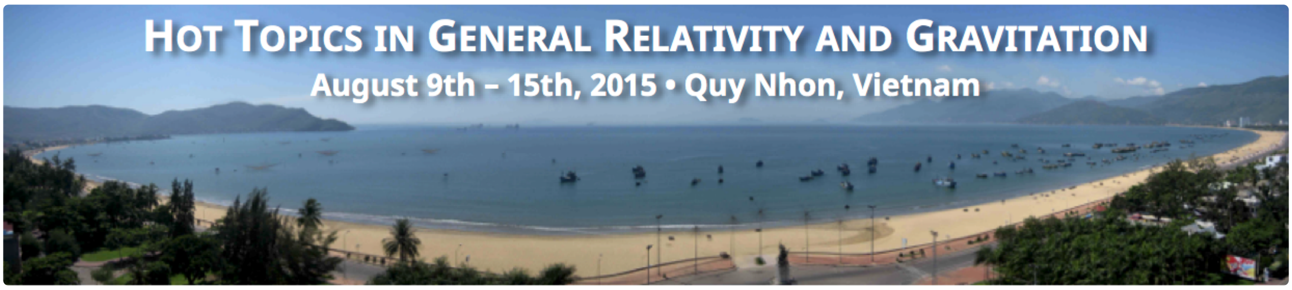

Hot Topics in General Relativity and Gravitation

August 9th – 15th, 2015, Quy Nhon, Vietnam

(Updated on August 25, 2015)

This international conference is held at ICISE as part of the Rencontres du Vietnam.

In this centennial anniversary of General Relativity, our aims are to discuss and review recent developments on:

— Mathematical Relativity
— Black Hole Physics
— Gravitational waves and Numerical Relativity
— Quantum Field Theory in Curved Spacetime
— Quantum Gravity
— AdS/CFT (gauge/gravity) Correspondence
— Strings, Branes, and Higher-dimensional Gravitational Theories
— Modified Gravity Theories
— Dark Energy and Dark Matter
— Inflation and the early universe
— Gravitational Lensing
— Relativistic Astrophysics

The International Centre for Interdisciplinary Science Education (ICISE) is located in a pleasant place at the seaside of the city of Quy Nhon (Central Vietnam) where conferences to the international standard can be organized. It contributes to the development of research and education in Vietnam and in this region of Asia. With this motivation in mind, Asian scientists are encouraged to meet for events (conferences, schools and workshops) and to share knowledge / expertise with their foreign counterparts.

Since 1993, the institution "Rencontres du Vietnam", which is an official partner of UNESCO, has organized international meetings (conferences and schools) to high scientific level with the motivation of foster exchanges between Vietnamese researchers or from Asia-Pacific and their colleagues coming from other parts of the world.

www.cpt.univ-mrs.fr/~cosmo/HTGRG-2/

Content


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CENTRE INTERNATIONAL DE SCIENCE ET D'EDUCATION INTERDISCIPLINAIRES
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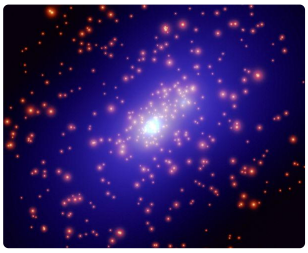
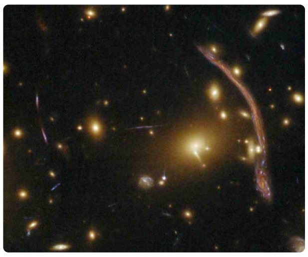
Scope

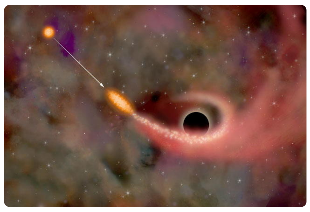
In this centennial anniversary of General Relativity, we will hold a conference on Hot Topics in General Relativity and Gravitation with the motivation to emphasize the tremendous progresses that have been made in Astrophysics and in Cosmology since Einstein's discovery of General Relativity (GR) in 1915.

Nowadays, the space-time dynamics has been enriched with new concepts that appeared in Cosmology, Black Holes Physics and Gravitational Waves. They provide us with enlightening on issues in which GR plays a fundamental role. Faced to these scientific goals to reach, observation technologies have been improved with impressive developments in a large window wavelength and for several types of sources, which initiates the era of multi-messenger astronomy.

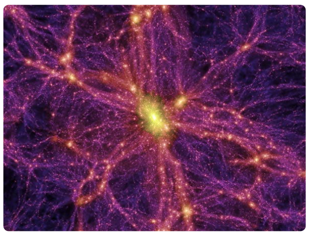




The Standard Cosmological Model describes the expansion of the observable universe by pointing out the presence of Dark Matter (DM) as the main component of massive gravitational sources. Also, it is a necessary ingredient for modeling the dynamics of gravitational sources at smaller scales, as for individual galaxies (the rotation curves of spiral galaxies) and galaxies in clusters (e.g., their kinematics and the surrounding gravitational lensing effects). However, High Energy Physics has not yet provides us with the corresponding weakly interacting massive particles, although new particles beyond the standard model might be promising DM candidates. Furthermore, the attempts at explaining the cosmological constant as related to the energy density of vacuum (quantum fluctuations) have failed. Hence, although a non-zero cosmological (universal) constant would be the simplest interpretation of the observed acceleration of the universe expansion, alternative approaches named Dark Energy have been also envisaged. They include modified theories of gravity or unknown non-standard matter fields such as quintessence. The inflationary paradigm successfully accounts the primordial era of the Universe, in agreement with recent observational data. However, while being confirmed at the phenomenological level, it suffers from conceptual difficulties (we still do not know the origin of the inflation). The understanding of these issues will lead to new advances in fundamental physics.



