Varying Constants and Fundamental Cosmology – VARCOSMOFUN'16

Report of Contributions

https://indico.cern.ch/e/varcosmo16

Contribution ID: **5** Type: **parallel**

Energy and momentum transferred by gravitational waves.

Monday, 12 September 2016 16:40 (30 minutes)

The all presentation is an updated version of my paper printed in Annalen der Physik (Leipzig , 11 (2002) 441-455. (ArXiv: gr-qc.0102072). In this paper I have considered exact, non-linear gravitational waves in the framework of general relativity and showed that they transfer energy-momentum and angular momentum.

Summary

I will present my old proof that exact gravitational waves transfer energy and momentum.This proof was published in 2001 (Annalen der Physik,11 (2002) 441-455). and relies on some kind of quasilocal quantities called canonical superenergy tensors.
My proof is local and it is complementary to old global proofs which were given in past by A. Trautman, H. Bondi, R.K. Sachs and others.

Primary author: Prof. GARECKI, Janusz (Institute of Mathematics, University of Szczecin)

Presenter: Prof. GARECKI, Janusz (Institute of Mathematics, University of Szczecin)

Session Classification: [OC/GW] Observational cosmology and gravitational waves

Contribution ID: **6** Type: **parallel**

NonLinear Gravitational Waves as Dark Energy in Warped Spacetimes

Tuesday, 13 September 2016 16:35 (25 minutes)

On a warped five-dimensional Friedmann-Lema\^{\i}tre-Robertson-Walker(FLRW) spacetime, dark energy can be induced by a U(1) scalar-gauge field on the brane. We consider a zero effective cosmological constant, i.e., the Randall-Sundrum(RS) fine-tuning and no bulk matter fields. The standard model fields interact via the bulk Weyl tensor and cause brane fluctuations. Due to the warp factor, disturbances don't fade away during the expansion of the universe. The late-time behavior could be significant deviate from the standard evolution of the universe. The effect is triggered by the time-dependent part of the warp factor with two branches and the modified brane equations. The self-gravitating cosmic string builds up a huge mass per unit length in the bulk and can induce massive Kaluza-Klein (KK)-modes felt on the brane. From a non-linear perturbation analysis, i.e., the so called multiple-scale method, it is found that the effective Einstein equations contain a "back-reaction" term on the righthand side caused by the projected five dimensional (5D) Weyl tensor and can act as a dark energy term. The propagation equation to first order for the (φ, φ) metric component is triggered by the disturbances coming from the bulk and is amplified by the warp factor. It turns out that the wavelike first order perturbations contain φ-dependent terms, so the approximate wave solutions are no longer axially symmetric. This result could be used to explain the recently found spooky alignment of the rotation axes of quasars over large distances.

Summary

On a warped five-dimensional Friedmann-Lema\^{\i}tre-Robertson-Walker(FLRW) spacetime, dark energy can be induced by a U(1) scalar-gauge field on the brane. We consider a zero effective cosmological constant, i.e., the Randall-Sundrum(RS) fine-tuning and no bulk matter fields. The standard model fields interact via the bulk Weyl tensor and cause brane fluctuations. Due to the warp factor, disturbances don't fade away during the expansion of the universe. The late-time behavior could be significant deviate from the standard evolution of the universe. The effect is triggered by the time-dependent part of the warp factor with two branches and the modified brane equations. The self-gravitating cosmic string builds up a huge mass per unit length in the bulk and can induce massive Kaluza-Klein (KK)-modes felt on the brane. From a non-linear perturbation analysis, i.e., the so called multiple-scale method, it is found that the effective Einstein equations contain a "back-reaction" term on the righthand side caused by the projected five dimensional (5D) Weyl tensor and can act as a dark energy term. The propagation equation to first order for the (φ, φ) metric component is triggered by the disturbances coming from the bulk and is amplified by the warp factor. It turns out that the wavelike first order perturbations contain φ-dependent terms, so the approximate wave solutions are no longer axially symmetric. This result could be used to explain the recently found spooky alignment of the rotation axes of quasars over large distances.

Primary author: Dr SLAGTER, Reinoud (Asfyon and Univ of Amsterdam, The Netherlands)

Presenter: Dr SLAGTER, Reinoud (Asfyon and Univ of Amsterdam, The Netherlands)

Session Classification: [DE] Dark energy

Contribution ID: **7** Type: **plenary**

Do we live in the Best of all Worlds? - The fine tuning of the constants of Nature

Saturday, 17 September 2016 12:00 (30 minutes)

On the occasion of the 300. anniversary of the death of G.W. Leibniz

Einstein once said: "What really interests me is whether God could have created the world any differently." Our existence depends on a variety of constants which appear to be extremely fine tuned to allow for the existence of Life. These include the number of spatial dimensions, the strengths of the forces, the masses of the particles, the composition of the Universe and others.

On the occasion of Leibniz' anniversary we discuss the question of whether we live in the "Best of all Worlds". The hypothesis of a multiverse could explain the mysterious fine tuning of so many fundamental quantities. Anthropic arguments are critically reviewed.

Summary

On the occasion of the 300. anniversary of the death of G.W. Leibniz

Einstein once said: "What really interests me is whether God could have created the world any differently." Our existence depends on a variety of constants which appear to be extremely fine tuned to allow for the existence of Life. These include the number of spatial dimensions, the strengths of the forces, the masses of the particles, the composition of the Universe and others.

On the occasion of Leibniz' anniversary we discuss the question of whether we live in the "Best of all Worlds". The hypothesis of a multiverse could explain the mysterious fine tuning of so many fundamental quantities. Anthropic arguments are critically reviewed.

Primary author: Prof. NAUMANN, Thomas (Deutsches Elektronen-Synchrotron (DE))

Presenter: Prof. NAUMANN, Thomas (Deutsches Elektronen-Synchrotron (DE))

Session Classification: [Phil] Philosophy and cutting edge of physics and cosmology

Contribution ID: **23** Type: **parallel**

New constraints on spatial variations of the fine structure constant from clusters of galaxies

Thursday, 15 September 2016 16:35 (25 minutes)

We propose an improved methodology to constrain spatial variations of the fine structure constant using clusters of galaxies. We use the *Planck* 2013 data to measure the thermal Sunyaev-Zeldovich effect at the location of 618 X-ray selected clusters. We then use a Monte Carlo Markov Chain algorithm to obtain the temperature of the Cosmic Microwave Background at the location of our galaxy clusters. When fitting three different
phenomenological parameterizations allowing for monopole and dipole amplitudes in the value of the fine structure constant we improve the results of earlier analysis involving clusters and CMB power spectrum, and we also found that the best-fit direction of a hypothetical dipole is compatible with the direction of other known anomalies.

Summary

Primary author: DE MARTINO, Ivan (Universidad del Pais Vasco)

Co-authors: Prof. MARTINS, Carlos J.A.P. (Centro de Astrofisica da Universidade do Porto, Rua das Estrelas s/n, 4150-762 Porto, Portugal); Prof. EBELING, Harald (Institute for Astronomy, University of Hawaii, Honolulu, HI 96822 USA)

Presenter: DE MARTINO, Ivan (Universidad del Pais Vasco)

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **25** Type: **parallel**

The Relation Between Fundamental Constants and Particle Physics Parameters

Monday, 12 September 2016 14:00 (40 minutes)

Astronomical observations provide constraints on the time variation of the fundamental constants, the proton to electron mass ratio and the fine structure constant. These constants are dependent on particular combinations of the Quantum Chromodynamic Scale, the Higgs Vacuum Expectation Value and the Yukawa Couplings. The coefficients of these particle physics parameters are model dependent but can be calculated from the model. The observational constraints on the time variation of the two fundamental constants therefore constrain the time variation of the combination of the three particle physics parameters. The proton to electron mass ratio and the fine structure constant provide two equations in the three particle physics parameters therefore one of the parameters can be eliminated providing a two parameter constraint. Both fundamental constants depend on the Quantum Chromodynamic Scale and the sum of the Higgs VEV and the Yukawa coupling. This makes it possible to solve for the QCD Scale and the sum of the Higgs VEV and Yukawa coupling separately placing a direct constraint on the QCD scale. Candidates for a third equation to constrain the Higgs VEV and Yukawa coupling individually will be discussed. Even with just the two equations the fundamental constants provide significant restrictions to the parameter space of theories that postulate that the particle physics parameters should be time variable.

Summary

This presentation describes the constraints on the time variation of the Quantum Chromodynamic Scale, the Higgs Vacuum Expectation Value and the Yukawa coupling imposed by the current constraints on the time variation of the proton to electron mass ratio and the fine structure constant.

Primary author: Prof. THOMPSON, Rodger (University of Arizona, Steward Observatory)

Presenter: Prof. THOMPSON, Rodger (University of Arizona, Steward Observatory)

Session Classification: [VC-T] Varying constants –theory

Contribution ID: **26** Type: **parallel**

Diatomic molecules as probes for variation of fundamental constants

Monday, 12 September 2016 14:40 (30 minutes)

Diatomic molecules are very promising probes for variation of fundamental constants (VFC), as their spectra can be very sensitive to both α and μ, making it possible to look for change in both constants in a single experiment [1].
Nearly degenerate levels with different sensitivity to VFC may provide huge enhancements of the relative variation, since δω/ω tends to infinity when the distance between the levels ω is close to zero. However, locating such fortuitous level combinations is not a trivial task. The talk will present some schemes for identifying rovibrational transitions with optimal sensitivity to VFC in diatomic cations. Examples of promising molecules include cations of dihalogens and hydrogen halides, which benefit from very low energy rovibrational transitions between the nearly degenerate sublevels of their X 2Π ground states [2].
Second topic discussed in the presentation will be our recent investigation of sensitivity of the equilibrium bond lengths in homonuclear dimers to variation of α [3], in the context of the recent proposal to search for VFC using laser interferometers [4].

[1] C. Chin, V. V. Flambaum, and M. G. Kozlov, New J. Phys. 11, 055048 (2009)

[2] L. F. Pašteka, A. Borschevsky, V.V. Flambaum, and P. Schwerdtfeger, Phys. Rev. A 92, 012103 (2015)

[3] A. Borschevsky, L. F. Pašteka, V.V. Flambaum, and P. Schwerdtfeger, in preparation

[4] Y.V. Stadnik and V.V. Flambaum, Phys. Rev. Lett. 114, 161301 (2015)

Summary

Primary author: BORSCHEVSKY, Anastasia (University of Groningen)

Co-authors: Dr LUKAS, Pasteka (Centre for Theoretical Chemistry and Physics, The New Zealand Institute for Advanced Study, Massey University Auckland, Private Bag 102904, 0632 Auckland, New Zealand); Prof. SCHWERDTFEGER, Peter (Centre for Theoretical Chemistry and Physics, The New Zealand Institute for Advanced Study, Massey University Auckland, Private Bag 102904, 0632 Auckland, New Zealand); Prof. FLAMBAUM, Victor (3School of Physics, University of New South Wales, Sydney 2052, Australia)

Presenter: BORSCHEVSKY, Anastasia (University of Groningen)

Session Classification: [VC-T] Varying constants –theory

Contribution ID: **27** Type: **parallel**

On a nonlinear gravitational wave

Monday, 12 September 2016 17:10 (30 minutes)

An exact, plane wave solution of the gravitational field equations is investigated. The source stress tensor is represented by an anisotropic null fluid with energy flux to which the energy density ρ and the pressure p_z are negative but finite throughout the spacetime. They depend on a constant length (taken of the order of the Planck length) and acquire Planck values close to the null surface $t - z = 0$, z-axis being the direction of propagation. The timelike geodesics of a test particle are contained in a plane whose normal has constant direction and the null trajectories are comoving with a plane of fixed direction.

Summary

Primary author: Dr CULETU, Hristu (Ovidius University)

Presenter: Dr CULETU, Hristu (Ovidius University)

Session Classification: [OC/GW] Observational cosmology and gravitational waves

Contribution ID: **28** Type: **parallel**

Effective gravitational couplings for cosmological perturbations in generalized Proca theories

Tuesday, 13 September 2016 14:35 (35 minutes)

We consider the finite interactions of the generalized Proca theory including the sixth-order Lagrangian and derive the full linear perturbation equations of motion on the flat Friedmann-Lema\^{i}tre-Robertson-Walker background in the presence of a matter perfect fluid.
By construction, the propagating degrees of freedom (besides the matter perfect fluid) are two transverse vector perturbations, one longitudinal scalar, and two tensor polarizations.
The Lagrangians associated with intrinsic vector modes neither affect the background equations of motion nor the second-order action of tensor perturbations, but they do give rise to non-trivial modifications to the no-ghost condition of vector perturbations and to the propagation speeds of vector and scalar perturbations.
We derive the effective gravitational coupling $G_{\rm eff}$ with matter density perturbations under a quasi-static approximation on scales deep inside the sound horizon.
We find that the existence of intrinsic vector modes allows a possibility for reducing $G_{\rm eff}$. In fact, within the parameter space, $G_{\rm eff}$ can be even smaller than the Newton gravitational constant G at the late cosmological epoch, with a peculiar phantom dark energy equation of state (without ghosts). The modifications to the slip parameter η and the evolution of growth rate $f\sigma_8$ are discussed as well.
Thus, dark energy models in the framework of generalized Proca theories can be observationally distinguished from the ΛCDM model according to both cosmic growth and expansion history. Furthermore, we study the evolution of vector perturbations and show that outside the vector sound horizon the perturbations are nearly frozen and start to decay with oscillations after the horizon entry.

Summary

Primary author: KASE, Ryotaro (Tokyo University of Science)

Co-authors: Prof. DE FELICE, Antonio (Yukawa Institute for Theoretical Physics, Kyoto University); HEISENBERG, Lavinia (ETHZ - ETH Zurich); Prof. MUKOHYAMA, Shinji (Yukawa Institute for Theoretical Physics, Kyoto University); Prof. TSUJIKAWA, Shinji (Tokyo University of Science); Dr ZHANG, Ying-li (Chinese Academy of Science)

Presenter: KASE, Ryotaro (Tokyo University of Science)

Session Classification: [DE] Dark energy

Contribution ID: **29** Type: **parallel**

The cosmological constant problem in piecewise-linear models of quantum gravity

Friday, 16 September 2016 14:35 (35 minutes)

We will present a recent result [1] regarding the cosmological constant problem. In the framework of the piecewise-linear approaches to the construction of the gravitational path integral, there are three contributions to the total cosmological constant (CC): the bare term, the matter vacuum fluctuations term, and the quantum gravity term. The existence of the quantum gravity term is necessary due to the requirement of the finiteness of the gravitational path integral, while its smallness is a nonperturbative consequence of the semiclassical limit of the theory. As it turns out, one can exactly cancel the bare term with the matter vacuum fluctuations term, leaving the quantum gravity term as the sole contribution to CC, which is moreover automatically small. This result opens the door to an alternative explanation of the observed smallness of the cosmological constant.

[1] A. Mikovic and M. Vojinovic, Europhys. Lett. 110, 40008 (2015).

Summary

Primary author: Dr VOJINOVIC, Marko (Institute of Physics, University of Belgrade)

Co-author: Dr MIKOVIC, Aleksandar (Lusofona University, Lisbon, Portugal)

Presenter: Dr VOJINOVIC, Marko (Institute of Physics, University of Belgrade)

Session Classification: [MV] Multiverse

Contribution ID: **31** Type: **poster**

The Speed of Light: A Symmetrically Varying Constant at the Farthest Distance From Us

As finite observers stationed here and now at the center of our universe, we observe ourselves and our nearby present world as being in a state of rest or low-velocity and conditioned by linear time. The geometry of our present world (space-time) appears to be approximately Euclidean, verifying Euclidean laws and analytic principles of organization. In this Euclidean zero-force world, any quantity of a given kind is seen as a finite and simple thing having at one time a unique magnitude. Light travels Euclidean empty space in a straight line and with a constant speed independent of the motion of the source and the observer. The speed of light, similar to any Euclidean quantity, has at one time a finite and unique magnitude—namely c, which we take as a unity: c = 1.

