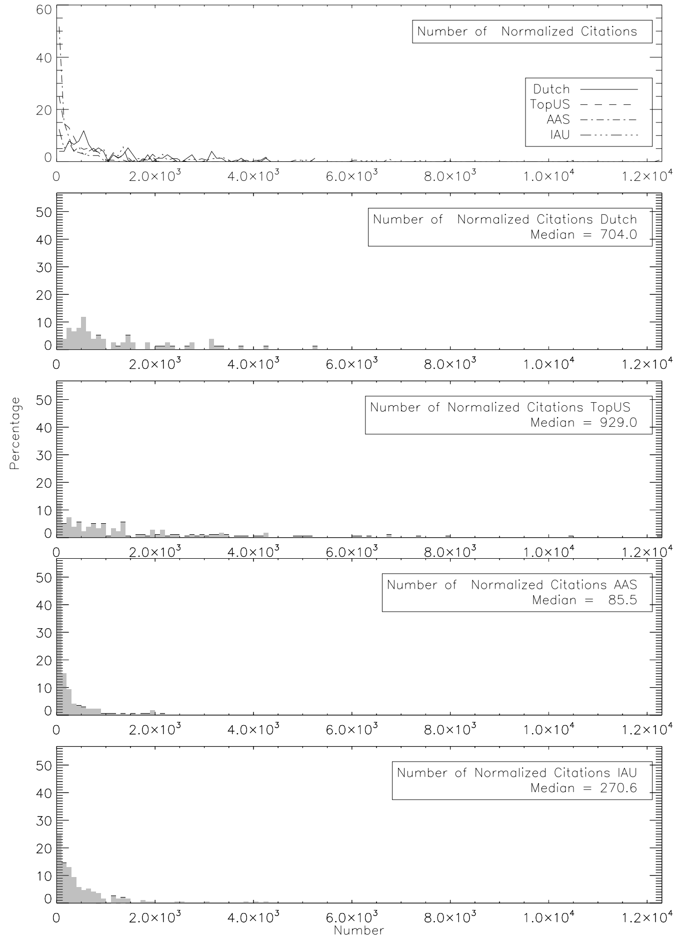


Figure 7: As Figure 5 but now the citations are normalised to the number of authors.

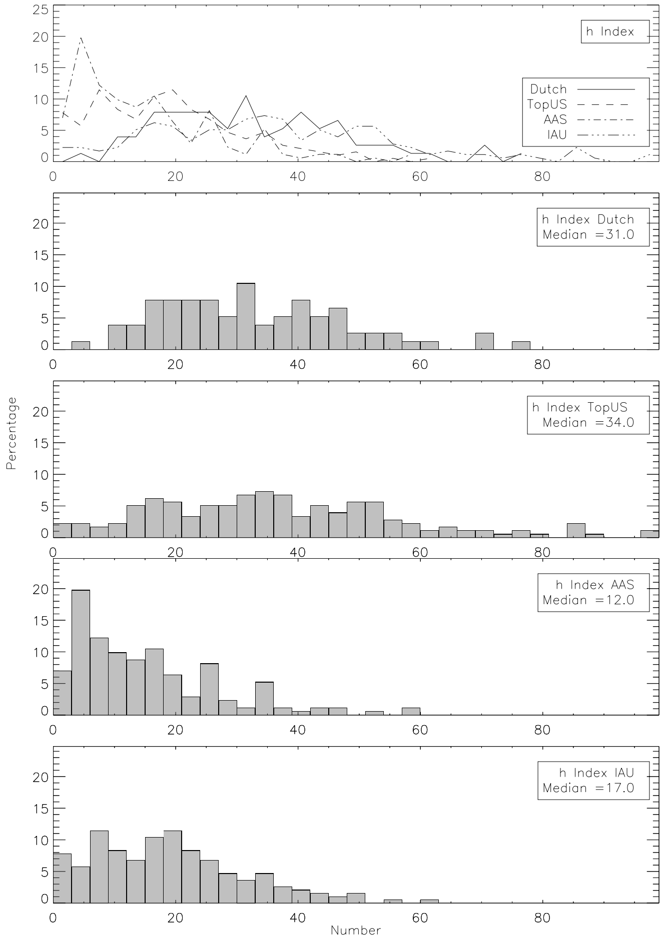


Figure 8: As Figure 1 but now for the h-index.

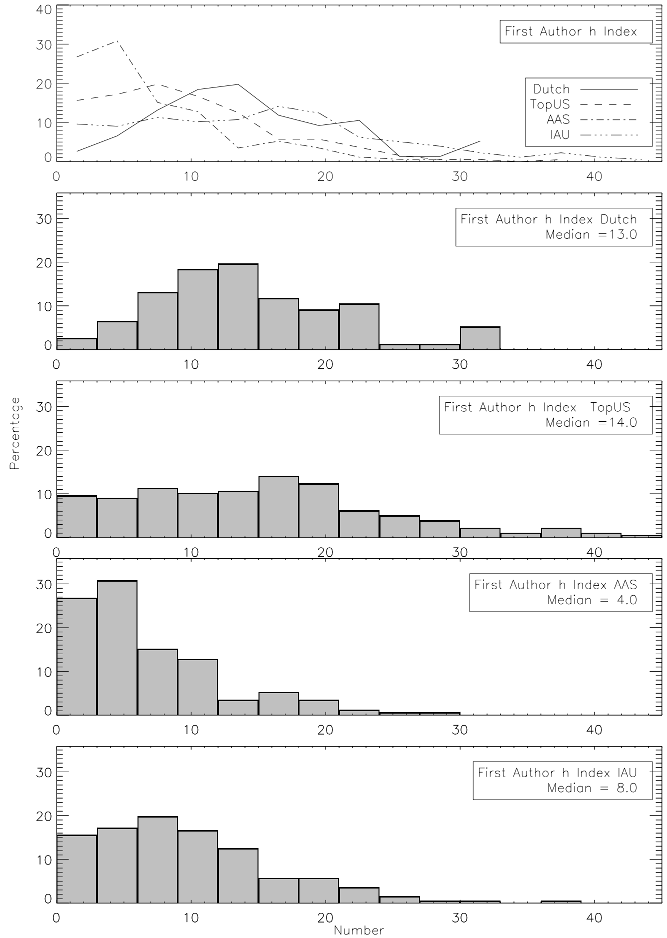


Figure 9: As Figure 8 but now only first author papers are considered.

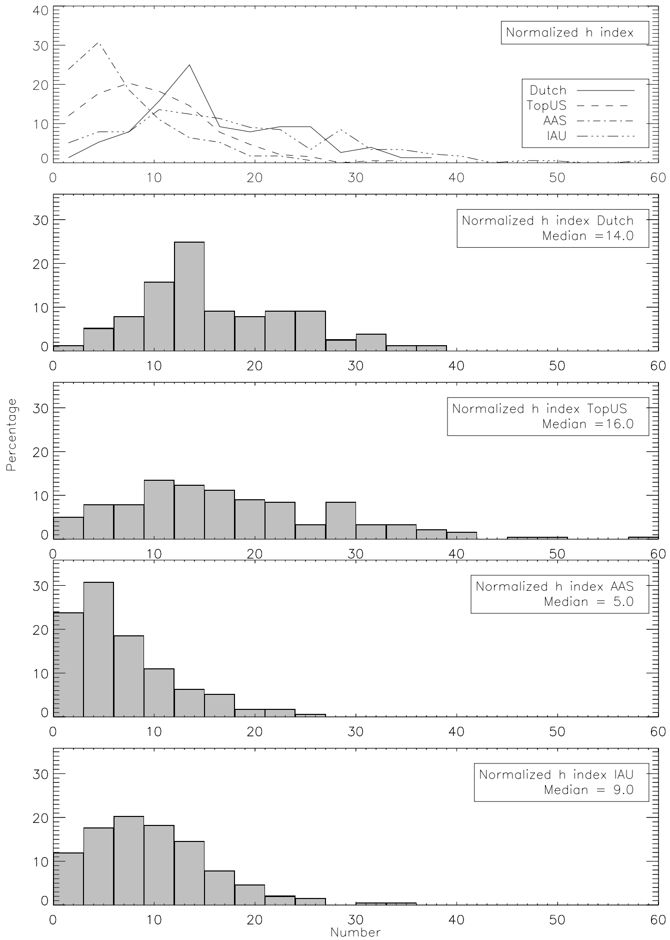


Figure 10: As Figure 8 but based on normalised citations.

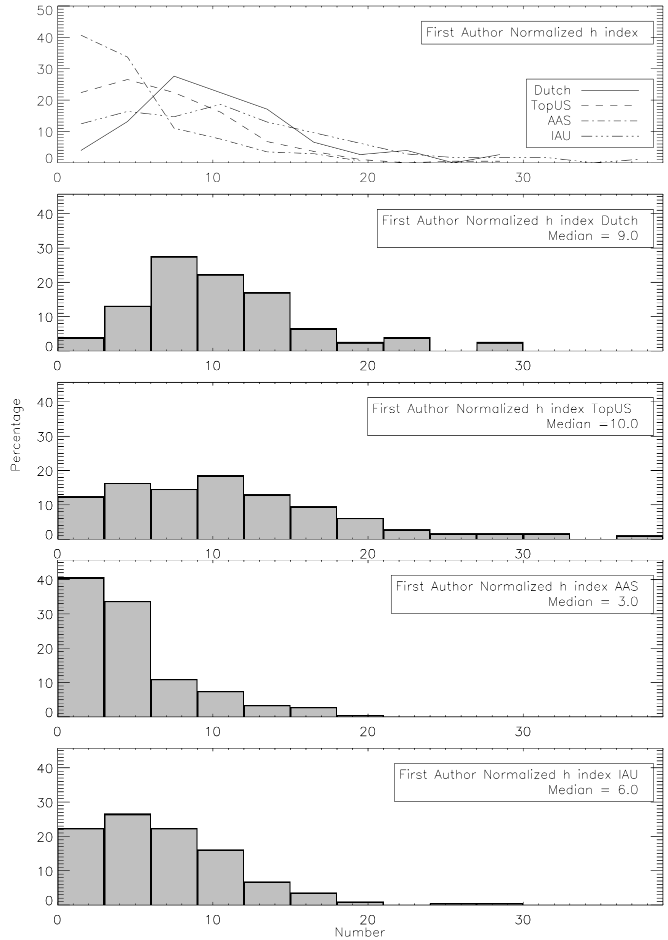


Figure 11: As Figure 9 but based on normalised citations.

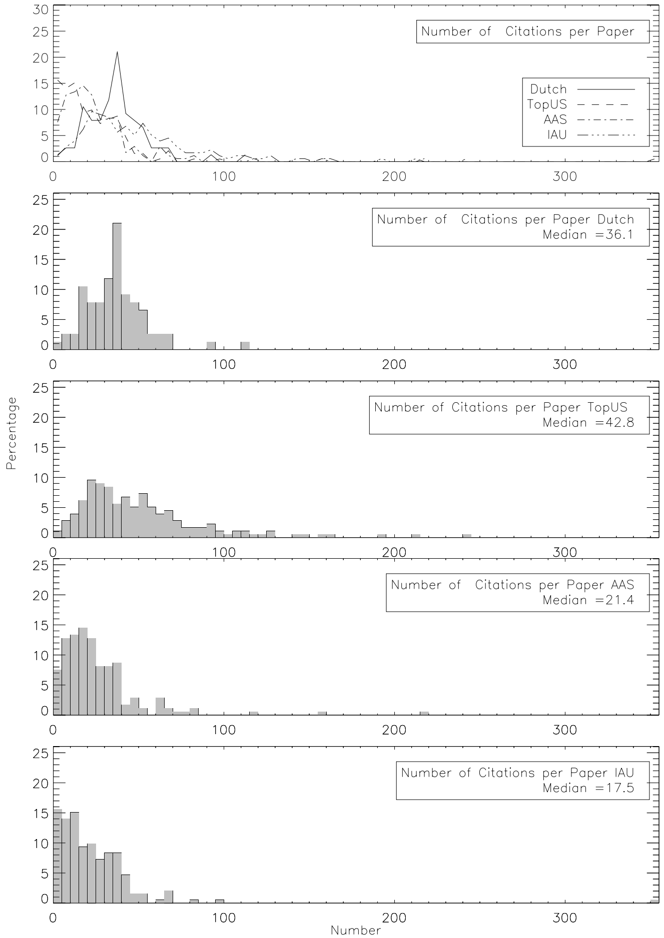


Figure 12: As Figure 1 but based on citations per paper.

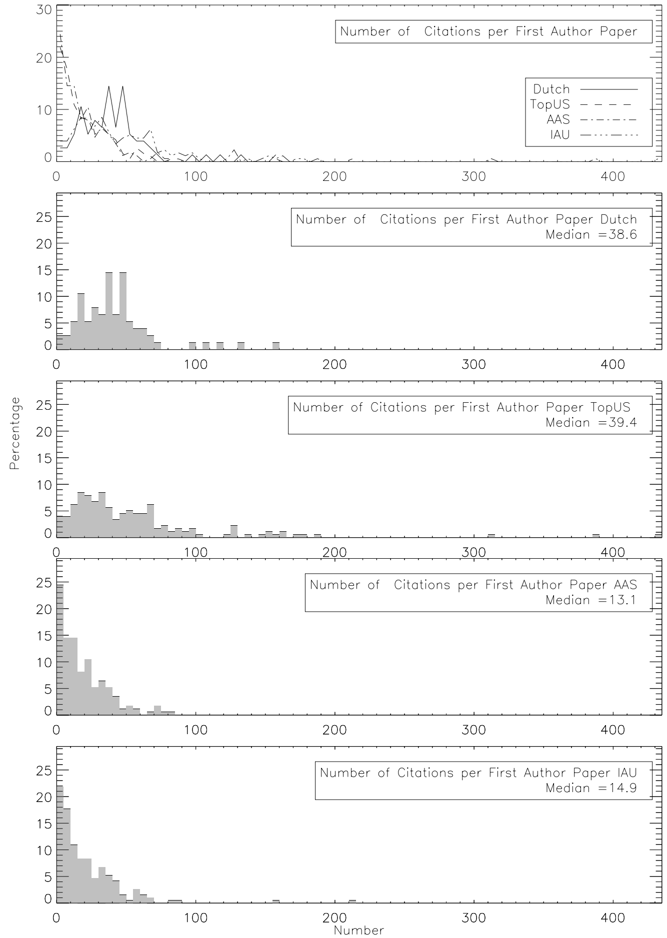


Figure 13: As Figure 12 but only considering first author papers.

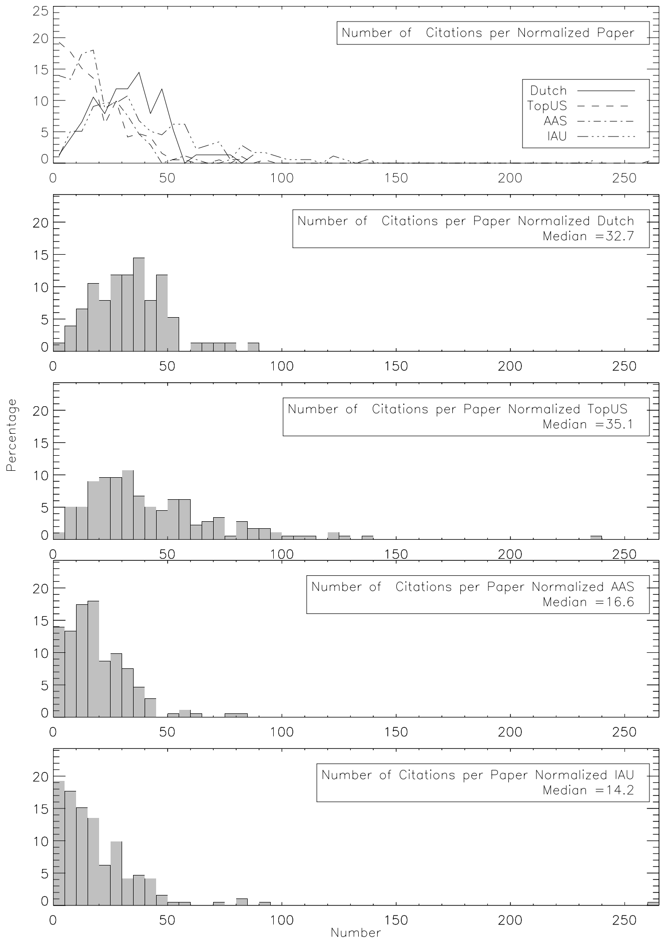


Figure 14: As Figure 12 but with citations and papers normalised to the number of contributing authors.

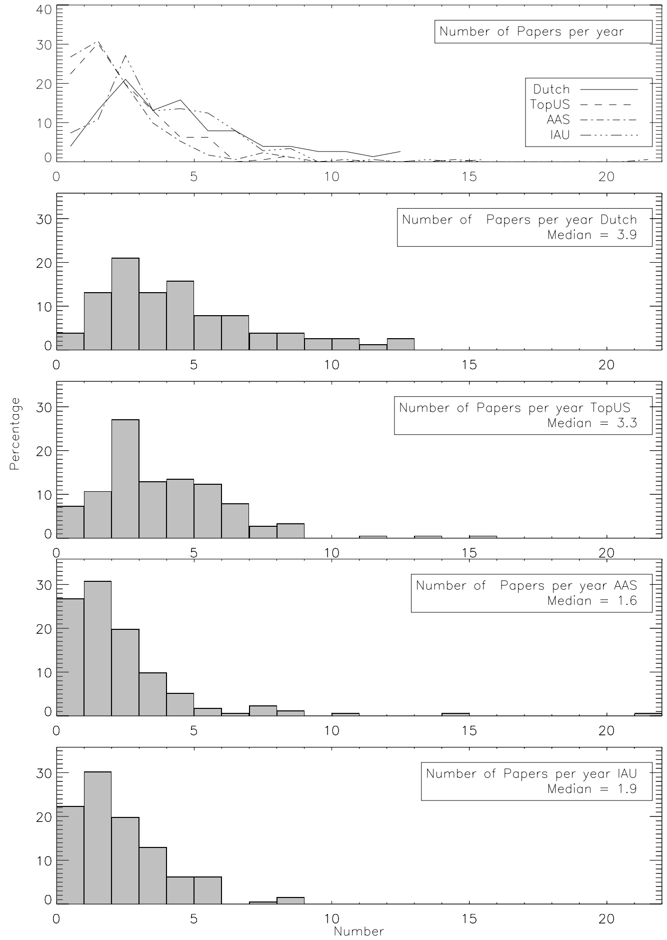


Figure 15: As Figure 1 but based on articles per year.

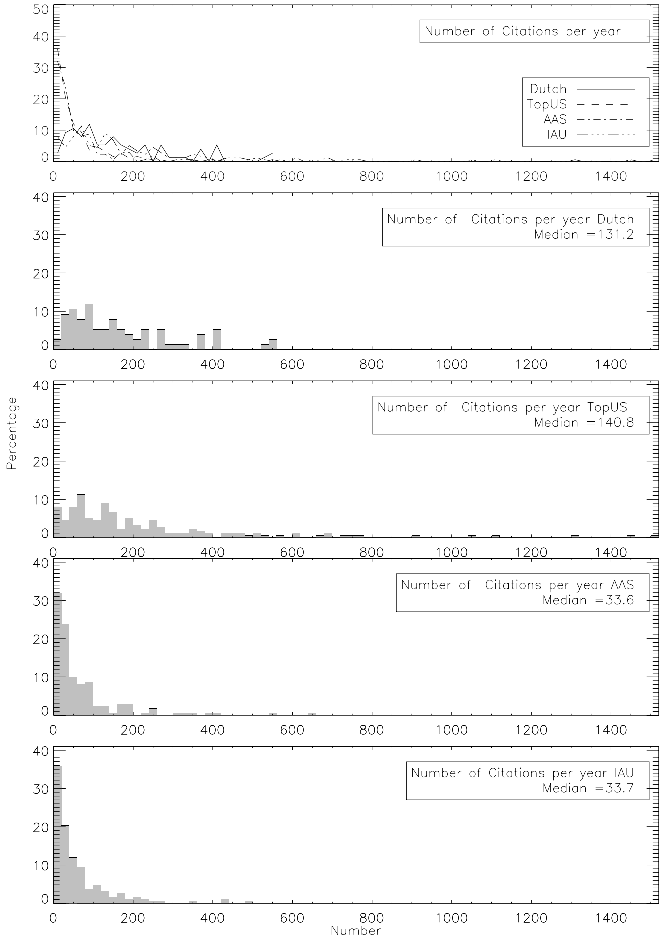


Figure 16: As Figure 1 but based on citations per year.

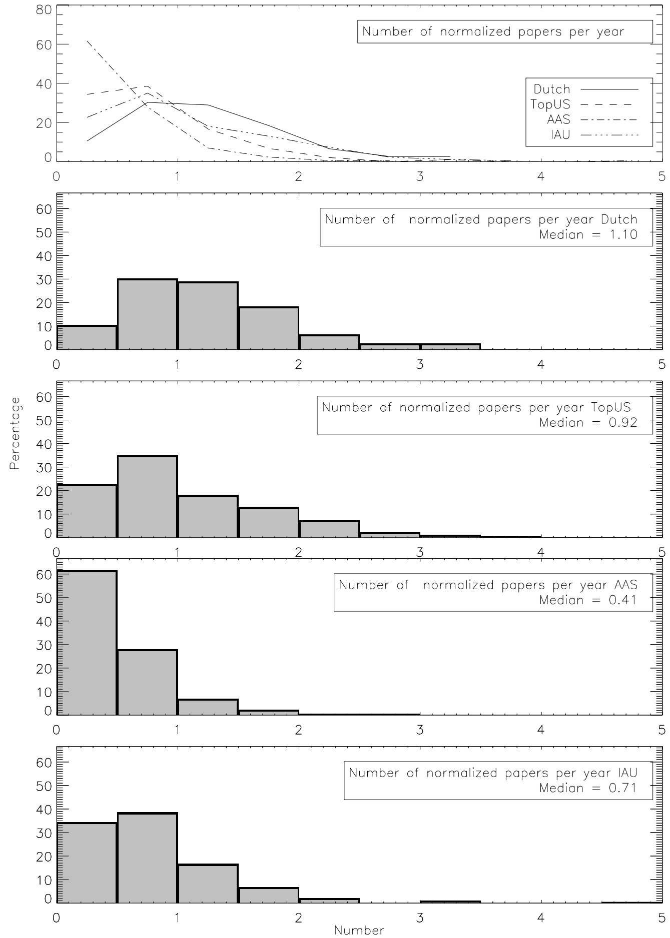


Figure 17: As Figure 1 but based on normalised articles per year.

