

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, 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 a

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

Numerical Python in Astronomy and Astrophysics Wolfram Schmidt, Marcel Völschow, 2021-07-14 This book provides a solid foundation in the Python programming language numerical methods and data analysis all embedded within the context of astronomy and astrophysics It not only enables students to learn programming with the aid of examples from these fields but also provides ample motivation for engagement in independent research The book opens by outlining the importance of computational methods and programming algorithms in contemporary astronomical and astrophysical research showing why programming in Python is a good choice for beginners The performance of basic calculations with Python is then explained with reference to for example Kepler's laws of planetary motion and gravitational and tidal forces Here essential background knowledge is provided as necessary Subsequent chapters are designed to teach the reader to define and use important functions in Python and to utilize numerical methods to solve differential equations and landmark dynamical problems in astrophysics Finally the analysis of astronomical data is discussed with various hands on examples as well as guidance on astronomical image analysis and applications of artificial neural networks

Handbook of Numerical Methods for Hyperbolic Problems Remi Abgrall, Chi-Wang Shu, 2017-01-16 Handbook on Numerical Methods for Hyperbolic Problems Applied and Modern Issues details the large amount of literature in the design analysis and application of various numerical algorithms for solving hyperbolic equations that has been produced in the last several decades This volume provides concise summaries from experts in different types of algorithms so that readers can find a variety of algorithms under different situations and become familiar with their relative advantages and limitations Provides detailed cutting edge background explanations of existing algorithms and their analysis Presents a method of different algorithms for specific applications and the relative advantages and limitations of different algorithms for engineers or those involved in applications Written by leading subject experts in

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Computational Methods for Astrophysical Fluid Flow Randall J. LeVeque, Dimitri Mihalas, E.A. Dorfi, Ewald Müller, 2006-04-18 This book leads directly to the most modern numerical techniques for compressible fluid flow with special consideration given to astrophysical applications Emphasis is put on high resolution shock capturing finite volume schemes based on Riemann solvers The applications of such schemes in particular the PPM method are given and include large scale simulations of supernova explosions by core collapse and thermonuclear burning and astrophysical jets Parts two and three treat radiation hydrodynamics The power of adaptive moving grids is demonstrated with a number of stellar physical simulations showing very crispy shock front structures

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Gergel, Iosif Meyerov, 2021-06-23 This book constitutes selected and revised papers from the 20th International Conference on Mathematical Modeling and Supercomputer Technologies MMST 2020 held in Nizhny Novgorod Russia in November 2020. Due to the COVID 19 pandemic the conference was held online. The 25 full papers and 8 short papers presented in the volume were thoroughly reviewed and selected from the 106 submissions. They are organized in topical sections on computational methods for mathematical models analysis computation in optimization and optimal control supercomputer simulation

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Facets of Virtual Environments Fritz Lehmann-Grube, Jan Sablatnig, 2010-02-17 In recent years the popularity of virtual worlds has increased significantly and they have consequently come under closer academic scrutiny. Papers about virtual worlds are typically published at conferences or in journals that specialize in something entirely different related to some secondary aspect of the research. Thus a paper discussing legal aspects of virtual worlds may be published in a law journal while a psychologist's analysis of situation awareness may appear at a psychology conference. The downside of this is that if you publish a virtual worlds paper at an unrelated conference in this manner you are likely to be one of only a handful of attendees working in the area. You will not therefore achieve the most important goal of attending conferences: meeting and conversing with like minded colleagues from the academic community of your field of study. Virtual worlds touch on many well established themes in other areas of science. Researchers from all these fields will therefore be looking at this new interesting and growing field. However to do effective research related to these complex constructs researchers need to take into account many of the other facets from other fields that impact virtual worlds. Only by being familiar with and paying attention to all these different aspects can virtual worlds be properly understood.

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