PACTS 2018: Particle, Astroparticle and Cosmology Tallinn Symposium

Monday 18 June 2018 - Friday 22 June 2018

Estonian Academy of Sciences

Book of Abstracts

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Welcome

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Black holes as brains: Holographic neural networks with area-law entropy and exponentially enhanced memory capacity

Corresponding Author: georgi.dvali@cern.ch

TBA

Gravity / 75

David and Goliath: black hole superradiance

Author: Vitor Cardoso[None]

Corresponding Author: vitor.cardoso@tecnico.ulisboa.pt

Superradiant-related phenomena are common manifestations across a wide range of topics. I will review some of these manifestations with special emphasis on astrophysical applications. In particular, energy extraction from black holes and compact stars are promising mechanisms to constrain dark matter candidates, and have observational consequences, both for gravitational-wave observatories and for electromagnetic telescopes.

Gravity / 51

Testing the nature of compact objects with gravitational waves

Author: Paolo Pani[None]

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Gravitational wave (GW) astronomy allows us for unprecedented tests of the nature of dark compact objects. In this context, I will discuss two signatures of new physics at the horizon scale: GW "echoes"in the postmerger ringdown phase of a binary coalescence, and finite-size effects of exotic compact objects that affect the inspiral premerger phase. In the first case, the ringdown wave-form of exotic ultracompact objects is initially identical to that of a black hole, and putative corrections at the horizon scale appear only at later times as a modulated and distorted train of echoes of the modes of vibration associated with the photon sphere. As for the second case, I will discuss the tidal heating and tidal Love numbers of different families of boson stars, gravastars, wormholes, and other toy models for quantum corrections at the horizon scale. These corrections display a universal logarithmic dependence on the location of the surface in the black-hole limit. I will discuss the ability of present and future GW detectors to measure these effects. Both LIGO, ET and LISA can impose interesting constraints on boson stars, while LISA is able to probe even Planckian corrections.
We argue that these effects provide a smoking gun of new physics at the horizon scale, and that future GW measurements of a binary coalescence provide a novel way to test black holes and general relativity in the strong-field regime.

Gravity / 66

Gravity with more or less variables

Author: Roberto Percacci[None]

Corresponding Author: percacci@sissa.it

I will review various formulations of gravity, their pros and cons. Some are just different off shell extensions of Einstein's theory, others are physically inequivalent. Certain formulations naturally suggest ways of unifying gravity with all the other interactions. I will review what little is known of such unified theories.

Cosmology / 19

A definitive test of cold dark matter

Author: Carlos Frenk[None]

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A fundamental prediction of the cold dark matter cosmology is that the mass function of halos and subhalos should extend to very small masses, of order the mass of the Earth. In constrast, alternative models, like warm dark matter, predict that the halo mass function should be truncated at some mass that dependes on the mass of the dark matter particle. The differences between the mass functions predicted in these models mostly occur on mass scales too small for gas to have been able to cool and make a galaxy. Thus, these discrimating halos are, for the most part, dark and detectable only through gravitational lensing. I will discuss the properties of these halos and subhalos and the prospects of detecting them in future lensing surveys.

Cosmology / 50

Fluctuations of the gravitational field generated by dark substructures

Author: Jorge Penarrubia[None]

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One of the most striking predictions from the Cold Dark Matter (CDM) paradigm postulates the existence of myriads of planet-sized subhaloes devoid of stars (i.e. 'dark'). A large population of these objects will generate a stochastic gravitational field that can in principle perturb the trajectories of visible systems.
In this talk I will present a statistical technique for deriving the spectrum of random fluctuations directly from the number density of substructures with known mass and size functions.
I will show that in galaxies like the Milky Way the fluctuations of the tidal field are completely dominated by the smallest and most abundant subhaloes.
In light of this result I will discuss observational experiments that may be sufficiently sensitive to Galactic tidal fluctuations to probe the "dark" low-end of the subhalo mass function and constrain the particle mass of warm and ultra-light axion dark matter models.