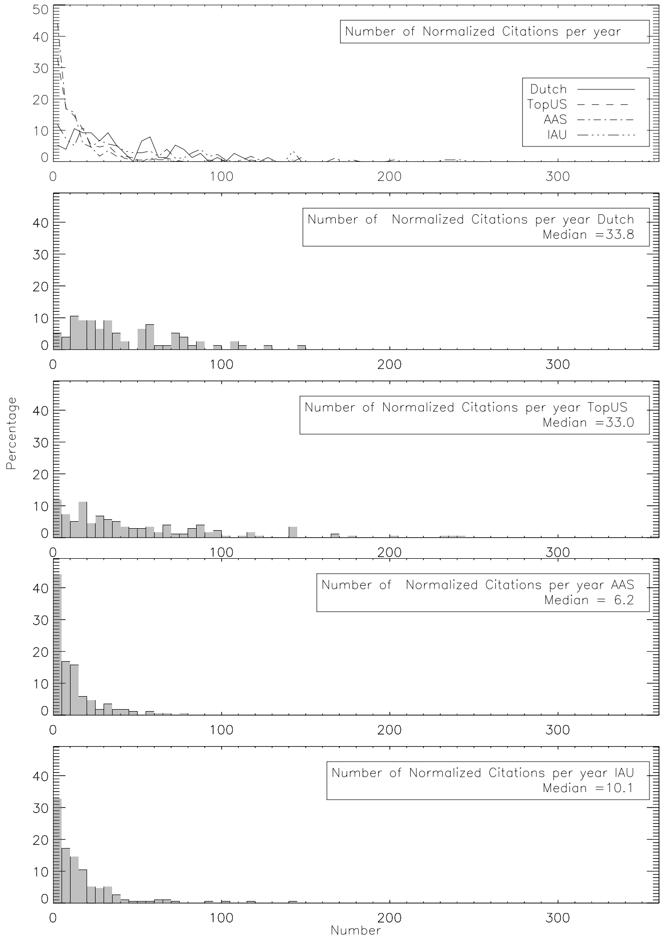


Figure 18: As Figure 1 but based on normalised citations per year.

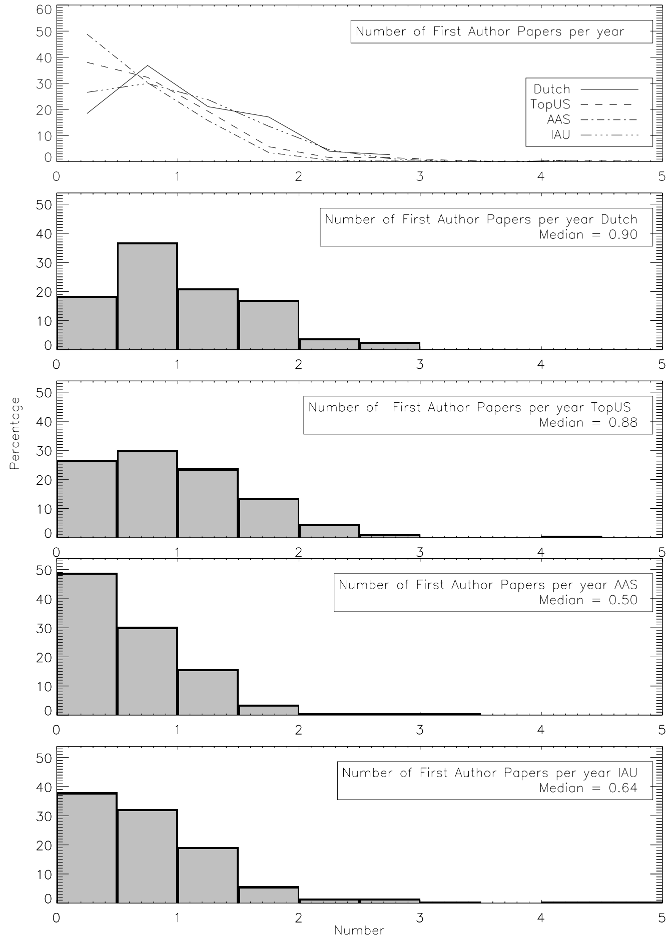


Figure 19: As Figure 15 but based on first author articles only.

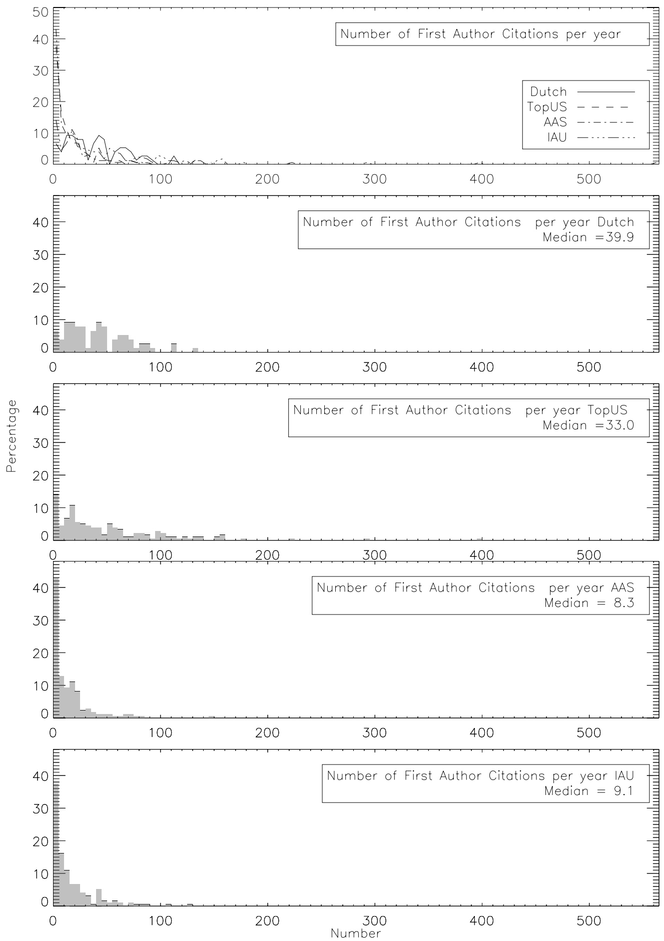


Figure 20: As Figure 19 but based on citations per year.

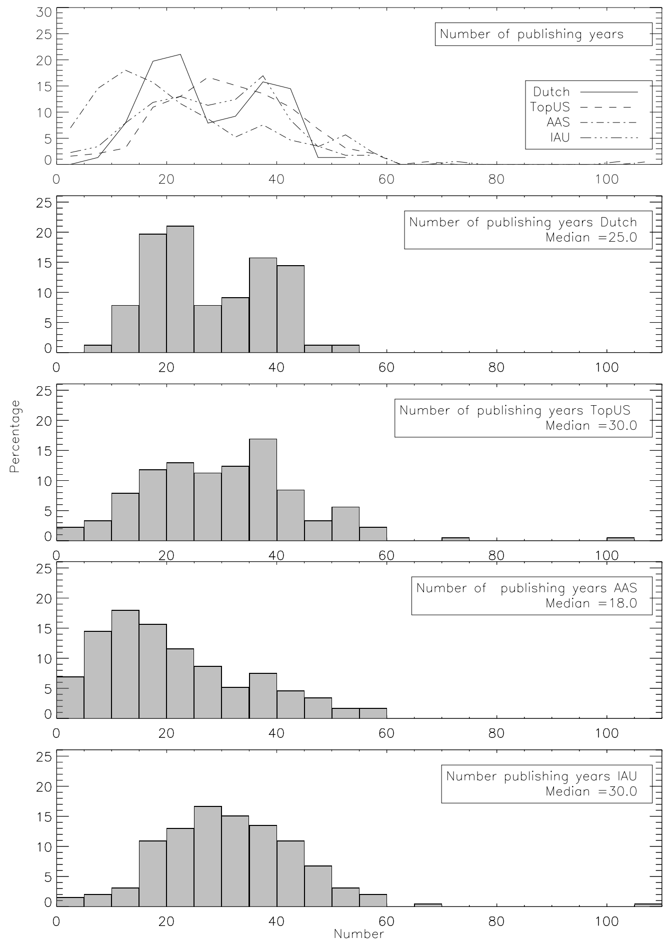


Figure 21: As Figure 1 but based on the number of years an author has been publishing (e.g. number of years between the first and last article).

Impact ratio												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)		1.19	1.19	1.18	1.03	1.26	1.13	0.84(s)	1.27(s)	1.13	0.85	0.22
2005(2000-2003)	1.27											
2003(1998-2001)	1.29	1.29	1.43	1.35		1.22	1.2	1.66(a)	1.04(a)			
2000(1994-1998)		1.3										
1998(1992-1996)	1.07	1.11										
Total number of publications												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)		1311	276	470	94	390	177	233(s)	300(s)	118	19	10
2005(2000-2003)	1807											
2003(1998-2001)								114(a)	463(a)			
2000(1997-1998)												
1998(1995-1996)	390											

Table 4: Impact ratios of astronomy from the NOWT reports.

(a) All institute publications (technical and astronomical). (s) Solely astronomy publications.

Impact ratio												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1.23	1.27	1.28	1.46	0.79	1.20	1.13	1.07	1.14	0.20	0.86	0.37
2008(2003-2005)	1.22	1.27	1.23	1.44	0.88	1.20	1.18	1.05	1.14	0.18	0.84	
2005(2000-2003)	1.18	1.21	1.17	1.29	0.46	1.25	1.12	0.87	1.22		0.78	
2005(2000-2002)	1.21	1.22	1.14	1.35	0.37	1.26	1.09	0.90	1.30		0.79	
Total number of publications												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1812	1399	292	475	95	365	172	163	228	1	18	3
2008(2003-2005)	1273	970	212	325	52	264	117	119	167	1	16	0
2005(2000-2003)	1570	1193	279	365	15	338	196	128	239	0	10	0
2005(2000-2002)	1125	873	211	260	6	245	151	80	165	0	7	0

Table 5: Impact ratios calculated from ADS solely based on the the 4 major journals (Astronomy & Astrophysics, Monthly Notices of the Royal Astronomical Society, Astrophysical Journal, Astronomical Journal). Citation window up to december 2008. Each range of years includes the last year.

Impact ratio												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1.26	1.31	1.29	1.47	0.84	1.34	1.10	1.09	1.11	2.07	0.84	0.36
2008(2003-2005)	1.26	1.31	1.24	1.46	0.95	1.31	1.15	1.08	1.11	1.86	0.82	
2005(2000-2003)	1.20	1.24	1.20	1.30	0.63	1.31	1.13	0.86	1.23		0.90	
2005(2000-2002)	1.21	1.23	1.16	1.34	0.75	1.25	1.11	0.89	1.31		0.94	
Total number of publications												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1848	1428	296	483	98	379	172	169	228	2	18	3
2008(2003-2005)	1300	1182	215	332	55	272	117	124	167	2	16	0
2005(2000-2003)	1603	1219	284	371	17	348	199	131	242	0	11	0
2005(2000-2002)	1146	889	214	263	8	250	154	81	168	0	8	0

Table 6: Impact ratios calculated from ADS solely based on the 6 major journals (Astronomy & Astrophysics, Monthly Notices of the Royal Astronomical Society, Astrophysical Journal, Astronomical Journal, Science, Nature). Citation window up to december 2008. Each range of years includes the last year. ¿From Nature and Science only articles listed as astronomical are included.

Impact ratio												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1.26	1.31	1.29	1.47	0.84	1.34	1.10	1.09	1.11	2.07	0.84	0.36
2008(2003-2005)	1.26	1.31	1.24	1.46	0.95	1.31	1.15	1.08	1.11	1.86	0.82	
2005(2000-2003)	1.20	1.24	1.20	1.30	0.63	1.31	1.13	0.86	1.23		0.90	
2005(2000-2002)	1.21	1.23	1.16	1.34	0.75	1.25	1.11	0.89	1.31		0.94	
Total number of publications												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1931	1490	321	514	98	382	175	187	231	2	18	3
2008(2003-2005)	1344	1024	228	349	55	274	118	134	168	2	16	0
2005(2000-2003)	1627	1238	289	384	17	349	199	135	243	0	11	0
2005(2000-2002)	1150	893	216	264	8	251	154	81	168	0	8	0

Table 7: Impact ratios calculated from ADS solely based on the 6 major journals (Astronomy & Astrophysics, Monthly Notices of the Royal Astronomical Society, Astrophysical Journal, Astronomical Journal, Nature, Science) plus two smaller journals (Astronomische Nachrichten and New Astronomy Reviews). Citation window up to december 2008. Each range of years includes the last year.

Impact ratio												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1.89	2.00	1.99	2.19	1.32	2.11	1.70	2.45	1.67	1.29	0.93	0.34
2008(2003-2005)	1.90	2.00	1.92	2.17	1.56	2.07	1.71	2.54	1.62	1.29	0.93	0.20
2005(2000-2003)	1.85	1.89	1.83	1.91	1.02	2.08	1.76	1.90	1.82	0.39	1.36	0.14
2005(2000-2002)	1.81	1.87	1.76	2.01	1.12	1.96	1.71	1.32	1.93	0.27	1.53	0.13
Total number of publications												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	2261	1721	349	593	113	430	236	215	273	11	31	10
2008(2003-2005)	1578	1182	252	406	60	308	156	152	203	8	26	7
2005(2000-2003)	1830	1376	315	438	20	371	232	155	280	5	12	2
2005(2000-2002)	1285	986	233	298	11	266	178	91	195	3	8	2

Table 8: Impact ratios calculated from ADS based on all refereed journals as listed by ADS. Citation window up to december 2008. Each range of years includes the last year.

Impact ratio												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	1.80	1.87	1.83	1.99	1.15	2.09	1.56	1.60	1.61	1.48	0.99	0.17
2008(2003-2005)	1.86	1.93	1.87	1.97	1.18	2.17	1.74	1.69	1.74	1.60	0.92	0.08
2005(2000-2003)	1.71	1.78	1.72	1.76	0.92	1.90	1.77	1.08	1.74	0.26	1.20	0.32
2005(2000-2002)	1.74	1.81	1.77	1.91	1.33	1.89	1.64	1.23	1.64	0.37	1.37	0.14
Total number of publications												
year report (calc)	Total	univ.	RUG	UL	RU	UvA	UU	ASTRON	SRON	NIKHEF	Rijnhuizen	KNMI
2008(2003-2006)	2261	1721	349	593	113	430	236	215	273	11	31	10
2008(2003-2005)	1578	1182	252	406	60	308	156	152	203	8	26	7
2005(2000-2003)	1830	1376	315	438	20	371	232	155	280	5	12	2
2005(2000-2002)	1285	986	233	298	11	266	178	91	195	3	8	2

Table 9: Impact ratios calculated from ADS based on all refereed journals as listed by ADS . Citation window is equal to the publication period. Each range of years includes the last year.

7 Appendix A

The 15 instutes that were considered as top in US are listed below. This list was constructed by taking the astronomy departments of the first 13 instutes as listed in Table 1 of A.L. Kinney's "The Science Impact of Astronomy PhD Granting Departments in the United States"[18] and supplemented with UCLA and the University of Texas at Austin. For our analysis only faculty that is listed as active and part of astronomy are considered. Faculty that is listed as physicist is excluded from our sample.

1 Caltech
2 UC Santa Cruz
3 Princeton University
4 Harvard University
5 Colorado
6 SUNY Stony Brook
7 Johns Hopkins University
8 Penn. State Univ.
9 Univ. Michigan
10 Univ. Hawaii
11 Univ. Wisconsin
12 UC Berkeley
13 Michigan State Univ.
14 UCLA
15 Univ. Texas

[18] arXiv:0811.0311

Portfolio Nederlandse Natuur- en Sterrenkunde

EINDVERSLAG

TWINS Raad
prof.dr.ir. P. Kruit

KONINKLIJKE NEDERLANDSE AKADEMIE VAN WETENSCHAPPEN

Inhoud

Samenvatting

In dit rapport worden de resultaten van het door de voormalige Raad voor Natuur- en Sterrenkunde (deze raad is in 2009 opgegaan in de TWINS Raad) opgestarte project Portfolio Nederlandse Natuur- en Sterrenkunde beschreven. In dit project stonden de volgende vragen centraal:

1. Zijn er gebieden in de natuur- en sterrenkunde waar Nederland (te) weinig aandacht aan besteedt in vergelijking met andere landen?
2. Is het mogelijk om aan te tonen dat de relatie tussen wetenschap en innovatief bedrijfsleven in Nederland zwakker is dan elders? Deze vraagstelling werd ingegeven door de observatie dat er in Nederland veel wordt gesproken over een vermeende kloof tussen wetenschappelijk onderzoek en het gebruik ervan, de zogenaamde innovatieparadox, maar dat hier eigenlijk nergens een objectief bewijs van wordt gegeven.

Onderzocht is of deze vragen beantwoord kunnen worden door een vergelijking te maken tussen de aandachtsgebieden in de Nederlandse fysica (en sterrenkunde) en de aandachtsgebieden in het buitenland. Het project bestond uit twee fases. In de eerste fase zijn door een analyse van wetenschappelijke publicatie activiteiten objectieve gegevens verzameld over de wetenschappelijke activiteit in verschillende deelgebieden van de natuur- en sterrenkunde. In de tweede fase is geprobeerd om een vergelijking te maken tussen de wetenschappelijke activiteit in bepaalde gebieden en het gebruik van de resultaten. Dit is gedaan door een analyse van de octrooiliteratuur.

In de eerste fase zijn in 160 verschillende (sub)vakgebieden in de natuur- en sterrenkunde publicatie aantallen geteld. Hoewel deze gegevens met de nodige voorzichtigheid moeten worden geïnterpreteerd, lijkt hieruit het volgende beeld te ontstaan:

1. Nederland is zeer actief in de astronomie en buitengewoon actief in de biofysica en medische fysica.
2. De Nederlandse activiteit vindt plaats op meer fundamentele gebieden, zoals theory, acoustics, flow, mesoscopic systems, biophysics, bio imaging, mathematics, simulation and computing. In bijvoorbeeld Zuid Korea zijn juist gebieden als surface- and interface physics, materials, dielectric properties en electronics relatief sterk, deze onderwerpen liggen dichter bij industriele interesses.
3. Algemene universiteiten hebben een duidelijk ander activiteitenprofiel dan technische universiteiten
4. De wetenschappelijke activiteit groeit in de rest van de wereld veel sneller dan in Nederland. In sommige landen als Zuid Korea is de activiteit in 10 jaar 3x zo hoog geworden, in Nederland is hij nauwelijks gegroeid.

Voor de beantwoording van de 2e vraag is geprobeerd een vergelijking te maken tussen de wetenschappelijke activiteit in bepaalde gebieden en het gebruik ervan. Daarbij is onderzocht of octrooigegevens voor dit doel bruikbaar zijn. Aangezien hieraan zoveel haken en hogen blijken te kleven, is deze fase niet verder gecontinueerd.

Inleiding

In 2009 heeft de TWINS Raad het door de voormalige Raad voor Natuur- en Sterrenkunde (deze raad is in 2009 opgegaan in de TWINS Raad) opgestarte project Portfolio Nederlandse Natuur- en Sterrenkunde afgerond. In dit rapport worden de gedachten achter dit project en de resultaten weergegeven.

De basis van het project werd gevormd door de volgende twee, gerelateerde vragen:

1. Zijn er gebieden in de natuur- en sterrenkunde waar Nederland (te) weinig aandacht aan besteedt in vergelijking met andere landen?
2. Is het mogelijk om aan te tonen dat de relatie tussen wetenschap en innovatief bedrijfsleven in Nederland zwakker is dan elders. Deze vraagstelling werd ingegeven door de observatie dat er in Nederland veel wordt gesproken over een vermeende kloof tussen wetenschappelijk onderzoek en het gebruik ervan, de zogenaamde innovatieparadox, maar dat hier eigenlijk nergens een objectief bewijs van wordt gegeven.

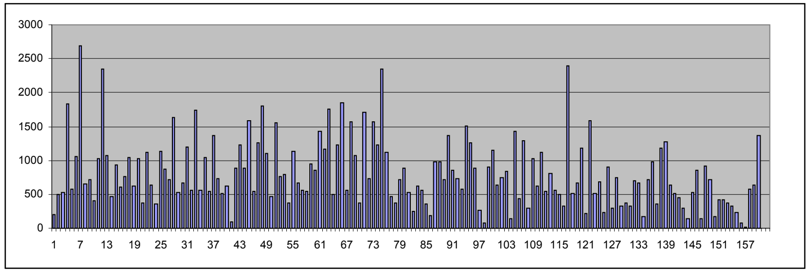
In het project is onderzocht of deze vragen beantwoord kunnen worden door een vergelijking te maken tussen de aandachtsgebieden in de Nederlandse fysica (en sterrenkunde) en de aandachtsgebieden in het buitenland. Daarbij is gekozen voor een vergelijking met de landen: Verenigde Staten, Zuid-Korea, Verenigd Koningrijk, Frankrijk, Duitsland, Zwitserland en Zweden om zowel de grote wetenschapproducerende landen mee te nemen als een aantal landen die een vergelijkbare grootte hebben als Nederland. Door niet alleen de wetenschappelijke literatuur te onderzoeken, maar ook de octrooiliteratuur is geprobeerd om ook de aansluiting tussen nieuwsgierigheidgedreven onderzoek, toegepast onderzoek en innovatief bedrijfsleven zichtbaar te maken worden.

Het project bestond uit twee fases. In de eerste fase zijn door een analyse van wetenschappelijke publicatie activiteiten objectieve gegevens verzameld over de wetenschappelijke activiteit in verschillende deelgebieden van de natuur- en sterrenkunde. In de tweede fase is geprobeerd om een vergelijking te maken tussen de wetenschappelijke activiteit in bepaalde gebieden en het gebruik van de resultaten. Dit is gedaan door een analyse van de octrooiliteratuur. In het oorspronkelijke plan was voorzien dat deze analyses vervolgens als basis zouden dienen voor een aantal discussiebijeenkomsten met deskundigen om ten slotte te komen tot een aantal gebieden die de moeite waard zijn om te stimuleren. Om verschillende redenen is uiteindelijk afgezien van deze laatste stap.

Fase 1: Onderzoek wetenschappelijke activiteit

Het uitgangspunt voor deze analyse is de aanname dat de wetenschappelijke activiteit in een bepaald gebied kan worden gemeten door het aantal publicaties in dat gebied te tellen.

Om een indruk te krijgen van de wetenschappelijke activiteit in een bepaald gebied van de natuurkunde is met behulp van het Centrum voor Wetenschaps- en Technologiestudies (CWTS) in Leiden een analyse gemaakt van de aantallen publicaties per (sub)vakgebied per land en voor de wereld als geheel. Voor de periode 1995 t/m 2005 is per jaar het aantal publicaties per (sub)vakgebied geteld. Hiervoor wordt de INSPEC database gebruikt, die voor de natuur- en sterrenkunde bijna dezelfde indeling in vakgebieden hanteert als de PACS (Physics and Astronomy Classification Scheme), zie appendix 1. Behalve de pure natuur- en sterrenkunde codes zijn ook een aantal codes uit de toegepaste wetenschappen zoals elektronica en materiaalkunde toegevoegd. Door op een bepaald detail niveau te kijken, worden er 3130 (sub)vakgebieden onderscheiden. Dat zijn er te veel voor een overzicht en bovendien zitten er in sommige codes slechts weinig artikelen. Daarom hebben we de codes gedeeltelijk automatisch, gedeeltelijk handmatig geclusterd tot 160 clusters die in Nederland een vergelijkbare omvang hebben (figuur 1).



Figuur 1: aantal Nederlandse publicaties per cluster.