Direct evidence of the existence of Black Holes (BH) has not yet been made but the phenomena they cause in their environment demonstrate their presence and help us to better understand how they work. Their detection can be done either by the interpretation of the trajectories of nearby stars, or by its activity as inferred from the interaction with its immediate environment. Before falling into the black hole, matter revolves around him and starts to heat up considerably by emitting intense radiation; the quasar could be interpreted as such a process. In the absence of interacting matter, the BH can also be stealthy. For example, the BH found at the center of our galaxy is part of the category of supermassive BH while is not active. According to astronomers, most galaxies could harboring one, the largest of which might reach several billion solar masses. Some high-energy astrophysical phenomena can be explained by assuming the existence of a BH but the models have still to be improved, with (possibly) a new physics. The most promising way to detect BHs would be the gravitational waves (GW) by using ground-based and space-based GW detectors, which stands for a new observation window in astronomy. The detailed study of the coalescence of compact binary systems will give not only a wealth of information about astrophysical parameters such as their masses but will also reveal the equation of state at quite high density. The coalescence of BH binaries may give an accurate test of the BH no-hair conjecture in GR. It can be also used to test gravitational theories. Numerical Relativity is a key method in these studies.



More fundamental questions also arise about the gravitational interaction, and in particular, the quantization of Gravity is one of the most important. Several approaches are competing on this issue and they have not yet reached a general approbation. For example, superstring theory reconciles quantum mechanics and Einstein's theory of gravitation but his mathematical construction remains incomplete. On the other hand, AdS/CFT correspondence is another interesting way to study gravitational phenomena in the relation to strongly coupled quantum field theories. It can be extended to gauge/gravity or fluid/gravity correspondence. It has been used to study nuclear and condensed matter physics.

The fundamental subjects in astrophysics, cosmology and high energy physics are closely related to GR. Hence, we will survey the progress and recent developments in some hot topics on GR and related subjects. We will also discuss the improvements on unsolved problems on general relativity and gravitation.

Schedule

Sunday, August 9, 2015 — Arrival of participants at Seagull Hotel

12:00 – 14:00 Lunch
14:00 – 18:30 Registration
18:30 – 19:30 Welcome cocktail
19:30 – 21:00 Dinner

Monday, August 10, 2015 — ICISE

08:00 – 08:30 Shuttle from Hotel to ICISE

08:30 – 09:00 **Presentation of HTGRG**

Main Conference Hall — Opening

Chairperson: Roland **Triay** (CPT-AMU)

08:30 – 08:45 Jean **Trân Thanh Vân** (ICISE)
Welcome at ICISE

08:45 – 09:00 Welcome address of the President of the Bình Định Province

09:00 – 09:15 Group photo

09:15 – 09:45 Coffee Break

09:45 – 10:00 **Scientific Activities**

Main Conference Hall — Scientific Activities

Chairperson: Roland **Triay** (CPT-AMU)

09:45 – 10:00 Kei-ichi **Maeda** (WU)
Scientific Opening

10:00 – 12:00 **Scientific Activities**

Main Conference Hall — Gravitational Waves

Chairperson: Kei-ichi **Maeda** (WU)

10:00 – 10:45 Takahiro **Tanaka** (Kyoto Univ.)
Testing modified gravity by gravitational waves

10:45 – 11:30 Seiji **Kawamura** (ICRR, UTokyo)
Gravitational Waves Astronomy

11:30 – 12:00 Jun'ichi **Yokoyama** (RESCEU)
Gravitational Waves from the Early Universe

12:00 – 13:30 Lunch

13:30 – 15:00 **Scientific Activities**

Main Conference Hall — Gravitational Waves

Chairperson: Seiji **Kawamura** (ICRR, UTokyo)

13:30 – 14:00 Kenta **Kiuchi** (YITP)
Recent progress of compact binary merger simulations in Kyoto numerical relativity group

14:00 – 14:30 Irene **Di Palma** (MPI - AEI)
Searches for continuous gravitational waves: recent results in data from the LIGO and Virgo detectors

14:30 – 15:00 Luc **Blanchet** (IAP)
Post-Newtonian theory versus Black Hole perturbations

15:00 – 15:30 Coffee Break

15:30 – 17:00 **Scientific Activities**

Main Conference Hall — Gravitational Waves — Gamma Rays Sources

Chairperson: Luc **Blanchet** (IAP)

15:30 – 16:00 Hirotaka **Yoshino** (KEK)
Axion Bosenova and Gravitational Waves

16:00 – 16:20 Laura **Bernard** (IAP)
Equations of motion of compact binaries at fourth post-Newtonian order

16:20 – 16:40 Vera Yurievna **Sinitsyna** (FIAN)
The results of 20-year observations of Cygnus Region at TeV energies

16:40 – 17:00 Vera Georgievna **Sinitsyna** (FIAN)
TeV gamma-ray emission from region of Perseus Cluster: NGC 1275 and GK Per

17:00 – 18:00 **Posters Session**

18:00 – 18:30 Leisure time and informal discussions

18:30 – 19:00 Shuttle from ICISE to Hotel

19:00 – 20:30 Dinner

Tuesday, August 11, 2015 — ICISE

08:00 – 08:30 Shuttle from Hotel to ICISE

08:30 – 10:00 **Scientific Activities**

Main Conference Hall — Black Holes

Chairperson: Hideo **Kodama** (KEK)

08:30 – 09:15 Hong **Lu** (BNU)
Black Holes — the First 99 Years

09:15 – 10:00 Vitor **Cardoso** (IST)
Black holes as particle detectors

10:00 – 10:30 Coffee Break

10:30 – 12:00 **Scientific Activities**

Main Conference Hall — Black Holes

Chairperson: Rong-Gen **Cai** (ITP-CAS)