While we know the main properties of our nearby present world—-a simple Euclidean world of immobility or low-velocity—-we know nothing about the nature of our ultra-distant universe at the distance of 15 billion light years away and 15 billion years ago. What are the properties of our present world and speed of light in this distant past? Is it possible that at this distant past, our present flat world is infinitely curved into a limiting point of infinite density, and our present Euclidean light of constant and finite speed is infinitely varied into infinite and zero speeds? Is there a maximum limit—a first origin—of our present Euclidean world? Or, does it continue forever? Is there an original light of infinite and zero speeds emitted by the first origin, or is light Euclidean and constant having uniquely a finite speed?

For the Kantian sceptics the above analytic question about the finite or infinite nature of our present world and its Euclidean light is impossible to answer because it constitutes one of the four primitive antinomies of analytic reason. However if we replace empirical analytic reason by synthetic apriori reason—the intellectual faculty of uniting opposites in an all-inclusive physical whole—then what is considered as an unanswerable antinomy, becomes a reconciled complexity in which the opposites coexist.

Beyond our here and now Euclidean world of our finite analytic perception there is a then and there of which we know nothing at present, but may eventually come to know something, if we change the solipsistic, finite- analytic paradigm of dogmatic science into the infinite- synthetic paradigm that corresponds to infinite nature herself.

— Paris, 25 May, 2016

contact@apeironcentre.org

Summary

Primary author: Ms SOTEROPOULOS, Ion (Apeiron Centre)

Presenter: Ms SOTEROPOULOS, Ion (Apeiron Centre)

Session Classification: Poster session

Contribution ID: **32** Type: **parallel**

Running of the Higgs quartic coupling, gravity and the stability of the Higgs effective potential

Thursday, 15 September 2016 14:30 (30 minutes)

Motivated by the cosmological setup, we investigated the influence of the gravity induced terms on the Higgs field effective action. Using the heat kernel approach we obtained the one-loop effective action in the classical curved spacetime. Specializing to the standard cosmological metric, we studied the effect of gravitational field of this form on the behavior of the Higgs effective potential in the high energy (around the putative instability scale) and the low energy (around the electrovacuum minimum) regimes. We found that the lowest order nontrivial gravity induced terms, which are proportional to the square of the Riemman and Ricci tensors, may have an impact on the structure of the electroweak minimum and the effective running of the Higgs quartic coupling.

Summary

Primary author: NAKONIECZNY, Lukasz (University of Warsaw)

Presenter: NAKONIECZNY, Lukasz (University of Warsaw)

Session Classification: [INF/DM] Inflation, early universe and dark matter

Contribution ID: **34** Type: **plenary**

Search for varying constants and new physics from molecular hydrogen

Tuesday, 13 September 2016 10:00 (1 hour)

The spectroscopy of molecular hydrogen can be used for a search into physics beyond the Standard Model. Differences between the absorption spectra of the Lyman and Werner bands of H_2 as observed at high redshift and those measured in the laboratory can be interpreted in terms of possible variations of the proton-electron mass ratio $\mu = m_p/m_e$ over cosmological history. Investigation of some ten of such absorbers in the redshift range $z = 2.0 - 4.2$ yields a constraint of $|\Delta\mu/\mu| < 5 \times 10^{-6}$ at 3σ, as was recently reported in a review [1]. Observation of H_2 from the photospheres of white dwarf stars inside our Galaxy delivers a constraint of similar magnitude on a dependence of μ on a gravitational potential 10^4 times as strong as on the Earth's surface [2].

While such astronomical studies aim at finding quintessence in an indirect manner, laboratory precision measurements target such additional quantum fields in a direct manner. Laser-based precision measurements of dissociation energies, vibrational splittings and rotational level energies in H_2 molecules and their deuterated isotopomers HD and D_2 produce values for the rovibrational binding energies fully consistent with quantum ab initio calculations including relativistic and quantum electrodynamical (QED) effects [3]. Similarly, precision measurements of high-overtone vibrational transitions of HD^+ ions, also result in transition frequencies fully consistent with calculations including QED corrections [4].
These comprehensive results of laboratory precision measurements on neutral and ionic hydrogen molecules can be interpreted to set bounds on the existence of possible fifth forces [5] and of higher dimensions [6], phenomena describing physics beyond the Standard Model.

[1] W. Ubachs, J. Bagdonaite, E.J. Salumbides, M.T. Murphy, L. Kaper, Rev. Mod. Phys. 88, 021003 (2016).

[2] J. Bagdonaite, E.J. Salumbides, S.P. Preval, M.A. Barstow, J.D. Barrow, M.T. Murphy, W. Ubachs, Phys. Rev. Lett. 113, 123002 (2014).

[3] W. Ubachs, J.C.J. Koelemeij, K.S.E. Eikema, E.J. Salumbides, J. Mol. Spectr. 320, 1 (2016).

[4] J. Biesheuvel, J.-Ph. Karr, L. Hilico, K.S.E. Eikema, W. Ubachs, J.C.J. Koelemeij, Nat. Comm. 7, 10385 (2016).

[5] E.J. Salumbides, J.C.J. Koelemeij, J. Komasa, K. Pachucki, K.S.E. Eikema, W. Ubachs, Phys. Rev. D87, 112008 (2013).

[6] E.J. Salumbides, A.N. Schellekens, B. Gato-Rivera, W. Ubachs, New. J. Phys. 17, 033015 (2015).

Summary

Primary author: UBACHS, Wim (VU University Amsterdam)

Presenter: UBACHS, Wim (VU University Amsterdam)

Session Classification: Plenary session II

Contribution ID: **36** Type: **plenary**

New, precise and reliable quasar absorption limits on alpha-variation

Thursday, 15 September 2016 10:00 (1 hour)

Previous evidence for time and space variations in the fine-structure constant (alpha) emerged from large samples of quasar spectra observed with the Very Large Telescope and Keck telescope. I will first review this evidence in light of our work that identified systematic wavelength calibration errors in these telescopes. These errors are subtle, complex and still not fully understood; they clearly change with time, making it difficult to estimate the detailed effect they had on the quasar spectra. Nevertheless, I will argue that they are likely to explain the previous evidence for variations in alpha, and at least substantially weaken that evidence.

Secondly, I will describe new observations and measurements which are corrected for, or are insensitive to, these calibration errors. In particular, I will report 11 new such measurements which, combined, constrain the relative deviation in alpha to be $\Delta\alpha/\alpha = 0.4 \pm 1.7$ parts-per-million from the current laboratory value at redshifts 1.0–2.4 (look-back times of 7.8–11 billion years). This is consistent with no variation in alpha at a precision level comparable to that of the two large quasar samples. However, the particular distribution of these quasars on the sky precludes a strong test of possible evidence variation in alpha across the sky in those large samples (ignoring the calibration errors above). I will report on progress towards several new measurements that, combined with those reported here, should enable such a test.

Summary

Previous evidence for time and space variations in the fine-structure constant (alpha) emerged from large samples of quasar spectra observed with the Very Large Telescope and Keck telescope. I will first review this evidence in light of our work that identified systematic wavelength calibration errors in these telescopes. These errors are subtle, complex and still not fully understood; they clearly change with time, making it difficult to estimate the detailed effect they had on the quasar spectra. Nevertheless, I will argue that they are likely to explain the previous evidence for variations in alpha, and at least substantially weaken that evidence.

Secondly, I will describe new observations and measurements which are corrected for, or are insensitive to, these calibration errors. In particular, I will report 11 new such measurements which, combined, constrain the relative deviation in alpha to be $\Delta\alpha/\alpha = 0.4 \pm 1.7$ parts-per-million from the current laboratory value at redshifts 1.0–2.4 (look-back times of 7.8–11 billion years). This is consistent with no variation in alpha at a precision level comparable to that of the two large quasar samples. However, the particular distribution of these quasars on the sky precludes a strong test of possible evidence variation in alpha across the sky in those large samples (ignoring the calibration errors above). I will report on progress towards several new measurements that, combined with those reported here, should enable such a test.

Primary author: MURPHY, Michael (Swinburne University of Technology)

Presenter: MURPHY, Michael (Swinburne University of Technology)

Session Classification: Plenary session IV

Contribution ID: **37** Type: **parallel**

High-precision limit on variation in the fine-structure constant from a single quasar absorption system

Thursday, 15 September 2016 14:25 (25 minutes)

In the last 15 years, studies of velocity shifts between metal transitions observed in high-resolution quasar spectra with the largest optical telescopes identified possible evidence for variation in the fine-structure constant, α. Recent 'supercalibration'techniques have shown that these spectra likely have significant systematic distortions in their wavelength scales that undermine the $\Delta\alpha/\alpha$ measurements.

We have selected the brightest southern quasar HE 0515−4414 at $z_{\rm abs} > 1$ to obtain the highest S/N spectrum available, achieve the smallest statistical error on $\Delta\alpha/\alpha$ to date and, most importantly, to allow systematic effects to be tracked and corrected with high fidelity. For this purpose we have combined HE 0515−4414 spectra observed with UVES/VLT over 10 years, producing an extremely high signal-to-noise ratio spectrum (peaking at S/N ≈ 250 pix^{-1}). This provides the most precise measurement of $\Delta\alpha/\alpha$ from a single absorption system to date, $\Delta\alpha/\alpha = -1.42 \pm 0.55_{\rm stat} \pm 0.65_{\rm sys}$ parts per million (ppm). This has a similar precision to previous measurements from large samples of ∼150 absorption systems. This measurement is corrected for the largest systematic effect present in all (except one) previous measurements, the long-range wavelength distortions, which would add 10 ppm to the systematic error budget. We also discuss how our methods for correcting the spectra, in this case, can be applied to future spectra, in particular from the upcoming ESPRESSO spectrograph. Our spectrum also offers a preview of the data quality available from the next generation of telescopes, but also the problems that must be overcome to access the full photon-limited precision.

Summary

Primary author: KOTUS, Srdan (Centre for Astrophysics and Supercomputing Swinburne University)

Co-authors: MURPHY, Michael (Swinburne University of Technology); Prof. CARSWELL, Robert (Institute of Astronomy, University of Cambridge)

Presenter: KOTUS, Srdan (Centre for Astrophysics and Supercomputing Swinburne University)

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **38** Type: **parallel**

Cosmological Isotropization from Symmetry Point of View

Thursday, 15 September 2016 17:10 (30 minutes)

Bianchi models can be used to address the isotropization problem during the cosmological expansion of a homogeneous universe at an earlier epoch of its evolution. As there is a large family of such models, therefore it is necessary to characterize them on the basis of their geometrical and dynamical properties which we accomplish using Noether point symmetries of the geodetic Lagrangian in these spacetimes. The existence of such symmetries not only helps us to specify a model but also provide us first integrals which can be used to comprehend the dynamics significantly. We then investigate the positive energy condition in all specified models which provides us critical bounds on the physical parameters. Lastly, the possibilities of involving physical fields (perfect fluid, dust or vacuum) for a consistent viable cosmological model and its evolution at different stages, is discussed.

Summary

Primary author: ALI, Sajid

Presenter: ALI, Sajid

Session Classification: [INF/DM] Inflation, early universe and dark matter

Contribution ID: **40** Type: **parallel**

From quantum regime to cosmology via forcing and 4-smoothness

Friday, 16 September 2016 17:25 (25 minutes)

Recently we proposed a cosmological model based on smooth 4-manifolds admitting non-standard smoothness structures. The manifolds are so-called exotic versions of $\mathbb{R}^4$ (R^4) and $S^3 \times \mathbb{R}$. This model has been developed further and we have shown how to derive some realistic cosmological parameters from these exotic smoothings in a new way. Besides, we indicated the quantum origin of the smoothings. In more detail: the cosmological constant is identified with the constant curvature of the embedding $R^4 \to \mathbb{R}^4$. The calculations are in good agreement with the observed small value of the dark energy density. Furthermore, the handle-body structure of R^4 implies an exponential potential rather than a polynomial potential for the inflaton field again in agreement with the Planck sattelite results. The important problem about a physical origin of the presence of exotic smoothness in the cosmological models is also settled. In particular, we found that the algebraic structure of the quantum mechanical lattice of projections enforces the exotic smoothness on $\mathbb{R}^4$. If the lattice were distributive and the corresponding observables were commutative, the resulting smoothness structure would be the standard $\mathbb{R}^4$. Additionally, the set-theoretical forcing, derived from the QM lattice and from exotic $\mathbb{R}^4$, explains the vanishing of the QFT contributions to cosmological constant.

Summary

Primary author: KROL, Jerzy (University of Silesia)

Co-authors: Mr BIELAS, Krzysztof (Institute of Physics, University of Silesia, Katowice, Poland); Mr KLIMASARA, Pawe\l (Institute of Physics, University of Silesia, Katowice, Poland); Dr ASSELMEYER--MALUGA, Torsten (German Aerospace Center (DLR), Berlin, Germany)

Presenter: KROL, Jerzy (University of Silesia)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **41** Type: **parallel**

Classical and quantum cosmology of Born-Infeld type models

Monday, 12 September 2016 15:15 (25 minutes)

We discuss the classical and quantum cosmology of a universe filled with a tachyon condensate and other Born-Infeld type fields. We analyse, in particular, the cases with a constant potential and with an inverse square potential. We apply the Wheeler-DeWitt equation of canonical quantum gravity to these models and show how it can be appropriately reformulated as a difference equation.

Summary

http://journals.aps.org/prd/abstract/10.1103/PhysRevD.93.083519

http://arxiv.org/abs/1602.01319

Primary author: KWIDZINSKI, Nick (Universität zu Köln)

Co-authors: KAMENSHCHIK, Alexander (Università di Bologna and INFN, Landau Institute for Theoretical Physics); KIEFER, Claus (Universität zu Köln)

Presenter: KWIDZINSKI, Nick (Universität zu Köln)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **42** Type: **parallel**

Tests of local Lorentz invariance of post-Newtonian gravity

Thursday, 15 September 2016 17:25 (25 minutes)

General relativity (GR) is the current tour de force of gravitation that passes all experimental scrutinies with great precision. However, the difficult in incorporating quantum principles motives alternative theories beyond GR. Some of these theories predict the breakdown of local Lorentz invariance. Standard-model extension (SME) is a convenient effective-theoretic framework to study such possibilities from experiments. I will talk about lunar-laser-ranging, atom-interferometry, pulsar-timing experiments that probe post-Newtonian effects in SME.

Summary

Primary author: Dr SHAO, Lijing (Albert Einstein Institute)

Presenter: Dr SHAO, Lijing (Albert Einstein Institute)

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **43** Type: **parallel**

Impact of long-range wavelength-scale distortion on fine-structure constant measurements.

Thursday, 15 September 2016 14:00 (25 minutes)

New ideas in unification theories suggest space-time variations of dimensionless physical constants may exist and that they might be within reach of current instrumental precision available from the world's best observatories. State-of-the-art observations already hint at such an effect. If confirmed, fundamental revisions in standard physics would be required.

Accurate calibrations are of course crucial in searches for space-time variations of dimensionless physical constants using spectroscopic observations from the world's best observatories. Several recent studies reveal wavelength distortions in optical echelle spectrographs. These are not yet understood and they have not yet been measured using the actual science data used to derive constraints on space-time variation of alpha (critical since they appear to vary with time). In this work we study the impact of such distortions on measurements of the fine structure constant, alpha, observed at high redshift using high-resolution quasar spectroscopy and show that whilst long-range wavelength-scale distortions do exist, and hence contribute an additional systematic error, these systematics (measured directly from the science exposures themselves) are small and unlikely to explain the spatial variations of alpha reported recently.