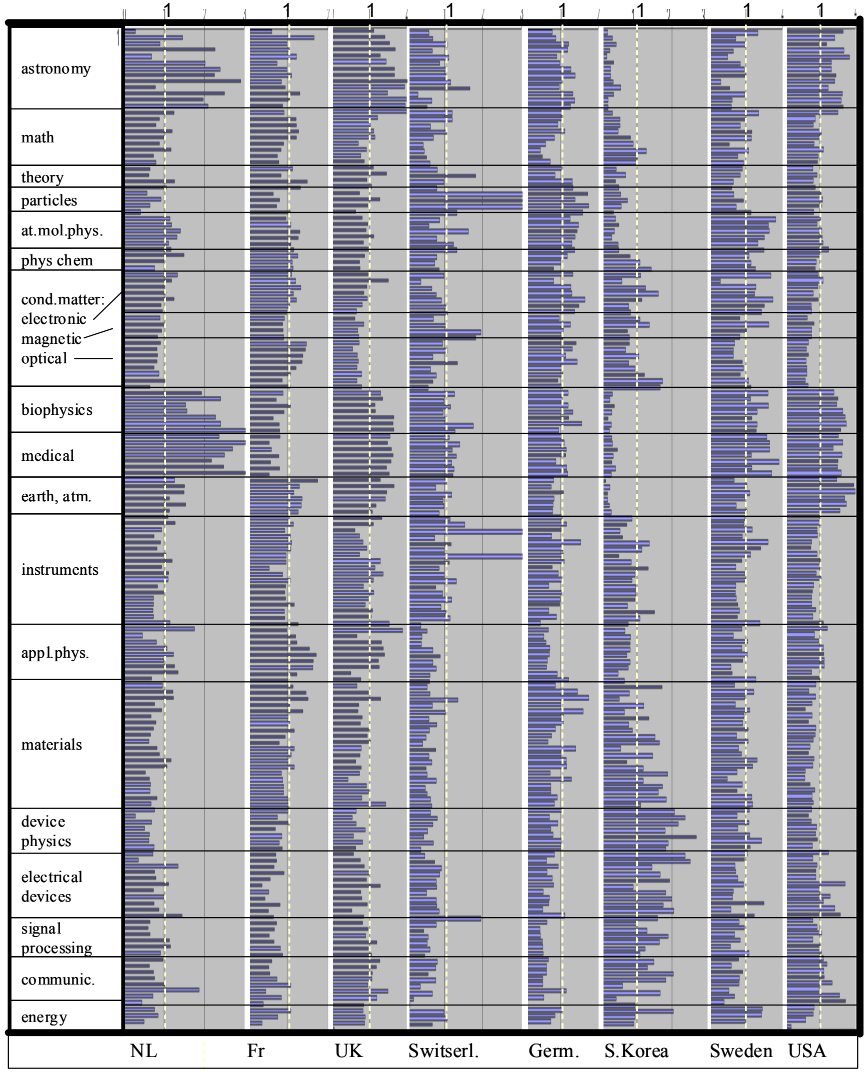
Vervolgens zijn de periodes 1996-2000 en 2001-2005 gegroepeerd en is per land (affiliatie van de eerste auteur) een zg. activiteitenindex berekend voor ieder (sub)vakgebied. Deze activiteitenindex laat zien hoeveel publicatieactiviteit een land op het betreffende (sub)vakgebied vertoont t.o.v. de gemiddelde activiteit van het land:

$$Act_i(x) = \frac{N_i(x)}{N_t(x)} \cdot \frac{N_t(world)}{N_i(world)}$$

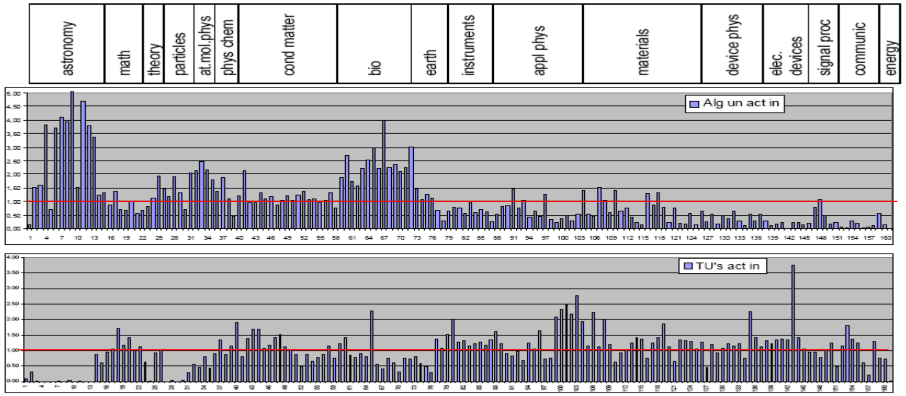
De 160 indices geven een activiteitsprofiel. Om de interpretatie van het profiel te vergemakkelijken zijn gerelateerde gebieden bij elkaar geplaatst. Appendix 1 geeft het resultaat voor de volledige periode 1996-2005. Figuur 2 geeft een grafische weergave van de wetenschappelijke activiteitenprofielen in de verschillende gebieden.

Door te rangschikken naar activiteitenindex kan nu snel inzicht worden gekregen in de wetenschapsgebieden waarin een land bovengemiddeld actief is. In Appendix 2 zijn voor Nederland de gebieden met de lagere respectievelijk hoogste activiteit weergegeven.

Voor Nederland is er in figuur 3 ook een onderscheid gemaakt tussen de activiteitenprofielen van de algemene universiteiten, de Technische Universiteiten en de industrie. Een complicatie daarbij is de rol van de instituten (AMOLF, Astron, CWI, Rijnhuizen, NIKHEF). Voor het gemak zijn die bij de algemene universiteiten geteld. Instituten TNO, SRON, KNMI zijn apart, maar tonen te weinig diversiteit om een apart profiel voor te geven. Een apart profiel voor de industrie blijkt zinloos omdat dit profiel volledig wordt gedomineerd door Philips NatLab.



Figuur 2: Activiteitenprofielen per land voor de periode 1996-2005.



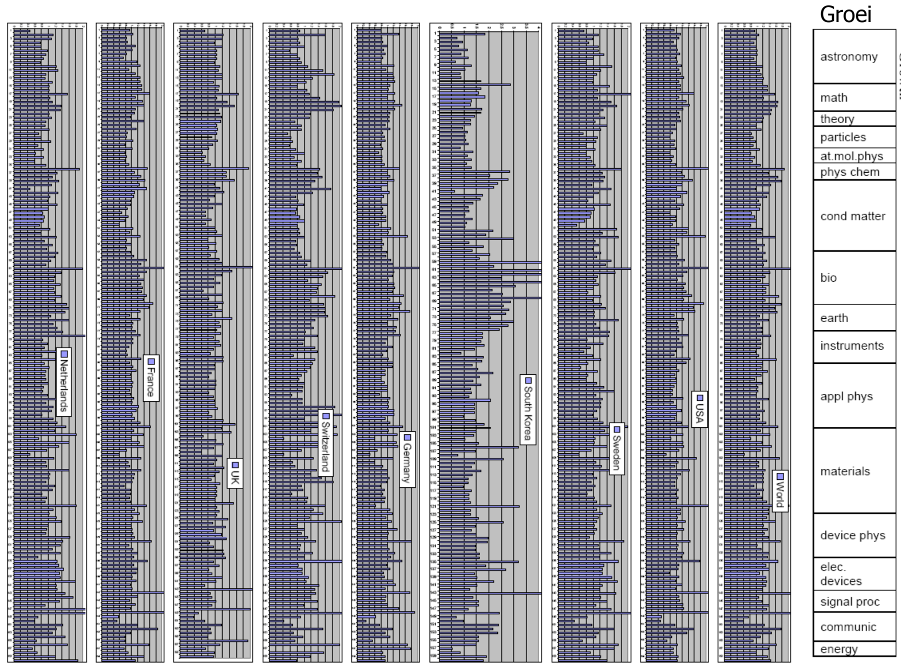
Figuur 3: Activiteitenprofielen van de algemene universiteiten en de technische universiteiten.

Observaties

De activiteitenprofielen van de verschillende landen laten opvallende verschillen zien, die duidelijk statistisch relevant zijn. De kleinere landen hebben ook minder vlakke profielen dan de grotere als VS, UK, Frankrijk en Duitsland: sommige activiteiten indices zijn hoger dan 3! De VS besteedde ten opzichte van de rest van de wereld meer aandacht aan astronomie, medische fysica, biofysica, earth- and atmosphere physics en electronic devices. Dat is niet onverwacht. In Zwitserland is de aanwezigheid van CERN direct duidelijk door de hoge score in deeltjes fysica en gerelateerde instrumenten. Het is interessant te zien dat Frankrijk achterblijft op het gebied van de bio- en medische fysica en Duitsland een bijzonder lage activiteit heeft in de toegepaste natuurkunde en alles wat aan de basis van de electronica ligt.

De Nederlandse activiteit in de astronomie was zeker te verwachten, waarbij het opvallend is dat het eigen zonnestelsel weinig aandacht krijgt. De bijzonder hoge activiteit in de medische fysica en de biofysica is verrassender: geen van de vergeleken landen komt daar maar in de buurt: het is twee maal zo hoog als de andere landen die hierin actief zijn (VS, UK en Zweden). Dit wordt gecompenseerd door een relatief lage activiteit in de materiaalkunde en device physics (dunne film technieken, halfgeleiders). De uitschieters bij devices en communicatie worden veroorzaakt door de bijdragen van Philips Natlab. De verschillen die de profielen van de algemene universiteiten (incl. instituten) laten zien ten opzichte van de technische universiteiten zijn niet onverwacht.
Het profiel van Zuid Korea is het meest afwijkend. We zien geen aandacht voor astronomie, bio- en medische fysica, maar uitgesproken aandacht voor alles wat met de industrie te maken heeft: materiaalkunde en vooral device physics met indices boven de twee.

Door het aantal publicaties van de periode 2000-2005 te delen door die van de periode 1996-2005 wordt een indruk verkregen van de groei in die periode, zie figuur 4.



Figuur 4: Groei van de activiteiten.

In tabel 1 is een overzicht gegeven van de abolute groei in de beschouwde landen. Duidelijk zichtbaar is dat Nederland goed mee groeit met de reeds lang ontwikkelde landen, maar dat het de gemiddelde wereldgroei niet kan bijhouden. Dit komt uiteraard vooral door enorme groei in de landen in Azië. De snelle groei van Zuid Korea is nog duidelijker als het aantal publicaties uit 2005 wordt vergeleken met het aantal in 1996: een toename met een factor 3!

	1996-2000	2001-2005	growth
world	3133481	3775737	1.20
USA	698740	771069	1.10
Sweden	33770	38642	1.14
South Korea	83193	127248	1.53
Germany	221144	220227	1.00
Switserland	40273	38715	0.96
UK	164088	169300	1.03
France	147259	154898	1.05
The Netherlands	40678	44335	1.09

Tabel 1: Absolute toename aantal publicaties in periode 1996-2000 en 2001-2005

Fase 2: Onderzoek innovatie activiteit

Als tweede stap in het proces is geprobeerd een vergelijking te maken tussen de wetenschappelijke activiteit in bepaalde gebieden en het gebruik ervan.
Zoals verondersteld werd dat de wetenschappelijke activiteit van een land is te meten aan het aantal publicaties, wordt nu verondersteld dat de innovatie activiteit kan worden gemeten door het aantal octrooien te tellen.

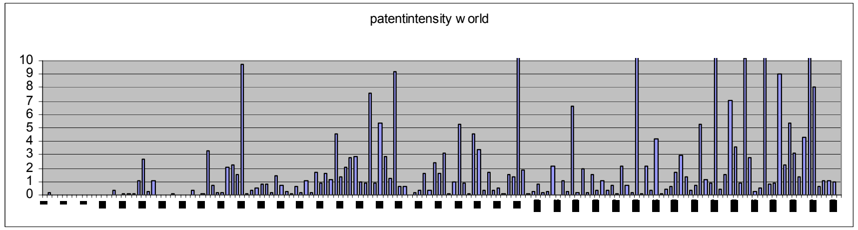
Concordantietabel
Om de octrooiactiviteit te kunnen correleren aan de wetenschappelijke activiteit moeten de octrooien in dezelfde categorieën worden ingedeeld. De octrooiwereld hanteert echter geen INSPEC of PACS codes, maar ECLA codes. Om een vergelijking toch mogelijk te maken heeft het Octrooicentrum Nederland een concordantie tabel geconstrueerd waarmee de PACS codes en de ECLA codes worden gekoppeld. Deze concordantietabel is als volgt gemaakt:

1. Voor de jaren 1998 tot en met 2001, die het midden van de onderzoeksperiode omvatten, zijn alle octrooidocumenten, die een Europese Classificatie hebben geselecteerd. De Europese classificatie (ECLA) is een verfijning van de International Patent Classification (IPC) en wordt toegekend door een *examiner* van het EOB op het moment dat de aanvraag daadwerkelijk behandeld wordt. ECLA is op het hoogste niveau gelijk aan de IPC, maar wordt door het EOB sinds het begin nauwkeurig bijgehouden en aangepast aan zich veranderende omstandigheden. De ECLA-codes van documenten worden ook gewijzigd op het moment dat er veranderingen in de classificatie optreden;
2. In de gevonden documentverzameling werd vervolgens gezocht naar octrooidocumenten die NPL citeren. Uiteindelijk werden er 2219 documenten gevonden waar expliciet naar een document uit de INSPEC-database werd gerefereerd. In totaal zijn er 7359 INSPEC-referenties verwerkt.
3. De octrooidocumenten geven nu de ECLA-code (op 4-symbool niveau, zoals: A01B e.d.) en via de verwijzing naar de niet literatuur de INSPEC-codes. Op deze wijze zijn combinaties te maken van ECLA-codes en bijbehorende verwijzingen naar INSPEC-codes. Er is alleen gebruik gemaakt van unieke combinaties van ECLA en INSPEC-code. Op deze wijze is een matrix samengesteld met als dimensies de 4-symbools ECLA-code en de INSPEC-code;
4. De aldus gevormde matrix is in de dimensie INSPEC-code gecondenseerd tot de 160 groepen zoals die ook in de analyse van de wetenschappelijke activiteit zijn gebruikt. Deze groepen worden in het vervolg als PAC-groepen aangeduid. Op deze wijze is dus een concordantietabel ontstaan met de dimensies de ECLA-code en de PAC-groep;
5. De ECLA-PAC tabel is een verdeelmodel dat ECLA-codes verdeeld over meerdere PAC-codes en omgekeerd;

De basis voor de verdere analyse werd gevormd door alle documenten in de periode 1996 t/m 2005, die bij het Europees Octrooibureau of bij de World Intellectual Property Organisation (WIPO) zijn ingediend en die aanwezig zijn in de EPODOC-database. De collectie is opgeschoond door dubbele publicaties van dezelfde uitvinding te verwijderen. Deze documenten zijn vervolgens net als bij de wetenschappelijke publicaties verdeeld in twee groepen. Groep 1 omvat de aanvragen uit de periode 1996-2000 en de Groep 2 omvat de aanvragen uit de periode 2001-2005. Binnen de groepen zijn octrooien wederom onderscheiden van aanvragers en uitvinders uit Nederland, Japan, de Bondsrepubliek Duitsland, het Verenigd Koninkrijk, de Verenigde Staten, Zuid-Korea, Zweden en Zwitserland. Vanwege de grote aantallen documenten is ervoor gekozen om als voor een land in een periode het aantal documenten meer dan 20.000 bedroeg om een random steekproef van 20.000 documenten te gebruiken. Aldus werden voor elk land in de twee periodes voor zowel de uitvinders als de aanvragers aantallen ECLA-codes bepaald. Aan de hand van de hierboven beschreven concordantietabel zijn de ECLA-codes omgezet in 160 PAC-groepen.

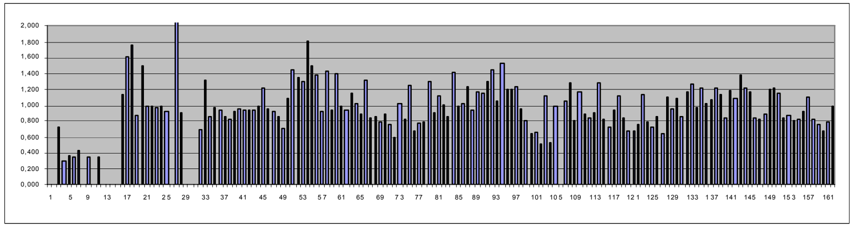
Octrooien zijn zowel ingedeeld per land van de eerste uitvinder als per land van de aanvrager. Voor dit rapport wordt alleen gebruik gemaakt van de indeling op uitvinderwoonplaats omdat dit het beste overeenkomt met waar het daadwerkelijke onderzoek of werk is verricht. Figuur 5 laat zien

dat er hele grote verschillen zijn in de aantallen octrooien per subgebied. Dit heeft invloed op de betrouwbaarheid van sommige indices. Langs de verticale as staat uitgezet:
$$\frac{N_{i-patents1995-2005}(world)}{N_{i-publications1995-2005}(world)} \cdot \frac{N_{t-publications}(world)}{N_{t-patents}(world)}.$$



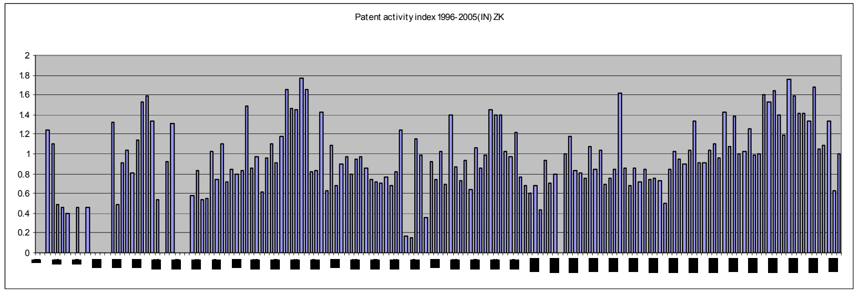
Figuur 5: Aantal patenten per (sub)vakgebied, genormaliseerd.

In figuur 6 en 7 worden de patentenprofielen van Nederland resp. Zuid Korea gegeven. Het volledige overzicht van de indices voor 2000-2005 staat in appendix 3.



Figuur 6: Nederlandse patenten activiteit 2000-2005.

astronomy	math	theory	particles	at.mol.phys	phys chem	cond matter	bio	earth	instruments	appl phys	materials	device phys	elec. devices	signal proc	communic	energy



Figuur 7: Zuid Koreaanse patenten activiteit.

Observaties
Het is niet gemakkelijk om deze profielen te interpreteren. Het gaat tenslotte eigenlijk om de wetenschapsgebieden waar de patenten naar verwijzen. Als er bijvoorbeeld wordt verwezen naar een wiskundige theorie, hoeft dit nog niet te betekenen dat het patent voortkwam uit die theorie. Het feit dat hoge index waarden geclusterd zitten lijkt toch wel aan te geven dat de uitkomst niet pure ruis is. Nederland gebruikt dan vooral kennis uit de magnetische en optische vaste stof fysica, de optiek, de elektronica en de signaalverwerking. Zuid Korea gebruikt vooral kennis uit de magnetische materialen, optiek, signaalverwerking en communicatie.

Interpretatie van de gegevens

Bij de gevolgde aanpak en de gevonden resultaten zijn verschillende kanttekeninen te plaatsten. De eerste vraag is natuurlijk: hoe betrouwbaar de gegevens zijn? Voor wat betreft het eerste deel van de analyse is dat vooral afhankelijk van de correcte en consistente indeling in INSPEC codes. Het zou bijvoorbeeld kunnen dat afhankelijk van de nationale gewoonten een bepaald vakgebied in de ene dan wel de andere categorie wordt ingedeeld. Vooral voor interdisciplinaire gebieden zoals biofysica zou dat het geval kunnen zijn. Op het eerste gezicht leveren de profielen een herkenbaar beeld maar zoals in de inleiding aangegeven, zouden de gevonden resultaten eigenlijk met een groep deskundigen moeten worden besproken om een goede interpretatie mogelijk te maken. Observaties die op basis van de profielen kunnen worden gedaan zijn:

1. Nederland is zeer actief in de astronomie en buitengewoon actief in de biofysica en medische fysica.
2. De Nederlandse activiteit vindt plaats op meer fundamentele gebieden, zoals theory, acoustics, flow, mesoscopic systems, biophysics, bio imaging, mathematics, simulation and computing. In bijvoorbeeld Zuid Korea zijn juist gebieden als surface- and interface physics, materials, dielectric properties en electronics relatief sterk, deze onderwerpen liggen dichter bij industriele interesses.
3. Algemene universiteiten hebben een duidelijk ander activiteitenprofiel dan technische universiteiten.
4. De wetenschappelijke activiteit groeit in de rest van de wereld veel sneller dan in Nederland. In sommige landen als Zuid Korea is de activiteit in 10 jaar 3x zo hoog geworden, in Nederland is hij nauwelijks gegroeid.

Het principe van de activiteitenindex lijkt een geschikt middel om te onderzoeken op welke onderwerpen een land relatief actief is ofwel achterblijft, hoewel de cijfers niet meer dan een indicatie geven die gecheckt moet worden door mensen die het veld inhoudelijk kennen.

Het gebruik van de octrooigegevens voor het gestelde doel levert meer twijfel op. De indeling in INSPEC categorieën via de concordantietabel laat zien dat sommige codes erg veel octrooien verzamelen en andere erg weinig. Voor sommige codes, bijvoorbeeld in de astronomie is dat logisch, maar voor veel andere categorieën helemaal niet. Als we kritisch naar de octrooicategorieën kijken (zie appendix 5) is het ook wel voor te stellen dat het soms moeilijk is om een relatie te vinden met wetenschapsgebieden: veel van die octrooicategorieën hebben niets met wetenschap te maken maar zijn gewoon een groep “slimmigheidjes”. In ieder geval is er het probleem dat nieuwe gebieden nog geen INSPEC code hebben en dus verdeeld worden over bestaande codes. Dit maakt het moeilijk zo niet onmogelijk om een van de doelvragen te beantwoorden, namelijk of we in Nederland een nieuw vakgebied missen. N.a.v. deze exercitie zijn daarom aan het slot van de 2^{e} fase de volgende conclusies getrokken:

- Er is geen overtuigende correlatie gevonden tussen het wetenschappelijke activiteitenprofiel en het patent-activiteiten profiel, noch in Nederland, noch in andere onderzochte landen. Het lijkt dat het merendeel der aangevraagde patenten niet gebaseerd is op wetenschappelijk onderzoek.

- Het bestaan van een innovatie paradox in Nederland (wel zeer goede wetenschap maar geen resulterende economische activiteit) kan niet uit dit onderzoek worden afgeleid. De in deze periode bij het CWTS uitgekomen gegevens over publicaties met auteurs uit zowel universiteiten als industrie wijst zelfs op het tegendeel van een innovatie paradox.

