Programma scientifico del Workshop annuale della Iniziativa Specifica **QUANTUM UNIVERSE** (**QGSKY**), Napoli, Sezione INFN e Dipartimento di Fisica **Ettore Pancini**.

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1 Settembre 2015

14.25: Saluti di benvenuto

14.30 C. Stornaiolo: **Phenomenological reconstruction of the tomogram of the universe**

15.00 E. Battista: **Earth-Moon Lagrangian points as a testbed for general relativity and effective field theories of gravity**

15.30 L. Fatibene: **Conformal gravity as a gauge natural theory**

16.00 Coffee Break

16.30 E. Piedipalumbo: **Accelerating universe in non-minimally coupled condensate cosmologies: comparison of theoretical predictions with observations**

17.00 G. Covone: **Recent cosmological results from weak gravitational lensing by galaxy clusters**

17.30 V. Bozza: **Gravitational lensing by black holes and their alternatives**

18.00 N. Radicella: **Weak-field spherically symmetric solutions in f(T) gravity**

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2 Settembre 2015

09.00 G. Vilasi: **Repulsive gravity of light beams**

09.30 G. Lambiase: **Some cosmological consequences of modified gravity**

10.00 D. Bini: **Gravitational self-force corrections to the motion of test particles in black hole spacetimes**

10.30 Coffee Break

11.00 S. Garruto: **Cauchy problem in general relativity**

11.30 L. Parisi: **Some results concerning Kantowski-Sachs spacetimes and the Einstein-Skyrme system**

12.00 G. Esposito**: A parametrix for quantum gravity?**

ABSTRACTS pervenuti:

Stornaiolo: I talk about the recent advances of the research followed in the last years about the reconstruction of the initial conditions in terms of a tomographic approach to quantum and classical cosmology. I illustrate the meaning of quantum tomography and show how some concepts developed in quantum optics and quantum computing can be implemented in our research. As a first step for the reconstruction of the initial conditions of the universe, we need to start from the fluctuations of the spacetime metric and of its momentum. We show how to derive such fluctuations and discuss the possibility of its realization. Last, we discuss the possible developments of this investigation.

Battista: We first analyse the restricted four-body problem consisting of the Earth, the Moon and the Sun as the primaries and a spacecraft as the planetoid. This scheme allows us to take into account the solar perturbation in the description of the motion of a spacecraft in the vicinity of the stable Earth-Moon libration points L4 and L5 both in the classical regime and in the context of effective field theories of gravity. A vehicle initially placed at L4 or L5 will not remain near the respective points. In particular, in the classical case the vehicle moves on a trajectory about the libration points for at least 700 days before escaping away. We show that this is true also if the modified long-distance Newtonian potential of effective gravity is employed. We also evaluate the impulse required to cancel out the perturbing force due to the Sun in order to force the spacecraft to stay precisely at L4 or L5. It turns out that this value is slightly modified with respect to the corresponding Newtonian one. In the second part of the paper, we first evaluate the location of all Lagrangian points in the Earth-Moon system within the framework of general relativity. For the points L4 and L5, the corrections of coordinates are of order a few millimeters and describe a tiny departure from the equilateral triangle. After that, we set up a scheme where the theory which is quantum corrected has as its classical counterpart the Einstein theory, instead of the Newtonian one. In other words, we deal with a theory involving quantum corrections to Einstein gravity, rather than to Newtonian gravity. By virtue of the effective-gravity correction to the long distance form of the potential among two point masses, all terms involving the ratio between the gravitational radius of the primary and its separation from the planetoid get modified. Within this framework, for the Lagrangian points of stable equilibrium, we find quantum corrections of order two millimeters, whereas for Lagrangian points of unstable equilibrium we find quantum corrections below a millimeter. In the latter case, for the point L1, general relativity corrects Newtonian theory by 7.61 meters, comparable, as an order of magnitude, with the lunar geodesic precession of about 3 meters per orbit. The latter is a cumulative effect accurately measured at the centimeter level through the lunar laser ranging positioning technique. Thus, it is possible to conceive a new, first-generation laser ranging test of general relativity with a relative accuracy in between 1/100 and 1/1000, by measuring the 7.61-meter correction to the L1 Lagrangian point, an observable never used before in the Sun-Earth-Moon system. Performing such an experiment requires controlling the propulsion to precisely reach L1, an instrumental accuracy comparable to the measurement of the lunar geodesic precession, understanding systematic effects resulting from thermal radiation and multi-body gravitational perturbations. This will be the basis to consider a second-generation experiment to set experimental constraints on deviations of effective field theories of gravity from general relativity in the Sun-Earth-Moon system.