Summary

Primary author: DUMONT, Vincent

Co-author: Prof. WEBB, John (University of New South Wales)

Presenter: DUMONT, Vincent

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **44** Type: **parallel**

The Nonlinear Field Space Theory

Monday, 12 September 2016 16:10 (25 minutes)

In recent years the idea that not only the configuration space of particles, i.e. spacetime, but also the corresponding momentum space can have a nontrivial geometry has attracted significant attention, especially in the context of quantum gravity. The aim of the talk is to discuss extension of this concept to the domain of field theories, the so-called Nonlinear Field Space Theory (NFST). After presenting the motivation and general aspects of the approach we will focus on analysis of the prototype (quantum) NFST of a scalar field. The case of a compact field space is especially interesting, which is a natural way to implement the "Principle of finiteness"of physical theories, which once motivated the Born-Infeld theory. Predictions and possible areas of application of NFST will be discussed, with a focus on two aspects of NFST: possible role of NFST in early universe cosmology and "predicted renormalization"of the charge and speed of propagation of field excitations.

Summary

Primary author: Dr MIELCZAREK, Jakub (Jagiellonian University)

Presenter: Dr MIELCZAREK, Jakub (Jagiellonian University)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **45** Type: **parallel**

Entropy/information flux in Hawking radiation

Friday, 16 September 2016 16:10 (25 minutes)

Blackbody radiation contains (on average) an entropy of 3.9+-2.5 bits per photon. This applies not only to provervial case of "burning a lump of coal", but also to the Hawking radiation from black holes. The flip side of this observation is the information budget: If the emission process is unitary, as it certainly is for normal physical burning, then this entropy is exactly compensated by the "hidden information"in the correlations. We shall now extend this argument to the Hawking radiation from black holes, demonstrating that the assumption of unitarity leads to a perfectly reasonable entropy/information budget. The key technical aspect of our calculation is the "average subsystem"approach, but applied to a tripartite pure system consisting of the (black hole)+(Hawking radiation)+(rest of the universe).

Summary

Blackbody radiation contains (on average) an entropy of 3.9+-2.5 bits per photon. This applies not only to provervial case of "burning a lump of coal", but also to the Hawking radiation from black holes. The flip side of this observation is the information budget: If the emission process is unitary, as it certainly is for normal physical burning, then this entropy is exactly compensated by the "hidden information"in the correlations. We shall now extend this argument to the Hawking radiation from black holes, demonstrating that the assumption of unitarity leads to a perfectly reasonable entropy/information budget. The key technical aspect of our calculation is the "average subsystem"approach, but applied to a tripartite pure system consisting of the (black hole)+(Hawking radiation)+(rest of the universe).

Primary author: ALONSO SERRANO, Ana (Institute for Fundamental Physics-CSIC)

Co-author: Prof. VISSER, Matt (Victoria University of Wellington)

Presenter: ALONSO SERRANO, Ana (Institute for Fundamental Physics-CSIC)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **47** Type: **parallel**

Different laws of nature in strong gravitational fields? Study dependence of fine-structure constant on gravitational potential by using white-dwarf spectra

Thursday, 15 September 2016 16:10 (25 minutes)

Constraining variation in fundamental constants offers an important test for physics beyond the Standard Model.

The fine-structure constant (α) might not be constant throughout the universe. Models involving scalar fields coupled to α, the scalar charge depending on environment (e.g. on gravitational potential) naturally lead to α variation. White dwarf photospheres, where the gravitational potential can be ˜10ˆ5 times that on Earth, provide an important testbed of such ideas.

In atoms, different transitions have different sensitivities (q) to α variation (Δα/α), which results in a unique pattern of line shifts.
By comparing with laboratory wavelengths, Δα/α can be solved with Monte Carlo method.

In this project, we have used high resolution (R ˜144,000) FUV spectra from white dwarf G191-B2B obtained with Hubble Space Telescope. A set of "clean", unblended FeV absorption lines from photosphere were sampled for the analysis. To better quantify impact of uncertainties in laboratory wavelengths, 2 new experiments have been set to re-measure FeV UV wavelengths. A set of tests for systematics enables us to constrain uncertainties associated with q calculation, Zeeman and Stark shifts, and long-range wavelength distortion in spectrograph. Here we will present our new results and the first comprehensive analysis of systematic errors.

Summary

Primary author: HU, JITING (University of New South Wales)

Co-authors: Dr NAVE, Gillian (National Institute of Standards and Technology (NIST)); Mr WARD, Jacob (National Institute of Standards and Technology (NIST)); Prof. BARROW, John (University of Cambridge); Prof. WEBB, John (University of New South Wales); Dr BERENGUT, Julian (University of New South Wales); Prof. TCHANG-BRILLET, Lydia (Universite UPMC); Prof. BARSTOW, Martin (University of Leicester); Dr BAINBRIDGE, Matthew (University of Leicester); Dr REINDL, Nicole (University of Leicester); Dr PREVAL, Simon (University of Strathclyde); Dr AYRES, Tom (University of Colorado); Prof. FLAMBAUM, Victor (University of New South Wales); Mr DUMONT, Vincent (University of New South Wales); Dr DZUBA, Vladimir (University of New South Wales)

Presenter: HU, JITING (University of New South Wales)

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **50** Type: **parallel**

Dark energy constraints from ESPRESSO tests of the stability of fundamental couplings

Thursday, 15 September 2016 15:15 (25 minutes)

ESPRESSO is a high-resolution-ultra-stable spectrograph for the VLT, whose commissioning will start in early 2017. One of its key science goals is to test the stability of nature's fundamental couplings with unprecedented accuracy and control of possible
systematics. A total of 27 nights of the ESPRESSO Consortium's guaranteed time observations (GTO) will be spent in testing the stability of the fine-structure constant and other fundamental couplings. A set of 14 priority optimal targets have been selected for
the GTO period. In this talk I will discuss the criteria underlying this selection, describe the selected targets, and present detailed forecasts
of the impact of these measurements on fundamental physics and cosmology, focusing on dark energy constraints and using future supernova type Ia surveys as a comparison point.

Summary

ESPRESSO is a high-resolution-ultra-stable spectrograph for the VLT, whose commissioning will start in early 2017. One of its key science goals is to test the stability of nature's fundamental couplings with unprecedented accuracy and control of possible systematics. A total of 27 nights of the ESPRESSO Consortium's guaranteed time observations (GTO) will be spent in testing the stability of the fine-structure constant and other fundamental couplings. A set of 14 priority optimal targets have been selected for the GTO period. In this talk I will discuss the criteria underlying this selection, describe the selected targets, and present detailed forecasts of the impact of these measurements on fundamental physics and cosmology, focusing on dark energy constraints and using future supernova type Ia surveys as a comparison point.

Primary author: LEITE, Ana Catarina (Instituto de Astrofísica e Ciências do Espaço)

Co-authors: MARTINS, Carlos (University of Porto); Prof. MOLARO, Paolo (OATs-INAF)

Presenter: LEITE, Ana Catarina (Instituto de Astrofísica e Ciências do Espaço)

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **51** Type: **parallel**

Cosmological perturbations in dark energy phantom models

Monday, 12 September 2016 14:25 (25 minutes)

On this talk, we will present classical dark energy models that induces abrupt cosmic events in the future. These events are intrinsic to phantom-like matter, we will as well present the cosmological pertubations of these models. We will also briefly comment on the quantisations of these models. Mariam Bouhmadi-López will give more details on the quantum cosmology of these models.

Summary

Primary author: ALBARRAN, Imanol (Universidade da Beira Interior (UBI))

Co-authors: MORAIS, João (Universidad del País Vasco / Euskal Herriko Unibertsitatea); Dr BOUHMADI, Mariam (UBI (Portugal))

Presenter: ALBARRAN, Imanol (Universidade da Beira Interior (UBI))

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **53** Type: **poster**

Does the anthropic principle entail the multiverse?

The anthropic principle says that the universe is extremely fine-tuned to host the life. To explain the fine-tuning of the constants of nature, mainly we have three ways. The first way is to explain that with a more fundamental theory. But the important problem is that how far we can move towards a more fundamental theory? The second way of explaining the fine-tuning of the constants of nature is multiverse theories. Several multiverse theories have been suggested in some areas of physics like cosmology, string theory and quantum mechanics and even some physicists are inclined to put away the principle of experimental verification of the physical theories in order to keep their multiverse theories remain in force. Assuming of the existence of an intelligent designer is the third way. But it doesn't seem to be a scientific solution. In what follows, I explain these three ways and their problems and finally, express an approach on the basis of inference to the best explanation(IBE).

Summary

Primary author: Mr AGHAEE, Faez (Sharif University of Technology, Philosophy of Science Department)

Presenter: Mr AGHAEE, Faez (Sharif University of Technology, Philosophy of Science Department)

Session Classification: Poster session

Contribution ID: **54** Type: **parallel**

Cosmology in genealized Proca theories and beyond

Friday, 16 September 2016 14:35 (35 minutes)

We consider a massive vector field with derivative interactions that propagates only the 3 desired polarizations (besides two tensor polarizations from gravity) with second-order equations of motion in curved space-time. The cosmological implications of such generalized Proca theories are investigated for both the background and the linear perturbation by taking into account the Lagrangian up to quintic order. In the presence of a matter fluid with a temporal component of the vector field, we derive the background equations of motion and show the existence of de Sitter solutions relevant to the late-time cosmic acceleration. We also obtain conditions for the absence of ghosts and Laplacian instabilities of tensor, vector, and scalar perturbations in the small-scale limit. Our results are applied to concrete examples of the general functions in the theory, which encompass vector Galileons as a specific case. In such examples, we show that the de Sitter fixed point is always a stable attractor and study viable parameter spaces in which the no-ghost and stability conditions are satisfied during the cosmic expansion history.

We also construct higher-order derivative interactions beyond second-order generalized Proca theories that propagate only the three desired polarizations of a massive vector field besides the two tensor polarizations from gravity.

Summary

Primary author: TSUJIKAWA, Shinji (Tokyo University of Science)

Presenter: TSUJIKAWA, Shinji (Tokyo University of Science)

Session Classification: [MG] Modifications of gravity

Contribution ID: **55** Type: **parallel**

Running of the Running and Entropy Perturbations During Inflation

Thursday, 15 September 2016 15:00 (30 minutes)

In single field slow-roll inflation, one expects that the spectral index $n_s - 1$ is first order in slow-roll parameters. Similarly, its running $\alpha_s = \mathrm{d}n_s/\mathrm{d}\log k$ and the running of the running $\beta_s = \mathrm{d}\alpha_s/\mathrm{d}\log k$ are second and third order and therefore expected to be progressively smaller, and usually negative. Recent analyses hinting that β_s may actually be positive, and larger than α_s are hence beginning to generate some tension with the simplest models of inflation. We take the first theoretical steps towards addressing the question, then, of what kind of inflationary models could explain such a hint, were it to be confirmed by future experiments, focusing on two-field models of inflation in which the late-time transfer of power from isocurvature to curvature modes allows for a much more diverse range of phenomenology. We calculate the runnings due to this effect and briefly apply our results to assess the feasibility of finding $|\beta_s| > |\alpha_s|$ in some specific models.

Summary

Primary author: LONGDEN, Chris (University of Sheffield)

Co-author: Prof. VAN DE BRUCK, Carsten (University of Sheffield)

Presenter: LONGDEN, Chris (University of Sheffield)

Session Classification: [INF/DM] Inflation, early universe and dark matter

Contribution ID: **57** Type: **parallel**

Vacuum dark energy and spacetime symmetry

Tuesday, 13 September 2016 17:00 (25 minutes)

1. Vacuum dark fluid presented by variable cosmological term

[I. Dymnikova, Phys. Lett. B 472 (2000) 33; I. Dymnikova, Class. Quant. Grav. 19 (2002) 725 (Honorable Mention-2001 of the Gravity Research Foundation); I. Dymnikova and E. Galaktionov, Phys. Lett. B 645 (2007) 358; I. Dymnikova, Int. J. Mod. Phys. A 31 (2016) 1641005]

1. Regular Cosmologies with Vacuum Dark Energy

2.1 Regular Lemaitre class models
[I. Dymnikova, A. Dobosz, M. Filchenkov and A.Gromov, Phys. Lett. B 506 (2001) 351;
K. A. Bronnikov, A. Dobosz and I. Dymnikova, Class. Quant. Grav. 20 (2003) 3797;
K. Bronnikov, I. Dymnikova and E. Galaktionov, Class. Quantum Grav. 29 (2012) 095025]

2.2 T-models of the Kantowski-Sachs type with regular pre-bang R-regions
[K. Bronnikov and I. Dymnikova, Class. Quant. Grav. 24 (2007) 5803]

2.3 Cosmological model singled out by the holographic principle
[I. Dymnikova, Int. J. Mod. Phys. D 21 (2012) 124007 (Honorable Mention-2012 of the Gravity Research Foundation)]

1. Regular Compact Objects with vacuum dark energy (de Sitter Vacuum) interiors

3.1 Regular black holes with de Sitter vacuum interior
[I. Dymnikova, Gen. Rel. Grav. 24 (1992) 235 (Awarded by the Gravity Research Foundation in 1991); I. Dymnikova and B. Soltysek, Gen. Rel. Grav. 30 (1997) 1775;
I. Dymnikova and E. Galaktionov, Class. Quant. Grav. 22 (2005) 2331]

3.2 Regular black hole remnants, G-lumps and graviatoms
[I. Dymnikova, Int. J. Mod. Phys. D 5 (1996) 529; I. Dymnikova and M. Korpusik,
Phys. Lett. B 685 (2010) 12; I. Dymnikova and M. Korpusik, Entropy 13 (2011) 1967;
I. Dymnikova and M. Fil'chenkov, Adv. High Energy Phys. 13 (2013) 746894 (2013);
I. Dymnikova and M. Khlopov, Int. J. Mod. Phys. D 24 (2015) 1545002]

3.3 Mass and spacetime symmetry
[I. Dymnikova, Class. Quant. Grav. 19 (2002) 725 (Honorable Mention-2001 of the Gravity Research Foundation); D. V. Ahluwalia and I. Dymnikova, Int. J. Mod. Phys. D 12 (2003) 1787 (Honorable Mention-2003 of the Gravity Research Foundation); I. Dymnikova, A. Sakharov and J. Ulbricht, Adv. High Energy Phys. 14 (2014) 707812]

Summary

The Petrov classification of stress-energy tensors provides a model-independent definition of a vacuum by the algebraic structure of its stress-energy tensor and implies the existence of vacua whose symmetry is reduced as compared with the maximally symmetric de Sitter vacuum associated with the Einstein cosmological term. This allows one to describe a vacuum in general setting by dynamical vacuum dark fluid, presented by a variable cosmological term with the reduced symmetry which allows vacuum dark energy be evolving and clustering. The relevant regular solutions to the Einstein equations describe regular cosmological models with

time-evolving and spatially inhomogeneous vacuum dark energy, and compact vacuum objects generically
related to a dark energy via de Sitter vacuum interiors: regular black holes, their remnants and self-gravitating vacuum solitons - which can be responsible for observational effects typically related to a dark matter. The mass of objects with the de Sitter interior is generically related to breaking of space-time symmetry from the de Sitter group in the origin.

Primary author: DYMNIKOVA, Irina (University of Warmia and Mazury)

Presenter: DYMNIKOVA, Irina (University of Warmia and Mazury)

Session Classification: [DE] Dark energy

Contribution ID: **58** Type: **parallel**

Nucleosynthesis predictions and high-precision deuterium measurements

Monday, 12 September 2016 14:00 (30 minutes)

I will present two new high-precision measurements of the deuterium abundance from absorbers along the line of sight to the quasar PKS1937–1009. The absorbers have lower column densities (N(HI)$\approx 18\mathrm{cm}^{-2}$) than for previous high-precision measurements, boding well for further extensions of the sample due to the plenitude of low column density absorbers. The total high-precision sample now consists of 12 measurements with a weighted average D/H = $2.55 \pm 0.03 \times 10^{-5}$. The sample does not favour a dipole similar to the one detected for the fine structure constant. The increased precision also calls for improved nucleosynthesis predictions. For that I present an updated version of the public AlterBBN code including new reactions, updated rates, and the possibility of adding new physics such as dark matter. The standard Big Bang Nucleosynthesis prediction of D/H = $2.456 \pm 0.057 \times 10^{-5}$ is consistent with the observed value within 1.7 standard deviations.

