Universidad Zaragoza

Academic Year/course: 2021/22

68362 - Astroparticle physics II: the dark Universe

Syllabus Information

Academic Year: 2021/22
Subject: 68362 - Astroparticle physics II: the dark Universe
Faculty / School: 100 - Facultad de Ciencias
Degree: 628 -
ECTS: 6.0
Year: 01
Semester: Second semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

This course will give students an updated view of the state of the art for dark matter searches.

The focus of the subject will be phenomenological, complementing the more theoretical approach that will be followed by other subjects of the master such as Cosmology I and Cosmology II. It will focus on the solutions that Particle Physics offers to the problem of dark matter by analyzing possible extensions to the standard model capable of providing candidates with the appropriate characteristics. It will also provide students with the knowledge and tools necessary to address their possible detection. Students come into contact with a wide variety of experimental efforts aimed at detecting galactic dark matter.

1.2. Context and importance of this course in the degree

This course, together with *Astroparticle Physics I: Gamma Rays, Neutrinos and Cosmic Rays*, forms the module of *Astroparticle Physics*. This second part offers students an in-depth review of theories and experiments in the field of matter. These topics will be of interest not only to students who want to pursue research lines in Astroparticle Physics but also to those interested in Particle Physics or Astrophysics.

Thus, the module, together with the three courses of the *Instrumental Techniques* module and courses of *Cosmology and relativity, Particle Physics or Astrophysics*, can be part of a curriculum oriented towards the experimental aspect of Astroparticle Physics. On the other hand, it can also be part of curricula oriented towards the phenomenology of Particle Physics, or towards Astrophysics

1.3. Recommendations to take this course

This course is complementary and continuation of *Astroparticle Physics I*, so it is advisable to take both. In particular, because the study of cosmic rays (integrated in *Astroparticle Physics I*) is essential to understand indirect dark matter detection techniques. Courses of the modules *Cosmology* and *Particle Physics* are also advisable. Likewise, it is recommended to take courses of *Instrumental Techniques*, in particular, *Physics and Engineering of particle detectors*.

2. Learning goals

2.1. Competences

After the course, the student will be more competent to:

- Join as qualified researcher or technician research teams in the fields of Cosmology, Astrophysics, Particles and Astroparticles.
- Use computer techniques and tools for modeling, simulations and data analysis.
- Analyze, treat and interpret experimental data obtained in experiments.
- Facing problems and theoretical developments in the fields of the Degree.

- Delve into a research topic and learn about the most recent advances and current lines of research in the fields of Cosmology, Astrophysics, Particles and Astroparticles.
- Expand his/her knowledge of the properties of dark matter, candidates, and observational techniques.

2.2. Learning goals

To pass this course, the student has to acquire the following learning outcomes:

- Understand the theoretical and experimental motivations for dark matter.
- Distinguish between the main types of dark matter, and the different ways to detect it.
- Know the extensions of the Standard Model that make up the *dark universe*.

2.3. Importance of learning goals

Astroparticle Physics is an expanding field of Physics where the development of detectors, Particle Physics, Cosmology, Astronomy and Nuclear Physics coincide. Because of this, the topics covered require a multidisciplinary approach that strongly enriches the education of students. In Spain, the Canfranc Underground Laboratory has allowed having an extensive experience in this field and its existence, together with the work of competitive national research groups, will promote Astroparticle Physics and the demand for professionals trained in science and technology in this type of study.

In addition, the course will allow students to develop critical and analytical skills, very useful to face many of the problems in Physics and related areas. Moreover, as Master studies are a bridge to the workplace or future PhD studies, their instruction will be supplemented in ways that go beyond purely academic by being in contact with researchers working in these lines.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

Students must demonstrate that they have achieved the expected learning outcomes through the following assessment activities:

- Reports and written works 20%
- Case analysis, problem solving, questions and other activities 30%
- Oral presentations of works 10%
- Evaluation tests 30%
- Computational work 10%

The final mark will be obtained according to the percentage assigned to each evaluation activity. To pass the course this final grade must be equal or higher than 5.0 and not lower than 4.0 in each of the activities.

A single global test

The course has been designed for students who attend face-to-face classes in the classroom, and carry out the assessment activities described above. However, there will also be an evaluation test for those students who have not carried out the evaluation activities or have not passed them.

This global test will be carried out on the dates established by the Faculty of Sciences and will consist of an evaluation of the same learning results as in the continuous evaluation tests.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The learning process that has been designed for this subject is based on the following:

- Master classes
- Problem-based learning
- Case resolution
- Computational classes
- Oral presentations of works
- Written reports
- Tutorials
- Work in small groups
- Work and personal study
- Assessment tests

4.2. Learning tasks

The program offered to the student to help him achieve the expected results includes the following activities:

1. Participation and attendance to lectures in person or online: 30 contact hours
2. Analysis of cases, sharing and debate on the contents of the subject: 10 hours, 7 face-to-face
3. Resolution of problems related to the contents of the subject: 10 hours, 7 face-to-face
4. Completion of computing practices: 10 hours, 7 face-to-face
5. Preparation and written presentation of work: 20 non-contact hours
6. Preparation and oral presentation of work: 10 hours, 1 face-to-face
7. Face-to-face or online tutorials: 10 hours, 5 face-to-face
8. Individual study: 40 non-contact hours
9. Written or oral evaluation tests: 3 contact hours
10. Debates in discussion forum: 7 non-contact hours

The teaching and evaluation activities will be carried out in person unless, due to the health situation, the provisions issued by the competent authorities and by the University of Zaragoza require them to be carried out electronically or semi-electronically with reduced capacity.

4.3. Syllabus

1. Dark matter: astrophysical and cosmological evidences.
2. Theories and candidates for dark matter.
3. Direct search for WIMPs.
4. Indirect searches for dark matter.
5. Signs of dark matter in accelerators.
6. Neutrinos as hot and warm dark matter.
7. The strong CP problem. Axions and ALPs.
8. Axion detection experiments.
9. Other dark matter candidates and models.

4.4. Course planning and calendar

Calendar of teaching sessions and assessments

The dates will be established and announced by the teachers at the beginning of the course.

Classes will begin and end on the dates indicated by the Faculty of Sciences.

- Theory and problems classes: 2/3 sessions per week.
- Computer practical classes: they will be announced by the teachers at the beginning of the course.
- Evaluation sessions: dates to be decided.

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=68362