3rd FLAG meeting: the Quantum and Gravity

Report of Contributions

https://agenda.infn.it/e/18114

Contribution ID: **1** Type: **not specified**

Stabilizing the EW vacuum

Thursday, 13 June 2019 09:15 (50 minutes)

Although the electroweak vacuum is not absolutely stable, when only Standard Model interactions are considered its lifetime T turns out to be much larger than the age of the Universe. However, T is extremely sensitive to the
presence of unknown high energy new physics: the latter can enormously lower T. This poses a serious problem for the stability of our Universe. In this talk I discuss physical mechanisms that "naturally" stabilize the electroweak vacuum.

Presenter: BRANCHINA, Vincenzo (CT)

Contribution ID: **2** Type: **not specified**

The Compton-Schwarzschild correspondence: primordial black holes as the link between microphysics and macrophysics

Thursday, 13 June 2019 10:10 (50 minutes)

Black holes could span 60 decades of mass - from the Planck scale (10-5g) to the cosmological scale (1022Mo) - and therefore provide an important link between microphysics and macrophysics. In the macroscopic domain, attention has recently turned to the possibility that primordial black holes (i.e. those formed in the early universe) could provide the dark matter or the black-hole mergers detected by LIGO or even some features of cosmic structure. In the microscopic domain, primordial black holes lighter than the Earth would have a Hawking temperature exceeding that of the cosmic microwave background, so that quantum effects are important. Such quantum black holes span the lower 30 decades of mass and provide a unique probe of the early universe and high energy physics. The micro-macro link is most striking at the Planck scale, with Planckian black holes likely to play a key role in quantum gravity. This raises the question of what happens to relativity theory as one approaches the Planck scale from above (eg. the Schwarzschild radius) and to quantum theory as one approaches it from below (eg. the Compton radius). It is argued that there should be a smooth transition between these two scales, corresponding to a unified Compton-Schwarzschild expression. In this case, there may also be a link between elementary particles and sub-Planckian black holes and the Hawking temperature should increase with mass in the sub-Planckian regime, leading to the possibility that stable black hole relics provide the dark matter. It is also argued that the duality between the Compton and Schwarzschild scales should be maintained if the number of spatial dimensions increases, which has important implications for the observability of black holes in accelerators.

Presenter: CARR, Bernard (Queen Mary University of London)

Contribution ID: **3** Type: **not specified**

Some features of the Hamiltonian Analysis of Asymptotic Safe Quantum Gravity

Thursday, 13 June 2019 11:35 (25 minutes)

After a brief introduction to the basic ideas underlying Asymptotic Safety, we analize a RG improved Einstein-Hilbert Lagrangian in which the cosmological constant and the gravitational constant are non geometrical fields, functions of the Space-Time and determined by the Renormalization Group. The main goal of this Hamiltonian analysis is to probe the vacuum of Asymptotic Safety. This Hamiltonian theory exibits non trivial Dirac's constraints which, despite Einstein General Relativity, are second class due to the breaking of diff-invariance by $G(x)$ and $\Lambda(x)$. To throw light on this complicated scenario, the parent Brans-Dicke theory is analyzed. Its Dirac's constraint analysis has first class constraints which are not equivalent to Einstein's General Relativity. Its Dirac's constraint algebra, contrary to some claims in the litterature, does not reduce to Einstein General Relativity algebra. In general it is believed that Brans-Dicke theory is equivalent to Einstein General Relativity by passing from the Jordan Frame to the Einstein Frame. We prove this transformation is not canonical and generates two inequivalent Hamiltonian theories and then two inequivalent quantum theories.

Presenter: GIONTI, Gabriele (Specola Vaticana)

Contribution ID: **4** Type: **not specified**

Phenomenology of scale-invariant gravity

Thursday, 13 June 2019 12:05 (25 minutes)

In this talk we discuss the possibility that tensor-scalar gravity is naturally scale-invariant, at least at the classical level. This assumption has a number of phenomenological consequences on the physics of the Universe at large scale and of black holes. We consider some of these to assess whether scale-invariance is a viable and fundamental symmetry.

Presenter: RINALDI, Massimiliano (TIFP)

Contribution ID: **5** Type: **not specified**

Time-energy uncertainty relation for neutrino oscillations in curved spacetime

Thursday, 13 June 2019 17:00 (25 minutes)

We derive the Mandelstam-Tamm time-energy uncertainty relation for neutrino oscillations in a generic stationary curved spacetime. In particular, by resorting to Stodolsky covariant formula of the quantum mechanical phase, we estimate gravity effects on the neutrino energy uncertainty. Deviations from the standard Minkowski result are explicitly evaluated in Schwarzschild, Lense-Thirring and Rindler (uniformly accelerated) geometries. Finally, we discuss how spacetime could affect the characteristic neutrino oscillation length in connection with the recent view of flavor neutrinos as unstable particles.

Presenter: SMALDONE, Luca (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **6** Type: **not specified**

Turnaround size of non-spherical structures

Thursday, 13 June 2019 17:30 (25 minutes)

The turnaround radius of a large structure in an accelerating universe has been studied only for spherical structures, while real astronomical systems deviate from spherical symmetry. We show that, for small deviations from spherical symmetry, the gauge-invariant characterization of the turnaround size using the Hawking-Hayward quasi-local mass and spherical symmetry still applies, to first order in the cosmological perturbation potentials and in the deviations from sphericity. This is the first step to include non-spherical systems in the physics of turnaround.

Presenter: GIUSTI, Andrea (Bishop University)

Contribution ID: **7** Type: **not specified**

Effective field theories for cosmological fluids, solids and supersolids

Thursday, 13 June 2019 14:30 (50 minutes)

I will review some cosmological applications of the effective field theories for condensed matter systems, characterised by the spontaneous symmetry breaking for spacetime symmetries. The associated Goldstone bosons represent the low-energy excitations, the phonons, of self-gravitating media (such as solids, fluids, superfluids and supersolids). Such an effective approach can be used to give a very general modelling of the dark sector based on symmetries, possibly explaining the accelerated expansion of the Universe.

Presenter: CELORIA, Marco (GSSI and ICTP)

Contribution ID: **8** Type: **not specified**

The Shadow of the Supermassive Black Hole M87

Thursday, 13 June 2019 15:30 (50 minutes)

Presenter: DE LAURENTIS, Mariafelicia (Napoli University and INFN)

Contribution ID: **9** Type: **not specified**

CMB lensing beyond the leading order: is there a new physical effect in E- and B-modes power spectra?

Friday, 14 June 2019 09:00 (50 minutes)

In this talk, I will present the weak lensing correction, to the cosmic microwave background temperature
and polarization anisotropies, including all the effects that go beyond the leading order. These are: post-Born corrections, LSS corrections and, for the polarization anisotropies, the correction due to the rotation of the polarization direction between the emission at the source and the detection at the observer. I will then concentrate on the effect coming from the rotation of the polarisation direction, showing how this is a true physical effect, which has to be taken into account at second order in perturbation theory, and clarifying inconsistencies on the treatment of this rotation in the recent literature. To conclude, focusing on B-mode power spectrum, I will consider the magnitude of this effect and discuss the reason because this has to be taken in consideration in future CMB survey, that aim to measure a tensor-to-scalar ratio of the order of 0.001.

Presenter: MAROZZI, Giovanni (Pisa University and INFN)

Contribution ID: **10** Type: **not specified**

Quantum Memories of de Sitter Universe

We show that the S-matrix formulation of the theory as well as the existence of Gibbons-Hawking entropy imply that de Sitter is a state of enhanced memory storage capability and as such is a subject to memory burden effect. Unlike ordinary semi-classical information, the quantum information encoded in the state of de Sitter cannot be erased by inflation and provides a quantum cosmic hair carrying information about the primordial state of the Universe.