Conclusie
De oorspronkelijke vraagstelling was tweeledig:

1. *Zijn er gebieden in de natuur- en sterrenkunde waar Nederland te weinig aandacht aan besteedt?*
   ”Te” weinig is een subjectief oordeel dat ik gaarne aan de lezer over laat. In hele grote lijnen is het wel duidelijk dat Nederland weinig aandacht besteedt aan materiaalkunde en op materiaalkunde gebaseerde toepassingen. In appendix 1 en 2 zijn ook specifiekere gebieden te vinden waarin weinig activiteit plaatsvindt zoals nuclear physics, power systems en kosmische straling. Maar zo’n conclusie behoeft direct een waarschuwing: Nederland besteedt waarschijnlijk bewust weinig aan de kernfysica en de conclusie over kosmische straling kan fout zijn omdat Nederlandse artikelen hierover in een andere categorie worden geteld.
2. *Is het mogelijk om aan te tonen dat de relatie tussen wetenschap en innovatief bedrijfsleven in Nederland zwakker is dan elders?*
   Beantwoording van deze vraag op basis van een koppeling naar de octrooigegevens is niet mogelijk gebleken. Wel is het duidelijk dat een typisch industrieel georiënteerd land als Zuid Korea een wezenlijk ander wetenschappelijk activiteitenprofiel heeft dan Nederland. Het Nederlandse profiel wijkt op dit punt echter niet ver af van landen als de UK, Zweden of de VS, waarvan wordt verondersteld dat zo’n innovatieparadox niet bestaat.

De ontwikkelde methode (objectieve activiteitsindex, eventueel gecombineerd met een groei-index) lijkt wel bruikbaar om bijvoorbeeld toe te passen in een beperkter vakgebied zoals de materiaalkunde om daar als basis te dienen voor een discussie over dat vakgebied.

Dankwoord
De hulp van Ed Noijons en Renald Buter (beiden CWTS), Jos Winnink (Octrooicentrum Nederland) en de ondersteuning door Arie Korbijn (KNAW) worden met erkentelijkheid genoemd.

Appendices

Appendix 1: activiteits indices in 160 clusters for the years 1996-2005.

	code	description	USA act in	Sweden act in	South Korea act in	Germany act in	Switserland act in	UK act in	France act in	Netherlands act in
1	A9400	Aeronomy, space physics, and cosmic rays	1.66	1.33	0.16	0.77	0.60	1.12	0.62	0.28
2	A9500	Fundamental astronomy and astrophysics,	1.43	0.73	0.30	0.88	0.72	1.42	1.66	1.46
3	A9530	Fundamental aspects of astrophysics	1.20	0.99	0.41	1.21	1.09	1.54	1.00	0.90
4	A9580	Astronomical observations	1.68	0.66	0.24	1.19	0.70	1.69	1.05	2.27
5	A9600	Solar system	1.83	0.50	0.15	0.90	1.13	1.29	1.23	0.68
6	A9700	Stars	1.33	0.84	0.35	0.97	0.89	1.45	0.75	2.01
7	A9710	Stellar characteristics	1.32	0.96	0.24	1.28	1.07	1.68	0.99	2.40
8	A9720	Normal stars (by class): general or individual	1.46	1.00	0.25	1.38	1.05	1.68	1.11	2.25
9	A9780	Binary and multiple stars	1.43	0.31	0.32	1.04	1.17	2.21	0.86	2.92
10	A9800	Stellar systems; Galactic and extragalactic	1.24	0.55	0.53	0.96	1.67	1.95	0.95	0.78
11	A9840	Interstellar medium; nebulae	1.64	0.97	0.34	1.32	0.33	1.50	1.31	2.50
12	A9850	The Galaxy, extragalactic objects and systems	1.60	0.63	0.19	1.37	0.68	2.01	1.06	1.97
13	A9870	Other astronomical sources and radiations	1.66	0.60	0.18	1.26	0.56	1.97	0.89	2.10
14	A0100	Communication, education, history, and phil	1.52	1.35	0.30	1.04	1.21	2.00	0.92	1.25
15	A0200	Mathematical methods in physics	0.88	0.99	0.52	1.04	1.21	1.22	1.21	0.88
16	A0230	Function theory, analysis	0.83	0.85	0.52	0.92	0.65	1.02	1.23	0.78
17	A0250	Probability theory, stochastic processes, and stat	1.05	1.16	0.46	1.12	1.07	1.12	1.28	1.21
18	A0260	Numerical approximation and analysis	1.03	1.15	0.82	0.84	0.73	1.15	1.23	0.99
19	B0200	Engineering mathematics and mathematical	0.85	0.54	0.90	0.61	0.45	0.70	0.91	0.87
20	B0240	Probability and statistics	1.11	1.07	1.27	0.47	0.49	0.92	0.84	1.17
21	B0260	Optimisation techniques	0.96	0.78	1.02	0.51	0.55	0.77	0.77	0.73
22	B0290	Numerical analysis	0.95	0.94	0.99	0.73	0.64	0.86	0.79	0.79
23	A0300	Classical and quantum physics; mechanics and	0.81	0.91	0.41	1.04	0.82	1.11	1.13	0.64
24	A0400	Relativity and gravitation	0.93	0.85	0.68	0.85	1.82	1.46	0.85	0.61
25	A0500	Statistical physics and thermodynamics	0.83	0.66	0.39	1.31	1.00	0.93	1.50	1.26
26	A0540	Fluctuation phenomena, random processes, and	0.87	0.62	0.48	1.33	0.81	1.06	1.32	1.06
27	A1000	The physics of elementary particles and fields	1.04	0.67	0.53	1.73	6.69	0.73	0.65	0.57
28	A1100	General theory of fields and particles	1.09	0.94	0.74	1.38	3.35	1.28	0.81	0.92
29	A1200	Specific theories and interaction models; particle	1.07	0.74	0.55	1.75	4.90	0.95	0.74	0.64
30	A2000	Nuclear physics	0.83	1.14	0.34	1.59	1.32	0.63	1.07	0.41
31	A3100	Theory of atoms and molecules	1.03	1.82	0.38	1.25	0.88	0.81	0.97	1.14
32	A3200	Atomic spectra and interactions with photons	0.94	1.62	0.49	1.48	0.60	0.96	1.09	1.18
33	A3300	Molecular spectra and interactions with photons	1.07	1.64	0.36	1.44	1.63	0.92	1.31	1.40
34	A3400	Atomic and molecular collision processes and	1.08	1.51	0.29	1.39	0.82	1.11	1.27	1.31
35	A3500	Properties of atoms and molecules; instruments	1.10	1.32	0.46	1.30	1.24	0.84	1.09	1.11
36	A3600	Studies of special atoms and molecules	1.25	1.50	0.48	1.38	1.32	1.00	1.17	1.17
37	A8200	Physical chemistry	1.00	1.09	0.80	1.18	0.81	0.87	1.26	1.49
38	A8230	Specific chemical reactions; reaction mechanisms	0.91	1.14	1.08	1.01	0.76	0.73	1.13	1.00
39	A8240	Chemical kinetics and reactions: special regimes	0.87	1.27	1.41	0.81	0.88	0.75	1.14	0.76
40	A8265	Surface chemistry	0.97	1.68	1.10	1.32	0.99	0.97	1.11	1.33
41	A6700	Quantum fluids and solids; liquid and solid helium	1.10	0.30	0.58	0.82	0.40	1.51	1.20	1.18
42	A6800	Surfaces and interfaces; thin films and whiskers	0.95	1.28	1.25	1.27	0.67	0.93	1.33	1.00
43	A6820	Solid surface structure	0.82	1.24	1.61	1.31	0.79	0.85	1.15	1.05
44	A6840	Surface energy of solids; thermodynamic prop	0.97	1.75	1.13	1.65	0.94	0.95	1.23	1.25
45	A7100	Electron states in condensed matter	0.77	1.51	0.77	1.49	1.04	0.81	1.06	0.92
46	A7120	Electronic density of states determinations	0.78	1.43	0.82	1.38	1.10	0.66	1.00	0.96
47	A7200	Electronic transport in condensed matter	0.66	0.84	1.10	0.97	0.72	0.61	0.93	0.90
48	A7300	Electronic structure of surfaces, interfaces, and	0.84	1.63	1.36	1.27	1.08	0.85	0.89	1.01
49	A7400	Superconductivity	0.78	1.01	0.74	1.08	1.95	0.69	0.90	0.94
50	A7470	Superconducting materials	0.78	0.83	0.79	1.06	1.82	0.72	0.91	0.83
51	A7500	Magnetic properties and materials	0.69	0.70	0.79	1.41	0.96	0.72	1.47	0.90
52	A7530	Magnetically ordered materials, other intrinsic	0.63	0.66	0.69	1.32	1.09	0.55	1.45	0.81
53	A7550	Studies of specific magnetic materials	0.69	0.66	1.06	1.14	0.71	0.67	1.39	0.83

54	A7600	Magnetic resonances and relaxation in	0.63	0.90	0.77	1.43	1.35	0.71	1.36	0.81
55	A7800	Optical properties and condensed matter	0.65	0.94	0.95	1.07	0.65	0.66	1.21	0.74
56	A7820	Optical properties of condensed matter	0.65	0.85	1.22	1.06	0.79	0.79	1.08	0.87
57	A7855	Photoluminescence (condensed matter)	0.61	1.07	1.74	0.92	0.71	0.67	0.88	1.02
58	A7865	Optical properties of thin films and low-	0.68	1.14	1.65	1.06	0.60	0.79	1.08	0.64
59	A8700	Biophysics, medical physics, and biomedical en	1.41	1.61	0.31	1.20	1.27	1.30	0.90	1.93
60	A8710	General, theoretical, and mathematical biophysics	1.51	1.13	0.22	1.04	1.00	1.35	0.73	2.42
61	A8715	Molecular biophysics	1.48	1.62	0.36	1.20	1.17	1.15	1.08	1.54
62	A8720	Membrane biophysics	1.65	1.31	0.29	1.32	0.97	1.16	0.92	1.57
63	A8730	Biophysics of neurophysiological processes	1.72	1.16	0.18	1.21	1.06	1.66	0.66	2.28
64	A8740	Biomagnetism	1.75	1.31	0.26	1.56	1.76	1.64	0.80	2.42
65	A8745	Biomechanics, biorheology, biological fluid	1.59	1.28	0.22	0.95	1.29	1.66	0.81	3.15
66	A8760	Medical and biomedical uses of fields, radiations,	1.53	1.58	0.29	1.08	1.14	1.55	0.83	2.37
67	A8760J	X-rays and particle beams (medical uses)	1.65	1.66	0.30	1.11	1.40	1.49	0.56	3.42
68	A8770	Biomedical engineering	1.39	1.65	0.44	1.16	1.21	1.60	0.61	2.71
69	A8770E	Patient diagnostic methods and instrumentation	1.62	1.15	0.32	1.14	1.31	1.64	0.80	2.50
70	B7500	Medical physics and biomedical engineering	1.51	1.91	0.28	0.88	1.19	1.58	0.59	2.18
71	B7510	Biomedical measurement and imaging	1.50	1.17	0.39	1.16	1.26	1.46	0.82	2.49
72	B7520	Patient care and treatment	1.61	1.71	0.26	1.19	1.23	1.54	0.56	3.10
73	A9100	Solid Earth physics	1.49	0.69	0.11	0.81	1.07	1.30	1.75	1.27
74	A9200	Hydrospheric and lower atmospheric physics	1.95	1.03	0.23	0.75	0.79	1.67	1.30	1.51
75	A9260	Lower atmosphere	2.00	1.11	0.17	1.08	1.19	1.47	1.17	1.50
76	A9300	Geophysical observations, instrumentation, and	1.71	0.98	0.15	0.82	0.97	1.43	1.36	1.13
77	A9385	Instrumentation for geophysical, hydrospheric and	1.75	0.74	0.21	0.81	0.99	1.18	1.34	1.53
78	B7700	Earth sciences	1.57	1.02	0.27	0.78	0.88	1.08	1.27	1.13
79	A0600	Measurement science, and instrumentation	1.01	0.97	0.86	1.04	1.16	1.34	1.05	1.09
80	A0700	Specific instrumentation and techniques of	1.04	0.95	0.72	1.16	1.54	1.10	1.16	1.28
81	A2900	instrumentation for elementary-particle and	0.93	1.18	0.52	1.07	3.68	0.61	0.94	0.93
82	A4100	Electricity and magnetism; fields and charged part	0.95	0.91	0.59	0.76	0.76	0.73	1.08	0.74
83	A7900	Electron and ion emission by liquids and solids;	0.78	1.61	1.36	1.54	1.19	0.83	1.11	0.91
84	A8280	Chemical analysis and related physical methods	0.76	1.40	1.15	1.06	1.01	0.94	1.09	0.82
85	B7400	Elementary particle and nuclear instrumentation	0.93	1.13	0.47	1.07	3.21	0.74	0.97	1.03
86	B7100	Measurement science	1.02	0.90	0.84	1.10	1.14	1.29	0.97	1.19
87	B7200	Measurement equipment and instrumentation	1.01	0.72	1.32	0.78	0.86	1.15	0.56	0.93
88	B7300	Measurement of specific variables	0.91	0.98	0.94	0.94	1.00	1.37	0.89	1.12
89	A0760	Optical instruments and techniques	1.04	0.99	0.86	1.02	1.31	1.11	1.08	1.09
90	A4200	Optics	0.84	0.73	0.97	0.69	0.79	0.84	0.97	0.83
91	A4250	Quantum optics	0.80	0.72	0.96	1.03	0.96	1.12	0.94	0.98
92	A4260	Laser optical systems: design and operation	0.78	0.74	0.95	0.99	1.20	1.00	0.97	0.73
93	A4265	Nonlinear optics	0.78	0.78	0.73	0.97	0.92	0.90	1.17	0.72
94	A4280	Optical elements, devices and systems	0.91	0.83	1.50	0.69	1.05	1.09	0.93	0.71
95	B4300	Lasers and masers	0.81	0.77	1.09	0.89	1.15	1.05	0.94	0.73
96	A4300	Acoustics	1.12	1.39	0.75	0.46	0.40	1.53	1.27	1.14
97	B7800	Sonics and ultrasonics	1.22	0.90	0.66	0.68	0.56	1.90	1.00	1.75
98	A4400	Heat flow, thermal and thermodynamic processes	0.85	0.66	0.82	0.55	0.42	0.66	1.20	0.46
99	A4600	Mechanics, elasticity, rheology	0.98	1.05	0.81	0.61	0.41	1.32	1.24	0.81
100	A4700	Fluid dynamics	1.11	0.89	0.80	0.71	0.71	1.38	1.55	1.07
101	A4710	General fluid dynamics theory, simulation and	1.13	1.04	0.71	0.70	0.90	1.41	1.71	1.23
102	A4720	Hydrodynamic stability and instability	1.13	0.92	0.80	0.65	0.71	1.25	1.64	0.97
103	A4750	Non-Newtonian dynamics	1.13	0.59	0.75	0.62	0.80	1.27	1.62	1.26
104	A5100	Kinetic and transport theory of fluids; physical	0.78	0.62	0.46	0.91	0.63	0.50	1.24	1.35
105	A5200	The physics of plasmas and electric discharges	1.01	1.28	0.64	1.21	0.62	0.77	1.02	0.69
106	A5270	Plasma diagnostic techniques and	0.90	0.69	1.72	0.87	0.56	0.66	1.15	0.95
107	A6100	Structure of liquids and solids; crystallography	0.70	1.22	0.79	1.45	0.64	1.02	1.46	1.21
108	A6110	X-ray determination of structures	0.89	0.97	0.51	1.76	1.36	1.30	1.51	1.22
109	A6140	Structure of amorphous, disordered and	0.79	0.72	1.20	1.00	0.70	0.71	1.06	0.75
110	A6150	Crystalline state	0.60	1.11	0.64	1.60	1.04	0.69	1.39	0.94
111	A6170	Defects in crystals	0.79	0.95	1.34	1.08	0.60	0.81	1.03	0.67
112	A6180	Radiation damage and other irradiation effects	0.69	0.91	0.76	1.07	0.82	0.75	1.06	0.79
113	A6200	Mechanical and acoustic properties of condensed	0.90	1.06	0.88	0.86	0.62	0.98	1.18	0.74
114	A6220F	Deformation and plasticity	0.88	0.75	1.52	0.76	0.53	0.94	0.96	0.66
115	A6220M	Fatigue, brittleness, fracture, and cracks	0.82	1.06	1.64	0.66	0.44	1.04	0.80	0.62
116	A6300	Lattice dynamics and crystal statistics	0.73	0.80	0.54	1.39	0.78	0.77	1.18	0.82
117	A6400	Equations of state, phase equilibria, and phase	0.69	0.88	1.44	1.02	0.60	0.74	1.10	0.88
118	A6500	Thermal properties of condensed matter	0.84	1.30	0.72	1.15	0.68	0.63	1.05	1.17

119	A6600	Transport properties of condensed matter	0.82	1.18	1.19	1.17	0.54	0.77	1.18	1.07
120	A8100	Materials science	0.60	0.76	1.88	0.72	0.56	0.73	0.86	0.53
121	A8110	Methods of crystal growth and purification	0.59	0.49	1.18	1.28	0.80	0.43	0.89	0.63
122	A8140	Treatment of materials and its effects on	0.73	0.91	1.74	0.74	0.52	0.92	0.91	0.66
123	A8140L	Deformation, plasticity and creep	0.87	0.76	1.60	0.74	0.56	0.98	0.91	0.64
124	A8160	Corrosion, oxidation, etching, and other surface t	0.79	1.16	1.84	0.91	0.66	0.79	1.01	0.82
125	A8170	Materials testing	0.83	1.19	1.10	0.84	0.67	1.44	1.05	0.68
126	A6855	Thin film growth, structure, and epitaxy	0.78	1.10	2.07	1.04	0.65	0.64	1.05	0.76
127	A7700	Dielectric properties and materials	0.70	0.75	2.37	0.71	0.83	0.54	0.77	0.28
128	A8115	Methods of thin film deposition	0.77	1.09	2.18	0.92	0.70	0.64	1.05	0.69
129	B0500	Materials science for electrical and electronic engi	0.92	0.78	1.80	0.74	0.58	0.89	0.71	0.52
130	B0520	Thin film growth and epitaxy	0.89	1.11	2.69	0.80	0.48	0.57	0.87	0.63
131	B2500	Semiconductor materials and devices	0.94	1.43	1.89	1.01	0.72	0.82	0.80	0.61
132	B2520	Semiconductor theory, materials and properties	0.81	1.12	1.83	1.00	0.40	0.63	0.87	0.75
133	B2550	Semiconductor device technology	1.25	1.04	2.38	0.83	0.50	0.57	0.72	0.72
134	B2800	Dielectric materials and devices	0.82	0.96	2.51	0.62	0.75	0.75	0.74	0.36
135	B3000	Magnetic and superconducting materials and devi	0.93	0.71	1.43	0.93	0.93	0.86	0.68	1.34
136	B4100	Optical materials and devices	0.91	0.73	1.67	0.63	0.88	1.00	0.92	0.76
137	B4200	Optoelectronic materials and devices	0.90	0.78	1.92	0.77	0.80	0.92	0.58	0.79
138	B0100	General electrical engineering topics	1.71	0.93	0.89	0.81	0.82	1.30	0.38	1.12
139	B1000	Circuit theory and circuits	1.02	0.66	1.82	0.53	0.55	0.77	0.55	0.73
140	B2000	Components, electron devices and materials	1.29	0.64	2.01	0.69	0.79	0.80	0.46	0.99
141	B2560	Semiconductor devices	1.10	1.49	1.75	0.68	0.82	0.94	0.83	0.75
142	B2570	Semiconductor integrated circuits	1.43	0.60	2.05	0.52	0.88	0.53	0.54	0.87
143	B2575	Micromechanical device technology	1.58	1.23	1.60	1.11	1.95	0.85	0.67	1.44
144	B5000	Electromagnetic fields	0.81	0.81	1.01	0.64	0.80	0.82	0.74	0.65
145	B5200	Electromagnetic waves, antennas and propag	0.94	0.96	1.29	0.45	0.47	0.97	0.69	0.60
146	B6100	Information and communication theory	1.06	0.69	1.89	0.46	0.60	0.90	0.56	0.64
147	B6130	Speech and audio signal processing	0.81	0.84	1.64	0.51	0.56	1.21	0.68	1.12
148	B6135	Optical, image and video signal processing	1.02	0.58	1.23	0.52	0.63	0.98	0.83	1.16
149	B6140	Signal processing and detection	1.06	1.09	1.09	0.54	0.50	1.05	0.89	0.91
150	B6200	Telecommunication	1.11	0.80	1.49	0.67	0.83	1.29	0.62	0.97
151	B6210	Telecommunication applications	1.20	0.60	1.31	0.62	0.78	1.20	0.55	0.63
152	B6250	Radio links and equipment	1.12	0.91	2.03	0.62	0.60	1.08	0.57	0.73
153	B6260	Optical communication	1.14	0.83	1.82	0.53	0.78	1.07	0.75	0.76
154	B6300	Radar and radionavigation	1.35	0.82	0.59	0.53	0.38	0.95	1.09	1.02
155	B6400	Radio, television and audio	0.98	0.53	1.66	1.15	0.69	1.50	0.48	1.87
156	B7600	Aerospace facilities and techniques	1.56	0.69	0.41	0.56	0.20	1.20	0.86	0.72
157	B7900	Military systems and equipment	1.73	0.40	0.95	0.13	0.11	0.84	0.41	0.45
158	A2800	Nuclear engineering and nuclear power studies	0.85	1.45	2.03	1.03	0.99	0.83	1.09	0.76
159	A8600	Energy research and environmental science	0.82	1.43	0.95	0.85	1.08	0.89	0.77	0.84
160	B8000	Power systems and applications	0.61	0.98	0.91	0.73	0.70	0.87	0.38	0.49

Appendix 2: Gebieden in Nederland met laagste en hoogste activiteit

Laagste Nederlandse activiteit

Aeronomy, space physics, and cosmic rays	0,28
Dielectric properties and materials	0,28
Dielectric materials and devices	0,36
Nuclear physics	0,41
Military systems and equipment	0,45
Heat flow, thermal and thermodynamic processes	0,46
Power systems and applications	0,49
Materials science for electrical and electronic engineering	0,52
Materials science	0,53
The physics of elementary particles and fields	0,57
Electromagnetic waves, antennas and propagation	0,60
Relativity and gravitation	0,61
Semiconductor materials and devices	0,61
Fatigue, brittleness, fracture, and cracks	0,62
Telecommunication applications	0,63
Thin film growth and epitaxy	0,63
Methods of crystal growth and purification	0,63
Classical and quantum physics; mechanics and fields	0,64
Information and communication theory	0,64
Specific theories and interaction models; particle systematics	0,64
Optical properties of thin films and low-dimensional structures	0,64
Deformation, plasticity and creep	0,64
Electromagnetic fields	0,65
Treatment of materials and its effects on microstructures and properties	0,66
Deformation and plasticity	0,66
Defects in crystals	0,67
Materials testing	0,68
Solar system	0,68
Methods of thin film deposition	0,69

Hoogste Nederlandse activiteit

X-rays and particle beams (medical uses)	3,42
Biomechanics, biorheology, biological fluid dynamics	3,15
Patient care and treatment	3,10
Binary and multiple stars	2,92
Biomedical engineering	2,71
Patient diagnostic methods and instrumentation	2,50
Interstellar medium; nebulae	2,50
Biomedical measurement and imaging	2,49
Biomagnetism	2,42
General, theoretical, and mathematical biophysics	2,42
Stellar characteristics	2,40
Medical and biomedical uses of fields, radiations, and radioactivity; health physics	2,37
Biophysics of neurophysiological processes	2,28
Astronomical observations	2,27