10:30 – 11:00 Tomohiro **Harada** (Rikkyo U)
Primordial black hole formation from cosmological fluctuation

11:00 – 11:30 Sang Pyo **Kim** (KNU)
Schwinger Effect and Hawking Radiation in Charged Black Holes

11:30 – 12:00 Tetsuya **Shiromizu** (Nagoya)
Positive mass theorem as a principle

12:00 – 13:30 Lunch

13:30 – 15:00 **Scientific Activities**

Main Conference Hall — Black Holes

Chairperson: Sang Pyo **Kim** (KNU)

13:30 – 14:00 David **Tong** (Cambridge)
Black Holes and Conductivity

14:00 – 14:30 Kentaro **Tanabe** (KEK)
The Large D limit of General Relativity

14:30 – 15:00 Masahide **Yamaguchi** (TITECH)
Galilean Creation of the Inflationary Universe

15:00 – 15:30 Coffee Break

15:30 – 17:00 **Scientific Activities**

Main Conference Hall — Miscelaneous

Chairperson: Roland **Triay** (CPT-AMU)

15:30 – 16:00 Yu-Qing **Lou** (THCA)
Hypermassive Black Holes in the Universe : Theoretical Prediction to Observational Evidence

16:00 – 16:20 Sousuke **Noda** (Nagoya-U)
Wave Optics in Kerr spacetime and Black Hole Shadows

16:20 – 16:40 Steven **Kauffmann** (APS)
Key Consequences of Theoretical Self-Consistency in GR

16:40 – 17:00 Thuan **Vo Van** (VINATOM)
Lepton mass hierarchy in the light of time-space symmetry with microscopic curvatures

17:00 – 18:30 Leisure time and informal discussions

18:30 – 19:00 Shuttle from ICISE to Hotel

19:00 – 20:30 Dinner

Wednesday, August 12, 2015 — ICISE (morning) and Excursion (afternoon)

08:00 – 08:30 Shuttle from Hotel to ICISE

08:30 – 10:00 **Scientific Activities**

Main Conference Hall — Quantization of Gravity —| AdS/CFT

Chairperson: Hideo **Kodama** (KEK)

08:30 – 09:15 Rong-Gen **Cai** (ITP-CAS)
Holographic models of superconductors

09:15 – 10:00 Hermann **Nicolai** (AEI)
Approaches to quantum gravity – a brief survey for non-specialists (1)

10:00 – 10:30 Coffee Break

10:30 – 12:00 **Scientific Activities**

Main Conference Hall — Holography

Chairperson: Tetsuya **Shiromizu** (Nagoya)

10:30 – 11:00 Rong-Gen **Cai** (ITP-CAS)
Magnetism from general relativity

11:00 – 11:30 Glenn **Barnich** (ULB)
Holographic aspects of gravity in 4 and 3 dimensions

11:30 – 12:00 Miok **Park** (KIAS)
Holography without SUSY and GR

12:00 – 13:30 Lunch

13:30 – 19:00 Excursion

19:00 – 20:30 Dinner

Thursday, August 13, 2015 — ICISE

08:00 – 08:30 Shuttle from Hotel to ICISE

08:30 – 10:00 **Scientific Activities**

Main Conference Hall — Cosmology

Chairperson: Jun'ichi **Yokoyama** (RESCEU)

08:30 – 09:15 Alexei **Starobinsky** (RAS)
Inflation: properties, viable models and perspectives of further research

09:15 – 10:00 Jérôme **Martin** (IAP)
Observing Inflationary Reheating

10:00 – 10:30 Coffee Break

10:30 – 12:00 **Scientific Activities**

Main Conference Hall — Cosmology

Chairperson: Shinji **Tsujikawa** (TUS)

10:30 – 11:00 Filippo **Vernizzi** (IPhT)
A unifying description of dark energy

11:00 – 11:30 Jérôme **Martin** (IAP)
How well can future CMB missions constrain cosmic inflation?

11:30 – 12:00 Clare **Burrage** (UoN)
Probing dark energy with atom interferometry

12:00 – 13:30 Lunch

13:30 – 15:00 **Scientific Activities**

Main Conference Hall — Cosmology

Chairperson: Luc **Blanchet** (IAP)

13:30 – 14:00 Shinji **Tsujikawa** (TUS)
Effective field theory approach to modified gravity with applications to inflation and dark energy

14:00 – 14:30 Vladimir **Dzhunushaliev** (KazNU)
Non-Abelian SU(3) gauge field as a dark matter candidate

14:30 – 15:00 Anjan **Giri** (IITH)
R^{2-q} **Inflation and f(R) Dark Energy Model revisted**

15:00 – 15:30 Coffee Break

15:30 – 17:00 **Scientific Activities**

Main Conference Hall — Cosmology

Chairperson: Rong-Gen **Cai** (ITP-CAS)

15:30 – 16:00 Rex **Liu** (DAMTP)
Cosmological modelling with the Collins-Williams Regge calculus formalism

16:00 – 16:30 Grasiele **Santos** (Sapienza)
Scalar Perturbations in a Friedmann-like metric with non-null Weyl Tensor

16:30 – 17:00 Rupert **Allison** (OU)
CMB lensing-galaxy weak lensing joint analysis

17:00 – 19:00 Leisure time and informal discussions

19:00 – 22:30 Conference Dinner

22:30 – 23:00 Shuttle from ICISE to Hotel

Friday, August 14, 2015 — ICISE

08:00 – 08:30 Shuttle from Hotel to ICISE

08:30 – 10:00 **Scientific Activities**

Main Conference Hall — Modified Gravity

Chairperson: Alexei **Starobinsky** (RAS)