Summary

Primary author: RIEMER-SORENSEN, Signe (University of Oslo)

Co-authors: Mr JENSSEN, Espen Sem (University of Oslo); Prof. WEBB, John (University of New South Wales); KOTUS, Srdan (Centre for Astrophysics and Supercomputing Swinburne University)

Presenter: RIEMER-SORENSEN, Signe (University of Oslo)

Session Classification: [OC/GW] Observational cosmology and gravitational waves

Contribution ID: **59** Type: **plenary**

Disformal electrodynamics: from varying alpha to vacuum Cherenkov radiation

Friday, 16 September 2016 09:00 (1 hour)

In scalar-tensor theories the gravitational sector is extended by including an additional scalar degree of freedom. The most general metric that can be built in such a theory includes disformal terms so that standard model fields move on a metric which is the sum of the space time metric and a tensor constructed from first derivatives of the scalar. In such a theory gravitational waves and photons can propagate at different speeds, and these can in turn be different from the maximum speed limit for matter particles. As I will discuss, disformal couplings can cause charged particles to emit Cherenkov radiation and bremsstrahlung apparently in vacuum, depending on the background evolution of the scalar field. In addition, the fine structure constant becomes time-dependent. I will discuss the implications of such a model in detail and discuss the constraints that arise for models of dark energy with disformal couplings.

Summary

Primary author: VAN DE BRUCK, Carsten (University of Sheffield)

Co-authors: BURRAGE, Clare (University of Nottingham); Mr MORRICE, Jack (University of Sheffield); Mr MIFSUD, Jurgen (The University of Sheffield); NUNES, Nelson (U. Heidelberg)

Presenter: VAN DE BRUCK, Carsten (University of Sheffield)

Session Classification: Plenary session V

Contribution ID: **60** Type: **parallel**

Phenomenology of MTMG

Tuesday, 13 September 2016 14:00 (35 minutes)

I will briefly introduce MTMG, and discuss its phenomenology for both the self-accelerating and normal branch.

Summary

Primary author: Prof. DE FELICE, Antonio (Yukawa Institute for Theoretical Physics)

Presenter: Prof. DE FELICE, Antonio (Yukawa Institute for Theoretical Physics)

Session Classification: [DE] Dark energy

Contribution ID: **62** Type: **parallel**

Quantum Discord in de Sitter spacetime

Tuesday, 13 September 2016 15:10 (30 minutes)

Recently, quantum entanglement in the context of cosmology has been widely discussed. There are many quantities which characterize quantumness of a state.Among such quantities, quantum discord is often mentioned as the best one. In this talk, we discuss the quantum discord in de Sitter spacetime.

Summary

Primary author: Prof. SODA, Jiro (Kobe University)

Co-author: Dr KANNO, Sugumi (University of the Basque country)

Presenter: Prof. SODA, Jiro (Kobe University)

Session Classification: [QE] Quantum entanglement and many-worlds interpretation

Contribution ID: **63** Type: **parallel**

Searching for variations of fundamental constants and dark matter using an atomic clock ensemble

Tuesday, 13 September 2016 14:00 (30 minutes)

The ratio of two atomic transition frequencies is by definition independent of the unit of frequency and therefore its value depends only on fundamental constants such as the fine-structure constant α or fundamental properties of particles like for instance the electron mass. Repeated measurements of frequency ratios performed in the laboratory, with suitable atomic structure calculations, are therefore a direct test of the present-day stability of fundamental constants with respect to space-time and, via the motion of the Earth, gravitational potential. Such tests are independent from any cosmological models and complementary to astrophysical tests.

At LNE-SYRTE we operate an ensemble of atomic clocks both in the microwave (hyperfine transition in the ground state of ^{133}Cs and ^{87}Rb) and in the optical part of the spectrum ($1S_0$ - $3P_0$ in ^{87}Sr and ^{199}Hg) providing for several atomic frequency comparisons [1]. In this talk we will report more specifically on highly accurate Rb/Cs hyperfine frequency comparisons performed with atomic fountains over more than 15 yr. They provide stringent limits on possible time variations of a particular linear combination of constants, or its coupling to gravity, involving α and the quark mass scaled to the chromodynamics mass scale [2]. The results also constitute a stringent differential redshift test for the Rb/Cs couple. Besides, they provide improved constraints on the coupling of a putative massive scalar dark matter field to standard matter [3]. We will also present repeated accurate measurements of the Sr/Cs and Hg/Cs frequency ratios which complement similar measurements performed in other laboratories, and for the first time, measurements of Sr/Rb and Hg/Rb frequency ratios which are sensitive to other linear combinations of constants [4][5].

[1] M. Abgrall *et al.*, C.R. Physique 16, 461-470 (2015)

[2] J. Guéna *et al.*, Phys. Rev. Lett. 109, 080801 (2012)

[3] A. Hees et *al.*, submitted, available at arXiv:1604.08514 (2016)

[4] Le Targat et al., submitted, available at arXiv:1605.03878 (2016)

[5] R. Tyumenev et al., submitted, available at arXiv:1603.02026 (2016)

Summary

Primary author: GUÉNA, Jocelyne (Observatoire de Paris)

Co-authors: Dr HEES, Aurélien (University of California); Dr LODEWYCK, Jérôme (Observatoire de Paris); Dr DE SARLO, Luigi (Observatoire de Paris); Dr ABGRALL, Michel (Observatoire de Paris); Dr WOLF, Peter (Observatoire de Paris); Dr LE TARGAT, Rodolphe (Observatoire de Paris); Dr BIZE, Sébastien (Observatoire de Paris); Dr LECOQ, Yann (Observatoire de Paris)

Presenter: GUÉNA, Jocelyne (Observatoire de Paris)

Session Classification: [VC-E] Varying constants –laboratory experiments

Contribution ID: **64** Type: **parallel**

The false vacuum bubble as the creation of our universe

Friday, 16 September 2016 14:00 (35 minutes)

We present the nucleation of a false vacuum bubble in curved space, which have compact geometries. The analytic computations for the radius and nucleation rate of a vacuum bubble are evaluated using the thin-wall approximation. We discuss possible cosmological implications of our new solutions.

Summary

Primary author: Dr WONWOO, Lee (CQUeST, Sogang University)

Presenter: Dr WONWOO, Lee (CQUeST, Sogang University)

Session Classification: [MV] Multiverse

Contribution ID: **65** Type: **parallel**

Lemaitre class dark energy model for relaxing cosmological constant

Tuesday, 13 September 2016 17:25 (25 minutes)

1. One-horizon spacetimes.
2. Holographic principle.
3. Spacetime singled out by evaporation of the cosmological horizon.
4. Lemaitre class model for relaxing cosmological constant.
5. Cosmological evolution.
6. Anisotropy.

Summary

Regular spacetimes with the de Sitter center contain a family of one-horizon spacetimes with the same global structure as that for the de Sitter spacetime. Regular cosmologica models belong to the Lemaitre class models with anisotropic pressures and describe time-dependent and spatially inhomogeneous vacuum dark energy. Among these models there is a special class singled out by quantum evaporation of a cosmological horizon. Cosmological evolution goes from a large initial value of the cosmological constant to a small non-zero final value which is tightlyfixed by the quantum dynamics of the horizon. For the case when we adopt the GUT scale for the initial value of cosmological constant, its present value appears in remarkable agreement with the value given by obserations. Degree of anisotropy, which intrinsic for the Lemaitre model, quickly grows after the inflationary stage and slowly decreases at he recombination time.

Primary author: DOBOSZ, Anna (University of Warmia and Mazury)

Co-authors: SOLTYSEK, Bozena (University of Warmia and Mazury); DYMNIKOVA, Irina (University of Warmia and Mazury)

Presenter: DOBOSZ, Anna (University of Warmia and Mazury)

Session Classification: [DE] Dark energy

Contribution ID: **66** Type: **parallel**

Constraint on transient variations of fine-structure constants with optical atomic clocks

Tuesday, 13 September 2016 16:10 (30 minutes)

One of possible scenarios predicts that the dark matter (DM) may have a form of stable topological defects [1]. For nonzero DM coupling to standard-model particles, the encounter with such object would effectively result in temporary variation of fundamental constants. Recently it was proposed by Derevianko and Pospelov [2] that the networks of correlated atomic clocks may be used for such searches. For the class of optical clocks [3-7] such measurements are mostly sensitive to the variations of the fine-structure constant since the electronic transitions are used. We present first experimental constraint on the coupling of transient DM coupling to standard-model particles obtained with optical atomic clocks. In our measurement [8] we used two non-separated strontium optical lattice clocks [9,10]. In contrast to the approach given in Ref. [2] we do not measure a phase difference between the clocks but the common signal in the readouts. Furthermore the sensitivity of our method does not scale with the distance between the sensors hence can applied to both distant and non-separated sensors. Our constraint already reaches the capability of a constellation of GPS atomic clocks [2] and substantially exceeds previous laboratory and astrophysical limits [11].

[1] A. Vilenkin, Physics Reports 121, 263 (1985).
[2] A. Derevianko and M. Pospelov, Nature Phys. 10, 933 (2014).
[3] T. Rosenband et al., Science 319, 1808 (2008).
[4] C. W. Chou et al., Phys. Rev. Lett. 104, 070802 (2010).
[5] N. Hinkley et al., Science 341, 1215 (2013).
[6] R. Le Targat et al., Nat. Commun. 4, 2109 (2013).
[7] B. J. Bloom et al., Nature 506, 71 (2014).
[8] P. Wcislo et al., ArXiv e-prints (2016), arXiv:1605.05763 [physics.atom-ph].
[9] M. Bober et al., Meas. Sci. Technol. 26, 075201 (2015).
[10] P. Morzyński et al., Sci. Rep. 5, 17495 (2015).
[11] K. A. Olive and M. Pospelov, Phys. Rev. D 77, 043524 (2008).

Summary

Primary author: WCISLO, Piotr (Nicolaus Copernicus University in Torun)

Co-authors: Dr CYGAN, Agata (Nicolaus Copernicus University in Torun); Prof. LISAK, Daniel (Nicolaus Copernicus University in Torun); Dr BOBER, Marcin (Nicolaus Copernicus University in Torun); Dr ZAWADA, Michal (Nicolaus Copernicus University in Torun); Dr MORZYNSKI, Piotr (Nicolaus Copernicus University in Torun); Prof. CIURYLO, Roman (Nicolaus Copernicus University in Torun)

Presenter: WCISLO, Piotr (Nicolaus Copernicus University in Torun)

Session Classification: [VC-E] Varying constants –laboratory experiments

Contribution ID: **67** Type: **parallel**

Thawing model seems to be preferable for dark energy potential in the quintessence scenario

Tuesday, 13 September 2016 15:10 (30 minutes)

The time variation of the equation of state w for quintessence scenario with a scalar field as dark energy is studied up to the third derivative (d^3w/da^3) with respect to the scale factor a, in order to predict the future observations and specify the scalar potential parameters. The third derivative of w for general potential V is derived and applied to several types of potentials.
They are the inverse power-law ($V = M^{4+\alpha}/Q^\alpha$), the exponential ($V = M^4 \exp(\beta M/Q)$), the cosine ($V = M^4(\cos(Q/f) + 1)$) and the Gaussian types ($V = M^4 \exp(-Q^2/\sigma^2)$), which are prototypical potentials for the freezing and thawing models.
If the parameter number for a potential form is n, it is necessary to find at least for $n + 2$ independent observations to
identify the potential form and the evolution of the scalar field (Q and $\dot{Q}$). Such observations would be the values of $\Omega_Q, w, dw/da, \cdots$, and dw^n/da^n. Since four of the above mentioned potentials have two parameters, it is necessary to calculate the third derivative of w for them to estimate the predict values.
If they are tested in observation, it will be understood whether the dark energy could be described by the scalar field with this potential.
Numerical analysis for d^3w/da^3 are made under some specified parameters in the investigated potentials.
It becomes possible to distinguish the freezing and thawing modes by the accurate observing dw/da and d^2w/da^2 in some parameters.
(arXiv:1605.02180)

Summary

Primary author: Prof. TETSUYA, Hara (Kyoto Sangyo University)

Presenter: Prof. TETSUYA, Hara (Kyoto Sangyo University)

Session Classification: [DE] Dark energy

Contribution ID: **68** Type: **parallel**

Analysing a forecast cosmological redshift drift

Monday, 12 September 2016 14:30 (30 minutes)

We create a model independent mock dataset to test the viability and possible properties of the cosmological redshift drift, also known as Sandage-Loeb test. The redshift of a given object will exhibit a specific variation through time due to the expansion of the universe. This mechanism was predicted by Sandage in 1962, but with the technology of that epoch it was impossible to detected the signal. When new spectroscopic techniques were being used in astrophysics, the concept was revisited by Loeb in 1998.

We also create, in the same model independent way as the SL data, future mock datasets of SN and BAO to compare with SL, and also to see its performance when using all datasets. The behaviour of the datasets are analysed through testing several cosmological models with MCMC. SL dataset presents interesting features, as for example different correlations between parameters comparing to other mock datasets. Besides, the ability of the SL mock dataset to constrain the matter content of the universe Ω_m is also remarkable, being quite better than the other datasets.

Summary

Primary author: LEANIZBARRUTIA ALONSO, Iker (Universiy of the Basque Country EHU/UPV)

Co-authors: Dr LAZKOZ, Ruth (University of the Basque Country EHU/UPV); SALZANO, Vincenzo (University of Szczecin)

Presenter: LEANIZBARRUTIA ALONSO, Iker (Universiy of the Basque Country EHU/UPV)

Session Classification: [OC/GW] Observational cosmology and gravitational waves

Contribution ID: **69** Type: **parallel**

Cosmological implications of quantum entanglement in the multiverse

Tuesday, 13 September 2016 14:00 (35 minutes)

We explore the cosmological implications of quantum entanglement between two causally disconnected universes in the multiverse. We first consider two causally separated de Sitter spaces with a state which is initially entangled. We derive the reduced density matrix of our universe and compute the spectrum of vacuum fluctuations. We then consider the same system with an initially non-entangled state. We find that scale dependent modulations may enter the spectrum for the case of initially non-entangled state due to quantum interference. This gives rise to the possibility that the existence of causally disconnected universes may be experimentally tested by analyzing correlators in detail.

Summary

Inflationary cosmology and the string landscape suggest that our universe may not be the only universe but part of a vast complex of universes that we call the multiverse. Until recently, however, this multiverse idea has been criticized as a philosophical proposal that cannot be tested. However, there may be quantum entanglement between two causally separated universes in the multiverse, and it may produce detectable signatures. I'm going to discuss that quantum entanglement would be able to provide some evidence for the existence of the multiverse.

Primary author: KANNO, Sugumi

Presenter: KANNO, Sugumi

Session Classification: [QE] Quantum entanglement and many-worlds interpretation

Contribution ID: **70** Type: **parallel**

Towards quantum logic spectroscopy of molecular ions

Tuesday, 13 September 2016 15:00 (30 minutes)

Precision spectroscopy is a driving force for the development of our physical understanding. A prime example is the search for variation of fundamental constants in laboratory experiments through the repeated frequency comparison of highly accurate frequency standards. It is advantageous to compare standards with a large difference in sensitivity of their transitions to a change in these fundamental constants. However, only few atomic and molecular systems of interest have been accessible for precision spectroscopy in the past, since they miss a suitable transition for laser cooling and internal state detection. This restriction can be overcome in trapped ions through quantum logic spectroscopy. I will show how the internal state of a molecular ion can be detected non-destructively on a co-trapped cooling ion by implemented a quantum logic algorithm involving only coherent laser manipulation on the molecular ion [1]. This represents a first step towards extending the exquisite control achieved over selected atomic species to much more complex molecular ions. Steps towards high resolution spectroscopy of molecular ions with the goal of improving the model-independent upper bound on a variation of the proton-to-electron mass ratio will be presented.

