A journey through the theoretical universe

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Université de Toulouse, Faculté de médecine

Recueil des résumés

Contents

2

LCDM is alive and well

Auteur: ALAIN BLANCHARD[1]

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The LCDM is expected to face two significant “tensions”, one on H0 and the other on S_8. I will discuss these two tensions to assess whether current observational data are at a sufficient level to conclude that LCDM is excluded.

3

Why we need to care about unobservable modes

Auteur: Fabien Lacasa[1]

[1] *Institut d’Astrophysique Spatiale, Orsay*

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In the coming decades, large observational efforts will allow us to map the distribution of the large scale structure in the evolved Universe, a.k.a. the cosmic web. The major purpose of these efforts is to extract the cosmological information present in the observed density fluctuations. However, from observations of the Cosmic Microwave Background, we know that there are also fluctuations on ultra-large scales, scales larger than these future surveys. In this talk, I will discuss the impact of these modes. They effectively renormalise the mean matter density and are essentially unobservables, however they contribute to increasing the statistical cosmic variance by their non-linear coupling to observed modes. This increase of uncertainties is called super-sample covariance and has been the subject of intense research since the 2010s. While not giving a comprehensive review of the field, I will present my contribution to it in historical order and showcase the expected impact for the coming European galaxy survey Euclid.

5

A Gaussian ansatz beyond the Zeldovich approximation

Auteur: Patrick VALAGEAS[1]

[1] *CEA Saclay*

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We present a new approach to model the gravitational dynamics of large-scale structures, where we follow the evolution of the probability distribution of the displacement field. This provides a nonperturbative scheme that goes beyond shell crossing and the truncations of the power spectra on nonlinear scales directly arise from the equations of motion. Although the density power spectrum is only recovered up to a smooth drift on BAO scales, the predicted density correlation function agrees with numerical simulations within 2% from BAO scales down to 7 Mpc/h at $z \geq 0.35$, without any free parameter.

6

Topology in the electroweak model

Auteur: Tanmay Vachaspati[1]

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I will discuss topology in the electroweak model.

7

Cosmology in Minkowski space

Auteur: Lucas Lombriser[1]

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Theoretical and observational challenges to standard cosmology such as the cosmological constant problem and tensions between cosmological model parameters inferred from different observations motivate the development and search of new physics. A less radical approach to venturing beyond the standard model is the simple mathematical reformulation of our theoretical frameworks underlying it. While leaving physical measurements unaffected, this can offer a reinterpretation and even solutions of these problems. In this talk, I will perform metric transformations to cast our Universe into different geometries. Of particular interest thereby is the formulation of cosmology in Minkowski space. Rather than an expansion of space, spatial curvature, and small-scale inhomogeneities and anisotropies, this frame exhibits a variation of mass, length, and time scales across spacetime. As applications of this reframed cosmological picture, the naturalness of the cosmological constant is reinspected and promising candidates of geometric origin are explored for dark matter, dark energy, inflation, baryogenesis, and as explanation of current observational tensions. Implications of such candidates include enhanced redshifts to distant galaxy clusters and a mass bias with cluster masses inferred from gravitational lensing exceeding those inferred kinematically or dynamically.

8

Bouncing cosmological model ambiguities

Auteur: Patrick Peter[1]

[1] *CNRS*

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I'll present recent results showing that getting a bounce by means of quantising the background may yield to a mild ambiguity on the spectral index of the perturbations, and a more serious one on its amplitude. We trace the origin of this issue to the fact that quantising and applying a canonical transformation do not commute.

9

Multipole Expansion of the Local Expansion Rate

Auteur: Christian MARINONI[1]

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The lack of convergence to a consensus value for the Hubble constant has triggered a search for the reliability of non-standard cosmological line elements. The question is whether metrics with a lower degree of symmetry than FRW, while remaining simple, provide a reliable description of the data in the local part of the universe where the global uniformity is violated. We address this problem by determining the multipole structure of the redshift-distance relation in the local universe. Unexpected symmetries appear, whether the spherical harmonic analysis of the local expansion rate field is performed on galaxy or SNIa samples. Implications for the determination of the Ω_0 parameter will be discussed and a proposal for a non-standard metric that accurately describes the local data will be suggested.

