Cores/Cusp in Elliptical galaxies and SMBHs

“Supermassive Black Holes and their host spheroids. I. Disassembling Galaxies”
G. A. D. Savorgnan and A. W. Graham

“The L ∝ σ^8 correlation for elliptical galaxies with cores: relation with black hole mass”
Jhon Kormendy and Ralf Bender

By Arianna Zirotti and Ottavia Zanello

Credit:ESA/Hubble, elliptical galaxy NGC 4150

The $L \propto \sigma^8$ correlation for elliptical galaxies with cores: relation with black hole mass

Jhon Kormendy and Ralf Bender (2013)

Main idea: Elliptical galaxies split into two types based on their central light profiles.

(Giant) Core galaxies

The core is “missing light” with respect to a Sérsic profile.

Coreless galaxies

They have extra light in the center (central power law).

First question asked: How does the Faber-Jackson relation changes between the two galaxy types?

The Faber-Jackson relation

Standard F-J relation:

$$L \propto \sigma^4$$

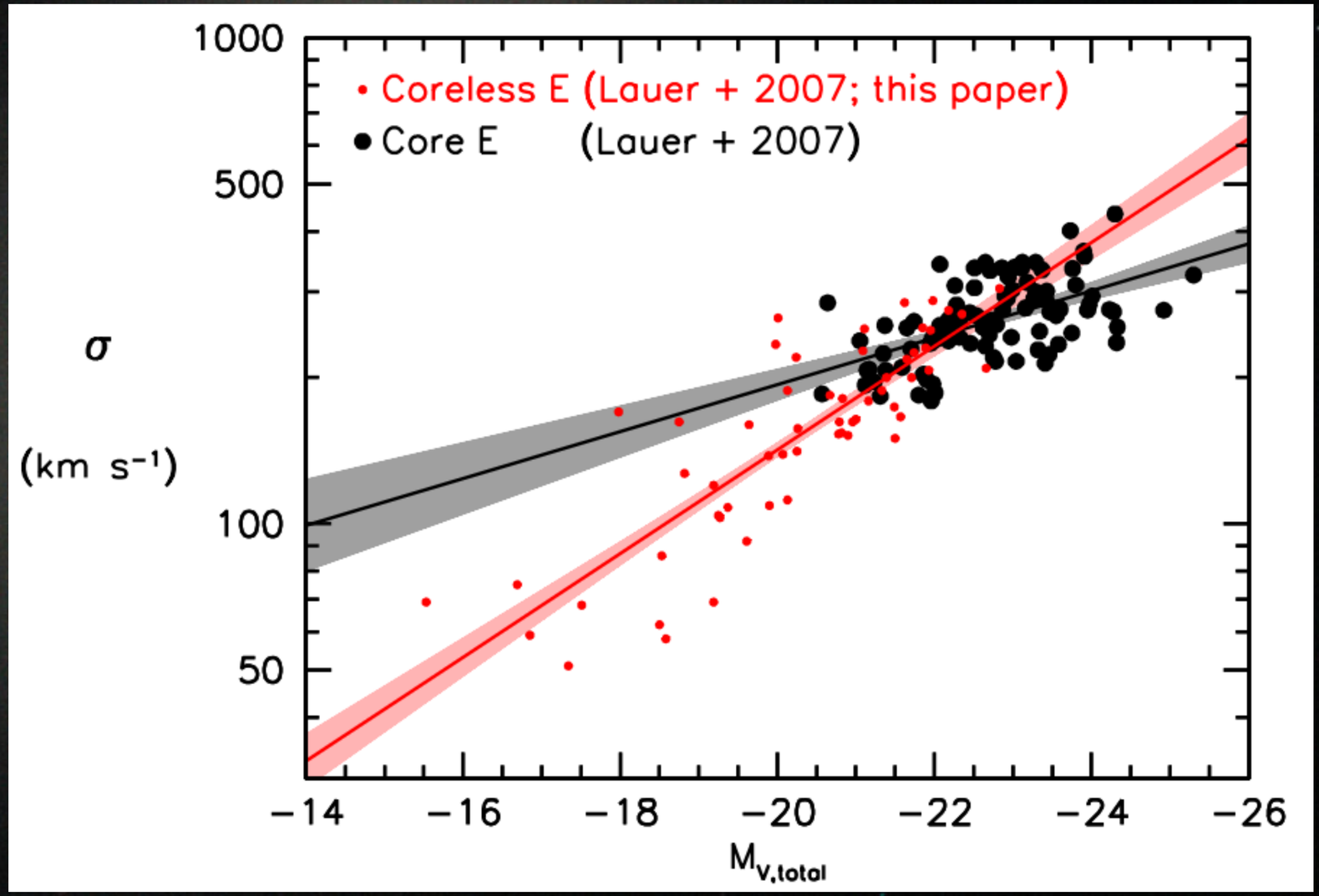
Observational results:

- **Core galaxies**

$$L \propto \sigma^{8.33}$$

- **Coreless galaxies**

$$L \propto \sigma^{3.74}$$



The Faber-Jackson relation

Translated in terms of mass:

- **Core galaxies** $\frac{d\log\sigma}{d\log\mathrm{M}} = 0.091$ $\longrightarrow$ Large increases of mass produce only small changes in the velocity dispersion.
- **Coreless galaxies** $\frac{d\log\sigma}{d\log\mathrm{M}} = 0.203$

Comparison with the Virial theorem: $M \propto \sigma^2 r_e$

This tells us that the structure of galaxies is not constant during their evolution.

Formation Pathways: wet and dry mergers

For core galaxies: $\frac{d\log\sigma}{d\log\mathrm{M}} = 0.091$

Comparison with merger simulations:

- **Minor wet mergers** $\frac{d\log\sigma}{d\log\mathrm{M}} = -0.05$
- **Major dry mergers** $\boxed{\frac{d\log\sigma}{d\log\mathrm{M}} = 0.15}$

Massive elliptical galaxies grow mainly through dissipationless (dry) mergers.

Core formation in elliptical galaxies

The process:

- Two galaxies merge, their SMBHs form a binary.
- The binary "scours" the center by ejecting stars via 3-body interactions.
- This creates the "missing light" deficit.

Evidence:

The mass deficit scales with the SMBH mass: $M_{\rm def} \propto M_\bullet$

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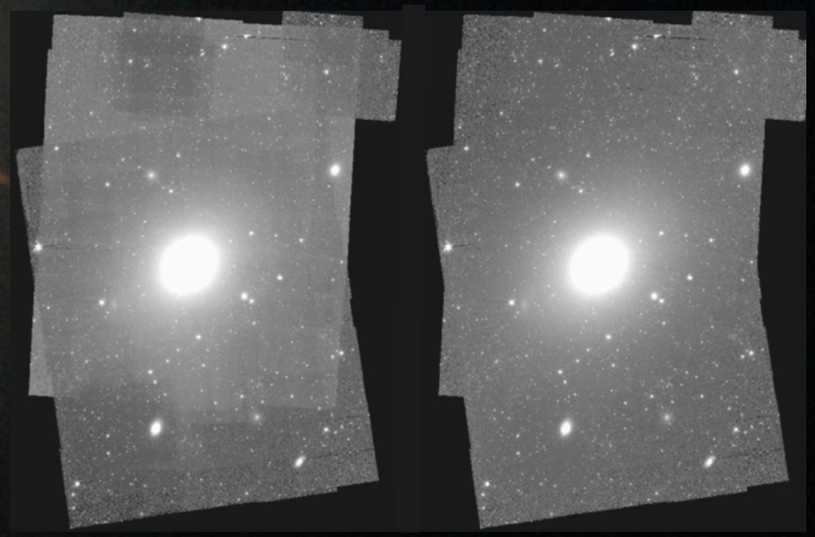
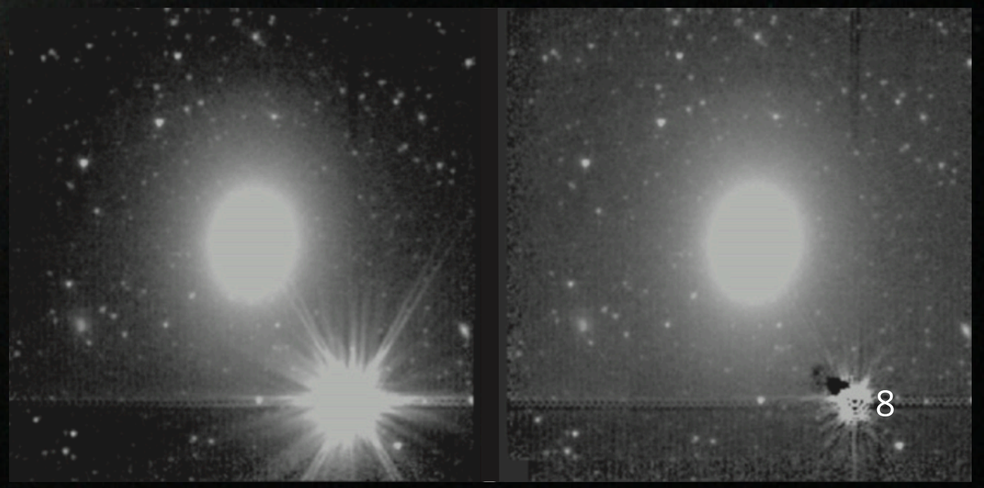
Data reduction