[1] F. Wolf, Y. Wan, J. C. Heip, F. Gebert, C. Shi, and P. O. Schmidt, Non-destructive state detection for quantum logic spectroscopy of molecular ions, Nature **530**, 457–460 (2016).

Summary

Primary author: Prof. SCHMIDT, Piet (PTB Braunschweig/LUH Hannover)

Co-authors: Dr SHI, Chunyan (PTB Braunschweig); WOLF, Fabian (PTB); Dr GEBERT, Florian (PTB); Dr WAN, Yong (PTB Braunschweig)

Presenter: Prof. SCHMIDT, Piet (PTB Braunschweig/LUH Hannover)

Session Classification: [VC-E] Varying constants –laboratory experiments

Contribution ID: **71** Type: **plenary**

Search for New Physics with Atomic Clocks

Monday, 12 September 2016 11:30 (1 hour)

The precision of atomic clocks improves at a rapid pace: While caesium clocks now reach relative uncertainties of a few 10^{-16}, several optical clocks based on different atoms and ions are now reported with systematic uncertainties in the low 10^{-18} range [1]. The Yb^+ optical clock at PTB has recently reached this uncertainty [2], following Hans Dehmelt's seminal ideas of using a single trapped ion, laser cooling and the observation of quantum jumps as a spectroscopic signal, but based on an unusual reference transition (S-F electric octupole) and special Ramsey interrogation schemes that suppress systematic frequency shifts. The availability of highly precise clocks relying on different quantum systems allows for improved tests of fundamental physics, especially quantitative tests of relativity and searches for violations of the equivalence principle. The strong relativistic contributions to the transition energy and the high electronic angular momentum of the F-state make the Yb^+ optical clock an especially sensitive test case. In comparisons with a ^{87}Sr optical lattice clock at PTB [3] we have performed improved tests for temporal variations of the fine structure constant and the proton-to-electron mass ratio, of coupling of α to gravity in the Solar potential and of violation of Lorentz invariance in the electron sector.

[1] A. D. Ludlow, M. M. Boyd, J. Ye, E. Peik, P. O. Schmidt, Rev. Mod. Phys. 87, 637 (2015)

[2] N. Huntemann, C. Sanner, B. Lipphardt, Chr. Tamm, E. Peik, Phys. Rev. Lett. 116, 063001 (2016)

[3] C. Grebing, A. Al-Masoudi, S. Dörscher, S. Häfner, V. Gerginov,
S. Weyers, B. Lipphardt, F. Riehle, U. Sterr, C. Lisdat, Optica 3, 563 (2016)

Summary

Primary author: Dr PEIK, Ekkehard (PTB)

Presenter: Dr PEIK, Ekkehard (PTB)

Session Classification: Plenary session I

Contribution ID: **72** Type: **parallel**

Effects from canonical quantum gravity for slow-roll inflationary models

Monday, 12 September 2016 16:35 (25 minutes)

The power spectrum of inflationary gauge-invariant perturbations is computed in the context of canonical quantum gravity for generic slow-roll models. A semiclassical approximation, based on an expansion on inverse powers of the Planck mass, is applied to the complete Wheeler-DeWitt equation describing a perturbed inflationary universe. This expansion leads to a hierarchy of equations at consecutive orders of the approximation and allows us to write down a corrected Schrödinger equation that encodes information about quantum-gravitational effects. The analytical dependence of the correction to the power spectrum on the wavenumber is obtained. Nonetheless, some numerical work is needed in order to obtain its precise value. Finally, it is shown that the correction turns out to be positive, which leads to an enhancement of the power spectrum especially prominent for large scales.

Summary

Primary author: BRIZUELA, David (University of the Basque Country)

Co-authors: KIEFER, Claus (U); KRÄMER, Manuel (University of Szczecin)

Presenter: BRIZUELA, David (University of the Basque Country)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **77** Type: **parallel**

Cosmology of the de Sitter Horndeski models

Friday, 16 September 2016 14:00 (35 minutes)

The discovery, in 1998, that the Universe is currently undergoing an accelerated expansion is one of the greatest milestones in all physics. Naturally, over the last 17 years, many proposals to explain this evolution have been brought forward. Most ideas involve scalar field dark energy or extensions of Einstein's gravity. These proposals are essentially phenomenological without any relation to each other. One major step forward was the realization in 2011 that all these proposals are subclasses of the most general scalar-tensor theory that leads to second order equations of motion, the Horndeski Lagrangian.

Seeking viable cosmological solutions, one can focus on the Friedmann-Lemaitre-Robertson-Walker spacetime and search for cosmological models that have a late time flat de Sitter critical point for any kind of material content or value of the vacuum energy. Such models were attained and in this proceedings we address their phenomenology following recent work.

The class of non-linear models with shift symmetry are in a better footing when they are compared with current observational constraints of the effective equation of state parameter and limits on early dark energy contribution. In order to further scrutinise these models, we are now required to face them against observables that depend on the evolution of the field and matter fluid fluctuations.

Summary

I will describe how one can construct a subclass of the Horndeski Lagrangian with a de Sitter critical point for any kind of material content. These models might alleviate the cosmological constant problem. I will present the cosmological evolution of two classes of families - the linear models and the non-linear models with shift symmetry. We conclude that the latter models can deliver a background dynamics compatible with the latest observational data.

Primary author: NUNES, Nelson (University of Lisbon)

Presenter: NUNES, Nelson (University of Lisbon)

Session Classification: [MG] Modifications of gravity

Contribution ID: **78** Type: **parallel**

Post-Newtonian parameter in f(R) gravity

Friday, 16 September 2016 16:40 (30 minutes)

We derive a formula for the post-Newtonian parameter γ in $f(R)$ gravity in a straightforward manner without using a scalar-tensor representation or the transformation to the Einstein frame.

The post-Newtonian parameters, defined in the parametrized post-Newtonian formalism, have been used in placing observational constraints on modified theories of gravity with local gravity tests.
In $f(R)$ gravity, it has been shown that $\gamma \approx 1/2$ for the case of light mass of the field $\partial_R f$, which is manifestly inconsistent with the constraint $|\gamma - 1| \leq 10^{-4}$ obtained from local gravity tests.
For the case that the effective mass of the field $\partial_R f$ becomes large in the solar-system scale, the effect of the gravity modification would be suppressed due to the chameleon mechanism, and the observational constraint could be satisfied.
An explicit formula for the parameter γ, however, has not been obtained for that case.

In our approach, we employ a cosmological post-Newtonian approximation, and carefully make an order-of-magnitude estimate of each term in the field equations for the derivation.
This approximation enables us to treat local-scale high-density regions, in which the chameleon mechanism would take place.
Our results update the previously known ones and provide more stringent constraints from local gravity tests than before.

Summary

Primary author: Dr MORITA, Masaaki (Okinawa National College of Technology)

Presenter: Dr MORITA, Masaaki (Okinawa National College of Technology)

Session Classification: [MG] Modifications of gravity

Contribution ID: **79** Type: **parallel**

Artifical intelligence applied to the automated analysis of absorption spectra.

Thursday, 15 September 2016 14:50 (25 minutes)

A new and fully-automated method is presented for the analysis of high-resolution absorption spectra (GVPFIT). The method has broad application but here we apply it specifically to the problem of measuring the fine structure constant at high redshift. For this we need objectivity and reproducibility. Three numerical methods are unified into one "artificial intelligence" process: a genetic algorithm that emulates the Darwinian processes of reproduction, mutation and selection, non-linear least-squares with parameter constraints (VPFIT), and Bayesian model averaging. In this talk we illustrate the method using a test-case, the $z_{abs} = 1.8389$ absorber towards the $z_{em} = 2.145$ quasar J110325-264515.

Summary

Primary author: BAINBRIDGE, Matthew (University of Leicester)

Co-author: Prof. WEBB, John (University of New South Wales)

Presenter: BAINBRIDGE, Matthew (University of Leicester)

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **80** Type: **poster**

Fundamental physics from observations of white dwarf stars.

Variation in fundamental constants provide an important test of theories of grand unification. Potentially, white dwarf spectra allow us to directly observe variation in fundamental constants at locations of high gravitational potential. We study hot, metal polluted white dwarf stars, combining far-UV spectroscopic observations, atomic physics, atmospheric modelling and fundamental physics, in the search for variation in the fine structure constant. This registers as small, but measurable shifts in the observed wavelengths of highly ionized Fe and Ni lines when compared to laboratory wavelengths. Measurements of these shifts were performed by Berengut et al. (2013) using high-resolution STIS spectra of G191-B2B, demonstrating the validity of the method. We have extended this work by; (a) using new (high precision) laboratory wavelengths, (b) refining the analysis methodology (incorporating robust techniques from previous studies towards quasars), and (c) enlarging the sample of white dwarf spectra. A successful detection would be the first direct measurement of a gravitational field effect on a bare constant of nature. We have recently been awarded 12 orbits of Cycle 24 HST time to observe hot DA white dwarf stars with a variety of masses, allowing a fully exploration of the compactness parameter space (M/R). This poster will focus on our methods and preliminary results in the search for variations in the fine structure constant at high gravitational potential, from the study of white dwarf spectra.

Summary

Primary author: BAINBRIDGE, Matthew (University of Leicester)

Co-authors: Mrs HU, Jiting (University of New South Wales); Prof. BARROW, John (Cambridge University); Prof. WEBB, John (University of New South Wales); Dr BERENGUT, Julian (University of New South Wales); Prof. BARSTOW, Martin (University of Leicester); Dr REINDL, Nicole (University of Leicester); Dr PREVAL, Simon (University of Strathclyde)

Presenter: BAINBRIDGE, Matthew (University of Leicester)

Session Classification: Poster session

Contribution ID: **81** Type: **parallel**

Tabletop experiments using atomic dysprosium and ytterbium for tests of fundamental physics.

Tuesday, 13 September 2016 14:30 (30 minutes)

Atomic dysprosium (Dy) and ytterbium (Yb) have proved to be valuable systems to study fundamental problems in modern physics. Their high atomic mass and their rich energy-level structure, which results in accidental degeneracies of opposite-parity energy states, make them ideal candidates for investigating parity-violating (PV) interactions. Dysprosium is particularly well-suited for searches of time variation of fundamental constants. In addition, atomic PV experiments offer the opportunity to study the weak interaction at low energy scales, providing valuable information about the Standard Model and nuclear physics. Most notably, the broad isotope distribution of both systems brings within reach the possibility of measuring neutron-skin variation among different isotopes, as well as detecting nuclear anapole moments.

We provide an overview of our group's experimental work on testing fundamental symmetries, searching for variations of fundamental constants, and measuring PV interactions using atomic Yb and Dy. The emphasis is on our newly revised PV experimental setups and current efforts, with a discussion of the present statistical sensitivities and future plans. Furthermore, we discuss two recent developments: (1) analysis of the Yb and Dy measurements that has been used to constrain possible PV interactions of cosmic fields with atomic electrons, and (2) precise radio-frequency spectroscopy in Dy that has provided strict limits on very-low-mass dark-matter particles.

Summary

Atomic dysprosium (Dy) and ytterbium (Yb) have proved to be valuable systems to study parity violating interactions at low energy scales, search for possible time variations of fundamental constants and violations of fundamental symmetries, and constraint light dark matter particles. We provide an overview of our experimental work on tests of fundamental physics using atomic Dy and Yb, and we discuss further recent developments.

Primary author: Dr BOUGAS, Lykourgos (Johannes Gutenberg Universität)

Co-authors: Ms FABRICANT, Anne (Johannes Gutenberg Universität); Dr ANTYPAS, Dionysis (Helmholtz Institut Mainz); Prof. BUDKER, Dmitry (Johannes Gutenberg Universität); Dr TSIGUTKIN, Konstantin (KLA Tencor); Dr LEEFER, Nathan (Helmholtz Institut Mainz)

Presenter: Dr BOUGAS, Lykourgos (Johannes Gutenberg Universität)

Session Classification: [VC-E] Varying constants –laboratory experiments

Contribution ID: **82** Type: **parallel**

Less-simplified models of dark matter for direct detection and the LHC

Thursday, 15 September 2016 16:40 (30 minutes)

We construct models of dark matter with suppressed spin-independent scattering cross section utilizing the existing simplified model framework. Even simple combinations of simplified models can exhibit interference effects that cause the tree level contribution to the scattering cross section to vanish, thus demonstrating that direct detection limits on simplified models are not robust when embedded in a more complicated and realistic framework. In general for fermionic WIMP masses > 10 GeV direct detection limits on the spin-independent scattering cross section are much stronger than those coming from the LHC. However these model combinations, which we call less-simplified models, represent situations where LHC searches become more competitive than direct detection experiments even for moderate dark matter mass. We show that a complementary use of several searches at the LHC can strongly constrain the direct detection blind spots by setting limits on the coupling constants and mediators' mass. We derive the strongest limits for combinations of vector + scalar, vector + "squark", and "squark" + scalar mediator, and present the corresponding projections for the LHC 14 TeV for a number of searches: mono-jet, jets + missing energy, and searches for heavy vector resonances.

Summary

Primary author: Dr CHOUDHURY, Arghya (University of Sheffield)

Co-authors: WILLIAMS, Andrew (NCBJ); SESSOLO, Enrico Maria (NCBJ, Warsaw); KOWALSKA, Kamila (TU Dortmund); ROSZKOWSKI, Leszek

Presenter: Dr CHOUDHURY, Arghya (University of Sheffield)

Session Classification: [INF/DM] Inflation, early universe and dark matter

Contribution ID: **83** Type: **parallel**

Higgs Starobinsky inflation

Thursday, 15 September 2016 14:00 (30 minutes)

The idea that inflation may be due to degrees of freedom already present in the standard model of particle physics or quantum general relativity is extremely attractive and has received much attention in the recent years. In particular two models stand out by their simplicity and elegance. Higgs inflation with a large non-minimal coupling of the Higgs boson H to the Ricci scalar ($\xi H^\dagger H R$) and Starobinsky's inflation model based on R^2 gravity are both minimalistic and perfectly compatible with the latest Planck data. The aim of this talk is to point out an intriguing distinct possibility, namely that
Starobinsky inflation is generated by quantum effects due to a large non-minimal coupling of the Higgs boson to the Ricci scalar. In this framework we do not need to posit that the Higgs boson starts at a high field value in the early universe which would alleviate constraints coming from the requirement of having a stable Higgs potential even for large Higgs field values.

Summary

Primary author: KUNTZ, Iberê

Co-author: Prof. CALMET, Xavier (University of Sussex)

Presenter: KUNTZ, Iberê

Session Classification: [INF/DM] Inflation, early universe and dark matter

Contribution ID: **84** Type: **parallel**

Current status on dark energy singularities

Monday, 12 September 2016 14:50 (25 minutes)

On this talk, we will present a review on dark energy singularities and abrupt events. We will start with a classical description of several models. On the second part of the talk, we will focus on the quantum analysis of these singularities/abrupt events. The analysis will encompass also modified theories of gravity.

Summary

On this talk, we will present a review on dark energy singularities and abrupt events. We will start with a classical description of several models. On the second part of the talk, we will focus on the quantum analysis of these singularities/abrupt events. The analysis will encompass also modified theories of gravity.