Normal stars (by class): general or individual	2,25
Medical physics and biomedical engineering	2,18
Other astronomical sources and radiations	2,10
Stars	2,01
The Galaxy, extragalactic objects and systems	1,97
Biophysics, medical physics, and biomedical engineering	1,93
Radio, television and audio	1,87
Sonics and ultrasonics	1,75
Membrane biophysics	1,57
Molecular biophysics	1,54
Instrumentation and techniques for geophysical, hydrospheric and lower atmosphere research	1,53
Hydrospheric and lower atmospheric physics	1,51
Lower atmosphere	1,50
Physical chemistry	1,49
Fundamental astronomy and astrophysics, instrumentation and techniques and astronomical observations	1,46

Appendix 3: Growth from 1996-2000 to 2001-2005

	code	description	World	USA	Sweden	South Korea	Germany	Switzerland	UK	France	Netherlands
1	A9400	Aeronomy, space physics, and cosmic rays	0.94	0.92	0.74	1.83	0.80	0.87	0.70	0.93	0.47
2	A9500	Fundamental astronomy and astrophysics,	1.06	1.14	1.14	0.73	1.37	1.60	1.23	1.03	1.15
3	A9530	Fundamental aspects of astrophysics	1.00	1.10	0.99	0.93	0.83	0.82	1.20	0.82	1.10
4	A9580	Astronomical observations	0.91	0.90	0.87	0.78	0.85	0.88	0.98	0.86	0.77
5	A9600	Solar system	1.00	1.00	1.16	1.14	1.00	1.01	1.19	1.12	0.79
6	A9700	Stars	1.01	1.05	1.14	0.86	0.87	0.57	1.04	1.02	0.99
7	A9710	Stellar characteristics	1.03	1.11	1.30	1.16	0.92	0.80	1.04	0.84	0.94
8	A9720	Normal stars (by class): general or individual	0.93	0.99	1.02	0.65	0.86	0.88	1.04	0.73	0.86
9	A9780	Binary and multiple stars	0.99	1.03	0.80	1.29	0.81	0.92	0.97	1.18	0.77
10	A9800	Stellar systems; Galactic and extragalactic	1.19	1.18	1.53	1.05	1.21	1.09	1.13	1.29	1.24
11	A9840	Interstellar medium; nebulae	1.09	1.10	1.21	0.84	0.96	1.53	1.08	0.90	1.28
12	A9850	The Galaxy, extragalactic objects and systems	1.15	1.15	1.09	0.86	1.18	1.85	1.20	1.12	0.94
13	A9870	Other astronomical sources and radiations	1.22	1.25	1.01	1.69	1.21	1.23	1.21	1.29	0.90
14	A0100	Communication, education, history, and phil	1.20	1.10	1.00	2.87	1.26	1.06	0.94	1.29	1.13
15	A0200	Mathematical methods in physics	1.34	1.14	1.46	1.67	1.09	0.80	1.11	1.32	1.04
16	A0230	Function theory, analysis	1.34	1.14	1.13	1.58	1.05	1.08	1.08	1.33	1.03
17	A0250	Probability theory, stochastic processes, and stat	1.57	1.59	2.13	1.84	1.24	1.15	1.65	1.61	1.55
18	A0260	Numerical approximation and analysis	1.23	1.08	1.12	1.29	1.01	1.45	1.03	1.13	1.06
19	B0200	Engineering mathematics and mathematical	1.67	1.34	1.51	1.26	1.24	1.98	1.34	1.35	1.13
20	B0240	Probability and statistics	1.65	1.44	1.66	1.71	1.49	2.06	1.54	1.41	1.38
21	B0260	Optimisation techniques	1.48	1.22	1.28	1.67	1.24	1.83	1.09	1.12	1.36
22	B0290	Numerical analysis	1.44	1.09	1.16	1.43	1.09	1.17	1.12	1.10	1.03
23	A0300	Classical and quantum physics; mechanics and	1.21	1.12	1.33	1.26	1.07	1.14	1.18	0.95	1.10
24	A0400	Relativity and gravitation	1.16	1.14	1.05	1.25	1.06	0.74	1.16	1.42	0.94
25	A0500	Statistical physics and thermodynamics	1.00	0.96	1.39	0.94	0.93	0.92	1.05	0.99	0.92
26	A0540	Fluctuation phenomena, random processes, and	1.15	1.02	1.21	1.13	1.08	0.92	1.07	1.14	1.02
27	A1000	The physics of elementary particles and fields	0.85	0.89	0.72	1.02	0.85	0.54	1.03	0.87	0.73
28	A1100	General theory of fields and particles	0.88	0.79	1.12	1.07	0.90	0.63	0.91	0.82	0.79
29	A1200	Specific theories and interaction models; particle	0.96	0.96	1.08	1.16	0.94	0.66	1.07	1.03	1.07
30	A2000	Nuclear physics	0.88	0.93	0.80	0.83	0.78	0.57	0.92	0.78	0.70
31	A3100	Theory of atoms and molecules	1.09	0.99	1.05	1.37	0.86	0.77	0.81	1.01	0.86
32	A3200	Atomic spectra and interactions with photons	0.82	0.80	0.81	1.12	0.71	1.02	0.62	0.77	0.64
33	A3300	Molecular spectra and interactions with photons	0.94	0.90	0.93	1.31	0.82	0.70	0.73	0.83	0.86
34	A3400	Atomic and molecular collision processes and	0.86	0.85	0.97	1.11	0.83	0.91	0.67	0.79	0.61
35	A3500	Properties of atoms and molecules; instruments	1.12	0.99	1.06	1.31	0.90	0.78	0.86	0.90	0.94
36	A3600	Studies of special atoms and molecules	1.87	2.18	1.81	2.84	1.40	1.45	1.95	1.52	1.91
37	A8200	Physical chemistry	1.37	1.17	1.25	2.05	1.01	1.37	1.32	1.09	1.25
38	A8230	Specific chemical reactions; reaction mechanisms	1.68	1.28	1.33	2.76	1.10	1.50	1.32	1.31	1.12
39	A8240	Chemical kinetics and reactions: special regimes	1.78	1.55	1.29	2.36	1.21	1.31	1.54	1.43	1.30
40	A8265	Surface chemistry	1.44	1.20	0.96	2.18	1.00	1.19	0.98	1.26	1.09
41	A6700	Quantum fluids and solids; liquid and solid helium	0.96	1.01	1.50	0.62	0.79	1.75	1.14	1.49	0.47
42	A6800	Surfaces and interfaces; thin films and whiskers	1.39	1.36	1.15	1.73	1.07	1.23	1.24	1.09	1.29
43	A6820	Solid surface structure	1.31	1.13	1.01	1.66	0.88	0.77	0.98	1.07	1.06
44	A6840	Surface energy of solids; thermodynamic prop	1.07	0.96	0.86	1.37	0.80	0.83	0.83	0.97	0.97
45	A7100	Electron states in condensed matter	1.13	1.25	1.49	1.17	1.01	0.99	1.21	0.97	1.26
46	A7120	Electronic density of states determinations	1.09	1.12	1.04	1.19	0.85	0.78	0.92	0.87	1.01
47	A7200	Electronic transport in condensed matter	0.85	0.79	0.95	1.05	0.86	0.75	0.73	0.68	0.84
48	A7300	Electronic structure of surfaces, interfaces, and	0.95	0.99	0.91	1.33	0.95	0.87	0.72	0.88	0.89
49	A7400	Superconductivity	0.99	0.99	0.76	1.09	0.95	1.02	0.89	0.77	0.86
50	A7470	Superconducting materials	0.81	0.88	0.53	1.04	0.73	0.80	0.72	0.58	0.76
51	A7500	Magnetic properties and materials	1.18	1.41	1.67	2.16	1.11	0.85	0.99	1.04	1.05
52	A7530	Magnetically ordered materials, other intrinsic	1.14	1.37	1.27	1.88	1.04	0.88	1.03	0.92	0.80
53	A7550	Studies of specific magnetic materials	1.60	1.95	1.71	2.99	1.66	1.00	1.20	1.27	1.23
54	A7600	Magnetic resonances and relaxation in	1.00	0.96	1.05	1.21	0.83	0.77	0.80	0.82	0.89
55	A7800	Optical properties and condensed matter	1.24	1.10	1.14	1.76	0.88	0.79	1.02	0.98	1.12
56	A7820	Optical properties of condensed matter	1.07	0.96	0.99	1.32	0.83	0.71	0.82	0.83	0.96

57	A7855	Photoluminescence (condensed matter)	1.26	1.02	1.22	2.05	0.97	0.88	1.03	0.97	1.29
58	A7865	Optical properties of thin films and low-	1.20	1.05	1.10	1.61	0.95	0.92	0.86	1.08	1.18
59	A8700	Biophysics, medical physics, and biomedical en	1.31	1.27	1.52	4.51	1.12	1.20	1.11	1.48	1.07
60	A8710	General, theoretical, and mathematical biophysics	1.21	1.09	1.35	2.20	1.20	1.08	1.20	1.31	0.94
61	A8715	Molecular biophysics	2.30	2.11	2.37	10.98	2.13	2.23	2.79	2.31	2.01
62	A8720	Membrane biophysics	1.42	1.36	1.62	4.23	1.23	1.66	1.47	1.48	1.38
63	A8730	Biophysics of neurophysiological processes	1.26	1.21	1.13	2.51	1.16	1.53	1.18	1.24	1.18
64	A8740	Biomagnetism	1.13	1.03	1.07	4.44	1.05	1.10	0.95	1.42	1.17
65	A8745	Biomechanics, biorheology, biological fluid	1.39	1.29	1.16	3.06	1.23	1.48	1.12	1.30	1.35
66	A8760	Medical and biomedical uses of fields, radiations,	1.30	1.26	1.02	2.12	1.24	1.37	0.96	1.37	1.17
67	A8760J	X-rays and particle beams (medical uses)	1.30	1.33	0.84	2.55	1.16	1.36	0.65	1.33	1.19
68	A8770	Biomedical engineering	1.70	1.52	1.21	4.81	1.55	1.87	1.21	1.48	1.37
69	A8770E	Patient diagnostic methods and instrumentation	1.28	1.25	0.98	2.86	1.09	1.15	0.81	1.39	1.18
70	B7500	Medical physics and biomedical engineering	1.78	1.91	1.24	2.57	1.46	1.55	1.23	1.71	1.54
71	B7510	Biomedical measurement and imaging	1.58	1.58	1.36	2.80	1.38	1.59	1.07	1.58	1.60
72	B7520	Patient care and treatment	1.65	1.61	1.04	2.69	1.74	1.58	1.21	1.27	1.49
73	A9100	Solid Earth physics	1.10	0.93	1.03	2.07	1.11	1.68	0.91	0.93	1.07
74	A9200	Hydrospheric and lower atmospheric physics	1.36	1.24	1.72	3.01	1.35	1.30	1.48	1.29	1.60
75	A9260	Lower atmosphere	1.09	1.03	1.07	2.79	1.00	1.20	1.10	1.03	1.15
76	A9300	Geophysical observations, instrumentation, and	1.18	1.07	1.18	2.42	1.31	1.26	1.15	1.01	1.25
77	A9385	Instrumentation for geophysical, hydrospheric and	1.17	1.08	1.46	1.73	1.27	1.03	1.05	1.13	1.42
78	B7700	Earth sciences	1.44	1.40	1.44	1.75	1.43	1.37	1.16	1.29	2.38
79	A0600	Measurement science, and instrumentation	1.12	1.10	0.82	1.69	1.01	1.01	0.94	1.04	0.85
80	A0700	Specific instrumentation and techniques of	1.15	1.19	1.29	1.82	0.92	0.96	1.11	1.05	0.98
81	A2900	instrumentation for elementary-particle and	1.13	1.23	0.93	1.42	1.17	1.30	1.16	0.91	0.88
82	A4100	Electricity and magnetism; fields and charged part	0.97	0.99	0.75	0.89	0.99	1.37	0.96	0.82	1.35
83	A7900	Electron and ion emission by liquids and solids;	1.06	0.92	1.00	1.78	0.84	0.69	0.86	0.85	0.82
84	A8280	Chemical analysis and related physical methods	1.62	1.45	1.22	1.72	1.05	1.31	1.22	1.31	1.20
85	B7400	Elementary particle and nuclear instrumentation	1.20	1.34	0.85	1.32	1.20	1.23	1.23	0.93	0.88
86	B7100	Measurement science	1.15	1.02	0.64	1.55	1.17	1.17	0.98	1.04	1.02
87	B7200	Measurement equipment and instrumentation	1.34	1.09	1.12	2.16	0.94	1.07	0.99	1.14	0.93
88	B7300	Measurement of specific variables	1.14	0.95	0.84	1.62	0.93	0.91	0.87	0.96	0.92
89	A0760	Optical instruments and techniques	0.95	0.98	0.81	1.35	0.79	0.84	0.81	1.00	0.94
90	A4200	Optics	1.16	1.01	1.11	1.67	0.91	1.01	1.01	1.03	1.00
91	A4250	Quantum optics	1.05	0.93	1.31	1.25	1.02	0.97	1.01	1.02	0.86
92	A4260	Laser optical systems: design and operation	1.05	0.87	1.60	1.31	1.00	0.94	1.00	0.93	0.85
93	A4265	Nonlinear optics	0.99	0.87	1.07	1.19	0.74	0.65	0.81	0.95	0.99
94	A4280	Optical elements, devices and systems	1.37	1.23	1.25	2.08	1.08	0.95	0.96	1.08	1.36
95	B4300	Lasers and masers	1.10	0.91	1.22	1.41	1.04	0.94	0.97	1.01	0.94
96	A4300	Acoustics	1.09	1.00	1.22	1.43	1.03	1.88	1.00	1.23	1.15
97	B7800	Sonics and ultrasonics	1.24	1.16	1.11	1.41	1.22	1.79	1.07	1.14	1.09
98	A4400	Heat flow, thermal and thermodynamic processes	1.10	1.00	1.00	0.96	1.22	2.82	0.81	1.02	0.81
99	A4600	Mechanics, elasticity, rheology	1.09	0.95	1.13	1.44	0.93	1.01	0.90	1.10	1.15
100	A4700	Fluid dynamics	1.30	1.18	1.29	1.81	1.10	1.58	1.23	1.29	1.26
101	A4710	General fluid dynamics theory, simulation and	1.67	1.41	2.00	2.08	1.50	1.93	1.56	1.62	1.51
102	A4720	Hydrodynamic stability and instability	1.13	0.97	1.32	1.48	1.04	1.20	1.17	1.08	1.19
103	A4750	Non-Newtonian dynamics	1.43	1.22	1.56	1.38	1.32	1.94	1.45	1.39	1.81
104	A5100	Kinetic and transport theory of fluids; physical	0.82	0.84	1.06	1.03	0.59	0.41	0.65	0.99	0.74
105	A5200	The physics of plasmas and electric discharges	1.17	1.23	1.03	1.57	1.30	1.83	1.01	1.24	1.61
106	A5270	Plasma diagnostic techniques and	1.46	1.25	1.40	3.20	1.36	1.70	1.23	1.40	1.30
107	A6100	Structure of liquids and solids; crystallography	1.13	1.09	0.94	1.45	0.66	0.91	0.95	0.84	0.96
108	A6110	X-ray determination of structures	0.63	0.67	0.61	0.76	0.44	0.42	0.61	0.59	0.47
109	A6140	Structure of amorphous, disordered and	1.73	1.68	1.48	2.58	1.20	1.25	1.21	1.30	1.16
110	A6150	Crystalline state	1.07	1.06	1.07	1.43	0.59	0.66	1.03	0.88	0.94
111	A6170	Defects in crystals	1.06	0.96	1.24	1.29	0.86	0.74	0.94	0.94	0.96
112	A6180	Radiation damage and other irradiation effects	1.26	1.42	1.46	1.69	1.01	1.36	1.24	1.31	1.61
113	A6200	Mechanical and acoustic properties of condensed	1.22	1.13	0.99	1.34	1.02	1.19	1.10	1.09	1.05
114	A6220F	Deformation and plasticity	1.23	1.03	1.11	1.17	1.07	1.49	0.97	1.07	1.02
115	A6220M	Fatigue, brittleness, fracture, and cracks	1.23	0.96	0.95	1.17	0.98	1.82	0.88	1.01	0.94
116	A6300	Lattice dynamics and crystal statistics	0.93	0.97	1.06	0.98	0.77	0.91	1.13	0.76	1.18
117	A6400	Equations of state, phase equilibria, and phase	1.22	1.07	0.97	1.30	0.89	0.96	1.03	0.95	1.13
118	A6500	Thermal properties of condensed matter	1.09	0.98	0.82	1.19	0.85	0.65	1.05	0.97	0.83
119	A6600	Transport properties of condensed matter	1.16	1.06	1.03	1.21	0.92	1.09	1.04	0.92	0.96
120	A8100	Materials science	1.33	1.01	1.09	1.25	0.89	1.08	1.00	0.95	0.92
121	A8110	Methods of crystal growth and purification	2.02	2.11	1.51	3.21	0.61	1.60	1.52	1.48	1.81

122	A8140	Treatment of materials and its effects on	1.37	1.15	1.10	1.26	1.10	1.27	1.03	1.10	1.14
123	A8140L	Deformation, plasticity and creep	1.37	1.15	1.27	1.25	1.16	1.53	1.11	1.25	1.03
124	A8160	Corrosion, oxidation, etching, and other surface t	1.31	1.04	1.14	1.59	0.96	1.15	1.05	1.04	1.24
125	A8170	Materials testing	1.60	1.29	1.10	2.58	1.14	2.05	1.35	1.35	1.38
126	A6855	Thin film growth, structure, and epitaxy	1.23	1.05	1.04	1.46	1.00	0.81	0.93	1.00	1.01
127	A7700	Dielectric properties and materials	1.34	1.24	1.10	1.28	1.33	1.00	1.28	1.01	0.95
128	A8115	Methods of thin film deposition	1.24	1.05	1.03	1.50	1.03	0.91	0.95	1.05	0.94
129	B0500	Materials science for electrical and electronic engi	1.38	1.01	0.89	1.97	1.00	1.10	1.18	1.09	1.64
130	B0520	Thin film growth and epitaxy	1.75	1.47	1.87	1.92	1.80	1.33	1.32	1.65	1.41
131	B2500	Semiconductor materials and devices	1.03	1.06	1.15	1.44	1.01	0.89	0.84	0.91	1.36
132	B2520	Semiconductor theory, materials and properties	1.14	1.03	1.20	1.45	1.06	0.88	0.96	1.05	1.12
133	B2550	Semiconductor device technology	1.39	1.26	1.50	1.60	1.25	1.24	1.23	1.20	1.36
134	B2800	Dielectric materials and devices	1.34	1.18	1.20	1.60	1.11	1.00	1.24	1.06	0.71
135	B3000	Magnetic and superconducting materials and devi	1.68	1.78	1.71	3.20	1.49	2.26	1.28	1.52	1.26
136	B4100	Optical materials and devices	1.30	1.10	1.31	1.87	0.97	0.82	0.95	1.07	1.31
137	B4200	Optoelectronic materials and devices	1.39	1.06	1.26	2.69	1.10	0.93	1.11	1.21	1.44
138	B0100	General electrical engineering topics	1.09	0.77	1.27	1.43	0.88	0.94	0.82	1.15	1.32
139	B1000	Circuit theory and circuits	1.29	1.10	1.53	1.52	0.91	1.12	0.90	1.01	1.36
140	B2000	Components, electron devices and materials	1.33	0.98	1.70	2.21	1.18	1.06	1.20	1.14	1.78
141	B2560	Semiconductor devices	1.29	1.20	1.27	1.51	1.27	1.41	1.02	0.95	1.23
142	B2570	Semiconductor integrated circuits	1.19	0.99	1.19	1.23	0.92	1.31	0.69	1.02	1.26
143	B2575	Micromechanical device technology	2.72	2.70	1.64	4.32	1.76	1.33	2.43	2.16	1.48
144	B5000	Electromagnetic fields	1.06	1.09	1.21	1.36	0.95	1.20	0.86	1.19	1.72
145	B5200	Electromagnetic waves, antennas and propag	1.17	1.11	1.41	1.59	0.94	1.37	0.91	0.92	1.32
146	B6100	Information and communication theory	1.40	1.21	1.07	1.57	1.00	0.99	1.02	1.11	0.92
147	B6130	Speech and audio signal processing	1.33	1.26	1.52	1.17	1.37	1.38	0.90	0.96	2.42
148	B6135	Optical, image and video signal processing	2.55	2.24	2.24	2.43	1.90	2.87	1.99	2.36	2.30
149	B6140	Signal processing and detection	0.74	0.52	0.82	0.68	0.61	0.89	0.51	0.56	0.70
150	B6200	Telecommunication	0.59	0.47	0.47	0.98	0.29	0.41	0.37	0.51	0.60
151	B6210	Telecommunication applications	1.25	0.96	0.96	2.39	0.74	0.67	0.70	1.21	1.41
152	B6250	Radio links and equipment	1.77	1.59	1.61	2.16	1.16	1.54	1.18	1.85	1.24
153	B6260	Optical communication	1.46	1.35	1.14	2.37	0.92	0.68	0.85	0.96	1.13
154	B6300	Radar and radionavigation	1.11	0.85	1.07	1.58	1.09	0.97	0.89	0.77	1.48
155	B6400	Radio, television and audio	0.89	0.68	0.68	1.59	0.50	0.74	0.78	0.79	0.65
156	B7600	Aerospace facilities and techniques	1.62	1.03	1.71	1.50	1.66	2.00	1.93	1.56	1.56
157	B7900	Military systems and equipment	1.38	0.90	1.60	0.53	1.78	0.00	1.12	0.75	0.55
158	A2800	Nuclear engineering and nuclear power studies	0.99	0.90	0.91	0.84	0.85	1.56	0.71	0.88	0.69
159	A8600	Energy research and environmental science	1.34	1.07	1.21	1.89	0.93	1.16	0.98	1.40	1.21
160	B8000	Power systems and applications	1.44	1.03	1.41	1.79	0.93	0.79	0.94	1.13	1.87