Cosmology / 79

Challenges in looking for new physics through cosmology

Author: Alan Heavens[1]

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Cosmological data from the next generation of cosmological surveys such as Euclid and LSST have the statistical power to distinguish modified gravity or dark energy models from LCDM, as well as determining neutrino masses. But with excellent data come formidable challenges in analysis. In this talk I report on recent advances that attempt to ensure that any evidence for new physics is well grounded. The natural Bayesian end-point of an experiment to determine parameters of a theoretical model is the posterior - the probability density of the parameters given the data. It encompasses everything that we know after collecting the data. It is not usually a straightforward quantity to compute, and often the only viable way is to build a hierarchical model for the data, where all sources of variability, from populations to measurement errors, are included. To build a relatively complete model of the data involves introducing very large numbers of unmeasured 'latent' variables, such as the true values of noisy data. Sampling the posterior then involves sampling a very high- (typically million-) dimensional parameter space. For cosmic shear, most of the parameters are the true values of the distortion in pixels on the sky. With efficient HMC samplers, the sampling can be done, to recover simultaneously cosmological parameters and samples of the mass maps on the sky.

Cosmology / 47

Testing the Cosmological Principle

Author: Subir Sarkar[1]

[1] *University of Oxford (GB) and Niels Bohr Institute (DK)*

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That the universe is statistically isotropic when averaged over large scales is a foundational 'principle' of the standard cosmological model. Recent surveys of the distribution of galaxies and studies of the CMB now make it possible to test this - with some intriguing results.

[arXiv:1703.09376, arXiv:1711.08441, arXiv:1712.03444]

Cosmology / 71

Bose condensation and decay of ALP dark matter

Author: Igor Tkachev[None]

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Bose condensation by gravitational interactions in the virialized dark matter halos/miniclusters is studied. I'll prove that this phenomenon does occur and is efficient even in the kinetic regime. Results suggest that Bose stars may form abundantly in the mainstream dark matter models such as invisible QCD axions and Fuzzy Dark Matter. In a certain parameter ranges Bose stars are unstable and burst into radiophotons.This may explain fast radiobursts (FRB) and some other observational anomalies.

Dark Matter / 38

Results of the WIMP search with XENON1T

Author: Marco Garbini[None]

Astronomical and cosmological observations indicate that a large amount of the energy content of the Universe is made of dark matter. The most promising dark matter candidates are the so-called WIMPs (Weakly Interacting Massive Particles).
The XENON project, at the Gran Sasso National Laboratory (LNGS), consists of a double-phase time projection chamber (TPCs) using ultra-pure liquid Xenon as both target and detection medium for dark matter particle interactions. The WIMPs can be indeed detected via their elastic scattering off Xenon nuclei.
The XENON Collaboration is now running the XENON1T experiment, the first ton scale liquid Xenon based TPC, with an active mass inside the TPC of about 2 ton. The first results were obtained in a run of 34.2 days acquired between November 2016 and January 2017. The detector achieved the lowest electronic recoil background in a dark matter experiment. Those data allowed to set the most stringent exclusion limits on the spin-independent WIMP-nucleon interaction cross section for WIMP masses above 10 GeV/cˆ2, with a minimum of $7.7 \times 10^{-47} cm^2$ for 35 GeV/c^2 WIMPs at 90% confidence level. After the first run XENON1T continued the data taking with a scientific run ended in February 2018, for a live time of about 250 days of dark matter search. In this contribution we will present the results of the WIMP search with the XENON1T experiment.

Dark Matter / 81

WIMPS and beyond — Super-cool dark matter

Author: Thomas Hambye[None]

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After a very short review of the WIMP dark matter scenario and constraints, I will discuss another possibility to account for the necessary suppression of the number of dark matter particles during the early Universe radiation dominated era: “super-cool dark matter”.
This is based on the recent work, arXiv:1805.01473, in collaboration with A. Strumia and D. Teresi.