Primary author: BOUHMADI-LOPEZ, Mariam

Presenter: BOUHMADI-LOPEZ, Mariam

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **85** Type: **parallel**

Perturbation vacua and primordial power spectra in Loop Quantum Cosmology

Monday, 12 September 2016 17:00 (25 minutes)

We discuss the primordial power spectra for both scalar and tensor perturbations in a inflationary model quantized by means of the hybrid quantization in Loop Quantum Cosmology. In order to compute the primordial power spectra we use the effective dynamics coming from the quantum theory and we neglect backreactions. As expected, the primordial power spectra obtained depend crucially in the initial conditions given for the perturbations (i.e. in the selected vacuum). We will show the results obtained for usual instances of adiabatic vacua of different orders and for a new proposed vacua that minimize the temporal variation of the amplitude of the perturbations.

Summary

We discuss the primordial power spectra for both scalar and tensor perturbations in a inflationary model quantized by means of the hybrid quantization in Loop Quantum Cosmology. In order to compute the primordial power spectra we use the effective dynamics coming from the quantum theory and we neglect backreactions. As expected, the primordial power spectra obtained depend crucially in the initial conditions given for the perturbations (i.e. in the selected vacuum). We will show the results obtained for usual instances of adiabatic vacua of different orders and for a new proposed vacua that minimize the temporal variation of the amplitude of the perturbations.

Primary author: MARTIN DE BLAS, Daniel

Co-author: Dr OLMEDO, Javier (Louisiana State University)

Presenter: MARTIN DE BLAS, Daniel

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **86** Type: **parallel**

3-form cosmology: phantom behavior, singularities and interactions

Tuesday, 13 September 2016 16:10 (25 minutes)

The latest cosmological observations by the Planck collaboration (and combined with others) are compatible with a phantom like behavior $(w < -1)$ for the dark energy equation of state that drives the current acceleration of the Universe. With this mindset we look into models where dark energy is described by a 3-form field minimally coupled to gravity. These models have the advantage, when compared to a scalar field, of accommodating more naturally cosmological-constant- and phantom-like behaviors. We show how the latter happens for a fairly general class of positive valued potentials and, through a dynamical system approach, we find that in such cases the 3-form field leads the Universe into a Little Sibling of the Big Rip singular event into the future. In this work we explore the possibility of avoiding such singularity via an interaction in the dark sector between Cold Dark Matter and the 3-form field. For the kind of interactions considered we deduce a condition for replacing the LSBR by a late time de Sitter phase. For specific examples of interactions that meet such condition we look for distinctive imprints in the statefinder hierarchy $\{S_1^{(3)}; S_1^{(4)}\}$, $\{S_1^{(3)}; S_1^{(5)}\}$, and in the growth rate of matter, $\epsilon(z)$, through the composite null diagnosis (CND).

Summary

Primary author: MORAIS, João (Universidad del País Vasco / Euskal Herriko Unibertsitatea)

Co-authors: Prof. MARTO, João (Universidade da Beira Interior); Mr SRAVAN KUMAR, K (Universidade da Beira Interior); Dr BOUHMADI-LOPEZ, Mariam (Universidade da Beira Interior); Dr TAVAKOLI, Yaser (Universidade Federal do Espírito Santo)

Presenter: MORAIS, João (Universidad del País Vasco / Euskal Herriko Unibertsitatea)

Session Classification: [DE] Dark energy

Contribution ID: **87** Type: **parallel**

Effective gravitational "constant" in scalar-(curvature)tensor and scalar-torsion gravities

Friday, 16 September 2016 16:10 (30 minutes)

Cosmology papers arXiv:1003.1686, 1006.1246, 1112.5308, 1411.1947, 1511.03933;
PPN papers arXiv:1309.0031, 1607.?????.

Summary

In theories where a scalar field couples nonminimally to gravity, the effective gravitational "constant" becomes dependent on the value of the scalar field. First, I review how the cosmological evolution provides a dynamical stabilization for the gravitational "constant" as the system relaxes towards general relativity in matter dominated and potential dominated regimes for scalar-(curvature)tensor and scalar-torsion gravities. Second, I review the radius dependence of the gravitational "constant" around a point mass in the parametrized post-Newtonian formalism for scalar-tensor and multiscalar-tensor gravity.

Primary author: JÄRV, Laur (University of Tartu)

Presenter: JÄRV, Laur (University of Tartu)

Session Classification: [MG] Modifications of gravity

Contribution ID: **88** Type: **plenary**

Observations of gravitational waves from binary black hole mergers

Wednesday, 14 September 2016 09:00 (1 hour)

Detection of gravitational waves from mergers of two black holes is one
of the greatest discoveries of this century. It will open a new window on the Universe.
I shall describe observations of these signals in the data of LIGO detectors
by consortium of LIGO Scientific Collaboration and Virgo Collaboration.
I shall present several aspects of this dicovery: gravitational wave detectors,
signal modeling and data analysis. I shall mention the follow-up observations of this
event by radio, optical, near-infrared, X-ray, and gamma-ray wavelengths
with ground- and space-based facilities.
I shall describe consequences of this result for physics of fundamental interactions.

Summary

Primary author: Prof. KROLAK, Andrzej (National Center for Nuclear Studies)

Presenter: Prof. KROLAK, Andrzej (National Center for Nuclear Studies)

Session Classification: Plenary session III

Contribution ID: **89** Type: **plenary**

How to justify the history of the universe?

Saturday, 17 September 2016 12:30 (1 hour)

The laws of physics not only allow for, but also enforce, in a sense, the origin of structures, even of such complex structures as living organisms. However, they mercilessly watch the balance: the grow must remain in agreement with the second law of thermodynamics –everything has to tend to the thermodynamical equilibrium, that is to say to the thermal death. Even the most stable structures must finally surrender to the statistical chaos. Physical evil: suffering, death, decay, find they raison d'etre in the structure of the Universe. They are a price for the very possibility of life.
But what about moral evil when, for instance, a human being, making use of a physical evil destroys another human being? Moral evil appeared in the history of the Universe together with a being able to choose between good and bad. Before that there existed physical evil but the Universe was morally innocent. The existence of moral evil does not find its raison d'etre in physical laws. It transcends physics.
Among various attempts to answer Leibniz's question "Why is there something rather than nothing?"there is one, especially rich in consequences. It claims that something exists because it is good. This is an echo of Plato's "the good and right ···hold and bring things together"(Phaedo). In this perspective, existence and goodness are interchangeable (esse and bonum convertuntur).
If goodness justifies existence then it also justifies rationality since everything that exists is implacably rational. It follows that evil is irrational and as such it cannot be rationally justified. This gap in rationality is tolerated since the Universe with evil and freedom (to make evil) is supposedly better than the Universe without evil and without freedom.
This story is told on canvas of a cosmological scenario.

Summary

Presenter: Prof. HELLER, Michael (Vatican Astronomical Observatory; Copernicus Center, Kraków, Poland)

Session Classification: [Phil] Philosophy and cutting edge of physics and cosmology

Contribution ID: **90** Type: **plenary**

Where do the laws of physics come from?

Saturday, 17 September 2016 10:30 (1 hour)

Since the time of Newton, the laws of physics have generally been regarded as absolute, universal, eternal and immutable. In the era of modern cosmology, early versions of the big bang theory assumed the laws were magically imprinted on the universe at the moment of its origin. Quantum cosmology, however, requires the laws to transcend the physical universe, while eternal inflation cosmology appeals to immutable meta-laws in a multiverse. Some cosmological theories renounce the notion of fixed laws altogether. Thus the status of the laws remains unclear and offers plenty of scope for misunderstanding and confusion. As a result, most physicists and cosmologists shrug aside the question of the source of the laws as lying outside the scope of science. I shall argue that the nature and origin of physical laws is a proper subject for scientific scrutiny and should not be summarily dismissed.

Summary

Presenter: Prof. DAVIES, Paul C. W. (Arizona State University, USA)

Session Classification: [Phil] Philosophy and cutting edge of physics and cosmology

Contribution ID: **91** Type: **plenary**

Plato and Modern Physics

Saturday, 17 September 2016 09:30 (1 hour)

The talk is devoted to the discussion why modern fundamental physics is closer to the objective idealism of Plato than to the Aristotelian empiricism, after more than 2 thousand years of the domination of the latter in classical physics.

Summary

Presenter: MEISSNER, Krzysztof (Institute of Theoretical Physics, University of Warsaw)

Session Classification: [Phil] Philosophy and cutting edge of physics and cosmology

Contribution ID: **92** Type: **parallel**

Bell violation in the Sky [talk via Skype]

Tuesday, 13 September 2016 16:55 (35 minutes)

In the present article, we have addressed the following points:

Firstly we have briefly reviewed Bell's inequality in quantum mechanics and its implications. For this we reviewed the proof of Bell's inequality.
Further we have discussed the violation of Bell's inequality in the context of quantum mechanics. Also we have given the explanation for such violation, which finally give rise to new physical concepts and phenomena.

Next we have briefly discussed about the setup for Bell's inequality violating test experiment in the context of primordial cosmology. Further we have studied creation of new massive particles as introduced in the context of inflationary paradigm for various choice of time dependent mass profile. To describe a very small fraction of particle creation after inflation we have computed the expression for Bogoliubov coefficient β in FLRW space-time, which characterizes the amount of mixing between the two types of WKB solutions. Next using the results for Bogoliubov co-efficients we have further calculated reflection and transmission co-efficients, number density and energy density of the created particles for various mass profiles. Here we have provided the results for three specific cases:-super horizon, horizon crossing, sub horizon.Further we have studied cosmological scalar curvature fluctuations in presence of new massive particles for arbitrary choice of initial condition and also for any arbitrary mass profile. Here we have explicitly derived the expression for one point and two point correlation function using in-in formalism. Here in our computation we have introduced a new cosmological observable which captures the effect of Bell's inequality violation in cosmology. Further we have expressed the scale of inflation in terms of the amount of Bell's inequality violation in cosmology experimental setup using model independent prescription like EFT. Additionally we have derived a model independent expression for first Hubble slow roll parameter $\epsilon = -\dot{H}/H^2$ and tensor-to-scalar ratio in terms of the Bell's inequality violating observable within the framework of EFT. Additionally, we have given an estimate of heavy field mass parameter m/H
to violate Bell's inequality within cosmological setup.

It is important to note that when all the EFT interactions are absent in that case effective sound speed $c_S \sim 1$ and one can get back the results for canonical slow-roll models.
On the other hand when the EFT interactions are switched on within the present description, one can able to accommodate the non-canonical as well
as non-minimal interactions within this framework. In that case both c_S and $\tilde{c}_S$ are less than unity and in such a situation one can always constraint the sound speed parameter as well the strength
of the EFT interactions using observational probes (Planck 2015 data).
One can easily compare the present setup with effective time varying mass
parameter with the axions with time varying decay constant.
For $m << h$ case the last term in the effective action is absent and in that case the reduced form of the action will able to explain
the EFT of inflation in presence of previously mentioned non-trivial effective interactions. Once we switch off all such interactions the above action mimics the case for single field slow-roll inflation.

Further we have given an example of axion model with time dependent decay constant as appearing in the context of string theory. Hence we have mentioned the effective axion interaction of axion fields.
Now to give a analogy between the newly introduced massive particle and the axion we have further discussed the creation of axion in early universe.
Next we have established the one to one correspondence between heavy field and axion by com-

paring the particle creation mechanism, one and two point correlation functions.
Additionally, we have given an estimate of axion mass parameter $m_{axion}/f_a h$
to violate Bell's inequality within cosmological setup. Finally, we have discussed the specific role of
isospin breaking interaction for axion type of heavy fields to measure the effect of Bell's inequality violation in primordial cosmology.

Next we have explicitly shown the role of quantum decoherence in cosmological setup to violate Bell's inequality. Additionally here we have also
mentioned a possibility to enhance the value of primordial non-Gaussianity from Bell's inequality violating setup in presence of massive time dependent field profile. Further we have discussed the role of
three specific time dependent mass profile for producing massive particles and to generate quantum fluctuations. Finally, we have discussed the role of arbitrary spin heavy field to violate Bell's inequality.
Here we have provided a bound on the mass parameter for massive scalar with spin S=0, axion with spin S=0, graviton with spin S=2 and for particles with high spin S>2 in horizon crossing, super horizon
and sub horizon regime.

Summary

In this work, we have studied the possibility of setting up Bell's inequality violating experiment in the context of cosmology, based on the basic principles of quantum mechanics. First we start with the physical motivation of implementing the Bell's inequality violation in the context of cosmology. Then to set up the cosmological Bell violating test experiment we introduce a model independent theoretical framework using which we have studied the creation of new massive particles by implementing the WKB approximation method for the scalar fluctuations in presence of additional time dependent mass contribution in the cosmological perturbation theory. Here for completeness we compute total number density and energy density of the newly created particles in terms of Bogoliubov coefficients using WKB approximation method. Next using the background scalar fluctuation in presence of new time dependent mass contribution, we explicitly compute the expression for the one point and two point correlation functions.Furthermore, using the results for one point function we introduce a new theoretical cosmological parameter which can be expressed in terms of the other known inflationary observables and can also be treated as a future theoretical probe to break the degeneracy amongst various models of inflation. Additionally, we also fix the scale of inflation in a model independent way without any prior knowledge of primordial gravitational waves. Also using the input from newly introduced cosmological parameter, we finally give a theoretical estimate for the tensor-to-scalar ratio in a model independent way. Next, we also comment on the technicalities of measurements from isospin breaking interactions and the future prospects of newly introduced massive particles in cosmological Bell violating test experiment. Further, we cite a precise example of this set up applicable in the context of string theory motivated axion monodromy model. Then we comment on the explicit role of decoherence effect and high spin on cosmological Bell violating test experiment. In fine, we provide a theoretical bound on the heavy particle mass parameter for scalar fields, graviton and other high spin fields from our proposed setup.

Primary author: Dr CHOUDHURY, Sayantan (Department of Theoretical Physics, Tata Institute of Fundamental Research, Mumbai)

Presenter: Dr CHOUDHURY, Sayantan (Department of Theoretical Physics, Tata Institute of Fundamental Research, Mumbai)

Session Classification: [QE] Quantum entanglement and many-worlds interpretation

Contribution ID: **95** Type: **parallel**

Tests and problems of the standard model in Cosmology

Monday, 12 September 2016 16:10 (30 minutes)

Main foundations of the standard Lambda-CDM model of Cosmology are:
1) The redshifts of the galaxies are due to the expansion of the Universe plus the peculiar motions;
2) The cosmic microwave background radiation and its anisotropies come from the high energy primordial Universe when matter and radiation become decoupled;
3) The abundance pattern of the light elements is to be explained in terms of the primordial nucleosynthesis;
4) The formation and evolution of galaxies can only be explained in terms of gravitation within a inflation+dark matter+dark energy scenario.
Numerous tests have been carried out on these ideas and, although the standard model works pretty well to fit many observations, there are also many data that present some apparent caveats to be understood with it. In this talk, I offer a brief review of these tests and problems, as well as some examples of alternative models.

Summary

Primary author: LÓPEZ CORREDOIRA, Martín (Instituto de Astrofísica de Canarias)

Presenter: LÓPEZ CORREDOIRA, Martín (Instituto de Astrofísica de Canarias)

Session Classification: [OC/GW] Observational cosmology and gravitational waves

Contribution ID: **96** Type: **parallel**

The Number of Tidal Dwarf Satellite Galaxies in Dependence of Bulge Index

Friday, 16 September 2016 17:10 (20 minutes)

ABSTRACT: We show that a significant correlation (up to 5σ) emerges between the bulge index, defined to be larger for a larger bulge/disk ratio, in spiral galaxies with similar luminosities in the Galaxy Zoo 2 of the Sloan Digital Sky Survey and the number of tidal-dwarf galaxies in the catalog by Kaviraj et al. In the standard cold or warm dark matter cosmological models, the number of satellite galaxies correlates with the circular velocity of the dark matter host halo. In generalized gravity models without cold or warm dark matter, such a correlation does not exist, because host galaxies cannot capture infalling dwarf galaxies due to the absence of dark-matter-induced dynamical friction. However, in such models, a correlation is expected to exist between the bulge mass and the number of satellite galaxies because bulges and tidal-dwarf satellite galaxies form in encounters between host galaxies. This is not predicted by dark matter models in which bulge mass and the number of satellites are a priori uncorrelated because higher bulge/disk ratios do not imply higher dark/luminous ratios. Hence, our correlation reproduces the prediction of scenarios without dark matter, whereas an explanation is not found readily from the a priori predictions of the standard scenario with dark matter. Further research is needed to explore whether some application of the standard theory may explain this correlation.