Appendix 4: Patenten activiteits indices 2000-2005

	description	USA act in	Sweden act in	South Korea act in	Germany act in	Switserland act in	UK act in	France act in	Netherlands act in	Aantal documenten NL
1	Aeronomy, space physics, and cosmic rays									0,00
2	Fundamental astronomy and astrophysics,	0,96	1,27	1,63	0,66	0,50	1,02		0,73	6,10
3	Fundamental aspects of astrophysics	0,27	0,15	0,00	0,19	15,44	0,54		0,30	1,65
4	Astronomical observations	0,71	0,75	0,24	1,66	0,98	0,80		0,37	1,20
5	Solar system	0,72	0,77	0,22	1,70	1,00	0,82		0,34	0,28
6	Stars	0,81	0,61	0,20	1,37	0,80	1,00		0,43	1,24
7	Stellar characteristics									0,00
8	Normal stars (by class): general or individual	0,72	0,77	0,22	1,70	1,00	0,82		0,34	0,28
9	Binary and multiple stars									0,00
10	Stellar systems; Galactic and extragalactic	0,72	0,77	0,22	1,70	1,00	0,82		0,34	0,28
11	Interstellar medium; nebulae									0,00
12	The Galaxy, extragalactic objects and systems									0,00
13	Other astronomical sources and radiations									0,00
14	Communication, education, history, and phil									0,00
15	Mathematical methods in physics	0,88	0,91	1,25	0,80	1,71	0,83		1,13	33,54
16	Function theory, analysis	1,02	0,62	0,41	0,87	1,14	1,19		1,61	1,47
17	Probability theory, stochastic processes, and stat	0,85	0,91	0,75	0,85	0,78	0,78		1,76	6,22
18	Numerical approximation and analysis	0,93	0,93	1,01	0,63	0,74	1,04		0,87	13,67
19	Engineering mathematics and mathematical	1,16	0,97	0,69	0,62	0,98	0,92		1,49	13,35
20	Probability and statistics	1,07	1,21	1,13	0,81	0,72	0,86		0,99	85,44
21	Optimisation techniques	1,01	1,35	1,79	0,69	0,53	0,90		0,99	125,64
22	Numerical analysis	0,91	1,45	1,86	0,77	0,53	0,87		0,97	34,31
23	Classical and quantum physics; mechanics and	0,97	1,21	1,41	0,90	0,68	0,87		0,99	98,07
24	Relativity and gravitation	0,43	1,32	0,73	1,14	2,42	0,97		0,93	1,19
25	Statistical physics and thermodynamics									0,00
26	Fluctuation phenomena, random processes, and	0,76	0,67	0,75	0,71	0,73	0,35		5,18	2,72
27	The physics of elementary particles and fields	1,15	0,82	1,25	0,54	0,74	0,88		0,90	7,63
28	General theory of fields and particles									0,00
29	Specific theories and interaction models; particle									0,00
30	Nuclear physics									0,00
31	Theory of atoms and molecules	1,28	1,15	0,46	0,99	1,34	1,50		0,69	20,52
32	Atomic spectra and interactions with photons	0,81	1,77	1,19	1,09	0,79	1,03		1,32	1,01
33	Molecular spectra and interactions with photons	0,99	1,20	0,57	1,32	1,15	1,04		0,86	6,66
34	Atomic and molecular collision processes and	1,38	0,99	0,57	1,11	1,36	1,30		0,97	92,61
35	Properties of atoms and molecules; instruments	1,20	1,04	1,02	0,71	1,17	1,18		0,93	53,20
36	Studies of special atoms and molecules	0,66	0,77	0,55	1,03	1,65	0,97		0,84	5,05
37	Physical chemistry	0,98	1,06	1,16	0,72	0,71	0,91		0,81	14,41
38	Specific chemical reactions; reaction mechanisms	1,07	0,77	0,64	1,05	1,15	1,16		0,92	116,43
39	Chemical kinetics and reactions: special regimes	0,93	0,81	0,79	1,19	1,04	1,09		0,96	110,39
40	Surface chemistry	0,87	0,77	0,72	1,26	1,02	0,71		0,93	42,94
41	Quantum fluids and solids; liquid and solid helium	0,84	0,73	0,80	1,12	1,03	0,85		0,93	53,59
42	Surfaces and interfaces; thin films and whiskers	1,41	0,85	1,42	0,47	0,50	0,93		0,95	4,40
43	Solid surface structure	0,97	0,68	0,85	0,98	1,33	0,93		0,99	29,12
44	Surface energy of solids; thermodynamic prop	0,87	0,79	0,92	1,10	1,22	0,83		1,22	33,37
45	Electron states in condensed matter	1,28	0,80	0,69	1,32	1,10	1,09		0,95	67,09
46	Electronic density of states determinations	0,77	0,79	1,09	1,57	1,05	0,86		0,93	26,39
47	Electronic transport in condensed matter	0,74	0,57	1,21	1,48	1,04	0,76		0,85	13,39
48	Electronic structure of surfaces, interfaces, and	1,28	1,03	0,66	0,96	1,98	1,87		0,71	147,20
49	Superconductivity	0,90	0,57	1,17	0,87	0,89	0,81		1,07	70,98
50	Superconducting materials	0,79	0,66	1,68	0,82	0,59	0,56		1,45	16,05
51	Magnetic properties and materials	0,82	0,74	1,44	0,88	0,77	0,65		1,34	17,92
52	Magnetically ordered materials, other intrinsic	0,72	0,72	1,26	1,08	0,88	0,75		1,31	59,13
53	Studies of specific magnetic materials	0,89	0,48	1,57	0,93	0,82	0,71		1,80	19,61
54	Magnetic resonances and relaxation in	0,74	0,60	1,40	1,03	0,89	0,74		1,49	54,22
55	Optical properties and condensed matter	0,81	0,65	0,80	1,41	1,00	1,11		1,37	39,93
56	Optical properties of condensed matter	1,07	0,73	0,78	0,94	1,02	1,12		0,93	105,47
57	Photoluminescence (condensed matter)	0,81	0,70	1,53	0,75	0,70	0,81		1,43	51,15
58	Optical properties of thin films and low-	1,31	0,79	0,70	1,23	1,01	1,14		0,93	68,74
59	Biophysics, medical physics, and biomedical en	0,82	0,56	1,04	1,09	0,87	0,95		1,40	68,99
60	General, theoretical, and mathematical biophysics	1,20	0,96	0,63	1,02	1,40	1,22		0,99	114,19
61	Molecular biophysics	1,24	0,87	0,83	1,05	1,09	1,01		0,93	76,03
62	Membrane biophysics	1,16	0,92	0,96	1,06	1,10	1,19		1,16	106,68
63	Biophysics of neurophysiological processes	1,15	0,78	0,76	1,25	1,16	0,99		1,03	116,43
64	Biomagnetism	1,24	1,18	0,88	0,80	1,28	0,92		0,88	50,49
65	Biomechanics, biorheology, biological fluid	1,28	1,16	0,99	0,87	1,19	1,55		1,32	32,46
66	Medical and biomedical uses of fields, radiations,	1,38	1,17	0,72	0,70	1,03	1,22		0,84	56,35
67	X-rays and particle beams (medical uses)	1,28	1,13	0,63	0,79	1,16	1,26		0,86	98,61
68	Biomedical engineering	1,29	1,20	0,60	0,88	1,21	1,34		0,79	36,03
69	Patient diagnostic methods and instrumentation	1,31	1,09	0,61	0,89	1,21	1,30		0,89	161,24
70	Medical physics and biomedical engineering	1,32	1,15	0,66	0,76	1,20	1,32		0,75	36,25
71	Biomedical measurement and imaging	1,55	1,51	0,54	0,61	1,41	1,33		0,60	41,63
72	Patient care and treatment	1,26	1,03	0,76	0,87	1,19	1,15		1,02	175,23
73	Solid Earth physics	1,47	1,18	0,95	0,63	1,14	1,21		0,81	58,24
74	Hydrospheric and lower atmospheric physics	1,29	0,90	0,18	0,40	0,22	2,00		1,25	84,27
75	Lower atmosphere	1,04	0,19	0,14	0,51	0,29	1,47		0,68	2,03
76	Geophysical observations, instrumentation, and	1,05	1,15	0,99	0,74	0,76	1,04		0,76	12,28
77	Instrumentation for geophysical, hydrospheric and	0,82	0,88	0,70	0,79	0,75	1,11		0,78	12,41
78	Earth sciences	1,32	1,01	0,36	0,40	0,28	1,88		1,30	81,51
79	Measurement science, and instrumentation	0,96	1,06	0,90	0,83	0,80	1,06		0,91	24,56
80	Specific instrumentation and techniques of	1,14	0,96	0,69	1,03	1,22	1,16		1,11	131,41
81	instrumentation for elementary-particle and	0,93	0,95	1,18	0,92	0,93	0,86		1,01	74,43
82	Electricity and magnetism; fields and charged part	1,16	1,09	0,60	0,98	1,22	1,34		0,85	68,56
83	Electron and ion emission by liquids and solids;	0,81	0,70	1,23	0,83	0,81	0,81		1,40	5,62
84	Chemical analysis and related physical methods	0,94	0,69	0,77	1,06	1,18	0,90		1,00	45,34
85	Elementary particle and nuclear instrumentation	1,06	0,89	0,69	1,02	1,19	1,07		1,03	128,05
86	Measurement science	0,89	0,78	0,83	0,86	0,88	0,98		1,24	15,29
87	Measurement equipment and instrumentation	1,19	1,13	0,56	0,99	1,25	0,95		0,93	7,14
88	Measurement of specific variables	1,10	1,02	1,09	0,86	1,00	1,05		1,16	371,72

89	Optical instruments and techniques	0,99	0,97	0,83	1,09	1,32	1,06		1,14	189,71
90	Optics	0,92	0,84	1,00	0,86	0,93	1,00		1,30	64,42
91	Quantum optics	1,00	0,80	1,43	0,67	0,71	0,84		1,44	169,61
92	Laser optical systems: design and operation	0,97	0,71	1,68	0,76	0,60	0,87		1,05	29,75
93	Nonlinear optics	0,81	0,73	1,47	0,84	0,76	0,80		1,53	51,49
94	Optical elements, devices and systems	0,98	1,02	1,23	0,80	0,94	0,98		1,21	22,10
95	Lasers and masers	1,01	0,83	1,02	0,94	1,01	0,98		1,20	226,52
96	Acoustics	0,97	0,97	1,40	0,91	0,72	0,81		1,23	105,19
97	Sonics and ultrasonics	0,85	1,02	0,68	1,10	1,10	0,87		0,96	169,01
98	Heat flow, thermal and thermodynamic processes	0,90	1,44	0,60	1,26	1,06	0,93		0,81	22,97
99	Mechanics, elasticity, rheology	0,38	1,00	0,54	0,45	0,60	0,30		0,64	3,90
100	Fluid dynamics	0,89	0,69	0,51	1,29	0,89	0,90		0,67	14,29
101	General fluid dynamics theory, simulation and	0,88	0,63	0,31	1,02	1,08	1,36		0,51	13,66
102	Hydrodynamic stability and instability	1,16	0,82	0,84	1,50	1,15	0,79		1,11	13,86
103	Non-Newtonian dynamics	0,98	0,61	0,56	0,82	1,06	1,41		0,52	5,88
104	Kinetic and transport theory of fluids; physical	0,85	0,41	0,64	1,27	0,74	0,80		0,99	15,38
105	The physics of plasmas and electric discharges									0,00
106	Plasma diagnostic techniques and	0,87	1,10	0,95	1,04	0,79	0,84		1,04	30,92
107	Structure of liquids and solids; crystallography	0,77	0,93	1,10	0,95	0,71	0,74		1,28	25,85
108	X-ray determination of structures	1,25	0,97	0,61	0,97	1,81	1,81		0,81	127,46
109	Structure of amorphous, disordered and	0,99	0,97	0,76	0,92	1,01	1,09		1,16	22,61
110	Crystalline state	0,91	0,78	0,73	1,17	1,33	1,03		0,88	101,41
111	Defects in crystals	0,95	1,00	1,16	0,86	0,62	0,81		0,83	21,24
112	Radiation damage and other irradiation effects	1,01	0,89	0,77	0,98	1,16	1,05		0,90	67,70
113	Mechanical and acoustic properties of condensed	0,82	0,63	0,95	0,85	0,78	0,68		1,29	32,83
114	Deformation and plasticity	0,99	1,02	0,60	0,99	1,83	1,11		0,81	56,22
115	Fatigue, brittleness, fracture, and cracks	0,75	1,08	0,70	1,28	1,32	0,85		0,73	13,93
116	Lattice dynamics and crystal statistics	0,83	0,96	0,80	0,95	1,72	0,81		0,95	19,78
117	Equations of state, phase equilibria, and phase	1,20	1,30	2,40	1,16	1,17	1,41		1,11	18,23
118	Thermal properties of condensed matter	0,79	1,01	0,82	1,17	0,91	0,72		0,83	54,39
119	Transport properties of condensed matter	1,14	0,91	0,59	0,92	1,21	1,26		0,68	27,07
120	Materials science	0,81	0,74	0,76	1,27	0,69	0,68		0,69	17,27
121	Methods of crystal growth and purification	0,98	0,94	0,66	1,17	1,35	1,06		0,75	215,91
122	Treatment of materials and its effects on	0,89	0,57	0,89	0,99	0,90	0,88		1,13	24,63
123	Deformation, plasticity and creep	0,88	0,99	0,69	1,08	1,56	0,94		0,79	99,06
124	Corrosion, oxidation, etching, and other surface t	0,75	1,08	0,70	1,28	1,32	0,85		0,73	13,93
125	Materials testing	0,74	0,97	0,61	1,13	0,90	0,77		0,86	81,08
126	Thin film growth, structure, and epitaxy	0,95	1,31	0,52	1,13	1,06	1,01		0,64	6,03
127	Dielectric properties and materials	0,82	0,85	0,79	0,99	0,99	0,75		1,09	37,30
128	Methods of thin film deposition	0,78	0,71	0,98	0,94	0,86	0,71		0,95	49,01
129	Materials science for electrical and electronic engi	0,80	0,72	0,89	0,98	0,92	0,74		1,08	73,49
130	Thin film growth and epitaxy	0,79	0,73	0,81	1,20	0,80	0,71		0,85	102,59
131	Semiconductor materials and devices	0,83	0,62	0,99	0,94	0,88	0,73		1,17	53,19
132	Semiconductor theory, materials and properties	0,82	0,58	1,36	0,88	0,77	0,73		1,27	34,32
133	Semiconductor device technology	0,70	0,79	0,76	1,13	0,86	0,80		0,97	45,21
134	Dielectric materials and devices	1,18	0,71	0,77	1,35	1,20	0,95		1,21	193,98
135	Magnetic and superconducting materials and devi	0,81	1,04	1,05	0,94	1,01	0,74		1,02	50,84
136	Optical materials and devices	0,71	1,26	0,97	1,49	0,60	0,72		1,06	87,28

137	Optoelectronic materials and devices	1,12	0,76	0,87	1,13	1,11	1,02		1,23	406,88
138	General electrical engineering topics	0,93	0,73	1,39	0,72	0,67	0,79		1,14	42,13
139	Circuit theory and circuits	0,85	1,06	1,13	1,08	0,75	0,78		0,84	170,21
140	Components, electron devices and materials	0,95	1,28	1,54	0,88	0,56	0,84		1,18	455,95
141	Semiconductor devices	0,80	0,81	0,98	1,15	0,91	0,72		1,08	191,33
142	Semiconductor integrated circuits	0,84	0,95	1,05	1,01	0,92	0,69		1,38	49,74
143	Micromechanical device technology	0,85	1,25	1,34	1,11	0,57	0,77		1,22	196,02
144	Electromagnetic fields	0,94	1,16	1,02	0,90	0,91	0,79		1,17	50,87
145	Electromagnetic waves, antennas and propag	0,75	1,12	0,89	1,36	0,94	0,82		0,84	17,17
146	Information and communication theory	0,86	1,47	1,95	0,76	0,57	0,91		0,82	69,31
147	Speech and audio signal processing	0,93	1,29	1,80	0,69	0,48	0,91		0,89	211,51
148	Optical, image and video signal processing	0,88	1,40	1,83	0,72	0,60	0,90		1,20	58,20
149	Signal processing and detection	1,01	1,02	1,40	0,66	0,72	0,96		1,21	81,94
150	Telecommunication	0,90	1,41	1,30	0,92	0,73	0,89		1,16	170,08
151	Telecommunication applications	0,88	1,58	2,18	0,75	0,48	0,91		0,83	119,66
152	Radio links and equipment	0,93	1,54	1,86	0,72	0,53	0,93		0,87	236,08
153	Optical communication	0,90	1,64	1,68	0,82	0,66	0,92		0,79	113,17
154	Radar and radionavigation	0,92	1,37	1,74	0,81	0,68	0,86		0,82	29,93
155	Radio, television and audio	0,88	1,45	1,51	0,90	0,74	1,00		0,91	55,43
156	Aerospace facilities and techniques	0,93	1,19	1,89	0,79	0,58	0,90		1,10	132,46
157	Military systems and equipment	0,84	0,99	1,07	0,95	0,77	0,93		0,81	31,41
158	Nuclear engineering and nuclear power studies	0,86	1,15	1,11	0,79	0,62	0,98		0,74	38,09
159	Energy research and environmental science	0,78	1,30	1,23	1,19	0,82	1,03		0,68	39,59
160	Power systems and applications	0,66	0,99	0,48	1,88	0,96	0,78		0,78	129,62

Appendix 5: voorbeeld van patentcategorieën.

A99	Onderwerpen zover niet vallend onder andere groepen in deze sectie
B01B	Koken; Kookapparatuur
B01D	Scheiden
B01F	Mengen, bijv. oplossen, emulgeren of dispergeren
B01J	Chemische of fysische processen, bijv. katalyse of colloïdchemie; Hun relevante apparatuur
B01L	Chemische of fysische laboratoriumapparatuur voor algemeen gebruik
B02B	Voorbewerken van graan voor het malen; Zuiveren van korrelvormig fruit tot commerciële producten door het oppervlak te bewerken
B02C	Breken, verpulveren of vermalen in het algemeen; Malen van graan
B03B	Scheiden van vaste materialen met vloeistoffen of met pneumatische tafels of deinmachines
B03C	Magnetisch of electrostatisch scheiden van vaste materialen uit vaste materialen of uit een fluïdum; Scheiden door electrische hoogspanningsvelden
B03D	Flotatie; Selectieve bezinking of sedimenteren
B04B	Centrifuges
B04C	Apparatuur met vrije wervelstroming, bijv. cyclonen
B05B	Sproei-apparatuur; Verstuivingsapparatuur; Spuitmonden
B05C	Apparatuur voor het aanbrengen van vloeistoffen of andere vloeibare materialen op oppervlakken in het algemeen
B05D	Processen voor het aanbrengen van vloeistoffen of andere vloeibare materialen op oppervlakken in het algemeen
B06B	Methoden of apparatuur voor het opwekken of overbrengen van mechanische trillingen met een infrasone frequentie, een hoorbare frequentie of een ultrasone frequentie ten behoeve van het uitvoeren van een mechanische bewerking in het algemeen
B07B	Afscheiden van vaste stoffen uit vaste stoffen door zeven, ziften en dergelijke of met behulp van gasstromen; Op een andere wijze droog scheiden van bulkmateriaal, bijv. losse artikelen die als bulkmateriaal kunnen worden gehanteerd
B07C	Sorteren van post; Sorteren van afzonderlijke artikelen of bulkmateriaal dat stuksgewijs moet worden gesorteerd, bijv. door uitnemen
B08B	Reinigen in het algemeen; Voorkomen van vervuiling in het algemeen
B09B	Afvoeren van vast afval
B09C	Terugwinnen van verontreinigde grond
B21B	Walsen van metaal
B21C	Maken van metalen platen, draad, staven, buizen of profielen op een andere wijze dan door walsen; Hulpbewerkingen die worden gebruikt bij het bewerken van metaal zonder feitelijk materiaal te verwijderen
B21D	Bewerken of verwerken van plaatmetaal of van metalen buizen, staven of profielen zonder feitelijk materiaal te verwijderen; Ponsen
B21F	Bewerken of verwerken van draad
B21G	Maken van naalden, pinnen of spijkers
B21H	Maken van specifieke metalen objecten door walsen, bijv. schroeven, wielen, ringen, vaten of kogels
B21J	Smeden; Hameren; Persen; Klinken; Smeedovens
H01P	Golfgeleiders; Resonatoren, leidingen of andere golfgeleiderinrichtingen
H01Q	Antenne's
H01R	Leidingkoppelingen; Stroomafnemers
H01S	Inrichtingen waarbij sprake is van geïnduceerde emissie
H01T	Vonkbruggen; Overspanningsafleiders waarbij vonkbruggen worden gebruikt; Bougies; Corona-inrichtingen; Genereren van ionen die in niet-ingesloten gassen moeten worden ingebracht
H02B	Panelen, onderstations of schakelvoorzieningen voor het toevoeren of distribueren van electrische energie
H02G	Installeren van electrische kabels of leidingen
H02H	Noodstroomcircuits
H02J	Circuits of circuitsystemen voor het toevoeren of distribueren van electrische energie; Systemen voor het opslaan van electrische energie
H02K	Dynamo-electrische motoren
H02M	Apparatuur voor het omzetten van wisselstroom in wisselstroom, wisselstroom in gelijkstroom of gelijkstroom in gelijkstroom, en ten behoeve van hoofdenergietoevoersystemen en dergelijke; Omzetten van ingevoerde gelijkstroomenergie of wisselstroomenergie in maximaal uitgangsvermogen; Regelen daarvan

EVALUATION OF THE NOVA PROGRAM
INCENTIVE BONUS SCHEME 2009-2010

Scope of the Assessment

An International Review Board (IRB) consisting of

- Prof. dr. F. H. Shu (chair), University of California, San Diego, USA
- Prof. dr. R. D. Blandford, Stanford University, USA
- Prof. dr. R. C. Kennicutt, University of Cambridge, UK
- Prof. dr. H. W. Rix, Max Planck Institut für Astronomie, Heidelberg, Germany
- Prof. dr. A. I. Sargent, California Institute of Technology, Pasadena, USA
- Prof. dr. R. A. Sunyaev, Max Planck Institut fur Astrophysik, Garching, Germany

was asked to perform an assessment of the research school NOVA and of the research in Astronomy at the Rijksuniversiteit Groningen (RUG), Utrecht University (UU), University of Amsterdam (UvA), Radboud University Nijmegen (RUN), and Leiden University (LEI). The assessment of the research, student training, and outreach covers the period 2003-2009.

Quality of the Research and Position in the National Knowledge Infrastructure

Through the NOVA research school, the Netherlands makes contributions to world astronomy far disproportionate to its population or GDP. These contributions include

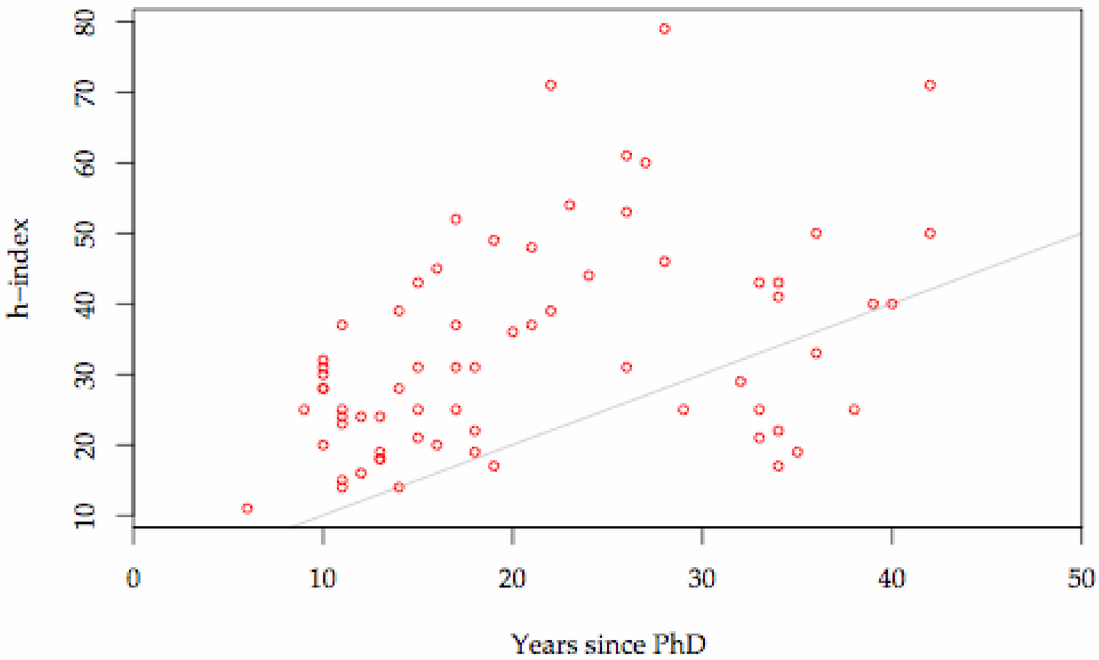
- Important scientific discoveries
- Development of forefront instrumentation
- Production of scientific leaders
- Training of young astronomers
- Outreach and public education

The discoveries occurred in the three areas of research focused upon by

- Network 1: Evolution of Galaxies – setting agenda with leading programs and a good balance of observers and theorists
- Network 2: Star and Planet Formation – best in the world in the fields of astrochemistry/astromineralogy
- Network 3: High-Energy Astrophysics – pioneering work in gamma-ray bursts and relationship between supermassive and stellar black holes

The nature, quantity, and quality of the scientific discoveries are too numerous to be listed individually (see NOVA Self-Evaluation Report); we have contented ourselves in the above list with only some highlights. We note that NOVA researchers have a total of 3,032 publications in refereed journals during the period of the review 2003-2009.

