Défense publique de la dissertation de doctorat de Ludovic Ducobu titulaire d'un Master en sciences physiques de l'Université de Mons ainsi que d'une formation doctorale

Composition du jury :

Promoteurs de thèse : Claude Semay (UMONS), Yves Brihaye (UMONS)

Personnel académique de l'UMONS : Patrick Palmeri (Président - UMONS), Nicolas Boulanger (Secrétaire - UMONS)

Autres experts étrangers à l'Université : Jutta Kunz (Université Carl von Ossietzky, Oldenburg, Allemagne), Christian Pfeifer (ZARM center, Bremen, Allemagne)

Réunion du jury pour statuer sur la recevabilité de la dissertation

Le jeudi 09 juin 2022 à 9h, dans la salle Mirzakahani, bâtiment De Vinci, UMONS.

Date et lieu de la défense publique

Le mercredi 22 juin 2022 à 15h, dans la salle Mirzakahani, bâtiment De Vinci, UMONS.

Titre de la dissertation

Compact objects in modified theories of gravity

Résumé de la dissertation

The formulation of General Relativity by Albert Einstein in 1915 revolutionized our understanding of the gravitational interaction. However, despite its tremendous successes, this theory struggle to explain certain important phenomena such as the accelerated expansion of the universe (which is attributed to the presence of some form of dark energy) or the fact that visible matter seems to correspond only to about 5% of the mass-energy content of the observable universe according to the Λ-CDM model of cosmology (the remaining 95% being attributed to dark energy, for about 68%, and to a form of 'exotic' matter called dark matter for the remaining 27%).

One of the simplest ways to address these problems is to retain the conceptual framework of general relativity while modifying the equations that determine how the presence of massive objects affects the geometry of spacetime. One very convenient way to do it, in the effective field theory approach, is to add new fields in the theory. Being a fundamental component of many models in theoretical physics and the simplest type of field, scalar fields seem to be prime candidates, at least for first attempts.

Furthermore, in the study of any relativistic theory of gravity, compact objects (such as boson stars, neutron stars and black holes) provide privileged laboratories since they allow to investigate the theory in extreme regimes.

The aim of this thesis is to study the influence of scalar fields on the compact objects known in general relativity to see if these fields can provide some clues to solve the aforementioned problems.

More precisely, this thesis is devoted to the study of physical properties of compact objects endowed with non-minimally coupled scalar field(s) via analytical and numerical methods.

Our contributions cover the study of real or complex scalar fields with minimal and/or non-minimal couplings to gravity in 4D and 5D theories.

In each case, our papers ended up in the construction of new spherically symmetric black hole, boson star and/or neutron star solutions in the corresponding theories. The spectrum of these solutions and the conditions for their existence where carefully discussed.

Our main results for 4D theories include (a) the numerical construction of a family of black hole and boson star solutions endowed with a scalar field non-minimally coupled to the Gauss-Bonnet invariant [work realized in collaboration with professor Yves Brihaye] that extrapolates between shift-symmetric and spontaneously scalarized solutions previously known in this type of theory and (b) the first construction of exact hairy black holes in an extension of the teleparallel equivalent of general relativity [work realized in collaboration with doctors Sebastian Bahamonde and Christian Pfeifer].

Our main results for 5D theories include the numerical construction of spinning-charged black holes in 5D Einstein gravity supplemented by a doublet of complex massive scalar fields minimally coupled to the geometry [work realized in collaboration with Professor Yves Brihaye]. This work generalizes previously known (uncharged) solutions for 5D spinning black holes in Einstein gravity supplemented by this type of scalar content.