Dark Matter / 76

Bounds on Dark Matter annihilations from 21 cm data

Author: Guido D'Amico[1]

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The observation of an absorption feature in the 21 cm spectrum at redshift z≈17 implies bounds on Dark Matter annihilations for a broad range of masses, given that significant heating of the intergalactic medium would have erased such feature. The resulting bounds on the DM annihilation cross sections are comparable to the strongest ones from all other observables.

Dark Matter / 57

Exploring WISPy Dark Matter

Author: Joerg Jaeckel[None]

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Very light bosons, produced non-thermally in the early Universe are an intriguing possibility for the cold dark matter of the Universe.
Particularly interesting candidates are axions, axion-like particles and hidden photons. This talk will discuss the current status of such light dark matter with a particular emphasis towards opportunities for its detection. We also venture to some more exotic candidates and motivations.

Dark Matter / **48**

Indirect DM searches

Author: Marco Cirelli[1]

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I will briefly review the current status of searches for Dark Matter using cosmic rays, intended in a broad sense (charged particles, gamma rays, neutrinos, possibly the CMB and radio waves).

Dark Matter / **52**

Possible cosmic ray tests of new physics

Author: Kfir Blum[1]

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tba

Dark Matter / **56**

Sterile neutrino dark matter and 3,5 kev line

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tba

Dark Matter and Gravity / **15**

Signatures of Primordial Black Holes as Dark Matter

Author: Juan Garcia-Bellido[1]

[1] *Universidad Autonoma de Madrid*

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In this talk I will review the multiepoch-multiscale-multiprobe scenario of spatially clustered and wide-mass distributed primordial black holes as the dominant contribution to the dark matter in the universe. I will give the present hints, possible constraints and future discovery opportunities.

Dark Matter and Gravity / 18

Primordial black holes, dark matter, and other cosmological puzzles.

Author: Alexander Dolgov[1]

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Abstract

It is shown that the model of massive primordial black hole formation with log-normal mass spectrum, suggested in 1993, is strongly supported by the recent astronomical data on the the early, z=10, and contemporary universe. Basic features of the model are described and the review of the astronomical observations is presented.

Dark Matter and Gravity / 30

Dark matter decay via the gravity portal

Author: Alejandro Ibarra[None]

Corresponding Author: alejandro.ibarra@ph.tum.de

We consider the Standard Model extended with a dark matter particle in curved spacetime, motivated by the fact that the only current evidence for dark matter is through its gravitational interactions, and we investigate the impact on the dark matter stability of terms in the Lagrangian linear in the dark matter field and proportional to the Ricci scalar. We show that this "gravity portal" induces decay even if the dark matter particle only has gravitational interactions, and that the decay branching ratios into Standard Model particles only depend on one free parameter: the dark matter mass. We study in detail the case of the singlet scalar dark matter candidate and we discuss the prospects to observe its gravitationally induced decay.

Dark Matter and Gravity / 40

Self interacting dark matter

Author: Matti Heikinheimo[1]

[1] *Helsinki Institute of Physics*

Corresponding Author: matti.p.s.heikinheimo@gmail.com

Self interacting dark matter (SIDM) is a long-standing candidate to alleviate the problems of collisionless cold dark matter (CDM) in cosmic structure formation at small scales. I will review the status of the small scale structure problems, and the feasibility of the SIDM solution in light of the current constraints on the DM self scattering cross section. I will present an overview of the particle physics models that can reproduce the SIDM phenomenology. Finally, I will discuss how the self interacting nature of the DM particles may impact the production mechanism of DM in the early universe.

Beyond General Relativity / 73

Spacetime and dark matter from spontaneous breaking of Lorentz symmetry

Author: Tomi Koivisto[None]

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TBA

Beyond General Relativity / 83

Recent developments in Bimetric and multimetric theories of gravity

Author: Sayed Fawad Hassan[None]

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Bimetric and multimetric theories are theories of gravition in the presence of extra spin-2 fields, that avoid the well known ghost instability of such set ups. This talk will describe recent developments in understanding the structure and implications of such theories.

