UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Numerical Relativity

2122-1-F5802Q015

Aims

Aim of the course is to provide a basic knowledge of neutron stars, of their observations via gravitational waves, and of the numerical methods needed to study them.

At the end of the course the student:

1. will be able to describe the properties of binary neutron star systems;
2. will be able to interpret, at least at a basic level, observational data, and in particular gravitational waves;
3. will be able to read and understand scientific articles on the topics covered in the classroom;
4. will have a basic knowledge of the main open source numerical codes available in the field of numerical relativity.

Contents

Neutron stars, binary neutron star systems and their observations, numerical relativity.

Detailed program

1. Neutron Stars
    1. TOV Equations and their numerical solution
    2. Neutron Star Collapse to Black Hole

2. Binary Neutron Stars
    1. Gamma-Ray Bursts
    2. Gravitational Waves from Binary Neutron Stars
    3. Electromagnetic Emission from Binary Neutron Stars
    4. Gravitational Wave Observations of Binary Neutron Stars
3. Numerical Relativity
    1. 3+1 Formulation
    2. ADM Formulation
    3. BSSN Formulation
    4. General Relativistic Magnetohydrodynamic Equations
    5. Einstein Toolkit

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

The course is divided into 42 hours of lectures conducted by the teacher in the classroom. During the lessons the theoretical bases will be exposed and the most recent observational data discussed. The lessons will take place partly on the blackboard, partly through the use of slides, and partly in the form of tutorials on the use of numerical codes. Slides will be uploaded before the lectures on the course e-learning site. All lectures will be held in English.

Textbook and teaching resource

Main textbooks:

1. "Introduction to High-Energy Astrophysics" by S. Rosswog and M. Brueggen
2. "Black Holes, White Dwarfs and Neutron Stars" by S. L. Shapiro and S. A. Teukolsky
3. "Numerical Relativity: Starting from Scratch" by T. W. Baumgarte and S. L. Shapiro

4. "Numerical Relativity: Solving Einstein's Equations on the Computer" by T. W. Baumgarte and S. L. Shapiro
5. "Relativistic Hydrodynamics" by L. Rezzolla and O. Zanotti

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 via e-learning 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 an oral exam in which the student will prepare a 20-minute seminar in which they will present one or more articles published on topics covered during the course (a list of possible articles will be provided at the end of the course).

The final grade will be given by the arithmetic average of the marks obtained in the homeworks and the mark of the oral exam. The student who, at the time of the oral exam, decides to refuse one or more of the grades of the homeworks will have to answer questions on the topics of the homeworks whose grades were refused.

Books and notes cannot be used during the oral exam. The use of slides for the seminar is permitted.

Office hours

by appointment, on line or in person.