NewCompStar Standard STSM scientific report

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STSM topic: Extended theories of gravity and observations
Host: Salvatore Capozziello
Host Institution: University of Naples Federico II, INFN of Naples, Italy

1. Goals

The purpose of this STSM was to continue a collaboration of Serbian group (P. Jovanovic, V. Borka Jovanović and me) with Prof. Capozziello and his group and to working on the models of extended theories of gravity (ETG) in order to explain different astrophysical phenomena connected to compact object and compact stars and to compare the results with the existing astronomical observations. ETGs are alternative theories of gravitational interaction, coming from the formulation of Quantum Field Theory on curved space-time. They are developed starting from General Relativity with the aim to cure its shortcomings. They are based on straightforward generalizations of the Einstein theory assuming that the gravitational action is not only linear in the Ricci curvature scalar R but can be any function of curvature invariants, in particular $f(R)$ gravity. These theories can have observational signatures at astrophysical and cosmological scales. In this initial stage our goal was to create a framework for further collaboration with Prof. Capozziello and his group.

2. Work

We consider possible signatures for hybrid modified gravity within the Galactic Central Parsec, based on our analysis of the S2 star orbital precession around the massive compact dark object at the Galactic Centre, and on the comparisons between the simulated orbits in hybrid modified gravity and two independent sets of observations. Using astrometric observations we make constraint on modified gravitation parameters, i.e. on the range of hybrid modified gravity interaction. The obtained results would be very important for further investigation of the gravitation physics of massive compact objects, particularly neutron stars. The one of the main result of our joint work during this STSM visit is to improve paper that has been recently submitted for publication (D. Borka, S. Capozziello, P. Jovanović and V. Borka Jovanović, *Probing hybrid modified gravity by stellar motion around Galactic Centre e-Print*: arXiv:1504.07832 [gr-qc]). We get the major revision of the paper. Also, we define other problems that we want to solve using ETGs, i. e. in order to investigate the possible existence of further gravitational radii which can play analogue roles as the Schwarzschild radius. Such new fundamental lengths emerge thanks to the further degrees of freedom of the considered theories. The approach we are proposing is sufficiently reliable to constrain ETGs from stellar orbits around the Galactic Centre. These investigations will provide an important test of general relativity and gravitation near compact objects. In the continuation of our work, these results will be used to model compact massive objects, as for instance neutron stars, black holes and their binary systems in these theories of modified gravity.

Also, I presented a seminar at the Department of Physics of University of Naples Federico II, entitled "Gravity around compact object in the Galactic center". Some

preliminary results obtained during this STSM, were already presented in the special session dedicated to NewCompStar during the 10th Serbian Conference on Spectral Line Shapes in Astrophysics which was held in Srebrno jezero, Serbia, June 15-19, 2015 http://servo.aob.rs/scslsa10/program10.html.

3. Future

This is a very active research area where important results are expected in the forthcoming years. The development of this cooperation will increase the scientific interaction between the two teams and will provide a suitable basis for training the highly-qualified personnel included in the STSM proposal. In addition to the scientific objectives, the project intends to be a pilot-project to start further bilateral collaborations in basic sciences (in particular Astronomy and Astrophysics) between Serbia and Italy for the education of learning people at various levels (Erasmus projects, joint PhD and post-doctoral programs).

We foresee a publication of two or three scientific papers as a direct result of this STSM.

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