Practical Hydrodynamics in Astrophysics

proposal for a lecture series
at Firenze University, Spring Semester 2003

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Purpose. The aim of this lecture series is fourfold: first, to acquaint the students with the basics of theoretical hydrodynamics; second, to show them which astrophysical problems can be attacked with this theory; third, to transcribe the theoretical equations into usable algorithms; fourth, to implement these in robust computer code.

Content. First, an introduction about cosmic hydrodynamics, based on the observed fact that 99.999 per cent of the cosmos is in gaseous form. The next part presents the usual hydrodynamics equations, but in a setting that makes explicit contact with classical mechanics and thermodynamics. Then, a basic introduction of techniques for numerically solving hyperbolic partial differential equations. Lastly, it all comes together in a working code and some applications thereof.

Method. The didactical method is designed to present the material in close connection with other areas, notably theoretical physics and computer science. For example, the equations of hydrodynamics will be presented as ensemble-averages of the simple and well-known equations of classical mechanics. The algorithms are discussed in connection with the underlying equations and their analytical properties.

Format. The lectures themselves will be spoken lectures, of a more or less classical form, but with as much interaction with the students as they desire (within the bounds of the programme).

Exercises. In parallel with the lectures, a sequence of practical (computer) exercises will lead towards the goal in which each

student ends up with an elementary, but well-functioning, hydro code. This part is dependent on local computer access. I will distribute "toy model" pieces of code, with which the students can begin building their own programs.

Pre-requirements. It is assumed that the students know classical mechanics, thermodynamics, ordinary and partial differential equations, basic astronomy, and (preferably) the beginnings of the computer language C.

Duration. The duration of the course must fit into the existing curriculum of the University. Provisionally, it is assumed that the course will take about 18 weeks, with two contiguous lecture hours per week.

Level. On a scale where a Bachelor's degree takes four years, this course should be accessible for third- and fourth-year students,

Literature. I will distribute relevant lecture notes during the course. A suitable book would be *Computational gasdynamics*, by C.B. Laney, Cambridge University Press, 1998.