Summary

Primary author: LÓPEZ CORREDOIRA, Martín (Instituto de Astrofísica de Canarias)

Presenter: LÓPEZ CORREDOIRA, Martín (Instituto de Astrofísica de Canarias)

Session Classification: [MG] Modifications of gravity

Contribution ID: **97** Type: **parallel**

Varying constants and cyclic universes

Monday, 12 September 2016 16:40 (30 minutes)

Using the method of regularization of singularities due to varying constants, I will first discuss some proposals to construct the cyclic models of the universe which can be connected by standard and non-standard singularities. Then, on the footing of thermodynamics and the 2nd law I will discuss the cyclic multiverse models having different values of the fundamental constants which can potentially exchange their entity due to quantum effects and quantum entanglement.

Summary

Primary author: MAROSEK, Konrad (University of Szczecin)

Co-authors: BALCERZAK, Adam; DABROWSKI, Mariusz (University of Szczecin)

Presenter: MAROSEK, Konrad (University of Szczecin)

Session Classification: [VC-T] Varying constants –theory

Contribution ID: **98** Type: **parallel**

Recovering a redshift-extended VSL signal from galaxy surveys

Thursday, 15 September 2016 17:00 (25 minutes)

We investigate a new method to recover (if any) a possible varying speed of light (VSL) signal from cosmological data on an extended redshift range. We use mock cosmological data from future galaxy surveys (BOSS, DESI, *WFirst-2.4* and SKA): the sound horizon at decoupling imprinted in the clustering of galaxies (BAO) as an angular diameter distance, and the expansion rate derived from those galaxies recognized as cosmic chronometers. We find that, given the forecast sensitivities of such surveys, a $\sim 1\%$ VSL signal can be detected at 3σ confidence level in the redshift interval $z \in [0., 1.55]$. Smaller signals ($\sim 0.1\%$) will be hardly detected
(even if some lower possibility for a 1σ detection is still possible). Finally, we discuss the degeneration between a VSL signal and a non-null spatial curvature: we show that, given present bounds on curvature, any signal, if detected, can be attributed to a VSL signal with a very high confidence. On the other hand, our method turns out to be useful even in the classical scenario of a constant speed of light: in this case, the signal we reconstruct can be totally ascribed to spatial curvature and,thus, we might have a method to detect a 0.01-order curvature in the same redhift range with a very high confidence.

Summary

Primary author: SALZANO, Vincenzo (University of Szczecin)

Presenter: SALZANO, Vincenzo (University of Szczecin)

Session Classification: [VC-O] Varying constants –astronomical observations

Contribution ID: **99** Type: **parallel**

Causality in "noncommutative spacetimes"

Friday, 16 September 2016 17:00 (25 minutes)

Drawing from the mathematical richness of noncommutative geometry, I will introduce the concept of an "almost commutative space-time" and show that it admits a sensible notion of causality. The latter does not affect classical causal relations in the space-time component, but it does induce highly non-trivial constraints on the "motion" in the "inner space". I will illustrate the general concept on a simple model and relate the outcomes to a relativistic quantum effect - the Zitterbewegung. I will conclude with a brief outlook into the nature of the causal relation in truly noncommutative spacetimes expected to emerge at the frontier of quantum theory and general relativity.

Summary

Primary author: ECKSTEIN, Michal (Jagiellonian University)

Presenter: ECKSTEIN, Michal (Jagiellonian University)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **100** Type: **parallel**

Causality for nonlocal phenomena

Friday, 16 September 2016 16:35 (25 minutes)

The talk will be based on a joint work with M. Eckstein (arXiv:1510.06386), in which we propose and study an extension of the causal precedence relation onto the space of Borel probability measures on a given spacetime. The developed formalism draws from the mathematical theory of optimal transport and rigorously codifies the intuition of a subluminal probability flow. This will be illustrated with several conditions, which are all equivalent provided the spacetime has a sufficiently robust causal structure. An application in the study of causality in quantum theory will be discussed.

Summary

Primary author: MILLER, Tomasz (Warsaw University of Technology)

Presenter: MILLER, Tomasz (Warsaw University of Technology)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **101** Type: **plenary**

Are We Alone in the Universe?

Thursday, 15 September 2016 18:30 (1 hour)

For 56 years astronomers have been sweeping the skies with radio telescopes in the hope of stumbling across a message from an extraterrestrial civilization. So far, nothing. Now the Search for Extraterrestrial Intelligence (SETI) has received a huge fillip with a $100 million donation by the philanthropist Yuri Milner. However, is the current search strategy misconceived? Should we abandon detecting messages in favour of a search for more diverse signatures of non-human technology? In this talk, which is based on my book The Eerie Silence, I shall outline the opportunities and challenges facing the new era of SETI.

Summary

Presenter: Prof. DAVIES, Paul C. W. (Arizona State University, USA)

Session Classification: Public lecture

Contribution ID: **102** Type: **plenary**

Measuring α-variation using highly-charged ions: clocks, calculations and astrophysics

Tuesday, 13 September 2016 11:30 (1 hour)

Several recent proposals to measure α-variation use highly-charged ions, in which the effects of a possible variation are enhanced [1]. These systems include potential new clocks that are predicted to have extraordinarily high accuracy [1-4]. In systems where the transitions are available due to level crossings, the clocks can have extremely high sensitivity to variation of the fine-structure constant α, potentially improving current limits on time-variation of α by up to two orders-of-magnitude.

The experimental spectroscopy of one such candidate, the Ir17+ ion which has two holes in the otherwise closed 4f14 5s2 valence shells, has shown that current theoretical methods have severe limitations in accurately describing the spectrum [5]. That study included (along with the experimental spectrum) the results of several calculations including different variants of configuration interaction (CI), multiconfigurational Dirac-Fock, and Fock-space coupled cluster. None of the theories tested were able to unambiguously identify the entire observed spectrum. Furthermore many existing methods of calculation –such as the combined configuration interaction and many-body perturbation theory (CI+MBPT), correlation potential methods, and coupled-cluster methods –are designed to work well in one or two-valence-electron atoms and particularly in near-neutral systems.

We have developed an ab initio method of calculating atomic spectra and properties in complicated systems, such as HCIs and particularly where electron-holes play an important role. Based on the CI+MBPT method [6], we have implemented Wick contractions numerically in AMBiT allowing the inclusion of configurations with arbitrary numbers of valence holes and electrons. As a first test case, we have performed calculations of spectra and sensitivity to α-variation for the Hg+ ion, where the clock transition 6s to 5d−1 6s2 has been compared with an Al+ clock to get the best current limit on time-variation of α [7]. We present results of the full CI+MBPT method with holes, and updated limits on time-variation of α based on the existing experiment [8].

The enhanced sensitivity to α-variation of highly-charged ions is also exploited in astrophysical measurements of metal lines in the spectra of white-dwarf stars [9]. These are used to probe the dependence of α on a strong gravitational field. While the FeV and NiV ions used in this study are less highly-charged, many of the limitations in the accuracy of calculations are common to the clock HCIs.

References

[1] J. C. Berengut, V. A. Dzuba, and V. V. Flambaum, Enhanced laboratory sensitivity to variation of the fine-structure constant using highly charged ions, Phys. Rev. Lett. 105, 120801 (2010).

[2] J. C. Berengut, V. A. Dzuba, V. V. Flambaum, and A. Ong, Hole Transitions in Multiply-Charged Ions for Precision Laser Spectroscopy and Searching for α-variation, Phys. Rev. Lett. 106, 210802 (2011).

[3] A. Derevianko, V. A. Dzuba, and V. V. Flambaum, Highly-Charged Ions as a Basis of Optical Atomic Clockwork of Exceptional Accuracy, Phys. Rev. Lett. 109, 180801 (2012).

[4] J. C. Berengut, V. A. Dzuba, V. V. Flambaum, and A. Ong, Optical transitions in highly-charged californium ions with high sensitivity to variation of the fine-structure constant, Phys. Rev. Lett. 109, 070802 (2012).

[5] A. Windberger et al., Identification of the Predicted 5s–4 f Level Crossing Optical Lines with Applications ?to Metrology and Searches for the Variation of Fundamental Constants, Phys. Rev. Lett. 114, 150801 (2015).

[6] V. A. Dzuba, V. V. Flambaum and M. G. Kozlov, Combination of the Many-body Perturbation Theory with the Configuration-Interaction Method, Phys. Rev. A 54, 3948 (1996)
[7] T. Rosenband et al., Frequency Ratio of Al+ and Hg+ Single-Ion Optical Clocks; Metrology at the 17th Decimal Place, Science 319, 1808 (2008).
[8] J. C. Berengut, Particle-hole configuration interaction and many-body perturbation theory: Application to Hg+, Phys. Rev. A, 94, 012502 (2016).
[9] J. C. Berengut, V. V. Flambaum, A. Ong, J. K. Webb, J. D. Barrow, M. A. Barstow, S. P. Preval, and J. B. Holberg, Limits on the Dependence of the Fine-Structure Constant on Gravitational Potential from White-Dwarf Spectra, Phys. Rev. Lett. 111, 010801 (2013).

Summary

Presenter: Prof. BERENGUT, Julian (University of New South Wales, Australia)

Session Classification: Plenary session II

Contribution ID: **104** Type: **plenary**

Predictions from the Quantum Multiverse

Friday, 16 September 2016 11:30 (1 hour)

In trying to understand the selection of the initial state of the universe, physics is experiencing a paradigm shift on the last decade. A multiverse extension of the standard model of cosmology is now a promising and active direction of research. I will provide a brief introduction of various efforts in extending cosmic inflation to a multiverse origin. I will then describe in some detail how we can derive, instead of postulating, the selection of the initial state of the universe in the context of my theory of the quantum multiverse; and, how, information about the origin of our universe can be revealed and tested with current astrophysical data.

Summary

Presenter: MERSINI-HOUGHTON, Laura (University of North Carolina at Chapel Hill, USA)

Session Classification: Plenary session V

Contribution ID: **105** Type: **plenary**

Frequency ratios of optical lattice clocks at the 17th decimal place

Tuesday, 13 September 2016 09:00 (1 hour)

Optical lattice clocks benefit from a low quantum-projection noise by simultaneously interrogating a large number of atoms, which are trapped in an optical lattice tuned to the "magic wavelength"to largely cancel out light shift perturbation in the clock transition. About a thousand atoms enable the clocks to achieve 10^{-18} instability in a few hours of operation, allowing intensive investigation and control of systematic uncertainties. It is now the uncertainty of the SI second ($\sim 10^{-16}$) itself that restricts the measurement of the absolute frequencies of such optical clocks. Direct comparisons of optical clocks are, therefore, the only way to investigate and utilize their superb performance beyond the SI second.
In this presentation, we report on frequency comparisons of optical lattice clocks with neutral strontium (^{87}Sr), ytterbium (^{171}Yb) and mercury (^{199}Hg) atoms. By referencing cryogenic Sr clocks [1], we determine frequency ratios, $\nu_{\mathrm{Yb}}/\nu_{\mathrm{Sr}}$ [2] and $\nu_{\mathrm{Hg}}/\nu_{\mathrm{Sr}}$ [3], of a cryogenic Yb clock and a Hg clock with uncertainty at the mid 10^{-17}. Such ratios provide an access to search for temporal variation of the fundamental constants. We also present remote comparisons between cryogenic Sr clocks located at RIKEN and the University of Tokyo over a 30-km-long phase-stabilized fiber link. The gravitational red shift $\Delta\nu/\nu_0 \approx 1.1\times10^{-18}\ \Delta\mathrm{h}\ \mathrm{cm}^{-1}$ reads out the height difference of Δh˜15 m between the two clocks with uncertainty of 5 cm, which demonstrates a step towards relativistic geodesy. We also mention our ongoing experiments that reduce clock uncertainty to 10^{-19} by applying "operational magic frequency,"[4], where light shifts due to dipole, multipolar, and hyper-polarizability effects effectively cancel out for a certain range of optical lattice intensity.

[1] I. Ushijima, et al., Nature Photon. 9, 185 (2015).
[2] N. Nemitz, et al., Nature Photon. 10, 258 (2016).
[3] K. Yamanaka, et al., Phys. Rev. Lett. 114, 230801 (2015).
[4] H. Katori, et al., Phys. Rev. A 91, 052503 (2015).

Summary

Presenter: Prof. KATORI, Hidetoshi (University of Tokyo, Japan)

Session Classification: Plenary session II

Contribution ID: **106** Type: **plenary**

Varying constants, cosmology and the puzzle of quantum gravity

Monday, 12 September 2016 10:05 (55 minutes)

Varying constants theories in several guises may be essential for the resolution of a number of impasses in cosmology and quantum gravity. Perhaps the most radical of them all –varying c theories –may be the clue to extracting phenomenology from quantum gravity theories, finally rendering the field properly a branch of science. I will review this possibility, with particular emphasis on the issue of the generation of cosmic structure and primordial gravitational waves.

Summary

Presenter: Prof. MAGUEIJO, João (Imperial College, London, United Kingdom)

Session Classification: Plenary session I

Contribution ID: **107** Type: **plenary**

Varying constants and the cosmological constant problem

Wednesday, 14 September 2016 10:00 (1 hour)

I will discuss how quantum mechanics makes the vacuum energy very sensitive to the values of physical parameters and how this exacerbates the cosmological constant problem in theories with varying 'constants'. Models of "interacting dark energy" in which the masses of dark matter states depend on the dark energy sector provide a striking example of this: in some models the finetuning of the vacuum energy is exacerbated from one part in 10ˆ50 to one part in 10ˆ(10ˆ10). I will discuss how such models are too fine-tuned to be compatible with an anthropic solution to the cosmological constant problem in the presently understood string theory landscape. Such models admit distinctive observational signatures that may be detected by future experiments, hence providing an opportunity to observationally rule out the anthropic
landscape solution of the cosmological constant problem in any theory with a finite number of vacua.

Summary

Presenter: MARSH, David (University of Cambridge)

Session Classification: Plenary session III

Contribution ID: **108** Type: **plenary**

Fundamental cosmology in the E-ELT era

Thursday, 15 September 2016 11:30 (1 hour)

The observational evidence for the recent acceleration of the universe demonstrates that canonical theories of cosmology and particle physics are incomplete (and possibly incorrect) and that new physics is out there, waiting to be discovered. The most fundamental task for the next generation of astrophysical facilities is to search for, identify and ultimately characterize this new physics. I will highlight the E-ELT's key role in this quest. After a short overview of theoretical motivations for new physics, the discussion will focus on precision spectroscopy tests of fundamental physics and cosmology. I will summarize the current status of these tests, discuss a classification of physically motivated models, and present some forecasts of the improvements that the E-ELT will enable (comparing them to ESPRESSO when appropriate). Time permitting I will also briefly comment on synergies with other E-ELT instruments, and with other facilities such as ALMA and Euclid.

