UAM/IFT

The UAM/IFT MultiDark group offers the realization of a Ph.D. work focused on the theoretical study of the dark matter problem. The student will analyze the nature and structure of the dark matter in the Universe in the context of physics beyond the standard model, such as for example in supersymmetric theories, and their possible detection on space-based detectors, atmospheric telescopes and underground laboratories. The project will also contemplate the study of the dark matter implications in colliders such as LHC.

UCM-Th

1. **Dark matter and dark energy in cosmology**

The project focuses in the so called modified gravity theories and their possible connection to the dark matter and dark energy problems. In particular, within the extra dimensions models, we will study brane fluctuations as a dark matter candidate and the possibility for indirect detection through annihiliation into photons, neutrinos, etc. We also consider the possibility of studying dark energy models responsible for the present phase of accelerated expansion of the universe based on vector-tensor theories and other modifications of gravity. Dark energy models which differ from the standard cosmological constant could have important implications in the determination of the cosmological parameters, and in particular in the present value of the dark matter abundance.

2. **Alternative Dark Matter Candidates**

The identity of the nature of dark matter is a major question in both particle physics and astrophysics. The traditional particle candidates are cold and collisionless, and they predict missing energy and momentum signals at particle colliders. However, recent progress has expanded the list of well-motivated candidates and their possible signatures. In this thesis, we will study the basic properties of non-standard candidates, their motivation, their expected production mechanisms, and their implications for particle colliders, direct detection, indirect searches, and other astrophysical observations as possible modifications of the cosmic microwave background or primordial abundances. This work is essential to discover or exclude these new possibilities by means of the interplay of very different experiments.

IAA

The Physical Cosmology group at IAA-CSIC in Granada is offering the possibility for a student, in possession of a Physics degree, to complete a PhD Thesis. The research to be leaded by the student during his/her doctorate will focus on the understanding the unknown nature of the dark components of the Universe and structure formation. The student will have access to the latest data from BOSS Galaxy Redshift Survey, the largest ongoing spectroscopic survey so far. The main goal of the project is a detailed comparison of BOSS data with high-resolution cosmological simulations of the large-scale structure, in order to study the clustering of dark matter and the evolution of dark energy. Travel availability to attend the meetings of the BOSS collaboration is strictly required. Computer skills are highly valued

IFAE

The MULTIDARK group at the Instituto de Física de Altas Energías IFAE, in Bellaterra (Barcelona) offers a Ph. D. opportunity for a student to work in the field of indirect search for dark matter. The group is participating in the MAGIC, which operates a system of two ground-based gamma-ray telescopes in the Observatorio del Roque de Los Muchachos (island of La Palma, Canary islands). The research work would consist in the search for the possible signatures of dark matter annihilation in gamma rays of energies above 50 GeV, through observations of promising astrophysical candidates with the MAGIC telescopes. The student would also work in the development of the data analysis tools necessary for the task. A degree in Physics is required. Having completed also a master degree would be an asset, but otherwise IFAE has its own master program which the successful candidate will be expected to follow. Availability for traveling to the MAGIC observatory site and to the meetings of the collaboration is required. The candidate should join the group by the end of October.

UIB

1. **Testing gravity and the geometry of the universe through observing gravitational waves from black hole coalescence**

Supervised by Sascha Husa and Alicia Sintes

Coalescing black hole binaries formed by stellar-mass or supermassive black holes provide extraordinarily clean physical systems. Their gravitational wave signature makes them cosmological "standard sirens", which advanced gravitational wave detectors will observe with extreme accuracy, telling us both about the strong field regime of gravity in the vicinity of black holes, and about gravitational effects on cosmological scales by being able to observe such signals throughout the universe. In this project the dynamics of merging black hole binaries and their gravitational wave signature will be simulated on supercomputers, comparing results in general relativity with modified theories of gravity (e.g. f(R) theories and modifications suggested by string theory). The results will inform searches for gravitational waves, and observations based on this work will constrain gravitational theories, provide an accurate measurement of the mass of the graviton, and constrain the cosmological parameters, in particular the content of dark matter and dark energy in the universe, and tell us about the interactions these forms of matter obey.

This project will require some background in general relativity, and an interest in numerical methods as well as in astrophysics and cosmology.

2. **Numerical and analytical modeling of galaxies and implications for the dark matter content of the universe**

Supervised by Sascha Husa and Jaume Carot

On galactic and cosmological scales the universe appears to be dominated by dark matter and dark energy, and the gravitational interaction. Yet our theory of gravity - general relativity - is not very well tested on such large scales. In this project, models of galaxies will be constructed numerically and compared within general relativity and families of modified theories (e.g. f(R) theories and modifications suggested by string theory). These studies will provide constraints both on the amount of dark matter required to explain observations, and on the parameters of modified theories of gravity. Dynamical studies will investigate the role of dark matter in the formation of supermassive black holes.

This project will require some background in general relativity, and an interest in numerical methods as well as in astrophysics and cosmology.