Figure 1. Distribution of h-index with time after PhD for Nova researchers.



An internal survey finds that the permanent staff of NOVA researchers have an average h-index of 36 (i.e., thirty-six papers with 36 or more citations). We note that the h-index of a typical member of the National Academy of Sciences in the United States is 50, so the performance level of senior researchers in NOVA, some of whom reach and exceed the US NAS benchmark, is good even by the highest international standards (Fig. 1). The putative decline in impact ratios found by CWTS is difficult to interpret because of the favorable decrease in the median age of the distribution of NOVA researchers during the period under review (h-indices increase with age), coupled with the huge improvement of research produced in developing nations such as China and India, and the waiting period for Herschel, LOFAR, etc.

The instrumentation program supported with NOVA funds is summarized in Appendix A. We note here only the depth and variety of astronomical instruments developed by NOVA scientists and engineers, and the remarkable achievement that most of these instruments were delivered on time and on budget. A national Instrument Steering Committee commendably provides oversight, management, schedule control, risk mitigation, and impact analysis. The instruments built with NOVA support include

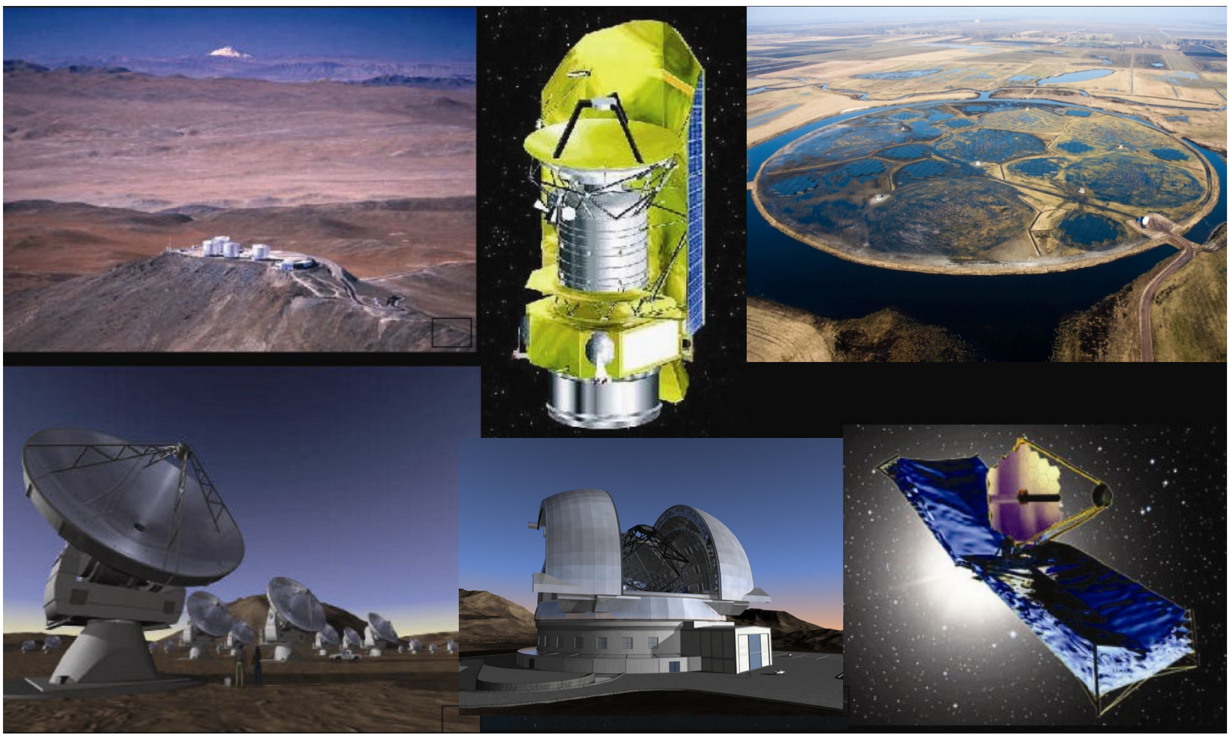
- X-shooter, the optical/ifrared spectrograph most in demand by observers at the Very Large Telescope (VLT) run by the European Southern Observatory (ESO)
- MIDI, a mid-infrared spectrometer coupled to the high spatial resolution achievable with the VLT in interferometry mode, that has revolutionized astronomers' knowledge of the mineralogy distribution of the dust in the disks around young stars where new planets are believed to be assembling
- OmegaCAM/Cen, a wide-field camera for the VLT operating in survey mode, with NOVA contributing to the software pipeline and database structure

The cooperation between SRON and RUG in building the Band 9 receivers for ALMA is very good and sets a fine example for how the boundary between space-based and ground-based efforts may be crossed to the mutual benefit of both disciplines. The combined group is holding productive discussions on new projects after the production of Band 9 receivers is complete.

Instruments for some of the world's most important ground-based and space-borne astronomical facilities are in the developmental or conceptual stages. These include

- Band 9, high frequency receivers for ALMA, the Atacama Large Millimeter-wave Array, rated as the most important radio facility to be built in this decade
- EPICS, a direct imager for exoplanets around nearby stars that will combine extreme adaptive optics, coronagraphic blocking of the light of the central star, and polarimetric detection of the scattered light from the exoplanet by the European Extremely Large Telescope (E-ELT)
- MIRI, the only infrared instrument with modest to high resolution spectral resolution for the James Webb Space Telescope (JWST) that is the successor to the famous and wildly popular Hubble Space Telescope

Figure 2. Clockwise from upper left: VLT, Herschel, LOFAR, JWST, E-ELT, ALMA



Dutch instrumentation prowess at radio, infrared, and optical wavelengths (Fig.2) is matched by its prowess in high-energy astrophysics and astroparticle physics (Fig. 3):

- Pierre Auger Observatory, whose mission is to detect and characterize the flight directions of the highest energy cosmic rays
- Laser Interferometric Space Antenna, LISA, designed to measure gravitational radiation from astronomical sources such as inspiraling compact binary stars, a prediction of Einstein's theory of General Relativity

Figure 3. Left to right: Antares Observatory, Auger Observatory, LISA

Complementing the observational facilities are NOVA's laboratory studies in astromineralogy that have led to the measurement of the spatial distribution of forsterite in the disks around young sunlike stars referred to earlier and unique experiments in gas phase and surface chemistry relating to the interstellar medium (Fig. 4).

Figure 4. Sackler Laboratory and the mineral Forsterite.

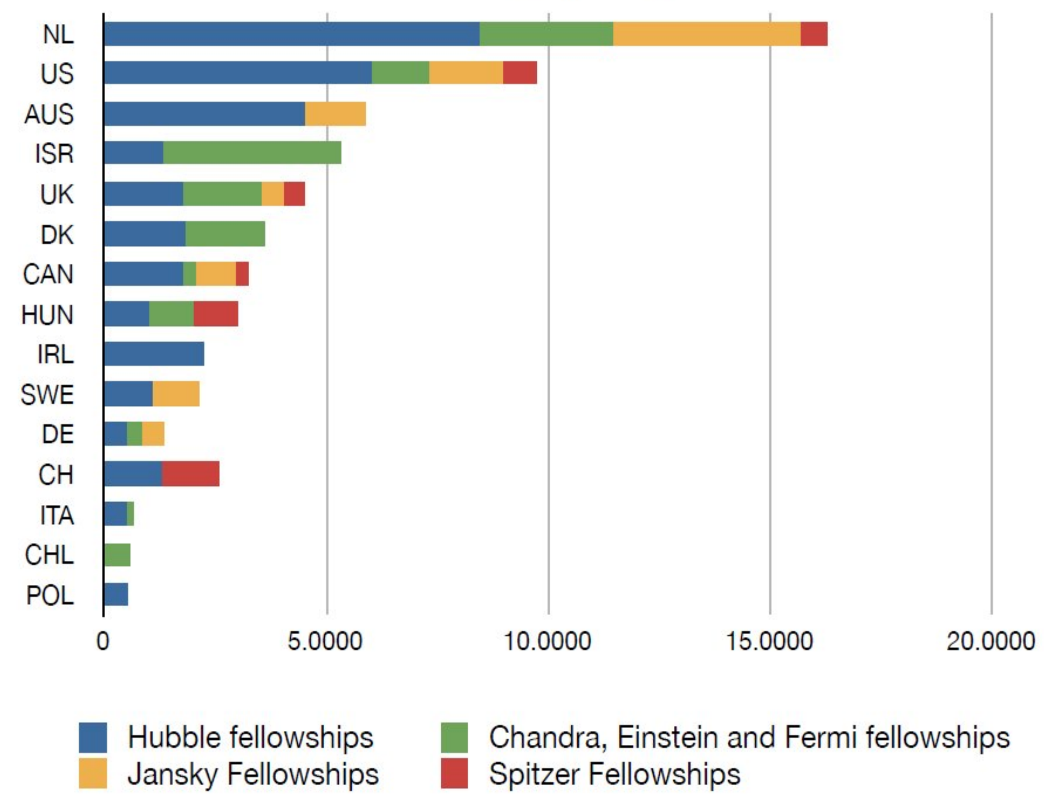
We should also mention NOVA researchers helping with the scientific exploitation of LOFAR, a phased array that has the potential to revolutionize radio astronomy. In a similar manner. NOVA researchers use HIFI, a spectrometer, produced by a broad international consortium coordinated by SRON and carried on the Herschel spacecraft launched by the European Space Agency (ESA), to detect the widespread presence of water molecules throughout interstellar space, an important coolant long suspected to be present in molecular clouds, but not generally observable from the ground because of the ample concentration of water vapor in the Earth's atmosphere

Thus, through impressive past accomplishments and far-sighted vision for future developments, Dutch astronomers are well poised to lead in the major astronomical advances likely to occur in the next two decades. However, this projection depends on a stable source of funding that guarantees the Netherlands commitment to the largest and most important projects being undertaken by the international astronomical community.

International Standing

Dutch PhDs are highly regarded by the international community, as judged by their performance in the award of the most prestigious postdoctoral fellowships in the United States (Fig. 5). On a per capita basis, the Netherlands leads the world by a very substantial margin. Compiled statistics indicate that 60 to 70% of Dutch PhDs continue in astronomy or other research-intensive fields for their professional careers. The high numbers who return to work in the Netherlands are particularly impressive.

Figure 5. Fellowships awarded per 10^7 people to different countries



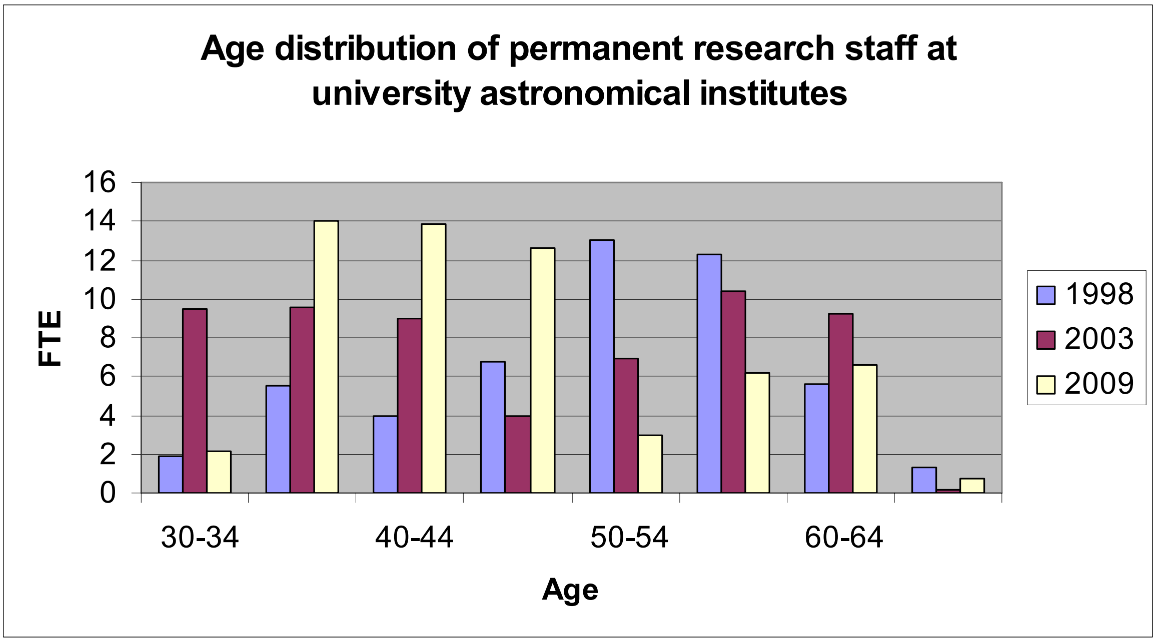
The esteem in which Dutch astronomers are held as scientific leaders by the international community is exemplified by this fact: Since its inception, the governing and operational body for ground-based astronomy in Europe, ESO, has had seven Director Generals. Four of these seven have been Dutch. The current ESO Director General, Tim de Zeeuw, was one of the founders of the NOVA research school.

The NOVA Self-Evaluation Report documents more generally that Dutch astronomers associated with the NOVA research school are sought for important committee posts and chairmanships. The Netherlands brand for acumen and fair play is highly valued by the international astronomical community.

Improvement during the Assessment Period

NOVA funding has made a big difference to the quantity and quality of Dutch astronomy. In the review period under consideration, NOVA has wisely invested roughly 5 million euros per year in human and material resources. About half of this investment has been in long-term funding of instrumental projects, which has borne fruit in the scientific output of NOVA-affiliated observers and theorists and resulted in hundreds of joint papers and collaborative projects (see Appendix B for representative examples from each network). Regular network meetings also contribute to collegial collaboration.

Perhaps the most visible indicator is the rejuvenation of the pool of astronomical researchers in the Netherlands. Figure 6 shows that the number distribution of astronomers in 1998 (blue), the year before the inauguration of NOVA, was a rising one from age 30 to age 65. By 2003, the first year of the period under review, the number distribution had become flat (purple), through a deliberate policy of replacing retiring professors with younger faculty and the hiring of overlap researchers. And by 2009, the number distribution had reversed to be higher at age 35 than age 65 (pale yellow). These healthy trends yield total benefits that greatly exceed the sum of the parts.



Another quantitative indicator that the NOVA program has accomplished its aims is shown in Figure 7, which depicts the activity index of different countries in the PACS code during the period 1996-2005 as compiled in 2009 by P. Kruit of Technical University Delft for KNAW. The activity index of the United States is fairly flat across all fields, appropriate for a country that strives to be excellent across all scientific disciplines. The sub-disciplines of astronomy are enclosed by the red oval. The Netherlands has sharp peaks and deep valleys in the astronomy sector, implying that Dutch astronomers do not attempt to do everything, but strive to be excellent in a selection of important sub-disciplines, a wise strategy for a country of limited population and financial resources. The spikes correspond to the sub-disciplines emphasized by the three NOVA networks. It is impressive that the peaks reached by these spikes rival in height the broad middle hump that corresponds to the more populous and better funded biomedical physics sector.

Figure 7. Activity index based on numbers of papers sorted by PACS code. The red oval contains astronomy.

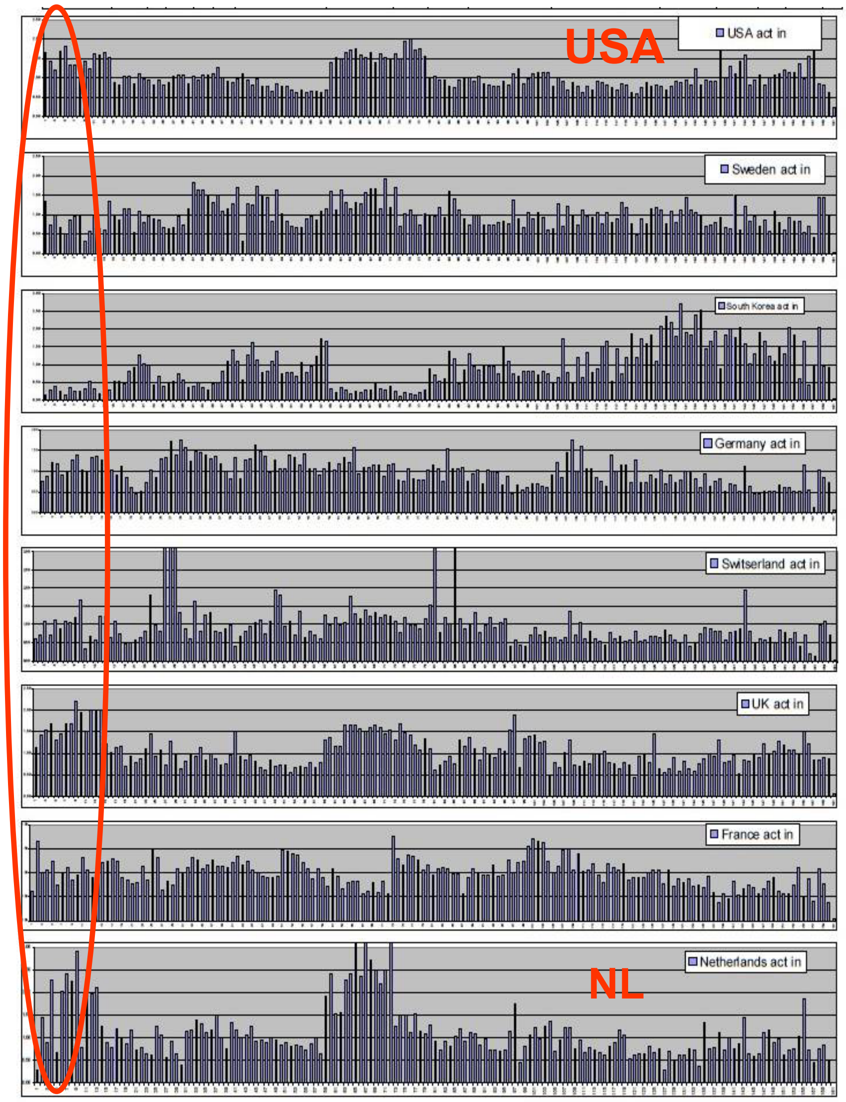


Figure 8. Percentages of population who are female astronomers in 2009.

Institute	PhD	Postdoc	Staff
Amsterdam	31	26	19
Groningen	31	54	19
Leiden	32	26	5
Nijmegen	17	17	5
Utrecht	45	22	0

Figure 8 shows that gender equality is an area where there has not been enough progress. Although the female percentages are comparable to international norms among PhD students and postdoctoral fellows, they are very low in terms of faculty and staff appointments. The attrition in female representation with advance through the academic ranks is a well-known phenomenon, but the rates seem especially severe at Leiden, Nijmegen, and Utrecht. Groningen has done well to appoint three women to its faculty recently. Amsterdam has two women faculty members, and Leiden has just made an offer to an additional woman. ***The IRB encourages NOVA institutes to do better.***

During the six-year period 2003 to 2009, a significant expansion occurred within NOVA in outreach and public education. The outreach program has national impact and reaches audiences ranging from one thousand people to ten million people, depending on the venue. In the process, the public has become more aware of the rich Dutch contributions to humanity's understanding of the universe. Astronomy has had much exposure on television and in the press, while NOVA members have contributed several successful popular books on astronomical subjects.

The education efforts undertaken by NOVA are equally innovative, resulting in significant increases in scientific literacy and awareness of the cosmos from which humans evolved. Since astronomy is regarded as a subject that attracts young people to a wide range of fields in science and technology, we are particularly impressed with the NOVA-sponsored outreach activities that improve the confidence of teachers with respect to astronomical materials of high intellectual interest to students of all ages. The outreach and education team is also to be commended on its mobile planetarium that engages young children in the limitless possibilities of explorations of the mind and eye.

Scientific Potential for the Long Term

Because of the steady investments that the NOVA program has made in astronomical instrumentation and human talent, Dutch astronomers are well positioned to continue to provide instruments and strategic leadership in Europe and to excel in the research fields emphasized by the three NOVA networks. The ability to produce seminal papers that exceed, say, five hundred or a thousand citations is limited, however, by the fact that two of the five astronomy programs in the Netherlands are under-staffed (RUN and UU). It is the experience of the members of the IRB that the critical mass for tenure-track faculty members in cutting edge departments of astronomy is ten FTEs (full-time equivalents). With fewer professors, one needs to overly focus and specialize, which decreases the attractiveness of the department or institute for graduate students. Without first-rate graduate students, all groups, no matter how promising they are at the beginning, will decline in vitality and creativity. Lacking the competition offered by nimble rival departments and research institutes, even well-established groups that exceed critical mass will become ponderous and risk-averse. ***Thus, the IRB recommends that the faculty at RUN and UU be increased***, so that the larger groups at Amsterdam, Groningen, and Leiden feel healthy competitive pressure from within the Netherlands to continue to climb the ranks of the international astronomy hierarchy.

In the realm of astrophysical theory, the strategy in the Netherlands has generally been to appoint theorists who can interact fruitfully with observers and help with the astronomical interpretations. This is a wise course when numbers are few; however, with the growth of Dutch astronomy in the last decade, the time may be ripe to adopt a more forward-looking view. ***The IRB recommends that the NOVA institutes consider recruiting young theorists who have original ideas in different fields and have a capacity to make connections between these fields, and who take a more first-principles approach to the formulation and solution of problems.*** The value of large numerical simulations is well demonstrated by Dutch astrophysical theorists, and this is likely to be a growing trend.

Organizational Form

The organization of Dutch astronomy at the graduate levels in a NOVA research school is an unqualified success. The national collaboration in instrumentation gives Dutch observational astronomers access to the most powerful telescopes of the world, a leveraging that would be impossible if individual institutes were to try to make their own arrangements and contributions. Collaboration on the building and maintenance of the largest international facilities is a win-win model for everyone.

On the other hand, competition to make great scientific discoveries is the surest path to research excellence. Within the Netherlands, the universities must compete with each other too, but the national contest must maintain collegiality, lest it undermines the cooperation needed to excel on the international level. The NOVA leadership has steered a wise course to maintain cooperation in an atmosphere of friendly competition among the member University partners.