Fatibene: I will present the gauge-natural structure of Conformal Gravity, review conservation laws and discuss observable quantities and physical states.

Piedipalumbo: We analyze a class of cosmological models based on a non-minimal coupling between the geometry and a fermionic condensate. We observe that the strong constraint resulting from the Dirac equation allows a detailed design of the cosmology of these models, and at the same time guarantees an evolution towards a state indistinguishable from general relativistic cosmological models. In this light, we show in detail how the use of some specific potentials can naturally fit the most recent observational data.

Garruto: I will review the initial-value problem in (vacuum) General Relativity by discussing the role of coordinate choices. The work is part of a project aimed at discussing the physical structure of a theory in terms of algebraic properties of the principal symbol of quasi-linear equations.

Bozza: Light rays passing close to a black hole experience very strong deflections and can give rise to infinite sequences of images for any given source. We show how these images can be analytically described for any kind of static or rotating metrics. In the case of Kerr metric, caustics become larger and larger for higher orders, and an exponentially large number of higher order images arises. We discuss how these results have been used in the popular movie "Interstellar". Some perspectives for observations of the strong deflection phenomenology come from the black hole in the Galactic center, where high resolution observational efforts are being concentrated. Finally, we consider metrics falling off as 1/r^n, which are characterized by quite peculiar phenomena related to violations of the energy conditions.

Radicella: We study weak-field solutions having spherical symmetry in f(T) gravity; for this purpose, we solve the field equations for a non-diagonal tetrad, starting from a Lagrangian in the form f(T)=T+αT^n, where α is a small constant, parameterizing the departure of the theory from General Relativity. We show that the classical spherically symmetric solutions of General Relativity, i.e. the Schwarzschild and Schwarzschild-de Sitter solutions, are perturbed by terms in the form ∝r^(2-2n) and discuss the impact of these perturbations on observational tests.

Covone: I will present recent results from our weak gravitational lensing analysis of a large and complete sample of massive galaxy clusters. We have determined the mass distribution in a sample of ~1500 galaxy clusters from the CFHT Lensing Survey. The analysis of this unique sample allowed us to detect the so-called second halo term, i.e., the signal due to the large-scale structure around galaxy clusters. We also proposed a new technique to determine cosmological parameters by means of a joint analysis of stacked gravitational lensing and clustering of galaxy clusters. Finally, I will present current works based on the new data from the VST surveys KiDS and VOICE.

Parisi: The Kantowski-Sachs cosmological model sourced by a Skyrme field and a cosmological constant is considered in the framework of General Relativity. The choice of the spacetime metric and the hedgehog ansatz with a constant radial profile function make it possible to simplify the Einstein-Skyrme system. By using dynamical-systems techniques, a qualitative analysis of the cosmological equations is presented. Physically interesting features of the model such as isotropization, bounce and recollapse are discussed.

Esposito: In the sixties, DeWitt discovered that the advanced and retarded Green functions of the wave operator on metric perturbations in the de Donder gauge make it possible to define classical Poisson brackets on the space of functionals that are invariant under the action of the full diffeomorphism group of spacetime. He therefore tried to exploit this property to define invariant commutators for the quantized gravitational field, but the operator counterpart of the classical Poisson brackets turned out to be a hard task. On the other hand, in the mathematical literature, it is by now clear that, rather than inverting an hyperbolic (or elliptic) operator, it is more convenient to build a quasi-inverse, i.e. an inverse operator up to an operator of lower order which plays the role of regularizing operator. This approximate inverse, the parametrix, makes it possible to solve inhomogeneous hyperbolic (or elliptic) equations. We here suggest that such a construction might be exploited in canonical quantum gravity, provided one understands what is the counterpart of classical smoothing operators in the quantization procedure.