08:30 – 09:15 Luc **Blanchet** (IAP)
Bimetric gravity and dark matter

09:15 – 10:00 Claudia **de Rham** (CWRU)
Massive Gravity and Its Cosmology

10:00 – 10:30 Coffee Break

10:30 – 12:00 **Scientific Activities**

Main Conference Hall — Quantum Gravity

Chairperson: Hermann **Nicolai** (AEI)

10:30 – 11:00 Andrew **Tolley** (CWRU)
On the Uniqueness of Einstein-Hilbert action in Massive Gravity

11:00 – 11:30 Guillermo Antonio **Mena Marugan** (IEM, CSIC)
Gauge Invariant Perturbations in Quantum Cosmology

11:30 – 12:00 Nobuyoshi **Ohta** (Kinki Univ.)
Asymptotic Safety and Quantum Gravity

12:00 – 13:30 Lunch

13:30 – 15:00 **Scientific Activities**

Main Conference Hall — Quantum Gravity

Chairperson: Hideo **Kodama** (KEK)

13:30 – 14:00 Yongge **Ma** (BNU)
Black Hole Entropy in Loop Quantum Gravity

14:00 – 14:30 Edward **Wilson-Ewing** (AEI)
Bouncing universes in loop quantum cosmology

14:30 – 15:00 Laura **Castelló Gomar** (IEM - CSIC)
Mukhanov-Sasaki equations in Hybrid Loop Quantum Cosmology

15:00 – 15:30 Coffee Break

15:30 – 17:00 **Scientific Activities**

Main Conference Hall — Quantum Gravity

Chairperson: Nobuyoshi **Ohta** (Kinki Univ.)

15:30 – 16:00 Mitsutoshi **Fujita** (YITP, Kyoto U.)
Towards a Holographic Bose-Hubbard Model

16:00 – 16:30 Shingo **Kukita** (Nagoya Univ)
Quantum Correlation of Unruh DeWitt Detectors

16:30 – 17:00 Kazunari **Shima** (SIT)
New Einstein-Hilbert type action with nonlinear symmetry and unity of Nature

17:00 – 18:30 Leisure time and informal discussions

18:30 – 19:00 Shuttle from ICISE to Hotel

19:00 – 20:30 Dinner

Saturday, August 15, 2015 — Departure of participants

08:00 – 08:30 Shuttle from Hotel to ICISE

08:30 – 09:30 **Scientific Activities**

Main Conference Hall — Toward next centenary of gravitation

Chairperson: Kei-ichi **Maeda** (WU)

08:30 – 09:00 Hermann **Nicolai** (AEI)
Approaches to quantum gravity – a brief survey for non-specialists (2)

09:00 – 09:30 Alexei **Starobinsky** (RAS)
Cosmology and gravitation: do we need to go beyond Einstein?

09:30 – 09:45 **Scientific Activities**

Main Conference Hall — Concluding

Chairperson: Kei-ichi **Maeda** (WU)

09:30 – 09:45 Roland **Triay** (CPT-AMU)
Closing

09:45 – 10:15 Coffee Break

10:15 – 11:15 Leisure time and informal discussions

11:15 – 11:45 Shuttle from ICISE to Hotel

11:45 – 13:15 Lunch

Departure for the Post-Conference Tour









Speakers

Rupert **Allison** *(OU)*, Oxford, United Kingdom

CMB lensing-galaxy weak lensing joint analysis

August, 13, 16:30 – 17:00, Main Conference Hall

I will review the current state-of-the-art in galaxy weak lensing - CMB lensing joint analysis. The cross-correlation of these dark matter probes is a clean window on structure formation in the late-time universe, and will be a vital cross-check for the control of systematics in future weak-lensing analyses. I will discuss the latest CMB lensing results from the Atacama Cosmology Telescope, the first experiment to present a detection of the galaxy lensing-CMB lensing cross-correlation [1, 2]. I will outline the science which can be extracted from this observable, and will examine - quantitatively - the prospects for current and future surveys such as DES, KiDS, LSST and Advanced ACTPol.

References:

[1] N. Hand et al. *First measurement of the cross-correlation of CMB lensing and galaxy lensing*, Phys. Rev. D, 91, 6 (2015)

[2] Liu, J and Hill, J. C. *Cross-correlation of Planck CMB Lensing and CFHTLenS Galaxy Weak Lensing Maps*, arxiv:1504.05598

Glenn **Barnich** *(ULB)*, Brussel, Belgium

Holographic aspects of gravity in 4 and 3 dimensions

August, 12, 11:00 – 11:30, Main Conference Hall

After a brief review of the symmetry groups of asymptotically AdS and flat spacetimes, I will discuss in some detail the status of the four dimensional flat case. In particular, I will explain why current algebras need to replace the more traditional algebra of ADM-type charges and briefly comment on the relation to soft theorems.

In three dimensions, more results are available. In particular, the complete solution space is entirely controlled by group theory, the coadjoint representation of the Virasoro group in the AdS case and of the BMS3 group in the flat case. This allows one for instance to prove positive energy theorems by using well-established results on the co-adjoint orbits of the Virasoro group.

Laura **Bernard** *(IAP)*, Paris, France

Equations of motion of compact binaries at fourth post-Newtonian order

August, 10, 16:00 – 16:20, Main Conference Hall

Coalescing compact binary systems are among the most promising sources of gravitational waves for the next generations of interferometers. Due to the faintness of the signal, one needs to construct highly accurate templates to be match-filtered against the detector data, for both detection and parameter estimation. During the inspiraling phase of the coalescence, when the two objects are widely separated, the post-Newtonian (PN) formalism allows one to describe the dynamics of the binary and to compute the radiation energy flux, from which the orbital phase evolution can be derived. In this talk, I will present the equations of motion at the fourth post-Newtonian order obtained from a Fokker action in harmonic coordinates. In particular I will explain the detailed method, including the treatment of the so-called tail effects which appear at 4PN.

