

Chapter 17

Numerical Methods
for Astrophysics

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ABSTRACT

The physical laws astrophysicists use to describe their phenomena are believed to have been understood in many cases. Thus modelling astrophysical phenomena is focussed on the numerical implementation of these models. The main issue astrophysicists have to overcome is the large range of spatial, temporal and density scales.

The models typically are the compressible inviscid Euler equations or magnetohydrodynamic equations in three space dimensions coupled with many source terms. The numerical methods used often are finite volume methods or particle methods. Numerical methods that deal with the large range of scales need to be addressed individually for each problem at hand. Examples of these methods are the introduction of subgrid scale models, using time implicit methods or moving mesh methods.

These notes are strongly indebted to discussions with Fritz Röpke from Heidelberg University and the Heidelberg Institute of Technological Science, <http://www.h-its.org/en/research/pso/people/>.

Numerical Astrophysics

Remi Abgrall, Chi-Wang Shu



Numerical Astrophysics:

Numerical Methods in Astrophysics Peter Bodenheimer, Gregory P. Laughlin, Michal Rozyczka, Tomasz Plewa, Harold W. Yorke, Harold W. Yorke, 2006-12-13 Numerical Methods in Astrophysics An Introduction outlines various fundamental numerical methods that can solve gravitational dynamics hydrodynamics and radiation transport equations This resource indicates which methods are most suitable for particular problems demonstrates what the accuracy requirements are in numerical simulations and suggests ways to test for and reduce the inevitable negative effects After an introduction to the basic equations and derivations the book focuses on practical applications of the numerical methods It explores hydrodynamic problems in one dimension N body particle dynamics smoothed particle hydrodynamics and stellar structure and evolution The authors also examine advanced techniques in grid based hydrodynamics evaluate the methods for calculating the gravitational forces in an astrophysical system and discuss specific problems in grid based methods for radiation transfer The book incorporates brief user instructions and a CD ROM of the numerical codes allowing readers to experiment with the codes to suit their own needs With numerous examples and sample problems that cover a wide range of current research topics this highly practical guide illustrates how to solve key astrophysics problems providing a clear introduction for graduate and undergraduate students as well as researchers and professionals **Numerical**

Astrophysics Shoken M. Miyama, Kohji Tomisaka, Tomoyuki Hanawa, 2012-12-06 These are the proceedings of international conference on Numerical Astrophysics 1998 NAP98 held at National Olympic Memorial Youth Center in Tokyo Japan in the period of March 10-13 1998 and hosted by the National Astronomical Observatory Japan NAOJ In the last decade numerical simulations have grown up as a major tool for astrophysics Numerical simulations give us invaluable information on complex systems and physical processes under extreme conditions which can be neither realized by experiments nor directly observed Super computers and special purpose computers may work as very large telescopes and special purpose telescopes for theoretical astrophysics respectively Numerical astrophysics ranks with other tool oriented astronomy such as radio astronomy infrared astronomy ultraviolet astronomy X-ray astronomy and gamma-ray astronomy This conference NAP98 was planned to explore recent advances in astrophysics aided by numerical simulations The subjects of the conference included the large scale structure formation galaxy formation and evolution star and planets formation accretion disks jets gravitational wave emission and plasma physics NAP98 had also sessions on numerical methods and computer science The conference was attended by 184 scientists from 21 countries We enjoyed excellent talks posters videos and discussions there are 40 oral presentations 96 posters and 16 video presentations We hope that these proceedings and accompanying CD ROM replay the friendly but inspiring atmosphere of the conference *Numerical Astrophysics* Shoken M. Miyama, Kohji Tomisaka, Tomoyuki Hanawa, 1999-03-31 This book contains all the oral and poster sessions presented at the Numerical Astrophysics 1998 symposium held in Tokyo on March 10-13 1998 It covers a wide variety of research fields from the large

scale structure of the Universe to planetary systems Astrophysics employing all kinds of supercomputers such as massive parallel computers parallel vector machines and special purpose computers are included Recent progress in numerical methods remote data analysis and special purpose computers are also reviewed This book is suitable for researchers and graduate students in astronomy astrophysics who want an overview of the present research fronts based on supercomputing

