UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Numerical Relativity

2425-1-F5802Q015

Aims

The aim of the course is to provide a basic knowledge of numerical methods and codes used to solve the equations of general relativity and of relativistic fluidodynamics, useful for the description of binaries of compact objects (with particular attention to neutron stars).

At the end of the course the student:

1. will have a knowledge of the main numerical methods and open-source codes available in the field of numerical relativity;
2. will have an updated view of the state of the art of numerical relativity simulations of neutron stars;
3. will be able to read and understand scientific articles on the topics covered in class.

Contents

3+1 formulation of space time, numerical methods for the solution of hyperbolic partial differential equations, numerical simulations of neutron stars.

Detailed program

3+1 Formulation

1. ADM formulation
2. BSSN formulation

Hyperbolic Partial Differential Equations

1. Equations of hydrodynamics in general relativity
2. Numerical methods for the solution of hyperbolic partial differential equations
3. Einstein Toolkit

Numerical Simulations of Neutron Stars

1. Gravitational Waves from Neutron Star Binaries
2. Electromagnetic Emission from Neutron Star Binaries
3. Observations of Neutron Star Binaries in Gravitational Waves

Prerequisites

This course requires a basic knowledge of special and general relativity. The latter can be obtained by following the Relativistic Astrophysics or General Relativity courses.

Teaching form

All lessons are held in person:

1. 14 lessons of 2 hours each in frontal-teaching delivery mode,
2. 12 practice sessions of 2 hours each in interactive mode.

During the lessons the theoretical bases will be exposed and the most recent theoretical and experimental results will be discussed. The lessons will take place partly on the blackboard and partly through the use of slides. Slides will be uploaded before the lectures on the course e-learning site. During the practice sessions the students will learn (under the guidance of the teacher) how to write numerical codes for the solution of hyperbolic partial differential equations and how to use publicly-available numerical relativity codes. The use of a laptop is required for the practice sessions. All lectures and practice sessions are held in English.

Textbook and teaching resource

Main textbooks:

1. "Numerical Relativity: Starting from Scratch" by T. W. Baumgarte and S. L. Shapiro
2. "Numerical Relativity: Solving Einstein's Equations on the Computer" by T. W. Baumgarte and S. L. Shapiro
3. "Relativistic Hydrodynamics" by L. Rezzolla and O. Zanotti

Other useful textbooks:

1. "Black Holes, White Dwarfs and Neutron Stars" by S. L. Shapiro and S. A. Teukolsky
2. "Numerical methods for conservation laws" by Randall J. LeVeque

Semester

I year, second semester

Assessment method

During the course, homeworks will be assigned with the aim of increasing the understanding of the topics covered in class. The homeworks have to be delivered to the teacher via e-mail at least two weeks before the date of the oral exam. Homeworks with obvious cases of plagiarism will be assigned a grade of zero.

The final exam consists of a discussion on the homeworks and of questions aimed at ascertaining the skills acquired during the course.

Books and notes cannot be used during the oral exam.

Office hours

by appointment, on line or in person.

Sustainable Development Goals

QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE