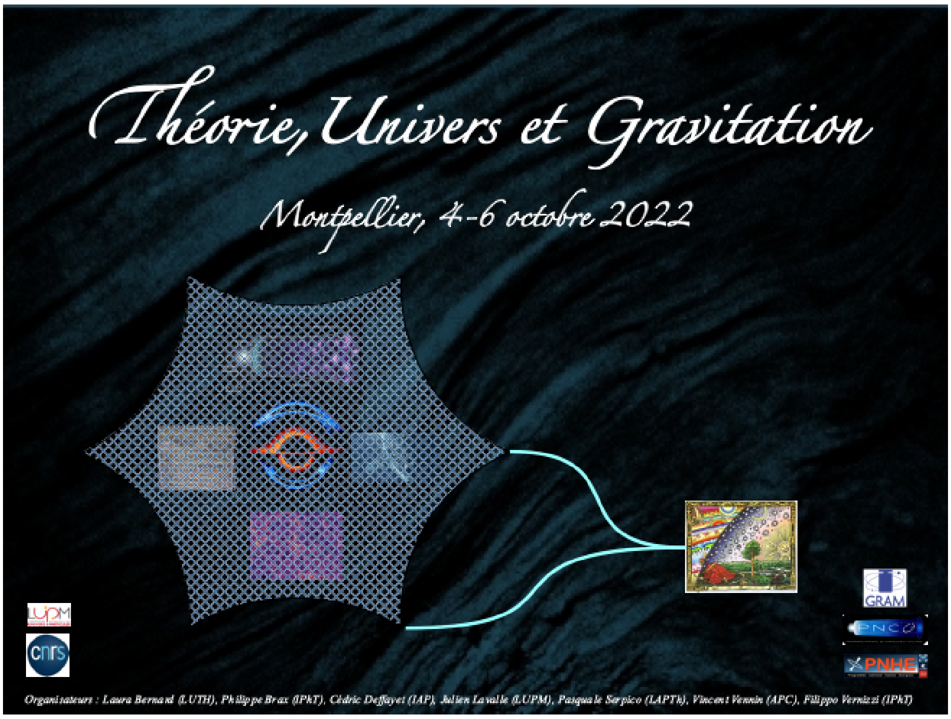
Théorie, Univers et Gravitation

mardi 4 octobre 2022 - jeudi 6 octobre 2022

TBA



Recueil des résumés

Contents

1

Quantum vacuum excitation of a quasi-normal mode in an analog model of black hole spacetime

Auteur: Maxime Jacquet[1]

[1] *Laboratoire Kastler Brossel, CNRS France*

Auteur correspondant maxime.jacquet@lkb.upmc.fr

Vacuum quantum fluctuations near horizons are known to yield correlated emission by the Hawking effect. We use a driven-dissipative quantum fluid of microcavity polaritons as an analog model of a quantum field theory on a black-hole spacetime and numerically calculate correlated emission. We show that, in addition to the Hawking effect at the sonic horizon, quantum fluctuations may result in a sizeable stationary excitation of a quasi-normal mode of the field theory. Observable signatures of the excitation of the quasi-normal mode are found in the spatial density fluctuations as well as in the spectrum of Hawking emission. This suggests a general and intrinsic fluctuation-driven mechanism leading to the quantum excitation of quasi-normal modes on black hole spacetimes. With this talk, I would like to discuss the possible generalisation of our results to generic fields on black hole spacetimes.

2

Quantum of action in entangled relativity

Auteur: Olivier Minazzoli[1]

[1] *ARTEMIS - OCA*

Auteur correspondant olivier.minazzoli@oca.eu

In this talk I will present the fact that the quantum field theory treatment of entangled relativity requires the existence of a new fundamental quantum of action that is not the usual constant of Planck (hbar). Instead, in entangled relativity, hbar can be thought to be an effective late times and low energy limit quantum of action, which therefore depends on the spacetime localisation. I will further show that the only fundamental scale that appears in the quantum phase of theory is the Planck energy—which, surprisingly, remains a fundamental constant in entangled relativity, although neither Newton's constant G nor hbar are. This is because it turns out that hbar is proportional to G in the semiclassical limit of entangled relativity, such that the weak gravity limit (G -> 0) corresponds to the classical limit (hbar -> 0). I will discuss the potential implications at the foundational level. I shall first recall that entangled relativity is a new general theory of relativity that does not allow gravity to be treated separately from matter fields, and that the theory possesses general relativity as one of its limits (for fairly generic classical situations) without any free parameter that can be fine tuned at the classical level.

3

Cosmological master equations

Auteur: Thomas Colas[1]

Co-auteurs: Vincent Vennin [2]; Julien Grain [3]

[1] *IAS/APC*

[2] *APC Paris*

[3] *Institut d'Astrophysique Spatiale*

Auteurs correspondants: thomas.colas@universite-paris-saclay.fr, vincent.vennin@apc.in2p3.fr, julien.grain@universite-paris-saclay.fr

Nearly scale-invariant, Gaussian and adiabatic scalar perturbations from quantum mechanical origin have been extensively tested using CMB and LSS data. Effective field theories aim at providing a systematic way to consider extensions to this adiabatic evolution, incorporating the knowledge of unknown physics in a parametrically controlled manner. In order to grasp the implications of some hidden sector at the quantum level, the formalism needs to incorporate non-unitary effects such as dissipation and decoherence. To achieve this goal, master equations can be a valuable tool. Ubiquitous in quantum optics where they describe the effects of an almost unspecified environment on the evolution of measurable degrees of freedom, they rely on assumptions that do not straightforwardly extend to cosmology where the background is curved and dynamical, the Hamiltonian time-dependent and the environment out-of-equilibrium. In this talk, I will present their implementation in cosmology and benchmark their efficiency on solvable models.

4

Gravitational portals in the early Universe

Auteur: Simon Cléry[1]

[1] *IJCLab - Pôle théorie*

Auteur correspondant simon.clery@ijclab.in2p3.fr

We present new results on gravitational matter production in the late time evolution of inflation, during coherent oscillation regime of the inflationary field, usually called "reheating". We consider the production of matter and radiation during reheating after inflation, restricting our attention to gravitational interactions, including minimal and non-minimal coupling to gravity. In particular, we consider the gravitational production of dark matter and production of radiation from inflaton scattering. In the latter, we derive a lower bound on the maximal temperature reached by the thermal bath in the early Universe and consider new perspectives for a purely gravitational reheating and leptogenesis.

5

Holographic stability of maximally symmetric spacetimes

Auteur: Valentin Nourry[1]

Co-auteurs: Francesco Nitti [1]; Elias Kiritsis [2]

[1] *APC, Université de Paris*

[2] *UoC and APC*

Auteurs correspondants: kiritsis@physics.uoc.gr, nitti@apc.in2p3.fr, nourry@apc.in2p3.fr

Maximally symmetric spacetimes are well known to be stable under small metric perturbations if they propagate into the vacuum. But this statement is not always verified in the presence of matter.

Starobinsky inflation is based on the idea that a quantum Conformal Field Theory (CFT) backreacts in an initial de Sitter spacetime, driving it to a FLRW spacetime after a period of inflation.

In this talk, we use AdS/CFT duality to construct correlation functions of the stress-tensor in a **strongly coupled CFT** with a **dynamical metric**. These correlations contain all the necessary information to study the stability of spacetimes such as (Anti) de Sitter.

Our work is a first step to generalize the Starobinsky model to a non-perturbative strongly coupled CFT. We find the existence of **tensor instabilities** which exist in addition to the usual scalar inflaton. Depending on the background curvature and a few other parameters of the holographic setup, we show that these tensor perturbations can destabilize (A)dS faster than the usual scalar inflaton. The backreacting CFT gives a possible inflationary model, in which the duration of inflation is fixed by the characteristic time of the most unstable mode.

6

Constraining decaying dark matter with the effective field theory of large-scale structures

Auteur: Théo SIMON[1]

[1] *Montpellier Universe and Particles Laboratory - CNRS*

Auteur correspondant theo.simon@umontpellier.fr

In this talk, I will present the first constraints on decaying cold dark matter (DCDM) models thanks to the effective field theory of large scale structure (EFTofLSS) applied to BOSS-DR12 data. I will consider two phenomenological models of DCDM: i) a model where a fraction $f_{\rm dcdm}$ of cold dark matter (CDM) decays into dark radiation (DR) with a lifetime τ; ii) a model (recently suggested as a potential resolution to the S_8 tension) where all the CDM decays with a lifetime τ into DR and a massive warm dark matter (WDM) particle, with a fraction ε of the CDM rest mass energy transferred to the DR.

7

Dark Matter Production from Preheating and Structure Formation Constraints

Auteur: Mathias Pierre[1]

[1] *DESY*

Auteur correspondant mathias.pierre@desy.de

In this talk I will discuss the production of scalar dark matter from the inflaton condensate during inflation and reheating. I will discuss the production regimes assuming that this scalar couples to the inflaton via a direct quartic coupling and gravity: purely gravitational, weak direct coupling (perturbative), and strong direct coupling (nonperturbative). For each regime, I will determine the dark matter phase space distribution, the corresponding relic abundance and derive the corresponding constraints from the Lyman-α forest measurement.

10

Primordial non-Gaussianities and gravitational waves: an intertwined story

Auteur: Lucas Pinol[1]

[1] *Instituto de Física Teórica (IFT), UAM-CSIC, Madrid*

Auteur correspondant lucas.pinol@ift.csic.es

Notoriously, scalar primordial non-Gaussianities constitute a key prediction of the inflationary paradigm that is yet to be discovered. Less famous, tensor non-Gaussianities as well as mixed scalar-tensor non-Gaussianities may also arise from non-linear interactions in the early Universe.

In this talk, I will explain how the latter types of bispectra (the three-point functions) may be probed through the anisotropies of the Stochastic Gravitational Wave Background. I will present a recent rigorous derivation of the key formula relating the two effects, found using the in-in formalism for quantum interactions in cosmology. Those findings will be exemplified with two models of multi-field inflation leading to:
- a homogeneous component of the SGWB that will be observable by future experiments like LISA, while being compatible with current constraints on CMB scales;
- anisotropies inherited from the tensor and scalar-tensor primordial non-Gaussianities at a potentially detectable level.

Time permitting, I will also mention a recent work where we prove that the connected scalar four-point function, the trispectrum, cannot induce a sizeable amount of gravitational waves when scalar perturbations re-enter the horizon during the radiation era.

11

Inflationary Correlators Beyond Weak Mixing: a Numerical Approach

Auteur: Denis Werth[1]

[1] *Sorbonne University – IAP*

Auteur correspondant denis.werth@iap.fr

Inflation is a widely accepted paradigm explaining the origin of the observed spatial correlation in cosmological structures. However, the physics of inflation remains elusive, and a key challenge of primordial cosmology is to decipher it through the study of cosmological correlators, which notably encode high-energy physics effects during inflation. Both on theoretical and practical grounds, as we enter in a precision physics era, it is vital to develop new computational tools to probe fine features of realistic models of inflation that are analytically intractable.

In this talk, I will present the transport approach directly implemented at the level of effective field theories of inflationary fluctuations, bypassing the intricacies of Feynman diagram computations. This framework enables one to capture all effects —including a large hierarchy of scales, breaking scale-invariance, and imprints of additional degrees of freedom —for the reason that it relies on following the time evolution of these inflationary correlators from the initial quantum vacuum state to the end of inflation boundary. I will present new results in various classes of inflationary models that are difficult to track analytically, such as the strongly mixed regime of the cosmological collider —a robust probe of the field content of inflation —that requires a non-perturbative treatment of quadratic mixings.

12

Precession resonances in triple systems

Auteur: Adrien Kuntz[1]

[1] *Scuola Normale Superiore*

Auteur correspondant adrien.kuntz@sns.it

Three-body systems are very common in the universe and it is likely that future gravitational-wave detectors will detect and measure the parameters of such systems. I will describe an interesting relativistic resonance taking place in hierarchical three-body systems when the precession frequency of an inner binary black hole matches the period of an outer perturber object. I will show how this resonance can dramatically increase the eccentricity of the binary, pushing it to values observable in the LISA band. This phenomenon is new and distinct from the Kozai-Lidov mechanism.

13

Self-similar solutions for Fuzzy Dark Matter

Auteurs: Patrick VALAGEAS[1]; Raquel Galazo-Garcia[2]; philippe brax[3]

[1] *CEA Saclay*

[2] *IPhT - CEA*

[3] *IPHT Saclay*

Auteurs correspondants: raquel.galazogarcia@ipht.fr, philippe.brax@cea.fr, patrick.valageas@ipht.fr

Fuzzy Dark Matter (FDM) models admit self-similar solutions which are very different from their Cold Dark Matter (CDM) counterparts and do not converge to the latter in the semiclassical limit. In contrast with the familiar CDM hierarchical collapse, they correspond to an inverse-hierarchy blow-up. Constant-mass shells start in the nonlinear regime, at early times, with small radii and high densities, and expand to reach at late times the Hubble flow, up to small linear perturbations. Thus, larger masses become linear first. This blow-up approximately follows the Hubble expansion, so that the central density contrast remains constant with time, although the width of the self-similar profile shrinks in comoving coordinates. As in a gravitational cooling process, matter is ejected from the central peaks through successive clumps. As in wave systems, the velocities of the geometrical structures and of the matter do not coincide, and matter slowly moves from one clump to the next, with intermittent velocity bursts at the transitions. These features are best observed using the density-velocity representation of the nonrelativistic scalar field, or the mass-shell trajectories, than with the Husimi phase-space distribution, where an analogue of the Heisenberg uncertainty principle blurs the resolution in the position or velocity direction. These behaviours are due to the quantum pressure and the wavelike properties of the Schrödinger equation. Although the latter has been used as an alternative to N-body simulations for CDM, these self-similar solutions show that the semiclassical limit needs to be handled with care.

14

Subsonic accretion and dynamical friction for a black hole moving through a self-interacting scalar dark matter cloud

Auteur: Alexis Boudon[1]

Co-auteurs: Patrick VALAGEAS [2]; philippe brax [3]

[1] *Institut de Physique Théorique - CEA, Saclay*

[2] *CEA Saclay*

[3] *IPHT Saclay*

Auteurs correspondants: alexis.boudon@ipht.fr, patrick.valageas@ipht.fr, philippe.brax@cea.fr

We investigate the flow around a black hole moving through a cloud of self-interacting scalar dark matter. We focus on the large scalar mass limit, with quartic self-interactions, and on the subsonic regime. We show how the scalar field behaves as a perfect gas of adiabatic index $\gamma_{\rm ad} = 2$ at large radii while the accretion rate is governed by the relativistic regime close to the Schwarzschild radius. We obtain analytical results thanks to large-radius expansions, which are also related to the small-scale

relativistic accretion rate. We find that the accretion rate is greater than for collisionless particles, by a factor $c/c_s \gg 1$, but smaller than for a perfect gas, by a factor $c_s/c \ll 1$, where c_s is the speed of sound. The dynamical friction is smaller than for a perfect gas, by the same factor $c_s/c \ll 1$, and also smaller than Chandrasekhar's result for collisionless particles, by a factor $c_s/(cC)$, where C is the Coulomb logarithm. It is also smaller than for fuzzy dark matter, by a factor $v_0/c \ll 1$.

15

Detection of dark photons through Stark effect measurement with Rydberg atoms in microwave cavities.

Auteur: Jordan Gué[1]

Co-auteurs: Aurelien Hees [2]; Jérôme Lodewyck [1]; Peter Wolf [3]; Rodolphe Le Targat [1]

[1] *SYRTE, Observatoire de Paris*

[2] *SYRTE - Observatoire de Paris*

[3] *SYRTE, Observatoire de Paris, CNRS, LNE, UPMC*

Auteurs correspondants: jerome.lodewyck@obspm.fr, jordan.gue@obspm.fr, rodolphe.letargat@obspm.fr, aurelien.hees@obspm.fr, peter.wolf@obspm.fr

In this paper, we present an experiment based on 1) the application of a strong electric field inside a microwave cavity and 2) electrometry using Rydberg atoms. This kind of experiment could be extremely useful at detecting dark photons through the stationary electric field filling the whole space it induces. The sensitivity of this experiment is significantly enhanced around the resonances of the cavity. We show that this experiment could improve the current constraint on the coupling constant of the dark photons to Standard Model photons around the μeV mass range. The main limiting factor on the sensitivity of the experiment is surprinsingly not the quality factor of the cavity but mainly the amplitude stability of the applied field.

16

STE-QUEST: a M-class mission proposal to test the equivalence principle at the level of 10^-17

Auteur: Aurelien Hees[1]

Co-auteurs: Peter Wolf [2]; Baptiste Battelier [3]; Robin Corgier [1]; Jordan Gué [4]; Gilles METRIS [5]

[1] *SYRTE - Observatoire de Paris*

[2] *SYRTE, Observatoire de Paris, CNRS, LNE, UPMC*

[3] *Institut d'Optique de Bordeaux*

[4] *SYRTE, Observatoire de Paris*

[5] *Géoazur (CNRS - Observatoire de la Côte d'Azur - Université de Nice)*

Auteurs correspondants: peter.wolf@obspm.fr, jordan.gue@obspm.fr, aurelien.hees@obspm.fr, gilles.metris@oca.eu

The Space Time Explorer and QUantum Equivalence principle Space Test (STE-QUEST) is a M-class mission proposal that has recently been submitted to the M7 call in ESA's science program. This proposal has successfully passed the phase 1 selection and is currently under investigation for the phase 2. STE-QUEST will provide an atom interferometric measurement of the universality of free fall in space by measuring the differential acceleration between Rb and K atoms. It will reach the impressive level of 10^-17 in measuring the Etovos parameter, improving by 2 orders of magnitude the most recent results provided by the MICROSCOPE space-mission. In this presentation, I will

present the principles of the STE-QUEST measurement, the main characteristic of the mission and discuss the main scientific expected outcome.

17

Probing dark matter energy injection with the 21 cm power spectrum

Auteur: Gaétan Facchinetti[1]

[1] *Université Libre de Bruxelles*

Auteur correspondant gaetan.facchinetti@ulb.be

Observations of the 21 cm line of atomic hydrogen with radio telescopes will provide an unparalleled probe of the Universe between reionization ($z \sim$ 6-12) and cosmic dawn ($z \simeq 30$). Because exotic energy injection in the intergalactic medium via dark matter decay or annihilation can be particularly efficient in that redshift range (due to a long lifetime or clustering into halos), the 21 cm line is a prime observable for dark matter searches. In this talk, I will first argue for the prospective power of the 21 cm line to constrain or point toward the presence of dark matter. I will then present how exotic energy injection impacts the 21 cm line. Finally, I will introduce the first analysis of the 21 cm power spectrum sensitivity to dark matter decay/annihilation using a combination of simulation codes and numerical solvers.

19

Introduction

20

Modified gravity and black holes (review)

Auteur correspondant eugeny.babichev@th.u-psud.fr

21

Tests of General Relativity with gravitational waves (review)

Auteur correspondant sylvain.marsat@l2it.in2p3.fr

22

Test of the QCD equation of state in neutron stars (review)

Auteur correspondant gulminelli@lpccaen.in2p3.fr

23

Loop quantum gravity: basic structure and recent developments (review)

Auteur correspondant perez@cpt.univ-mrs.fr

25

Bouncing Universes (review)

Auteur correspondant peter@iap.fr

26

Swampland and Cosmology (review)

Auteur correspondant sluest@g.harvard.edu

27

Big-Bang Nucleosynthesis (review)

Auteur correspondant pitrou@iap.fr

28

Effective Field Theory applied to Dark Energy (review)

Auteur correspondant federico.piazza@univ-amu.fr

30

Cosmology with the growth of structures (review)

Auteur correspondant marinoni@cpt.univ-mrs.fr

31

Lensing in Cosmology (review)

32

Alternatives to Dark Matter (review)

Auteur correspondant benoit.famaey@astro.unistra.fr

33

Primordial magnetic fields (review)

Auteur correspondant karsten.jedamzik@umontpellier.fr

34

Self-gravitating bosonic systems (review)

Auteur correspondant chavanis@irsamc.ups-tlse.fr

35

Conclusion

36

Monge-Ampère problem applied to large-scale structures

Auteur correspondant boldrini@iap.fr

37

Multi-messenger avenues towards primordial black hole detection

Auteur correspondant francesca.scarcella@umontpellier.fr

Black holes formed in the early Universe (PBHs) could constitute (a component of) the dark matter. In this talk I will consider primordial black holes (PBHs) of O(1) - O(100) solar masses. First, I will discuss the possibility of detecting PBHs in the Milky Way through the process of gas accretion, presenting a comprehensive study of the uncertainties associated to this observation channel. Moving on to cosmological distances, merging black holes in the same mass range can be detected through gravitational waves. I will discuss the potential of the Einstein Telescope, a planned third-generation GW observatory, to identify and measure the abundance of a subdominant population of PBHs, based exclusively on redshift evolution of the observed merger rate. The analysis I will present is based on the generation of realistic mock catalogues of binary black hole merger events, consisting of the inferred luminosity distances and corresponding errors.

38

Exploring the effects of primordial non-Gaussianity at galactic scales

Auteur correspondant clement.stahl@astro.unistra.fr

39

Supersymmetric black holes and modularity

Auteur correspondant sergey.alexandrov@umontpellier.fr

40

Introducing holography

Auteur correspondant nitti@apc.in2p3.fr

41

Status of the GdR CoPhy (physical cosmology)

Auteurs correspondants: serpico@lapth.cnrs.fr, vincent.vennin@ens.fr