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Numerical Astrophysics Joan M. Centrella, James M. LeBlanc, Richard L. Bowers, 1985 *Numerical Modelling of Astrophysical Turbulence* Wolfram Schmidt, 2013-09-20 In this SpringerBrief the author considers the underlying problems and questions that are common to numerical models of turbulence in different astrophysical systems Turbulence has emerged as an important research topic in several areas of astrophysics Understanding and modeling turbulence is particularly important for the dynamics of the interstellar medium but also for the intergalactic medium as well as in stars The advancement of methods for numerical simulations of astrophysical turbulence however is still challenging because of gravity strong compressibility magnetic fields and other effects The book begins with a review of general aspects of numerical simulations of turbulence In the main part the author presents findings from his numerical studies on astrophysical turbulence and discusses the astrophysical implications He also explains in detail the numerical schemes utilized Readers will find that this book offers a compact yet comprehensive introduction

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addressed with minimum mathematical derivations so as to suit all faculties of the readers For graduate students there are solved problems with exercises at the end of each chapter for researchers some recent works on the calculation of physical parameters of astrophysical importance like the calculation of S-factors at low energies have been included and for amateur readers there are lot of history information and discussion on the astronuclear phenomenon Please note Taylor Francis does not sell or distribute the Hardback in India Pakistan Nepal Bhutan Bangladesh and Sri Lanka *Astronomy and Astrophysics Abstracts* S. Böhme, U. Esser, H. Hefele, I. Heinrich, W. Hofmann, D. Krahn, V. R. Matas, L. D. Schmadel, G. Zech, 2013-12-14 From the reviews *Astronomy and Astrophysics Abstracts* has appeared in semi annual volumes since 1969 and it has already become one of the fundamental publications in the fields of astronomy astrophysics and neighbouring sciences It is the most important English language abstracting journal in the mentioned branches The abstracts are classified under more than hundred subject categories thus permitting a quick survey of the whole extended material The AAA is a valuable and important publication for all students and scientists working in the fields of astronomy and related sciences As such it represents a necessary ingredient of any astronomical library all over the world *Space Science Reviews* 1 Dividing the whole field plus related subjects into 108 categories each work is numbered and most are accompanied by brief abstracts Fairly comprehensive cross referencing links relevant papers to more than one category and exhaustive author and subject indices are to be found at the back making the catalogues easy to use The series appears to be so complete in its coverage and always less than a year out of date that I shall certainly have to make a little more space on those shelves for future volumes *The Observatory Magazine* 1 **Current Trends in Relativistic Astrophysics** Leonardo Fernández-Jambrina, Luis Manuel González-Romero, 2003-05-21 Table of contents *Astrophysics* İbrahim Küçük, 2012-03-30 This book provides readers with a clear progress to theoretical and observational astrophysics It is not surprising that astrophysics is continually growing because very sophisticated telescopes are being developed and they bring the universe closer and make it accessible *Astrophysics Book* presents a unique opportunity for readers to demonstrate processes do occur in Nature The unique feature of this book is to cover different aspects in astrophysics covering the topics Astronomy Theoretical Astrophysics Observational Astrophysics Cosmology The Solar System Stars Planets Galaxies Observation Spectroscopy Dark Matter Neutron Stars High Energy Astrophysics **Cellular Automata: Prospects In Astrophysical Applications - Proceedings Of The Workshop On Cellular Automata Models For Astrophysical Phenomena** A Lejeune, J M Perchang, 1993-11-23 This book provides a survey of the basic ideas of the cellular automaton CA modelling environment emphasising the relevance of this framework to astrophysical applications It contains introductory level lectures on lattice gases and on CA turbulence diffusion reaction processes percolation and self organised criticality Further it gives a variety of astrophysical applications including stellar oscillations galactic evolution distribution of luminous matter in the universe etc *The Grid* 2 Ian Foster, Carl Kesselman, 2004 The Grid is an emerging infrastructure that will fundamentally change the

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