Presenter: DVALI, Giorgi (LMU and MPI, Munich and NYU)

Contribution ID: **11** Type: **not specified**

Binary Neutron Star Mergers: Numerical Simulations and Observation

Friday, 14 June 2019 14:30 (50 minutes)

I will review the current state of the art of fully general
relativistic numerical simulations of binary neutron star mergers. I will focus in particular on what we can learn from the gravitational wave and electromagnetic emission. These sources emit indeed strong gravitational waves and power bright electromagnetic signals that are strongly correlated with the properties of matter and spacetime in a strong-gravity regime. I will also describe how observations of these systems match theoretical predictions and how they can be used to provide further information on cosmological
parameters and alternative theories of gravity.

Presenter: GIACOMAZZO, Bruno (TIFP)

Contribution ID: **12** Type: **not specified**

Homogeneous and Inhomogeneous full-GR cosmological dynamics

Friday, 14 June 2019 15:30 (50 minutes)

In this talk I will first describe results from cosmological simulations in the nonlinear post-Friedman approximation, a kind of post-Newtonian formalism for cosmology, showing how gravito-magnetic effects are produced by structure formation. Then I will focus on recent fully nonlinear numerical relativity simulations representing the evolution of initial perturbations in a Einstein de Sitter background. Main results are: 1) back-reaction effects on the overall expansion of the model are very small; 2) voids expansion rate is significantly higher than that of the background; 3) overdensities can reach turn-around later than predicted by the standard top-hat model. I will end the talk with some more speculative work on homogenous Bianchi IX models that can be taken to represent the most general spatial average of the universe: using a nonlinear equations of state and anisotropic stress we show that Einstein equations admit bouncing (nonsingular) solutions where the typical Bianchi IX chaos and anisotropies are suppressed. In this scenario, therefore, the isotropic universe in which we live is the results of the dynamics. To establish the significance of these results is the goal of future work.

Presenter: BRUNI, Marco (Portsmouth University)

Contribution ID: **13** Type: **not specified**

Time in quantum theory, the Wheeler-DeWitt equation and the Born-Oppenheimer approximation

Friday, 14 June 2019 11:30 (25 minutes)

We compare two different approaches to the treatment of the Wheeler-DeWitt equation and the introduction of time in quantum cosmology. One approach is based on the gauge-fixing procedure in theories with first-class constraints, while the other uses the Born-Oppenheimer method. We apply both to a very simple cosmological model and observe that they give similar predictions. We also discuss the problem of time in non-relativistic quantum mechanics and some questions concerning the correspondence between classical and quantum theories.

Presenter: VARDANYAN, Tereza (BO)

Contribution ID: **14** Type: **not specified**

Stochastic gravitational waves background and its anisotropies

Friday, 14 June 2019 12:00 (25 minutes)

The direct detections of Gravitational Waves (GWs) by the Advanced LIGO and Advanced Virgo interferometers have opened a new era of astronomy. Aside the current detections associated with individual loud events, one expects a superposition of coincident unresolved events leading to a stochastic GW background (SGWB). After reviewing briefly the SGWB, I will discuss how the anisotropic distribution of sources and the inhomogeneous geometry of the intervening spacetime can induce anisotropies. I will consider a SGWB produced by (1) cosmic strings and (2) by compact binary coalescences. I will show that while the SGWB monopole is sensitive to the particular model one uses, the anisotropic angular power spectrum is basically insensitive to the cosmic string model or the nature of binary black holes population. I will then discuss the noise in the anisotropies of the astrophysical GW background sourced by the finite sampling of both the galaxy distribution and the compact binary coalescence event rate.

Presenter: SAKELARIADU, Mairi (King's College London)

Contribution ID: **15** Type: **not specified**

Bootstrapping Newtonian gravity

Friday, 14 June 2019 17:00 (25 minutes)

Presenter: LENZI, Michele (B)

Contribution ID: **16** Type: **not specified**

Characterizing black hole metrics in quadratic gravity

Friday, 14 June 2019 17:30 (25 minutes)

The recent discovery of non-Schwarzschild black hole spacetimes has opened new directions of research in higher-derivative gravitational theories. However, despite intense analytical and numerical efforts, the link with the linearized theory is still poorly understood. In this work we address this point for the Einstein-Weyl Lagrangian, whose weak field limit is characterized by the standard massless graviton and a spin-2 ghost. We show that the strength of the Yukawa term at infinity determines the thermal properties of the black hole and the structure of the singularity near r = 0. Moreover, inspired by recent results in the Asymptotic Safety scenario we investigate the consequences of an imaginary ghost mass. In this case we find a countable set of solutions all characterized by spatial oscillations of typical wavelength determined by the mass of the spin-2 field.