Summary

Presenter: MARTINS, Carlos (University of Porto)

Session Classification: Plenary session IV

Contribution ID: **109** Type: **plenary**

Dark Matter, Dark Energy, Gravitational Waves and Black Holes

Friday, 16 September 2016 10:00 (1 hour)

The standard model of cosmology features three key theoretical paradigms:

1) Inflation
2) Dark Matter
3) Dark Energy (accelerated expansion of the universe)

Inflation has severe fine-tuning problems and the need for eternal inflation and a multiverse. The alternative model Variable Speed of Light Cosmology (VSL) can avoid these problems and fit available observational data. The CMB is described with remarkable success by the standard concordance model, based on six parameters. Of these the dark matter Ωm and dark energy ΩΛ parameters are poorly understood. Dark matter particle candidates have not been conclusively observed in the present universe in laboratory and satellite experiments. Dark Energy can be explained by the cosmological constant at the price of a huge fine-tuning problem. Moreover, the assumptions of a homogeneous and isotropic LFRW universe and the Copernican principle have not been fully tested. A modified gravitation (MOG) theory will be reviewed that can explain the lack of direct non-gravitational detection of Dark Matter in the present universe and its ability to fit galaxy and galaxy cluster data will be described. The conservative explanation of the accelerated expansion of the universe based on voids will be reviewed. The LIGO-Virgo experimental detection of gravitational waves and Event Horizon Telescope imaging of the supermassive black holes Sagittarius A* and M37 will be able to distinguish MOG black holes from the Schwarzschild and Kerr black holes.

Summary

Presenter: MOFFAT, John (Perimeter Institute)

Session Classification: Plenary session V

Contribution ID: **110** Type: **plenary**

Fundamental constants, gravitation and cosmology – recent developments

Monday, 12 September 2016 09:10 (55 minutes)

Fundamental constants play a central role in the laws of physics. Any detection of the variation of these constant would signal a violation of the Einstein equivalence principle, and thus the need to go beyond general relativity. After recalling the links between fundamental constants and theories of gravity, I will focus on recent developments to constrain their time variation, mostly concentrating on big-bang and stellar nucleosynthesis as well as the analysis of the observations by the Planck satellite. The connection with cosmology, in particular the physics of the dark sector and fine tuning issues will be discussed.

Summary

Presenter: Prof. UZAN, Jean-Philippe (Institut d'Astrophysique de Paris (IAP), France)

Session Classification: Plenary session I

Contribution ID: **111** Type: **plenary**

Spacetime variations of the varying alpha: The first 1000 high-precision measurements

Thursday, 15 September 2016 09:00 (1 hour)

We are preparing a large sample of high-precision varying alpha measurements using quasar spectra. The measurements are being made using the new automated AI methodology described in arXiv:1606.07393 which eliminates any important human bias. A detailed study of long-range wavelength distortions in UVES/VLT and HIRES/Keck samples will also be described. I will show that such distortions are indeed present, but do not explain the tentative spatial variation of alpha, contrary to a previous claim. Moreover, long range wavelength distortions can be accurately measured using the quasar spectra themselves and hence can be removed from the final set of alpha measurements.

Summary

Presenter: WEBB, John (UNSW)

Session Classification: Plenary session IV

Contribution ID: **113** Type: **parallel**

Varying constant theories from thermodynamics perspective

Monday, 12 September 2016 16:10 (30 minutes)

We formulate the basic framework of thermodynamical entropic force cosmology which allows variation of the gravitational constant G and the speed of light c. Some cosmological solutions are given and tested against combined observational data (supernovae, BAO, and CMB). We observationally test that the fit of the data is allowed for the speed of light c growing and the gravitational constant G diminishing during the evolution of the universe. We also obtain a bound on the variation of c to be 916;c / c 8733; 10^{-5} > 0 , which is at least one order of magnitude weaker than the quasar spectra observational bound.

Summary

Primary author: GOHAR, Hussain (University of Szczecin, Poland)

Presenter: GOHAR, Hussain (University of Szczecin, Poland)

Session Classification: [VC-T] Varying constants –theory

Contribution ID: **114** Type: **parallel**

Complete Hamiltonian analysis of cosmological perturbations at all orders

Thursday, 15 September 2016 16:10 (30 minutes)

The work is based on two following papers:

1. D. Nandi and S. Shankaranarayanan, Complete Hamiltonian analysis of cosmological perturbations at all orders, JCAP 1606 (2016), no. 06 038, [arXiv:1512.02539].
2. D. Nandi and S. Shankaranarayanan, Complete Hamiltonian analysis of cosmological perturbations at all orders II: Non-canonical scalar field, submitted in JCAP, [arXiv:1606.05747].

Summary

Cosmological perturbation theory is currently a preferred mathematical procedure to compare the equations of gravity with precise observations. However, due to the difficulties in interpreting gauge-invariance and invertibility in Hamiltonian formalism, there is no consistent and generalized Hamiltonian analysis for cosmological perturbation theory at any order for any kind of model of gravity. In this work, using a simple model, we provide a simple mathematical approach to deal with all the difficulties to obtain a consistent Hamiltonian formalism and extend the approach to canonical scalar field. We show that our approach can be applied to any order of perturbation for any first order derivative fields. We also apply our approach to Galilean scalar field model and show that, there is no extra degrees of freedom, as expected, at every order of perturbation and obtain all consistent equations of motion. We compare and contrast our approach to the Lagrangian approach (Chen et al [2006]) for extracting higher order correlations and show that our approach is quick and robust and can be applied to any model of gravity and matter fields without invoking slow-roll approximation. This approach can not only be used for higher order correlation but can also be used to obtain mixed-mode correlation functions at any level of perturbations. Finally, by introducing a new phase-space variable, we show that the approach can also be easily extended to generalized non-canonical scalar field and it leads to a new definition of speed of sound in phase-space.

Primary author: NANDI, Debottam

Co-author: Prof. SHANKARANARAYANAN, S. (IISER-TVM)

Presenter: NANDI, Debottam

Session Classification: [INF/DM] Inflation, early universe and dark matter

Contribution ID: **117** Type: **parallel**

Vacua and correlators on hyperbolic de Sitter sections

Tuesday, 13 September 2016 14:35 (35 minutes)

Keywords:

- Eternal inflation
- Bubble nucleation
- de Sitter space
- Entanglement

Summary

I study the power- and bi-spectrum of vacuum fluctuations in a hyperbolic section of de Sitter space, comparing two states of physical interest: the Bunch-Davies and the hyperbolic vacuum. By introducing a one-parameter family of de Sitter hyperbolic sections and identifying a limit in which it reduces to the planar section, the family of hyperbolic states can be explicitly related to the standard Bunch-Davies state. Using this relation I then display the deviations from the standard inflationary predictions for the power- and bi-spectrum by considering the pure hyperbolic vacuum. In particular, for the bi-spectrum in the hyperbolic vacuum I will show that the corrections as compared to the standard Bunch-Davies result are not enhanced in specific momentum configurations and strongly suppressed for momenta large compared to the hyperbolic curvature scale. We close with some final remarks on physical states in de Sitte and its consequences for the stability of de Sitter space-time, which might have important implications for eternal inflation.

Primary author: VAN DER SCHAAR, Jan Pieter (University of Amsterdam)

Presenter: VAN DER SCHAAR, Jan Pieter (University of Amsterdam)

Session Classification: [QE] Quantum entanglement and many-worlds interpretation

Contribution ID: **118** Type: **parallel**

Non-minimally coupled varying constants quantum cosmologies

Monday, 12 September 2016 15:10 (30 minutes)

We consider gravity theory with varying speed of light and varying gravitational constant. Both constants are represented by non-minimally coupled scalar fields. We examine the cosmological evolution in the near curvature singularity regime. We find that at the curvature singularity the speed of light goes to infinity while the gravitational constant vanishes. This corresponds to the Newton's Mechanics limit represented by one of the vertex of the Bronshtein-Zelmanov-Okun cube. The cosmological evolution includes both the pre-big-bang and post-big-bang phases separated by the curvature singularity. We also investigate the quantum counterpart of the considered theory and find the probability of transition of the universe from the collapsing pre-big-bang phase to the expanding post-big-bang phase.

Summary

Primary author: BALCERZAK, Adam

Presenter: BALCERZAK, Adam

Session Classification: [VC-T] Varying constants –theory

Contribution ID: **119** Type: **parallel**

Universe's memory and spontaneous coherence in loop quantum cosmology

Monday, 12 September 2016 17:25 (25 minutes)

The quantum bounce a priori connects several (semi)classical epochs of Universe evolution, however determining if and how well the semiclassicality is preserved in this transition is highly nontrivial. We review the present state of knowledge in that regards in the isotropic sector of loop quantum cosmology. This knowledge is next extended by studies of an isotropic universe admitting positive cosmological constant (featuring an infinite chain of large Universe epochs). It is also shown, that such universe always admits a semiclassical epoch thanks to spontaneous spontaneous coherence, provided it is semiclassical in certain constant of motion playing the role of energy.

Summary

Primary author: PAWLOWSKI, Tomasz (Center for Theoretical Physics, Polish Academy of Science)

Presenter: PAWLOWSKI, Tomasz (Center for Theoretical Physics, Polish Academy of Science)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **120** Type: **parallel**

Searching for optical counterparts to gravitational wave events –and how it might be done by wide field surveys

Monday, 12 September 2016 15:00 (30 minutes)

The talk will focus on different observation strategies that might be used for wide field telescope surveys in order to find electromagnetic (EM) counterpart to gravitational wave (GW) event, and possible implication of finding such counterpart. Information carried by GW and EM bands are complementary. GW brings information about acceleration of the mass in the source when EM carries the information about the outcome of the event. If for example a gravitational wave would be observed jointly with short GRB, than the nature of such event might fully understood. In order to find EM counterparts to GW events LSC-Virgo with many astronomical partners created EM Follow-up project. The strategies of observations for wide field telescopes that I would like to present are derived from observations done by Pi of the Sky telescope for LSC-Virgo in 2010 (Looc-Up project) and 2015 - ... (EM Follow-up project).

Summary

Primary author: ZADROZNY, Adam (National Centre for Nuclear Research, Poland)

Presenter: ZADROZNY, Adam (National Centre for Nuclear Research, Poland)

Session Classification: [OC/GW] Observational cosmology and gravitational waves

Contribution ID: **121** Type: **parallel**

Observational consequences of an interacting multiverse

Friday, 16 September 2016 15:10 (30 minutes)

The paradigm of an interacting multiverse opens the door to a new wide variety of cosmic phenomena to be explored. In this talk, we shall show that the interactions among the universes of the multiverse may change the global properties of the universes without violating their notion of causal closure (in the local sense). These changes would eventually have observational consequences on the properties of the universes, some of which turn out to be distinguishable and distinctive of the multiverse. Thus, the interacting multiverse turns out to be testable, a feature that was probably untenable not so many years ago. We shall also analyse different processes that can be given in the interacting multiverse like the creation of the universes in entangled pairs, the appearance of a landscape-like structure of vacuum states, or the effective modification of the value of the field potential, among others.

Summary

The paradigm of an interacting multiverse opens the door to a new wide variety of cosmic phenomena to be explored. In this talk, we shall show that the interactions among the universes of the multiverse may change the global properties of the universes without violating their notion of causal closure (in the local sense). These changes would eventually have observational consequences on the properties of the universes, some of which turn out to be distinguishable and distinctive of the multiverse. Thus, the interacting multiverse turns out to be testable, a feature that was probably untenable not so many years ago. We shall also analyse different processes that can be given in the interacting multiverse like the creation of the universes in entangled pairs, the appearance of a landscape-like structure of vacuum states, or the effective modification of the value of the field potential, among others.

Primary author: Dr ROBLES-PEREZ, Salvador (IFF-EEBM)

Co-authors: Dr ALONSO-SERRANO, Ana (Institute for Fundamental Physics); Dr BASTOS, Catarina (Instituto de Plasmas e Fusao Nuclear, IT); Prof. BERTOLAMI, Orfeu (Departamento de Física e Astronomia, UP)

Presenter: Dr ROBLES-PEREZ, Salvador (IFF-EEBM)

Session Classification: [MV] Multiverse

Contribution ID: **122** Type: **parallel**

Observational Consequences of Scalar-tensor Entanglement During Inflation

Tuesday, 13 September 2016 16:10 (35 minutes)

We consider the effects of entanglement in the initial quantum state of scalar and tensor fluctuations during inflation. We allow the gauge-invariant scalar and tensor fluctuations to be entangled in the initial state and compute modifications to the various cosmological power spectra. We compute the angular power spectra (C_l's) for some specific cases of our entangled state and discuss what signals one might expect to find in CMB data. This entanglement also can break rotational invariance, allowing for the possibility that some of the large scale anomalies in the CMB power spectrum might be explained by this mechanism.

Summary

Primary author: BOLIS, Nadia (UC Davis)

Presenter: BOLIS, Nadia (UC Davis)

Session Classification: [QE] Quantum entanglement and many-worlds interpretation

Contribution ID: **123** Type: **parallel**

Synthetic approach to the singularity problem

Monday, 12 September 2016 14:00 (25 minutes)

We try to convince the reader that the categorical version of differential geometry, called Synthetic Differential Geometry (SDG), offers valuable tools which can be applied to work with some unsolved problems of general relativity. We do this with respect to the space-time singularity problem. The essential difference between the usual differential geometry and SDG is that the latter enriches the real line by introducing infinitesimal of various kinds. Owing to this geometry acquires a tool to penetrate "infinitesimally small"parts of a given manifold. However, to make use of this tool we must switch from the category of sets to some other suitable category. We try two topoi: the topos
$calG$ of germ determined ideals and the so-called Basel topos
$calB$. The category of manifolds is a subcategory of both of them. In
$calG$, we construct a simple model of a contracting sphere. As the sphere shrinks, its curvature increases, but when the radius of the sphere reaches infinitesimal values, the curvature becomes infinitesimal and the singularity is avoided. The topos
$calB$, unlike the topos
$calG$, has invertible infinitesimal and infinitely large nonstandard natural numbers. This allows us to see what happens when a function "goes through a singularity". When changing from the category of sets to another topos, one must be ready to switch from classical logic to intuitionistic logic. This is a radical step, but the logic of the universe is not obliged to conform to the logic of our brains.

Summary

Primary author: Prof. HELLER, Michael (Vatican Astronomical Observatory; Copernicus Center, Kraków, Poland)

Presenter: Prof. HELLER, Michael (Vatican Astronomical Observatory; Copernicus Center, Kraków, Poland)

Session Classification: [QC] Quantum gravity and cosmology

Contribution ID: **124** Type: **parallel**

Modified gravity with vector distortion and cosmological applications

Friday, 16 September 2016 15:10 (30 minutes)

I will introduce a geometrical framework with a connection that is fully determined by a vector field as a generalization of Weyl geometry. Within these geometries, it is possible to formulate gravitational theories that lead to interesting vector-tensor theories with non-minimal couplings and derivative self-interactions such that the vector only propagates the 3 polarizations corresponding to a Proca field. I will discuss some cosmological applications of these theories.

Summary

Primary author: BELTRAN JIMENEZ, Jose (Universite d'Aix-Marseille)

Presenter: BELTRAN JIMENEZ, Jose (Universite d'Aix-Marseille)

Session Classification: [MG] Modifications of gravity

Contribution ID: **126** Type: **parallel**

Varying constants quantum cosmology

Monday, 12 September 2016 17:10 (30 minutes)

In the talk I will focus on quantum cosmology minisuperspace models based on the Wheeler–DeWitt equation which apart from standard matter and 3-geometry configuration degrees of freedom allow those related to the variability of physical constants –varying speed of light (VSL) c and varying gravitational constant G. The probability of tunneling of the universe "from nothing"to the Friedmann phase will be discussed and its dependence on these extra degrees of freedom and on the matter content.

Summary

Primary author: LESZCZYŃSKA, Katarzyna (University of Szczecin)

Presenter: LESZCZYŃSKA, Katarzyna (University of Szczecin)

Session Classification: [VC-T] Varying constants –theory