Luc **Blanchet** *(IAP)*, Paris, France

Bimetric gravity and dark matter

August, 14, 08:30 – 09:15, Main Conference Hall

Dark matter as we see it in cosmology (through its gravitational influence on ordinary matter) is described by particles, the so-called WIMPs, within the concordance cosmological model Lambda-CDM, which has been brillantly confirmed by the PLANCK satellite. However, it has long been disappointing that Lambda-CDM, when extrapolated down to galactic scales, meets severe challenges when compared to observations, and seems to be fundamentally incompatible with the phenomenology of MOND (MOdified Newtonian Dynamics). In this talk we shall: (i) review the physical basis for MOND at galactic scales and the modified gravity theories proposed so far; (ii) present a different interpretation for MOND in terms of a mechanism of gravitational polarization; (iii) show that this interpretation naturally fits within bimetric extensions of general relativity, notably the recently proposed massive bigravity theories motivated by the graviton's mass.

Speakers

Luc **Blanchet** *(IAP)*, Paris, France

Post-Newtonian theory versus Black Hole perturbations

August, 10, 14:30 – 15:00, Main Conference Hall

Perturbative self-force (SF) computations, both numerical and analytical, have determined that half-integral post-Newtonian (PN) terms arise in the conservative dynamics of black-hole binaries moving on exactly circular orbits. In this talk we explain the origin of these terms and report their computation up to 7.5PN order using standard PN theory [1, 2]. The perfect agreement found with SF calculations is a significant test of the PN machinery as applied to the computation of the motion and radiation of compact binaries.

References:

[1] Luc Blanchet, Guillaume Faye and Bernard F. Whiting, *Half-integral conservative post-Newtonian approximations in the redshift factor of black hole binaries*, Physical Review D **89**, 064026 (2014).

[2] Luc Blanchet, Guillaume Faye and Bernard F. Whiting, *High-order half-integral conservative post-Newtonian coefficients in the redshift factor of black hole binaries*, Physical Review D **90**, 044017 (2014).

Clare **Burrage** *(UoN)*, Nottingham, United Kingdom

Probing dark energy with atom interferometry

August, 13, 11:30 – 12:00, Main Conference Hall

This talk is based on [1]. Theories of dark energy and modified gravity commonly require a screening mechanism to explain why the associated scalar fields do not mediate observable long range fifth forces. The archetype of this is the chameleon field, where the field's mass becomes dependent on the environment. I will review the way in which the field behaves in the presence of a spherical source and then go on to show that individual atoms are too small to screen the chameleon field inside a large high-vacuum chamber. This makes them sensitive probes of the chameleon field. I will review the technique of atom interferometry, and show that it can detect fifth forces due to dark energy with high sensitivity. This has already been used to rule out large regions of the chameleon parameter space [2] and I will show that most of the remaining chameleon parameter space is readily accessible, leading to the tantalising prospect that the first evidence for the nature of dark energy may be found through metre scale laboratory based atom interferometry experiments.

References:

[1] C. Burrage, E. J. Copeland and E. A. Hinds, JCAP **1503** (2015) 03, 042 [arXiv:1408.1409 [astro-ph.CO]].

[2] P. Hamilton, M. Jaffe, P. Haslinger, Q. Simmons, H. Müller and J. Khoury, arXiv:1502.03888 [physics.atom-ph].

Rong-Gen **Cai** *(ITP-CAS)*, Beijing, China

Holographic models of superconductors

August, 12, 08:30 – 09:15, Main Conference Hall

This talk gives a quick and introductory overview of some holographic superconductor models with s-wave, p-wave and d-wave orders in the literature, and summarizes some basic properties of these holographic models in various regimes. The competition and coexistence of these superconductivity orders are also discussed.

References:

[1] Introduction to Holographic Superconductor Models, Rong-Gen Cai, Li Li, Li-Fang Li, Run-Qiu Yang. arXiv:1502.00437

Rong-Gen **Cai** *(ITP-CAS)*, Beijing, China

Magnetism from general relativity

August, 12, 10:30 – 11:00, Main Conference Hall

In this talk I will introduce our recent works on magnetism from holographic models. First, we will build a holographic ferromagnetic/paramagnetic phase transition model by introducing a real anti-symmetric 2-form field in an AdS black hole background. When temperature is lowered, the condensation happens spontaneously and the magnetic susceptibility obeys the Curie-Weiss law. We then generalize this model to the anti-ferromagnetic/paramagnetic phase transition and find a quantum critical point induced by external magnetic field and study the quantum critical behavior. We will also discuss the competition and coexistence between ferromagnetic phase and superconductivity.

Vitor **Cardoso** *(IST)*, Lisboa, Portugal

Black holes as particle detectors

August, 11, 09:15 – 10:00, Main Conference Hall

Black holes are multifaceted objects that probe the strong-field nature of gravity and can be used to test fundamental physics. Astrophysical black holes may undergo superradiant instabilities in the presence of light bosonic fields. This effect, together with precision measurements of the mass and spin of massive black holes, has been used to constrain axions and ultralight scalars, to derive bounds on light vector fields and on the mass of the graviton, as well as to put intrinsic bounds on magnetic fields near black holes and on the fraction of primordial black holes in dark matter. The theoretical potential of these phenomena as almost-model-independent smoking guns for beyond-Standard Model physics and modified gravity are presented.