10

A visual and theoretical journey into some black hole and wormhole universes

Auteur: Alain Riazuelo[1]

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Although it looks mathematically simple, the Schwarzschild metric describes a complicated spacetime that is endowed with two asymptotic regions and two singularities. When including electric charge and spin, other black hole metrics are even more complicated. Although causal diagrams help to figure out what an observer can possibly see, it is almost impossible to guess how different regions of such spacetimes are actually seen. In this talk, I will show a few movies of what an observer would see when travelling within a few black hole metric maximal analytic extensions: Schwarzschild, Reissner-Nordström and Kerr.

11

Probing the primordial power spectrum on small scales with dark matter subhalos

Auteur: Julien Lavalle[1]

[1] *CNRS - LUPM - Montpellier*

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I will discuss the role dark matter subhalos may play in unveiling or constraining both the nature of dark matter and the properties of the primordial power spectrum on small scales. This is a topic in which semi-analytical predictions can be made without resorting to cosmological simulations, in the regime where dark matter subhalos are too light to accrete baryons, as expected in the cold dark matter scenario. I will discuss a few examples of how subhalos may manifest themselves through different local or distant probes.

12

Structure formation and scale-free models

Auteur: Michael Joyce[1]

[1] *LPNHE*

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I will discuss some of the applications of called scale-free models to the problem of non-linear structure formation: as a tool to control the accuracy of measurements from numerical simulations, as a tool for precision testing of theoretical approaches to matter clustering, and more generally as a tool to better understand and model clustering in standard cosmological models

13

Introduction

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14

Nonlinearity in relativistic cosmology of the early and late universe

Auteur: Marco Bruni[None]

In this talk I will give a brief overview of work on three topics: 1) nonlinear perturbation theory, observables and gauge-invariance; 2) bouncing cosmology based on dark energy with a nonlinear equation of state, possibly interacting with CDM; 3) full-GR simulations of nonlinear structure formation

15

Gravitational waves from (magneto)hydrodynamic turbulence at LISA and PTA

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17

Measuring the anisotropic stress with future galaxy surveys

Auteur: Isaac Tutusaus[1]

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Galaxy surveys provide one of the best ways to constrain the theory of gravity at cosmological scales. They can be used to constrain the two gravitational potentials encoding time, Ψ, and spatial, Φ, distortions, which are exactly equal at late time within general relativity. Hence, any small variation leading to a nonzero anisotropic stress, i.e. a difference between these potentials, would be an indication for modified gravity. Current analyses usually consider gravitational lensing and redshift-space distortions to constrain the anisotropic stress, but these rely on certain assumptions like the validity of the weak equivalence principle, and a specific time evolution of the functions encoding deviations from general relativity. In this talk, I will propose a reparametrization of the gravitational lensing observable, together with the use of the relativistic dipole of the correlation function of galaxies to directly measure the anisotropic stress with a minimum amount of assumptions.

18

Two-field screening and its cosmological dynamics

Auteur: philippe brax[1]

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I will present how screening could (or could not) occur in two-field models of the axio-dilaton type and
present a simplified analysis of their cosmology.

19

Gravitational wave standard sirens: cosmological constraints from LVK observations and future prospects with LISA

Auteur: Danny Laghi[1]

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Compact binary systems that emit detectable gravitational waves, such as binary black holes and binary neutron stars, can be used as "standard sirens" to constrain cosmological parameters. This talk will review cosmological results obtained from the most recent gravitational wave observations, with a focus on the most stringent constraints produced by the LIGO-Virgo-KAGRA Collaboration, while also discussing forecasts with future gravitational wave detectors, such as the Laser Interferometer Space Antenna.

20

Concluding remarks

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21

Relativistic asymmetry in galaxy-galaxy and galaxy-ellipticity correlations

Auteur: Shohei Saga[1]

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The observed galaxy distribution via galaxy redshift surveys appears distorted due to redshift-space distortions (RSD). One dominant contribution to RSD comes from the Doppler effect induced by the peculiar velocity of galaxies. The Doppler effect produces the even multipole anisotropy in the correlation function and it has been well studied in a few decades. I will present my recent work on the asymmetric galaxy clustering (odd multipoles). As the asymmetric distortions arises from the other relativistic effects than the standard Doppler effect, it contains qualitatively different cosmological information from the even multipoles. I will show that one can use the asymmetric distortions as a probe of the gravitational redshift effect, leading to a new probe of gravity theory.

22

Relativistic cosmology in the nonlinear regime

Auteur: Francesca Lepori[1]

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Relativistic cosmology in the nonlinear regime