Presenter: SILVERAVALLE, Samuele (Milano University)

Contribution ID: **17** Type: **not specified**

Is the standard Higgs just a simple massive field?

Friday, 14 June 2019 18:00 (25 minutes)

A recent re-analysis of the ATLAS and CMS data indicates a sizeable excess of events in the 4 leptons
channel, for a total invariant mass around 700 GeV. Its natural interpretation is in terms of a new scalar boson which decays into ZZ and then into (l+l-)(l+l-) charged final states. I will argue that this picture might have an intriguing relation with the other 125 GeV scalar particle which, so far, has been identified as the fundamental Higgs boson. The relation is based on both numerical and analytical evidence that, in the broken-symmetry phase, the scalar propagator is more complicated than usually expected, as if there were a 2-pole structure. I will show that, in this perspective, the existence of a pair of states, respectively at 125 and 750 GeV, would not be completely unexpected.

Presenter: CONSOLI, Maurizio (CT)

Contribution ID: **18** Type: **not specified**

Hyperbolic vacuum decay

Thursday, 13 June 2019 18:00 (25 minutes)

The properties of an hyperbolically-expanding wormhole are studied. Using a particular equation of state for the fluid on the wormhole throat, we reached an equation of motion for the throat that leads to a constant surface energy density σ. The Lagrangean leading to the above equation of motion contains the ”rest mass”of the expanding particle as a potential energy. The associated Hamiltonian corresponds to a relativistic free par- ticle of a total Planck energy EP . From the energy constraint we obtained that the cosmological constant is of Planck order but hidden at very tiny scales, in accordance with Carlip’s recipe.

Presenter: CULETU, Hristu (Ovidius University)

Contribution ID: **19** Type: **not specified**

Duality between static spherically or hyperbolically symmetric solutions and cosmological solutions in scalar-tensor gravity

Friday, 14 June 2019 10:00 (25 minutes)

We study static spherically and hyperbolically symmetric solutions of the Einstein equations in the presence of a conformally coupled scalar field and compare them with those in the space filled with a minimally coupled scalar field. We then study the Kantowski-Sachs cosmological solutions, which are connected with the static solutions by the duality relations. The main ingredient of these relations is an exchange of roles between the radial and the temporal coordinates, combined with the exchange between the spherical and hyperbolical two-dimensional geometries. A brief discussion of questions such as the relation between the Jordan and the Einstein frames and the description of the singularity crossing is also presented.

Presenter: KAMENSHCHIK, Alexander (BO)

Contribution ID: **20** Type: **not specified**

Opening

Thursday, 13 June 2019 09:00 (15 minutes)

Contribution ID: **21** Type: **not specified**

Compact binary coalescences: Constraints on waveforms

Friday, 14 June 2019 10:30 (25 minutes)

To obtain gravitational waveforms, results of analytical approximations for the early phase of compact binary coalescences are 'stitched'with –or calibrated against–numerical simulations for the late phase. Each of these calculations requires external inputs and there are additional ambiguities associated with the stitching procedure. Nonetheless, the resulting waveforms have been invaluable for the initial detections by the LIGO-Virgo collaboration. We are now entering an era of abundant detections, requiring greater theoretical precision not only for a better estimation of source parameters assuming general relativity (GR), but also for testing GR itself using gravitational waves data. In this talk I will show that full non-linear GR imposes an infinite number of sharp constraints on the CBC waveforms which can be used as clear-cut measures (i) to evaluate the accuracy of any waveform in the template bank against exact GR, and (ii) to discriminate between various choices that have to be made to resolve the ambiguities.

Presenter: DE LORENZO, Tommaso (Penn State University)