Subject identification

Subject	11271 - Elements of Numerical Relativity
Credits	1 de presencials (25 hours) 2 de no presencials (50 hours) 3 de totals (75 hours).
Group	Group 1, 1S (Campus Extens)
Teaching period	1st semester
Teaching language	Spanish

Professors

Lecturers	Horari d'atenció als alumnes					
	Starting time	**Finishing time**	**Day**	**Start date**	**Finish date**	**Office**
Carles Bona García cbona@uib.es	13:00h	14:00h	Friday	06/02/2015	26/06/2015	F.313

Contextualisation

It is a matter of time for the new generation of interferometric gravitational wave detectors to produce their first results. Going past the pure detection, the profile of the waves arriving to us can provide information about the sources: astrophysical systems like supernovae, neutron stars, binary systems containing black holes…But the exploitation of this information requires the possibility to explore computationally different options, each one leading to a different wave pattern.

Building a numerical simulation code in General Relativity is not a trivial task. It requires to master very different aspects, like coordinate conditions, evolution algorithms, boundary conditions…and in order to be reliable all these elements must work correctly at the same time. It is like an orchestra, where strings, brass and percussion must play together in an harmonic way. A violin virtuoso, no matter how good, cannot play Vivaldi's Four Seasons by himself.

It is true that nowadays there are 'industrial' codes, tuned for specific applications, running on supercomputers. But the idea is to provide the elements for a student which, armed just with his or her PC, could be able to develop a working code, at least for some simple applications, like black hole evolution. One can get in this way a basic insight of the most relevant elements of Numerical Relativity, which is a valuable background for entering the world of research in this field.

Prof. Carles Bona has been one of the pioneering researchers in the field of Numerical Relativity. He developed the first hyperbolic formulation (Bona-Massó formalism) suitable for black-hole simulations. Later, he developed the first fully covariant formalism (Z4 formalism), which can be derived in addition from a minimal action principle. He is the author of the de la monograph recommended as the basic bibliography for the subject, edited by Springer in the prestigious collection 'Lecture Notes in Physics'.

Requirements

Recommendable

Basic Computing concepts

Skills

Specific

* The students must have the learning skills that allow them to combine a specialized training in Relativity and Astrophysics, Geophysical Fluids, Materials Physics, Quantum Systems or Applied Mathematics, with the multiple abilities provided by an open curriculum..
* The students must have the ability to use and adapt mathematical models in order to describe different kinds of physical phenomena..
* To get advanced learning, at the border of knowledge, and show, in the context of internationally-recognized scientific research, a full understanding of the theoretical and practical aspects of scientific methodology..
* To develop the ability of applying numerical simulation methods to the field of Relativity.

Generic

* Systematic understanding of a field of study and mastery of the research methods and skills related with this field..

Basic

* You may consult the basic competencies students will have to achieve by the end of the Master's degree at the following address: http://estudis.uib.cat/master/comp_basiques/

Content

Theme content

A. Initial data formulation in General Relativity

B. Structural analysis of partial derivatives equations

C. Dealing with Einstein's equations: evolution formalisms and hyperbolicity

D. Simulation platforms

Teaching methodology

In-class work activities

Modality	Name	Typ. Grp.	Description	Hours
Theory classes		Large group (G)	Classroom lessons	18
ECTS tutorials		Small group (P)	Individual or grup tutorials	5
Assessment		Small group (P)	Project presentation	2

At the beginning of the semester a schedule of the subject will be made available to students through the UIBdigital platform. The schedule shall at least include the dates when the continuing assessment tests will be conducted and the hand-in dates for the assignments. In addition, the lecturer shall inform students as to whether the subject work plan will be carried out through the schedule or through another way included in the Campus Extens platform.

Distance education work activities

Modality	Name	Description	Hours
Individual self-study		Individual projects	30
Group self-study		Group projects	20

Specific risks and protective measures

The learning activities of this course do not entail specific health or safety risks for the students and therefore no special protective measures are needed.

Student learning assessment

Assessment

Modality Assessment
Technique Oral tests **(retrievable)**
Description Project presentation
Assessment criteria
Final grade percentage: 20%

Individual self-study

Modality Individual self-study
Technique Papers and projects **(retrievable)**
Description Individual projects
Assessment criteria
Final grade percentage: 50%

Group self-study

Modality	Group self-study
Technique	Papers and projects **(retrievable)**
Description	Group projects
Assessment criteria	

Final grade percentage: 30%

Resources, bibliography and additional documentation

Basic bibliography

Elements of Numerical Relativity and Relativistic Hydrodynamics, C.Bona, C.Palenzuela-Luque and C.Bona-Casas
Springer Lecture Notes in Physics 783 (Springer, Berlin-Heidelberg 2009)
ISBN 978-3-642-01163-4 e-ISBN 978-3-642-01164-1