Laura **Castelló Gomar** *(IEM - CSIC)*, Madrid, Spain

Mukhanov-Sasaki equations in Hybrid Loop Quantum Cosmology

August, 14, 14:30 – 15:00, Main Conference Hall

Scalar cosmological perturbations are analyzed in the framework of Loop Quantum Cosmology, using a hybrid quantization approach and Mukhanov-Sasaki variables. A kind of Born-Oppenheimer ansatz is employed to extract the dynamics of the inhomogeneous perturbations, separating them from the homogeneous sector of the geometry. With this ansatz, we derive an approximate Schrodinger equation for the cosmological perturbations and study its range of validity. We obtain the effective equations that are naturally associated with the Mukhanov-Sasaki variables. They provide the master equation to extract predictions about the power spectrum of primordial scalar perturbations.

References:

[1] L. Castello Gomar, Mikel Fernandez-Mendez, G. A. Mena Marugan, and J. Olmedo, *Cosmological Perturbations in Hybrid Loop Quantum Cosmology: Mukhanov-Sasaki variables*, Phys. Rev. D **90**, 064015 (2014).

Claudia **de Rham** *(CWRU)*, Cleveland, United States

Massive Gravity and Its Cosmology

August, 14, 09:15 – 10:00, Main Conference Hall

Recent years have seen an increased interest in theories of modified gravity. If the particle carrier of the gravitational force had a mass, gravity could behave differently as GR on cosmological scales thereby potentially tackling the dark energy and cosmological constant problems [1]. After reviewing these types of models, I will present their typical cosmological behavior before focusing on exact FLRW solutions and their expected observational signatures [2].

References:

[1] C. de Rham, Living Rev Rel **17**, 7 (2014) [arXiv:1401.4173 [hep-th]].

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Irene **Di Palma** *(MPI - AEI)*, Hannover, Germany

Searches for continuous gravitational waves: recent results in data from the LIGO and Virgo detectors

August, 10, 14:00 – 14:30, Main Conference Hall

Continuous gravitational waves are extremely weak signals expected to be emitted by rapidly rotating neutron starts. The main challenge of such data analysis is the recovery of very weak signals from the noise. These analyses range from targeted searches from known pulsars to all-sky searches for unknown neutron stars, including stars in binary systems. Between these extremes lie directed searches for known stars. Results obtained so far will be summarised, along with future searches using data from Advanced LIGO and Virgo detectors.

Vladimir **Dzhunushaliev** *(KazNU)*, Almaty, Kazakhstan

Non-Abelian SU(3) gauge field as a dark matter candidate

August, 13, 14:00 – 14:30, Main Conference Hall

The model of dark matter is presented where the dark matter is a classical gauge field. A spherical symmetric solution of Yang - Mills equation is obtained. The asymptotic behavior of the gauge fields and matter density is investigated. It is shown that the distribution of the matter density allows us interpret it as the dark matter. The fitting of a typical rotational curve with the rotational curve created by the spherical solution of SU(3) Yang - Mills equation is made.

References:

[1] V. Dzhunushaliev, "Classical SU(3) Gauge Field as a Dark Matter," Journal of Modern Physics, 2013, 4, 111-120.

[2] V. Dzhunushaliev, "Classical color fields as a dark matter candidate," Central Eur. J. Phys. **5**, 342 (2007); [arXiv:astro-ph/0612473].

Mitsutoshi **Fujita** *(YITP, Kyoto U.)*, Kyoto, Japan

Towards a Holographic Bose-Hubbard Model

August, 14, 15:30 – 16:00, Main Conference Hall

We present a holographic construction of the large-N Bose-Hubbard model. The model is based on Maxwell fields coupled to charged scalar fields on the AdS2 hard wall. We realize the lobe-shaped phase structure of the Bose-Hubbard model [1] and find that the model admits Mott insulator ground states in the limit of large Coulomb repulsion. In the Mott insulator phases, the bosons are localized on each site. At zero hopping we find that the transitions between Mott insulating phases with different fillings correspond to first order level-crossing phase transitions. At finite hopping we find a holographic phase transition between the Mott phase and a non-homogeneous phase. We then analyze the perturbations of fields around both the Mott insulator phase and inhomogeneous phase. We find an almost zero mode in the non-homogeneous phase.

References:

[1] M. P. A. Fisher, P. B. Weichman, G. Grinstein and D. S. Fisher, "Boson localization and the superfluid-insulator transition," Phys. Rev. B 40, 546 (1989).

Anjan **Giri** *(IITH)*, Hyerabad, India

R^{2-q} Inflation and f(R) Dark Energy Model revisted

August, 13, 14:30 – 15:00, Main Conference Hall

This talk is based on the model where standard R^2 Inflation is considered [1]. In the generalized theory $f(R)$ is consideredd to be $f(R) = R + F(R) + \alpha R^{2-q}$, where q is a very small parameter ($\leq O(10^{-2})$) and $F(R)$ is responsible for late time evolution, the dark energy. After the Inflation era is over the term R^{2-q} is irrelevant and late time dark energy component F(R) becomes dominant, like the one discussed by Starobinsky [2]. We will review the scenario of R^2 Inflation and dark energy in f(R) modified gravity model and comment on the current status [3].

References:

[1] A. A. Starobinsky, *A new type of Isotropic Cosmological models without singularity*, Phys. Lett. B91 (1980) 99.

[2] A. A. Starobinsky, *Disappearing Cosmological constant in f(R) gravity*, JETP Lett. 86 (2007) 157 [gr-qc/ 0706.2041].