Beyond General Relativity / 84

Testing DM and MOND models with galactic rotation curves

Author: Mads Frandsen[None]

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Tba

Flavour / 26

B-anomalies: an experimental overview

Author: Siim Tolk[1]

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Recent measurements of B-meson decay branching fractions, angular observables and ratios of branching fractions to different lepton species have resulted in several unexpected results and attracted keen theoretical interest. In this talk we will give an overview of the latest experimental evidence on the B-anomalies with a focus on the results from the LHCb collaboration.

Flavour / 69

The flavor of Higgs

Author: Yosef Nir[None]

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Measuring Yukawa couplings of the Higgs boson provides an opportunity to probe new physics and possibly to make progress on the flavor puzzles.

Flavour / 53

Are the LHCb etc. Tensions due to Non-perturbative Effects in Pure Standard Model ?

Author: Holger Becht Nielsen[None]

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We discuss the suggestion that the (small) tensions seemingly violating the Stadard Model predictions for lepton universality and for Flavour changing neutral current (FCNC) decay of B-mesons could be actual effects but still compatible with pure Standard Model, because they should be due to non-perturbative effects. In fact we want to point out that to settle whether a given coupling cosntant - being perhaps of order unity - should indeed be counted as so large as to truly give rise to non-perturbative effects one shall not only look at how large it is compared to 4π or $(4\pi)^2$, but also as to how many internal degrees of freedom the coupled particles have. The coupling constant, which we have long speculated to be large enough to cause non-perturbative effects of significans is of course the top-yukawa-coupling g_t.

Flavour / 49

B-physics anomalies and flavor non-universal gauge interactions

Author: Gino Isidori[1]

[1] *Universitaet Zuerich (CH)*

Corresponding Author: gino.isidori@cern.ch

tba

Flavour / 17

Flavour anomalies. where we are and what is next?

Author: Joaquim Matias[None]

I will present the status of the global fit on the b->sll data, including the latest data. I will discuss the anomalies observed and the prospects for improvement, the coherence between LFUV and b->s mumu anomalies and the present and future information that can be extracted. I will present a decision tree to disentangle between the different scenarios of NP that may serve as the main guideline for model building.

Flavour / 46

Clockwork Flavor

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tba

Naturalness / 44

Status and perspectives of BSM searches at the LHC

Author: Maurizio Pierini[None]

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tba

Naturalness / 85

Hard talk on compositeness

Author: Francesco Sannino[1]

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tba

Naturalness / 65

SUSY GUTs of Flavour

Author: Steve King[None]

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In this talk we discuss SUSY GUTs with Discrete Flavour Symmetry (with or without extra dimensions), and their phenomenological implications for SUSY searches and flavour violating processes.

Naturalness / 77

⋯or naturallessness

Author: Kimmo Tuominen[None]

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Physics beyond the Standard Model is undeniably needed, but the clues for its precise nature are sparse. I will first review some concepts related to naturalness as a model building guide and its alternatives. Then I will discuss few model building examples, also in light of the current experimental and observational results.

Naturalness / 68

Conformal symmetry: towards the link between the Fermi and the Planck scales

Author: Mikhail Shaposhnikov[None]

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TBA

Naturalness / 72

Conformal Extensions of the Standard Model

Author: Manfred Lindner[None]

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The talk will cover reasons and obstacles for conformally symmetric extensions of the standard model. Furthermore models which realize the underlying ideas and their phenomenology will be discussed.