- Data acquisition from Spitzer Space telescope
- Mosaicking and Overlaping
- Sigma Mosaics
- Aestetic corrections and imaging masking
- 2D PSF



- Kinematics movements
- AGNs and Dust
- Core and Coreless

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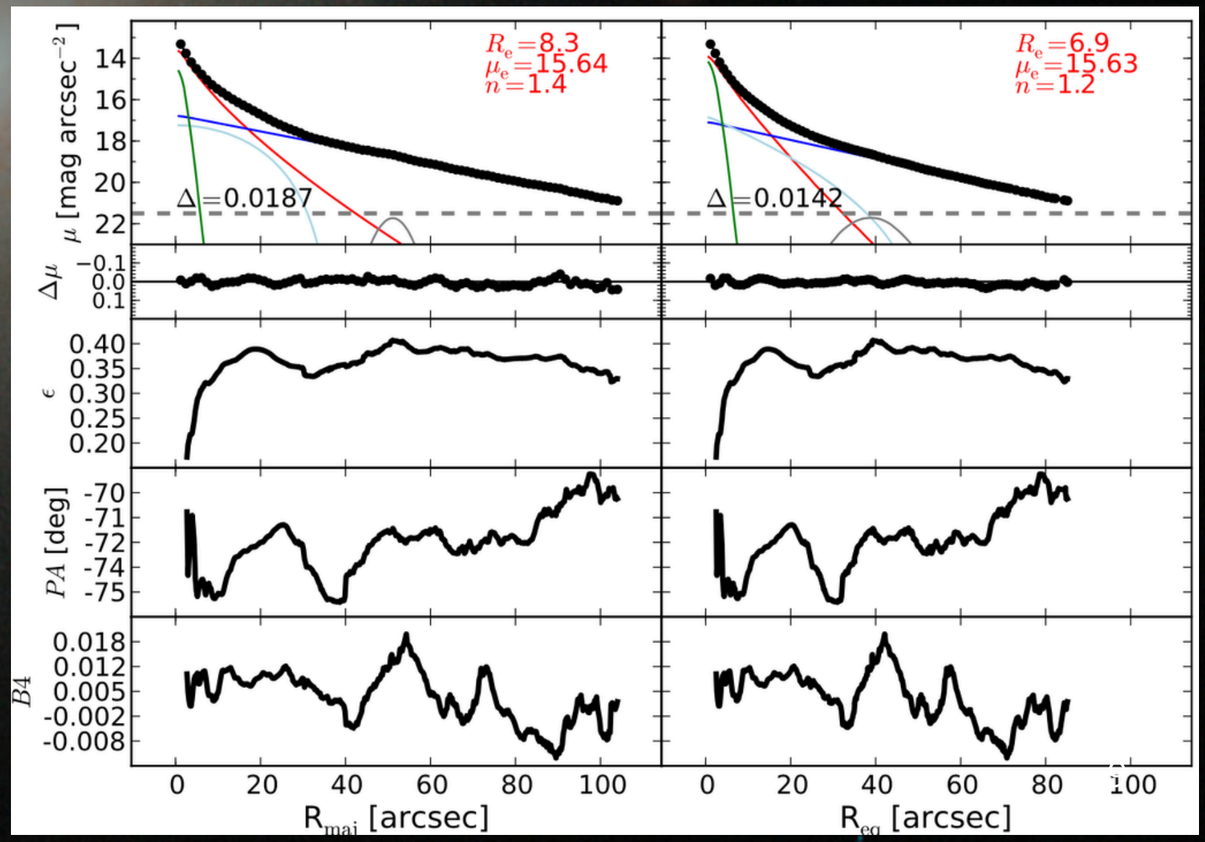
Analysis and Results