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Tomohiro **Harada** *(Rikkyo U)*, Tokyo, Japan

Primordial black hole formation from cosmological fluctuation

August, 11, 10:30 – 11:00, Main Conference Hall

Primordial black holes are black holes which may have formed in the early universe and affected the subsequent evolution of the universe through Hawking radiation and as the source of gravitational field. To predict the abundance of primordial black hole formation for given cosmological scenarios,it is essential to determine the formation threshold for primordial cosmological fluctuations, which are naturally described by cosmological long-wavelength solutions.After a brief introduction, I will talk the recent analytical and numerical results on the primordial black hole formation.This talk is based on our recent work [1,2,3].

References:

[1] T.Harada, C.M. Yoo, T. Nakama and Y. Koga, Phys. Rev. D **91** (2015) 8, 084057 [arXiv:1503.03934 [gr-qc]].

[2] T. Nakama, T. Harada, A. G. Polnarev and J. Yokoyama, JCAP **1401** (2014) 01, 037 [arXiv:1310.3007 [gr-qc], arXiv:1310.3007].

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Steven **Kauffmann** *(APS)*, Coolangatta, Australia

Key Consequences of Theoretical Self-Consistency in GR

August, 11, 16:20 – 16:40, Main Conference Hall

The theorem that a contracted tensor transforms as a tensor of lower rank is a linchpin of Einstein's GR, but the proof of this theorem cannot be extended beyond space-time points where the space-time transformation involved has a Jacobian matrix and a matrix-inverse thereof which both have exclusively finite components. Thus space-time transformations must be regarded as unphysical other than at such points; indeed in classical theoretical physics nonfinite entities don't even make sense. This, together with the Equivalence Principle, implies that a metric tensor can be physical only at space-time points where it and its inverse both have exclusively finite components, and where its signature is identical to that of the Minkowski metric tensor. However, some metric-tensor solutions of the Einstein equation flout these physical constraints on a subset of space-time, just as some well-known solutions of the Maxwell and Schrödinger equations also flout physical constraints—and are therefore discarded. Some common unphysical solutions of the Maxwell, Schrodinger and Einstein equations are briefly examined: these physically deviant solutions are found to reflect unphysical boundary conditions.

Seiji **Kawamura** *(ICRR, UTokyo)*, Kashiwa, Japan

Gravitational Waves Astronomy

August, 10, 10:45 – 11:30, Main Conference Hall

The existence of gravitational waves was predicted by Albert Einstein about 100 years ago, but we have not yet succeeded in the direct detection. If we detect gravitational waves, it could not only provide the proof of general theory of relativity, but also reveal various mysteries of the Universe, such as the collision of black holes and the beginning of the Universe, which cannot be accessed by electromagnetic waves and other cosmic rays. The most promising method for the detection of gravitational waves at present is a Michelson laser interferometric detector. Actually there are several large-scale gravitational wave detectors being built in the world, such as Advanced LIGO, Advanced Virgo, GEO-HF, and KAGRA. It is expected that those second-generation detectors would be able to detect gravitational waves very soon for the first time in the history of mankind. The most promising sources of gravitational waves, which could be detected first, are neutron star binary coalescence or black hole binary coalescence. Pulsars and supernovas are also possible targets. The third-generation detectors, such as ET, are also developed to further expand the gravitational wave astronomy. There are also plans for space gravitational wave antennas, which make it possible to extend the arm length drastically, thus to improve the sensitivity at low frequencies. eLISA is trying to detect gravitational waves mainly coming from massive black hole binaries, and DECIGO is seeking to detect gravitational waves coming from the inflation of the Universe. In my talk I will start with the review of gravitational waves and the detection method, and then explain the objectives, design, current status, and future plan of each gravitational wave detector.

Sang Pyo **Kim** *(KNU)*, Kunsan, Korea, Republic of

Schwinger Effect and Hawking Radiation in Charged Black Holes

August, 11, 11:00 – 11:30, Main Conference Hall

A charged Reissner-Nordström (RN) black hole emits not only the Hawking radiation of all species of particles due to the event horizon but also the Schwinger emission of charged particles due to electric field near the horizon, and thus provides an arena where one may explore the intertwinement between quantum electrodynamics and quantum aspect of black holes. We advance the phase-integral method to compute the particle production from the charged RN black hole and then interpret the radiation of particles in terms of an effective temperature. In the phase-integral method the out vacuum is distinguished from the in-vacuum by the presence of simple poles of the frequency or momentum of the field in the background spacetimes and/or electromagnetic fields [1]. Hence, particle production is characterized and determined by polons, that is, contour integrals of all homotopy classes of poles [2,3]. The thermal interpretation of the Schwinger emission in an (A)dS and an RN black holes has recently been advanced [4,5]. Using the geometry $AdS_2 \times S^2$ near the horizon of the extremal or near-extremal black hole, the Schwinger effect has been explicitly formulated [6]. The Schwinger effect in the extremal black hole has the same form as the QED action in the dS_2 and AdS_2 space [4]. In the tunneling picture, particles are produced as pairs through or near the horizon and locally the Rindler coordinates near the horizon are an accelerated frame for the Minkowski spacetime when the acceleration is the surface gravity [7]. We calculate the Hawking radiation and the Schwinger effect in the Rindler coordinates for non-extremal black holes or $AdS_2 \times S^2$ for the extremal or near-extremal black holes and propose a thermal interpretation of charge emission[3]. Finally, we discuss the entropy and black hole thermodynamics for an extremal black hole.

References:

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[2] S. P. Kim, *JPS Conf. Proc.* **1** (2014) 013110.

[3] R-G. Cai and S. P. Kim, *Particle Production from Charged Black Holes*, in preparation.

[4] R-G. Cai and S. P. Kim, *JHEP* **09** (2014) 72.