Naturalness / 43

Quantum scale symmetry in particle physics, gravity and cosmology

Author: Christof Wetterich[None]

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Quantum scale symmetry arises at fixed points of the flow of couplings as an exact symmetry. Particle scale symmetry is related to the second order character of the vacuum electroweak phase transition. It makes the gauge hierarchy technically natural.
In the context of quantum gravity even the tiny dimensionless ratio Fermi scale over Planck scale may be explained. Gravity scale symmetry is associated to the ultraviolet fixed point of asymptotic safety that makes quantum gravity a non-perturbatively renormalizable quantum field theory. New predictions for particle physics, as the mass of the Higgs boson, become possible. In cosmology, the presence of a fixed point is at the origin of the almost scale invariant primordial fluctuation spectrum. Spontaneously broken scale symmetry associated to an infrared fixed point can explain the smallness of the cosmological „constant"in the form of dynamical dark energy. We relate these different facets of scale symmetry.

Gravitational waves, phase transitions and vacuum stability / 63

Gravitational waves from first order phase transitions

Author: Mark Hindmarsh[None]

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About 10 picoseconds after the beginning of the Universe, the Higgs field turned on. In extensions of the Standard Model of particle physics, this could have been a first order phase transition, with the spontaneously nucleated bubbles of the Higgs phase expanding and colliding at relativistic speeds. I will discuss the generation of gravitational radiation, prospects for observing the radiation at the future space-based gravitational wave detector LISA, and outline how LISA complements the LHC as a probe of physics beyond the Standard Model.

Gravitational waves, phase transitions and vacuum stability / 60

Gravitational Waves from Dark Matter Genesis

Author: Jiusuke Kubo[None]

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We assume that the electroweak scale is generated in a hidden sector which is described by a non-abelian gauge theory. The non-perturbative effect in the hidden sector generates dark matter as well. Since this dynamical scale genesis appears as a first-order phase transition at finite temperature, it can produce
a gravitational wave background.

Gravitational waves, phase transitions and vacuum stability / 55

Spacetime curvature and vacuum stability during and after inflation

Author: Arttu Rajantie[1]

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tba

Gravitational waves, phase transitions and vacuum stability / 13

Higgs-inflaton mixing

Author: Oleg Lebedev[1]

[1] *University of Helsinki*

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I motivate the presence of the Higgs–inflaton mixing in general and show how it can have a stabilizing effect on the electroweak vacuum.

Gravitational waves, phase transitions and vacuum stability / 64

Semiclassical approach to Higgsplosion

Author: Valentin Khoze[None]

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TBA

Gravitational waves, phase transitions and vacuum stability / 86

The Higgs self-coupling and its implications

Author: Christophe Grojean[1]

[1] *DESY (Hamburg) and Humboldt University (Berlin)*

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While the Higgs couplings to heavy Standard Model particles have now been measured reasonably well, the Higgs self-interactions remain notoriously intangible at the LHC. There exist some particular new physics dynamics that parametrically enhance these self-interactions over the SM expectations. Given that these self-interactions control the fate of the electroweak vacuum and are also at the heart of the hierarchy problem, assessing them is an urgent question. I'll show how to probe, via its quantum effects, the cubic self-coupling in a global fit of the Higgs data. I'll discuss some prospects at HL-LHC as well as at future lepton colliders. Some implications for Higgs portal model and the production of a stochastic gravitational wave background will be discussed.

Inflation and New Physics / 70

Present theoretical status of inflation and expected discoveries

Author: Alexei Starobinsky[None]

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Outlined are the two simplest classes of phenomenological models of slow-roll inflation in the early Universe based either on scalar fields in General Relativity or on modified $f(R)$ gravity, their relation and basic assumptions necessary for their realization. At the present state-of-the-art, the simplest inflationary models from these classes producing the best fit to all existing astronomical data requires one, maximum two dimensionless parameters taken from observations only. It is shown that inflation in $f(R)$ gravity represents an intermediate dynamical attractor for slow-rolling scalar fields strongly coupled to gravity. The main discoveries expected for these models in future are discussed, too. Among them the most fundamental are primordial quantum gravitational waves generated during inflation. It is argued that the measured value of the slope $n_s - 1$ of the primordial scalar power spectrum, under the additional assumption of the absence of new fundamental scales both during and after inflation, implies small, but not too small tensor-to-scalar ratio $r \sim 3(1 - n_s)^2 \sim 0.0004$ or even more, similar to that in the original $R + R^2$ inflationary model (1980). Another possible discovery is related to small local features in the CMB temperature anisotropy power spectrum in the multipole range $l = (20 - 40)$ beyond which new physics during inflation may be hidden. Also considered is the onset of inflation from generic anisotropic curvature singularity preceding it in GR and $f(R)$ gravity, and which conditions are needed for it. Since this process is generic, too, for inflation to begin inside a patch including the observable part of the Universe, causal connection inside the whole patch is not necessary. However, it becomes obligatory for a graceful exit from inflation in order to have practically the same number of e-folds during inflation inside this patch.