- 1D Isophotal Analysis
- Upsharp Masking
- Mathematical Modeling



Galaxy NGC 2974

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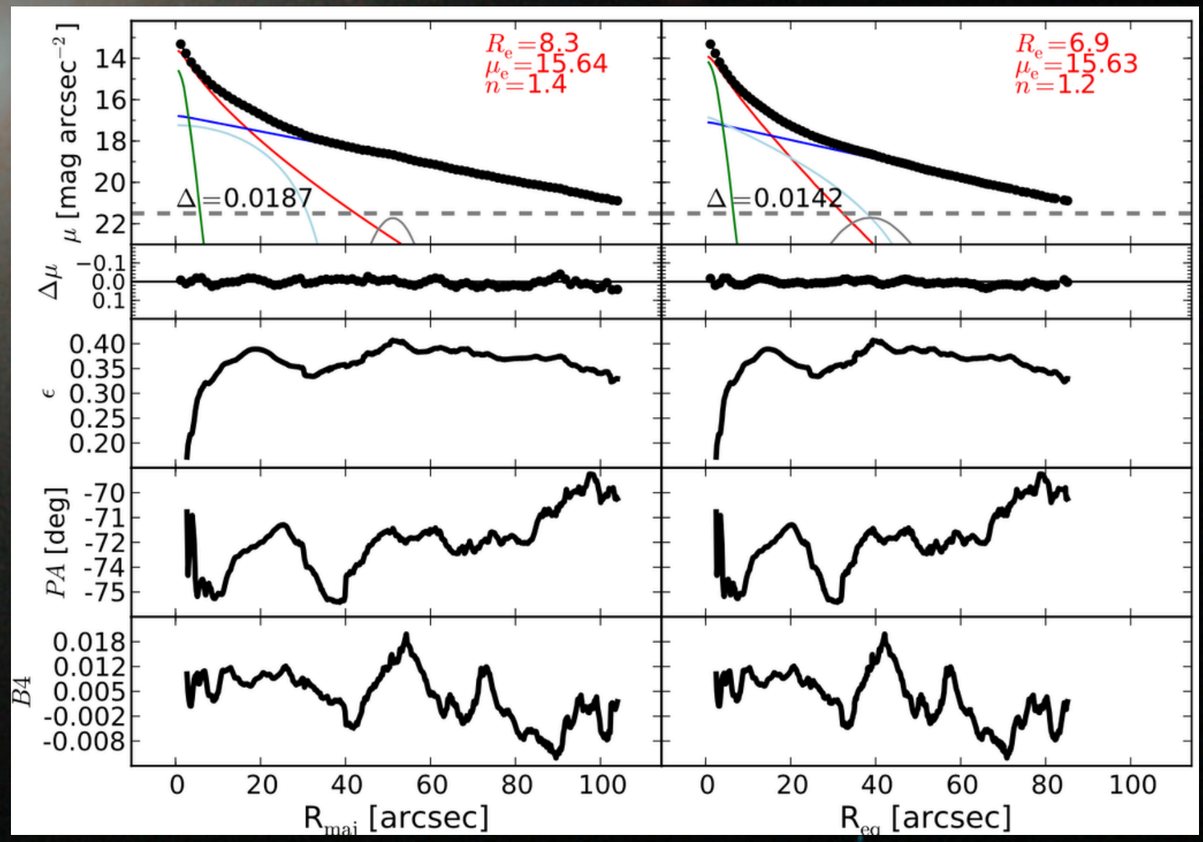
Analysis and Results

- 1D Isophotal Analysis
- Upsharp Masking
- Mathematical Modeling

Work	Model	$R_{e,sph}$ (arcsec)	n_{sph}
1D maj.	S-bul + e-d + F-bar + G-n + G-r	8.3	1.4
1D eq.	S-bul + e-d + F-bar + G-n + G-r	6.9	1.2
2D	S-bul + e-d + G-bar + m-n	10.6	1.3
S+11 2D	S-bul + G-n	27.2	3.0



Galaxy NGC 2974