There is only one aspect to this balance that the IRB feels is less than perfect in the Netherlands. The laboratories represented by ASTRON and SRON are national resources. But the cohesiveness between these two institutions and the five research universities could be better. ***The IRB recommends that better formal relations be established between the research universities under the NOVA umbrella and ASTRON and SRON.*** Addressing this concern may require inter-agency initiative as well as the professional interactions that happen under the auspices of the National Committee on Astronomy.

Use and Availability of Funding

The decision to allocate about half of the total NOVA resources to building forefront facilities has yielded the single largest impact of the bonus incentive program: the ascendance of Dutch astronomers from supporting players to leading providers of cutting-edge optical/infrared instrumentation. The effective leveraging of NOVA resources has helped to enhance the Netherlands status in ESO and ESA, as well as gained it the highest levels of access to the great international projects in astronomy of the present era: ALMA, JWST, E-ELT, SKA, LISA.

The consequences of a discontinuance of bonus incentive funding beyond 2013 would therefore be dire:

- It would threaten the strategic cohesion of Dutch astronomy so painstakingly achieved by NOVA over the past decade.
- It would cripple the Dutch science program for ALMA just when this major international facility is scheduled for completion.
- It would probably lead to a flight of the best Dutch researchers to greener pastures.
- It would reduce by half the astronomy PhD production. If the quantity were kept high by digging deeper into the talent pool, there would be a serious erosion of the quality of the science done by young Dutch astronomers.
- Without the current optical/infrared instrumentation group funded by NOVA, Dutch astronomers would be relegated to mere users of other people's facilities, with a precipitous drop in the knowledge of how to exploit the associated instruments and how to build the next generation of improvements that drive scientific breakthroughs, particularly those anticipated for the E-ELT.
- The opportunity may be lost of leveraging the lessons learned in building and using LOFAR into pioneering cosmological explorations with the SKA.

Have recommendations of Interim Evaluation of 2002-2003 been addressed?

In 2003, the IRB recommended that NOVA should continue the practice of overlap appointments to ease relatively young scientists into responsible positions in the university research programs. We are pleased to report that this advice has been followed with the advantageous result depicted in Figure 6.

The IRB also recommended in 2003 that tenure-track appointments be created for young scientists. We note that such appointments have occurred with NOVA support, and it is time that some of the salaries be absorbed back into the University structures.

The IRB considered the 2003 ratio of temporary positions (postdocs and PhD candidates) to permanent positions very desirable and suggested that the ratio be maintained. This has happened to the extent that it is possible to recruit qualified candidates.

The IRB in 2003 thought it useful to make some joint temporary appointments between ASTRON, SRON, and the participating universities. These refer primarily to scientific personnel, e.g., Ger de Bruyn from ASTRON with a joint appointment at RUG, rather than technical staff. The most notable example of the latter is the establishment of a group housed at ASTRON in optical/infrared instrumentation. ***The present IRB endorses the agreement by the NOVA Board that the optical/infrared instrumentation group should move to Utrecht, providing UU commits to supplying sufficient resources to maintain the high productivity on a continuing basis.***

The IRB noted in 2003 the proximity of SRON and UU, which offers a particularly attractive opportunity to make joint appointments. ***The present IRB makes the same note and encourages the administrations of UU and SRON to take action to increase their cohesiveness.***

Finally, we reiterate the concern of the IRB in 2003: "Even though phase 2 will extend NOVA's lifetime to 10 years, there is already the need to look beyond that horizon. Some fixed-term appointments will need to be made, … Moreover, the attractiveness of senior positions (e.g., new overlap appointments) to distinguished candidates from abroad will depend on a clear perception that the successful impetus provided by NOVA will not dissipate but will be a springboard for further enhancements of Dutch astronomy."

Summary of Recommendations

1. The IRB encourages the NOVA institutes to do better in terms of promoting gender equality at staff levels.
2. The IRB recommends that the faculty numbers at RUN and UU be increased to more closely approaching critical mass.
3. The IRB recommends that the NOVA institutes consider recruiting young theorists who have original ideas in different fields and have a capacity to make connections between these fields, and who take a more first-principles approach to the formulation and solution of problems.
4. The IRB recommends that better formal relations be established between the research universities under the NOVA umbrella and ASTRON and SRON.
    a. The IRB endorses the agreement by the NOVA Board that the optical/infrared instrumentation group should move to Utrecht, providing UU commits to supplying sufficient resources to maintain the high productivity on a continuing basis.
    b. The IRB especially encourages the administrations of UU and SRON to take action to increase their cohesiveness,
    c. The IRB commends the healthy relationship that has grown between RUG and SRON in the construction of Band 9 receivers for ALMA and hopes that such collaboration will continue in the future.
5. The IRB encourages the establishment of a mechanism in the Netherlands to ensure the long-term viability of the NOVA research school beyond the episodic renewal schedule of the Bonus Incentive Scheme.

APPENDIX A: NOVA Instrumentation Projects

Project	Start	Completion original	Completion actual	
MIRI spectrometer	2002 Oct	2007 May	2009 Febr	a
ALMA Band-9 receivers	2007 Nov			b
X-Shooter	2004 Jan	2007 Jan	2008 Mar	c
SINFONI				
MIDI	1998 Sep	2000 Sep	2001 May	d
OmegaCAM calibration software	2000 Apr	2003 Aug	2005 Oct	e
SPHERE-Zimpol	2006 Mar	2010 Jun	2011 Jan	
MUSE-Assist	2006 Jan	2009 Dec	2010 Dec	
PuMa-II	1999 Feb	2004 Dec	2005 Dec	
Phase-A studies for E-ELT instruments				
Micado	2008 Jan	2009 Oct	2009 Oct	
METIS	2008 May	2009 Nov	2009 Nov	
Epics	2007 Oct	2009 Oct	2010 Jan	
Optimos-EVE	2008 Oct	2010 Febr	2010 Febr	

a Delivery of spectrometer hardware to UK; other partners are more than 1 year late in delivery their share
b Planned for delivery 1 receiver cartridge every 3 weeks; now on schedule and delivery rate is one every 2.5 years
c ESO demanded change of cooling method at PDR --> redesign
d Delivery of optical bench to MPIA
e Work package extended over 2 years to adopt for telescope delay; instrument now waiting for VST delivery now scheduled for late 2010

APPENDIX B: Sample of publications with authors from multiple Dutch universities

Network 1

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8. Jelic, V., Zaroubi, S., Labropoulos, P., Thomas, R.M., Bernardi, G., Brentjens, M.A., de Bruyn, A.G., Ciardi, B., Harker, G., Koopmans, L.V.E., Pandey, V.N., Schaye, J., Yatawatta, S. 2008: *Foreground simulations for the LOFAR-epoch of reionization experiment*, MNRAS, 389, 1319
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Network 3

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Appendix J: List of abbreviations

2SB	Sideband Separating
AAS	American Astronomical Society
ACS	Advanced Camera for Surveys (instrument on HST)
AGN	Active Galactic Nuclei
AIO	Assistant-in-onderzoek - PhD student
AIP	Astrophysical Institute Postdam (Germany)
ALLEGRO	ALMA Local Expertise GROup
ALMA	Atacama Large Millimeter/submillimeter Array
AMBER	Astronomical Multiple Beam Recombiner (instrument on VLTI)
AMUSE	Astrophysical Multipurpose Software Environment (NOVA project)
ANTARES	Neutrino telescope in Mediterranean Sea; prototype of KM3NeT
AO	Adaptive Optics
AOF	Adaptive Optics Facility
APERTIF	APERture Tile in Focus (Multi-beam receiver for WSRT)
APEX	ALMA Pathfinder Experiment
API	Astronomical Institute Anton Pannekoek (UvA)
ARC	ALMA Regional Center
ASMI	High tech company in Almere, The Netherlands
ASML	High tech company in Veldhoven, The Netherlands
ASSIST	Adaptive Secondary Setup and Instrument Simulator (NOVA project)
ASTRON	ASTRON - Netherlands Institute for Radio Astronomy (NWO institute)
ASTROSIM	EU-funded network on computational astrophysics
ASTRO-WISE	Astronomical Wide-field Imaging System for Europe (EU-funded network involving NOVA-RuG)
AU	Astronomical Unit
Auger	see PAO
Band-9	ALMA receiver for the atmospheric window between 610 and 720 GHz
Beppo-SAX	Italian-Dutch satellite for X-ray astronomy
BESI	High tech company in Duiven, The Netherlands
Caltech	California Institute of Technology
CCD	Charge-Coupled Device
CEA Saclay	Commissariat à l' Energie Atomique (institute at Saclay, France)
CERN	European Organization for Nuclear Research

CESSS	Cavity Enchanced Solid State Spectometer (laboratory set-up at Sackler Laboratory at Leiden Observatory)
CFHT	Canada France Hawaii Telescope
CFHTLS	CFHT Legacy Survey
CHAMP+	CHAMP+ is a dual-frequency heterodyne submillimeter array receiver built by MPIfR and NOVA/SRON/TuD for APEX
Chandra	NASA's X-ray space observatory
CMB	Cosmic Microwave Background
CNC	Computer Numeric Control (for hardware manufacturing)
COB	Cold Optical Bench
COROT	French led astronomical space observatory to search for extrasolar planets and stellar seismology
COSMOGrid	Worldwide super-computer collaboration for astrophysical simulations
CRAL	Centre de Recherche Astronomique de Lyon (Fr)
CRIRES	Cryogenic high-Resolution InfraRed Echelle Spectrograph (instrument on VLT)
CRs	Cosmic Rays
CRYOPAD	CRYOgenic Photoproduct Analysis Device (set-up at Sackler Laboratory at Leiden Obdervatory)
CSO	Caltech Submillimeter Observatory
CTA	Cherenkov Telescope Array
CWTS	Centre for Science and Technology Studies (institute at Leiden University)
DAS-4	Distributed ASCI Supercomputer-4 (High performance computer network, see http://wiki.cs.vu.nl/das-4/index.php/Main_Page)
DCLA	Development and Commissioning of LOFAR for Astronomy
DPAC	Data Processing and Analysis Consortium (on development data processing software for Gaia)
DSM	Deformable Secondary Mirror (for one of the VLT telescopes)
E-ELT	European Extremely Large Telescope
EoR	Epoch of Reionization
EPICS	Exo-Planet Imaging Camera and Spectrograph (Instrument in study for the E-ELT)
EPOL	EPICS Polarometer
ERC	European Research Council
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
eSMA	extended SMA
ESO	European Southern Observatory
ETH	Eidgenössische Technische Hochschule (Zürich)
EU	European Union

EU FP7	EU Framework Program 7
EUCLID	Possible ESA Cosmic Vision mission to map the geometry of the dark universe
EUV	Extreme Ultra Violet
eV	electron Volt
EVN	European VLBI Network
ExPo	Exoplanet Polarimeter (instrument on WHT)
Fermi	Fermi Space Telescope for gamma ray wavelengths (NASA)
FIRES	Faint Infrared Survey (large program at the VLT)
FLAMES	Fibre Large Array Multi Element Spectrograph (instrument on VLT)
FOM	Fundamenteel Onderzoek der Materie (NWO institute for physics)
FP	Framework Program (EU)
FRI	Fano-Riley type I radio galaxy
Gaia	Gaia - ESA's astrometric cornerstone mission
GALACSI	Ground Atmospheric Layer Adaptive Corrector for Spectroscopic Imaging (for MUSE)
GALEX	Galaxy Evolution Explorer (NASA satellite for UV wavelengths)
GBE	NWO Council for Exact Sciences (same as NWO-EW)
GEPI	Galaxies Etoiles Physique et Instrumentation (Division of Observatoire de Paris, France)
GHz	Giga Herz
GRAAL	Ground layer Adaptive optics Assisted by Lasers (ESO facility for instrument tests)
GRAPPA	Astroparticle physics and gravitation initiative (at UvA)
GRB	Gamma Ray Burst
GTO	Guaranteed Time Observations
GZK	Greisen-Zatsepin-Kuzmin limit (energy cut-off for cosmic rays)
HAWK-I	High Acuity Wide field K-band Imager (instrument on VLT)
Herschel	Herschel - Far infrared space observatory (ESA)
HI	Hydrogen 21 cm line
HIFI	Heterodyne Instrument for the Far-Infrared for Herschel
HST	Hubble Space Telescope
HV-setup	High Vacuum setup (at Sackler Laboratory at Leiden Observatory)
IAU	International Astronomical Union
IceCube	Neutrino telescope at South Pole
IFS	near-IR integral Field unit (part of SPHERE)
IFU	Integral Field Unit

IGM	Inter-Galactic Medium
IMAPP	Institute for Mathematics, Astrophysics and Particle Physics (at RU, Nijmegen)
IMAU	Institute for Marine and Atmospheric Research (at Utrecht University)
IMF	Initial Mass Function
INAF	Instituto Nazionale di Astro-Fisica (Italy)
ING	Isaac Newton Group of the Roque de los Muchachos Observatory on La Palma
INSU/CNRS	Institut National des Sciences de l'Universe du Centre National de la Recherche Scientifique (funding agency, Fr)
IR	Infra-Red
IRAM	Institut de Radio Astronomie Millimétrique (Grenoble, Fr)
IRAS	InfraRed Astronomical Satellite
IRDIS	InfraRed Dual Imaging Spectrograph (part of SPHERE)
IRS	InfraRed Spectrometer (instrument on Spitzer Space Telescope)
ISAAC	Infrared Spectrometer And Array Camera (instrument on VLT)
ISC	Instrument Steering Committee (NOVA)
ISO	Infrared Space Observatory (ESA)
IXO	International X-ray Observatory (under consideration, ESA, NASA, JAXA)
IYA2009	International Year of Astronomy 2009
JAXA	Japan Aerospace Exploration Agency
JCMT	James Clerk Maxwell Telescope (on Mauna Kea, Hawaii)
JIVE	Joint Institute for VLBI in Europe
JPL	Jet Propulsion Laboratory, Pasadena, USA
JWST	James Webb Space Telescope (successor of Hubble Space Telescope)
KiDS	Kilo-Degree Survey (planned for VST/OmegaCAM)
KM3NeT	Neutrino telescope in Mediterranean Sea; successor of ANTARES
KNAW	Koninklijke Nederlandse Akademie van Wetenschappen (Royal Academy of Arts and Sciences)
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Royal Dutch Meteorogical Institute)
KOSMA	Kölner Observatorium für SubMillimeter Astronomie (Germany)
KRP	Key Research Project
KRs	Key Researchers (leaders of the NOVA research networks)
KVI	Kernfysisch Versneller Instituut (institute for atomic and subatomic physics, at RuG)
LAM	L'Observatoire Astronomique de Marseille-Provence (Fr)
LAOG	Laboratoire d'Astrophysique de l'Observatoire de Grenoble (France)
LAOMP	Laboratoire d'Astrophysique Observatoire Midi-Pyrénées (Fr)

LASSIE	Laboratory Astrophysics Surface Science In Europe (EU-funded network)
LERMA	Laboratoire d'Etude du Rayonnement et de la Matière en Astropysique (part of Observatoire de Paris)
LESIA	Laboratoire d'études spatiales et d'instrumentation en astrophysique (part of Observatoire de Paris)
LEXUS	Laser EXcitation setup for Unstable Species (setup at Sackler Laboratory at Leiden Observatory)
LGS	Laser Guide Star
LIGO	Laser Interferometer Gravitational-Wave Observatory (USA)
LISA	Laser Interferometer Space Antenna (possible ESA mission to detect gravitational waves)
LLAGN	Low Luminosity Active Galactic Nucleus
LMC	Large Magellanic Cloud
LOFAR	LOw Frequency ARray - new radio observatory managed by ASTRON in collaboration with European partners
LOPES	LOFAR PrototypE Station (at Karlsruhe, Germany)
LUAN	Laboratoire Univeritaire d'Astrophysique de Nice (Fr)
M2-unit	Secundary mirror in telescope
MATISSE	Multi AperTure Mid-Infrared Spectroscopic Experiment (2nd generation VLTI instrument)
MATRI^{2}CES	Mass Analytical Tool of Reactions in Interstellar ICES (set-up at Sackler laboratory at Leiden Observatory)
METIS	Mid-infrared ELT Imager and Spectrograph (possible E-ELT instrument)
MICA	Meta Institute for Computational Astrophysics (at Drexel University, USA)
MICADO	Near-infrared wide-field imager (possible E-ELT instrument)
MICHELLE	Mid-Infrared imager and spectrometer (instrument on Gemini-north)
MIDI	MID-Infrared instrument (instrument on VLTI)
Mid-IR	Mid-InfraRed
MIRI	Mid Infra-Red Instrument (under construction for JWST)
MIT	Massachusetts Institute of Technology
MODEST	MOdeling DEnse STellar systems (international consortium, see www.manybody.org)
MPE	Max-Planck-Institut für Extraterrestrische Physik (Garching, Germany)
MPIA	Max-Planck-Institut für Astronomie (Heidelberg, Germany)
MPIfR	Max-Planck Institut für Radioastronomie (Bonn, Germanny)
MUSE	Multi Unit Spectroscopic Explorer (instrument under construction for VLT)
NAC	Nederlandse Astronomen Club
NASA	National Aeronautics and Space Administration (USA)
NCA	Nederlands Comité Astronomie (Netherlands Committee for Astronomy)
NIC	NOVA Information Center

NICMOS	Near Infrared Camera and Multi-Object Spectrometer
NIKHEF	Nationaal Instituut voor Kernfysica en Hoge-Energiefysica (institute of FOM)
NL	Netherlands
nm	nanometer
NOVA	Nederlandse Onderzoekschool Voor Astronomie (Netherlands Research School for Astronomy)
NRAO	National Radio Astronomical Observatory (USA)
NSO	National Solar Observatory (USA)
NW	NOVA research network
NWO	Nederlandse organisatie voor Wetenschappelijk Onderzoek (Netherlands Organization for Scientific Research)
NWO-EW	NWO Council for Exact Sciences
NWO-G	NWO grant for large investments
NWO-M	NWO grant for medium-size investments
OCW	Dutch ministry for Education, Culture and Science
OG	Observatoire de Genève (Switzerland)
OmegaCAM	Wide-field camera for the VLT Survey Telescope
OmegaCEN	OmegaCAM data center (at RuG)
ONERA	Office National d'Etudes et de Recherches Aérospatiales (Fr)
OP/IR	Optical to InfraRed
OPTIMOS	OPTical to Infrared Multi-Object Spectrograph (possible instrument for E-ELT)
OPTIMOS-EVE	Fr-UK-NL consortium for Phase-A study for OPTIMOS
OSO	Onsala Space Observatory (in Sweden)
OWLS	OverWhelmingly Large Simulations
PACS	Photodetector Array Camera and Spectrometer (instrument on Herschel)
PAH	Polycyclic Aromatic Hydrocarbon molecule
PAO	Pierre Auger Observatory (international cosmic ray observatory in Argentina)
pc	parsec
Ph	Phase
PI	Principal Investigator
PLATO	PLAnetary Transits and Oscillations of stars (ESA mission in preparation)
PSF	Point Spread Function
PuMa	Pulsar Machine (instrument on WSRT)
R&D	Research and Development
RadioNet	EU-funded network for radio astronomy
RAIRS	Reflection Absorption InfraRed Spectroscopy

RAL	Rutherford Appleton Laboratory (Didcot, UK)
RNS	Raad van Natuur- en Sterrenkunde (of the KNAW) (succeeded by TWINS)
RU	Radboud Universiteit, Nijmegen
RuG	Rijksuniversiteit Groningen
RXTE Rossi	X-ray Timing Explorer (NASA satellite)
S^5T	Small Synoptic Second Solar Spectrum Telescope (NOVA project)
SAFARI	SpicA FAR-infrared Instrument (instrument on Japanese-European SPICA mission)
SAURON	Spectroscopic Areal Unit for Research on Optical Nebulae (instrument on WHT)
SCUBA-2	Submilimetre Common-User Bolometer Array (instrument on JCMT)
SDSS	Sloan Digital Sky Survey
SINFONI	Spectrograph for INtegral Field Observations in the Near Infrared (instrument on VLT)
SIS	Superconductor Insulator Superconductor; detector technology for (sub)-mm and far-IR
SKA	Square Kilometer Array
SLACS	Sloan Lens ACS Survey
SMA	SubMillimeter Array (on Mauna Kea, Hawaii)
SMC	Small Magellanic Cloud
SMO	Spectrometer Main Optics
SNN	Samenwerkingsverband Noord Nederland
SOLIS	Synoptic Optical Long-term Investigations of the Sun (facility at NSO)
SPHERE	Spectro-Polarimetric High-contrast Exoplanet Research (instrument under construction for VLT)
SPICA	SPace Infrared telescope for Cosmology and Astrophysics (likely Japanese mission with European participation)
SPIRAS	Supersonic Plasma InfraRed Absorption Spectrometer (set-up for Sackler Laboratory at Leiden Observatory)
Spitzer	NASA's infrared space observatory
SRON	SRON - Netherlands Institute for Space Research
STW	Stichting Technische Wetenschappen (division of NWO)
SURFRESIDE	SURFace Reactions Simulation Device (setup for Sackler Laboratory at Leiden Observatory)
SWS	Short Wavelength Spectrometer (instrument on ISO)
TNO	Research Institute for applied physics in the Netherlands
TPD	Temperature Programmed Desorption
TUD	Technical University Delft
TWINS	Raad voor Technische Wetenschappen, Wiskunde en Informatica, Natuur- en Sterrenkunde en Scheikunde (of KNAW)
UD	Assistant professor

UHD	Associate professor
UHE	Ultra-High Energy
UHECR	Ultra-High Energy Cosmic Rays
UK	United Kingdom
UKIRT	United Kingdom Infrared Telescope
UL	Universiteit Leiden
ULIRG	Ultra Luminous Infra-Red Galaxy
UltraVISTA	Ultra deep near-IR imaging program with VISTA
ULX	Ultra-luminous X-Rays
UNAWE	Universe Awareness (international outreach activity aimed at kids of 4-10 years)
UNESCO	United Nations Educational, Scientific and Cultural Organization
USM	Universität-Sternwarte München (Germany)
UU	Universiteit Utrecht
UV	ultra violet
UvA	Universiteit van Amsterdam
VIKING	Vista Kilo-degree Infrared Galaxy survey
VISIR	VLT-Imager and Spectrometer for mid InfraRed (instrument on VLT)
VISTA	Visible and Infrared Survey Telescope for Astronomy (ESO)
VLA	Very Large Array
VLBI	Very Long Baseline Interferometry
VLT	Very Large Telescope (ESO)
VLTI	Very Large Telescope Interferometer (ESO)
VO	Virtual Observatory
VST	VLT Survey Telescope
VU	Vrije Universiteit (Free University, Amsterdam)
WFPC	Wide-Field Planetary Camera (instrument on HST)
WHT	William Herschel Telescope (part of ING)
WMAP	Wilkinson Microwave Anisotropy Probe
WSRT	Westerbork Synthesis Radio Telescope
XMM-Newton	X-Ray Multiple Mirror (ESA's X-ray observatory)
XRB	X-Ray Binary
X-Shooter	Single target optical and near-IR spectrometer (instrument on VLT)
YSO	Young Stellar Object
ZIMPOL	Zurich IMaging POLarimeter - part of SPHERE