Inflation and New Physics / 74

Quintessential Inflation with α-attractors

Author: Konstantinos Dimopoulos[1]

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A novel approach to quintessential inflation model building is studied, within the framework of α-attractors (motivated by supergravity theories), which naturally result in a scalar potential featuring two flat regions, the inflationary plateau and the quintessential tail. The "asymptotic freedom" of α-attractors, near the kinetic poles, suppresses radiative corrections and interactions, which would otherwise threaten to lift the flatness of the quintessential tail and cause a 5th-force problem respectively. Since this is a non-oscillatory inflation model, special attention is paid to the reheating of the Universe through instant preheating, which avoids gravitino overproduction and respects nucleosynthesis constraints. Inflationary observables are in excellent agreement with the latest CMB observations, while quintessence explains the dark energy observations without any fine-tuning. The model predicts potentially sizeable tensor perturbations (at the level of 1%) and a slightly varying equation of state for dark energy, to be probed in the near future. A distinct correlation between the produced gravitational waves and the running of the barotropic parameter of dark energy is a smoking gun of this scenario.

Inflation and New Physics / 54

Classifying single-field inflationary models

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tba

Cosmology / 45

CMB Cosmology beyond thermal equilibrium

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tba

Cosmology / 59

Present and future of CMB observations

Author: Jacques Delabrouille[None]

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As the Planck space mission is delivering its final results, it has become clear that much is still to be learnt from observing the polarization and electromagnetic spectrum of the Cosmic Microwave Background Radiation. In the light of current results and remaining questions, I will discuss the scientific case of future CMB projects and how to address the challenges of measurement accuracy and of detailed characterization of the observations that are required for precision cosmology with these future experiments.

Cosmology / 39

Black hole lasers powered by axion superradiant instabilities

Author: Joao Rosa[1]

Co-author: Thomas Kephart [2]

[1] *U*

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The superradiant instability can lead to the generation of extremely dense axion clouds around rotating black holes. We show that, despite the long lifetime of the QCD axion with respect to spontaneous decay into photon pairs, stimulated decay becomes significant above a minimum axion density and leads to extremely bright lasers. The lasing threshold can be attained for axion masses $\mu > 10^{-8}$ eV, which implies superradiant instabilities around spinning primordial black holes with mass $< 0.01M_\odot$. Although the latter are expected to be non-rotating at formation, a population of spinning black holes may result from subsequent mergers. We further show that lasing can be quenched by Schwinger pair production, which produces a critical electron-positron plasma within the axion cloud. Lasing can nevertheless restart once annihilation lowers the plasma density sufficiently, resulting in multiple laser bursts that repeat until the black hole spins down sufficiently to quench the superradiant instability. In particular, axions with a mass $\sim 10^{-5}$ eV and primordial black holes with mass $\sim 10^{24}$ kg, which may account for all the dark matter in the Universe, lead to millisecond-bursts in the GHz radio-frequency range, with peak luminosities $\sim 10^{42}$ erg/s, suggesting a possible link to the observed fast radio bursts.

Higher derivatives Gravity and Ghosts / 62

The Case against Ghosts in Fundamental Theory

Author: Richard Woodard[None]

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I review the theorem of Ostrogradsky and discuss some of the common misconceptions concerning kinetic energy instabilities. Alternate quantizations that attempt to avoid the problem all sacrifice the classical correspondence limit which is a disaster for theories of gravitation. I also argue that efforts to legitimize local higher derivative models with ghosts are misguided because stronger infrared effects occur in nonlocal effective actions, without the ghosts.

Higher derivatives Gravity and Ghosts / 58

From fakeons and Lee-Wick models to quantum gravity

Author: Damiano Anselmi[None]

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A consistent theory of quantum gravity is presented. It is built as a higher derivative theory, where the would-be ghosts are tuned into "fakeons" (i.e. fake degrees of freedom) by means of a new quantization prescription. The fakeons disentangle the real parts of the amplitudes from their imaginary parts, thereby making renormalizability compatible with unitarity. The theory is essentially unique. Calculations at one loop are presented to illustrate how the graviton/fakeon prescription works. A number of phenomenological predictions are addressed.

Higher derivatives Gravity and Ghosts / 6

Classical and quantum dynamics of higher-derivative systems

Author: Andrei Smilga[None]

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A brief review of the physics of systems including higher derivatives in the Lagrangian is given. All such systems involve ghosts, i.e. the spectrum of the Hamiltonian is not bounded from below and the vacuum ground state is absent. Usually this leads to collapse and loss of unitarity. In certain special cases, this does not happen, however: ghosts are benign.
We speculate that the Theory of Everything is a higher-derivative field theory, characterized by the presence of such benign ghosts and defined in a higher-dimensional bulk. Our Universe represents then a classical solution in this theory, having the form of a 3-brane embedded in the bulk.

Higher derivatives Gravity and Ghosts / 61

Recent progress in fighting ghosts in quantum gravity

Author: Ilya Shapiro[None]

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The main difficulty of perturbative quantum gravity (QG) in D=4 is the conflict between renormalizability and unitarity of the theory. The simplest version of QG is based on General Relativity and is non-renormalizable. One can construct renormalizable and even superrenormalizable versions of

QG by introducing higher derivatives, but this leads to emergence of unphysical higher-derivative massive ghosts. The non-polynomial models of QG have no ghosts at the tree
level, but taking loop corrections into account one meets infinite amount of ghost-like complex states. The same is true for the string-induced gravitational action, which requires an infinite amount of fine-tuning to remain free of ghosts. We discuss the recent proposal of dealing with ghosts at the energies much lower than their masses, when they can not be presumably generated from vacuum. The very recent result is that even if initial frequencies of the tensor gravitational perturbations are transplanckian, due to the fast expansion of the universe in the period when such waves could be generated, these frequencies rapidly decrease and the explosion caused by ghosts does not have destructive effect on the classical cosmological solutions.

Higher derivatives Gravity and Ghosts / 37

Quadratic Gravity

Author: Salvio Alberto[1]

[1] *CERN*

Adding terms quadratic in the curvature to the Einstein-Hilbert action renders gravity renormalizable. This property is preserved in the presence of the most general renormalizable couplings with (and of) a generic quantum field theory. The price to pay is a massive ghost, which is due to the higher derivatives that the terms quadratic in the curvature imply. This quadratic gravity scenario will be summarized including recent progress on the related stability and unitarity problems of higher derivative theories. The theory can be extrapolated up to infinite energy through the renormalization group if all matter couplings flow to a fixed point (either trivial or interacting). In this case the theory can approach conformal gravity at infinite energy. A way to address the hierarchy problem within this scenario will also be discussed.

Closure Talks / 80

Roadsigns for cosmology

Author: Kari Enqvist[1]

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I give a personal and biased account of what there might be in store for cosmology in the next decade. My focus will be on theoretical considerations.

Closure Talks / 67

Naturalness: SUSY and other solutions.

Author: Graham Ross[None]

Corresponding Author: graham.ross@physics.ox.ac.uk

The hierarchy problem has been a driving force in our attempts to go beyond the Standard Model. In this talk I will discuss the extent to which realistic models are able to avoid excessive fine tuning and the prospects for testing them.

Registration / 89

Welcome

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