[5] S. P. Kim, H. K. Lee, and Y. Yoon, *Thermal Interpretation of Schwinger Effect in Near-Extremal Reissner-Nordström Black Hole* [arXiv:1503.00218]

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[7] S. P. Kim, *JHEP* **11** (2007) 048.

Kenta **Kiuchi** *(YITP)*, Kyoto, Japan

Recent progress of compact binary merger simulations in Kyoto numerical relativity group

August, 10, 13:30 – 14:00, Main Conference Hall

The merger of a binary composed of a neutron star and/or a black hole is one of the most promising source of gravitational waves. If we detected gravitational waves from them, it could tell us a validity of the general relativity in a strong gravitational field and the equation of state of neutron star matter. Furthermore, if gravitational waves from a compact binary merger and a short-hard gamma-ray burst are observed simultaneously, a long-standing puzzle on the central engine of short gamma-ray bursts could be resolved. In addition, compact binary mergers are a theoretical candidate of the rapid process nucleosynthesis site. Motivated by these facts, it is mandatory to build a physically reliable model of compact binary mergers and numerical relativity is a unique approach for this purpose. We are tackling this problem from several directions; the magneto-hydrodynamics, the neutrino radiation transfer, and a comprehensive study with simplified models. I will talk our understanding and future prospect on the compact binary mergers.

Hideo **Kodama** *(KEK)*, Tsukuba, Japan

Axion Bosenova and Gravitational Waves

String theories suggest possible existence of many axionic scalar fields with tiny masses. If there is a scalar field with a mass whose Compton wavelength is comparable to astrophysical black holes (BHs), it extracts BH rotation energy via *superradiant instability* and forms an axion cloud. In this talk, I clarify the dynamics of an axion cloud caused by its nonlinear self-interaction and the property of gravitational wave emission from this system by numerical simulations. The nonlinear self-interaction intermittently causes violent phenomena called *bosenovae*, during which burst-like gravitational waves are emitted. A BH-axion system can be regarded as a "gravitational wave geyser" in our universe.

References:

[1] H. Yoshino and H. Kodama, *"Bosenova and Axiverse,"* arXiv:1505.00714 [gr-qc].

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[3] H. Yoshino and H. Kodama, *"Bosenova collapse of axion cloud around a rotating black hole,"* Prog. Theor. Phys. **128**, 153 (2012)

Shingo **Kukita** *(Nagoya Univ)*, Nagoya, Japan

Quantum Correlation of Unruh DeWitt Detectors

August, 14, 16:00 – 16:30, Main Conference Hall

We investigate entanglement of two Unruh De Witt detectors interacting with a scalar field. By using a master equation, we can study the long time behaviour of the entanglement between the detectors [1]. We use the approximation which has the free parameter called "coarse grained time"Δt [2]. The detectors can be entangled each other under the dynamics by the master equation even if the detectors is in the ground state initially. This behaviour is different from the behaviour within the rotating wave approximation which is often investigated in the context of Unruh De Witt detector models [3][4].

In this talk, We present the time evolution and the stationary state of the entanglement between the detectors in the following two situations:

1) the detectors are at rest in the flat space and interact with a massless scalar field in a thermal state.

2) the detectors are uniformly accelerated and interact with a massless scalar field in the Minkowski vacuum state.

and discuss the physical meaning.

References:

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[2] Schaller, Gernot and Brandes, Tobias, "Preservation of positivity by dynamical coarse graining," Phys. Rev. A **78**, 022106 (2008)

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Rex **Liu** *(DAMTP)*, Cambridge, United Kingdom

Cosmological modelling with the Collins-Williams Regge calculus formalism

August, 13, 15:30 – 16:00, Main Conference Hall

The late universe's matter distribution obeys the Copernican principle at only the coarsest of scales. The relative importance of such inhomogeneity is still not well understood. Because of the Einstein field equations' non-linear nature, some argue a non-perturbative approach is necessary to correctly model inhomogeneities, and may even obviate any need for dark energy. I shall discuss an approach based on Regge calculus [1], a discrete approximation to general relativity: I shall discuss the Collins-Williams formulation [2] of Regge calculus and its application to two toy universes [3]. The first is a universe for which the continuum solution is well-established, the Λ-FLRW universe. The second is an inhomogeneous universe, the 'lattice universe' wherein matter consists solely of a lattice of point masses with pure vacuum in between, a distribution more similar to that of the actual universe compared to FLRW universes. I shall discuss both a regular lattice of masses and one where one mass gets perturbed.

References:

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[2] P. A. Collins and R. M. Williams, "Dynamics of the Friedmann universe using Regge calculus", *Phys Rev D* 7 (1973) 965; L. C. Brewin, "Friedmann cosmologies via the Regge calculus", *Class Quantum Grav* 4 (1987) 889.

[3] R. G. Liu and R. M. Williams, "Regge calculus models of the closed vacuum Λ-FLRW universe" [arXiv:1501.07614]; "Regge calculus models of closed lattice universes" [arXiv:1502.03000].

Yu-Qing **Lou** *(THCA)*, Beijing, China

Hypermassive Black Holes in the Universe : Theoretical Prediction to Observational Evidence

August, 11, 15:30 – 16:00, Main Conference Hall

We introduce the original physical concept of HyperMassive Black Holes (HMBHs), describe the theoretical framework of self-gravitating hydrodynamics for general polytropic dynamic collapses, and explain the difficulty of forming black holes via disk accretions in the Universe especially in the early Universe. In 2013, we published the theoretical prediction that HMBHs in the range of 10-1000 billion solar masses or even higher may form in the Universe including the early Universe. The recently discovered 12 billion solar mass black hole in the ultraluminous quasar at high redshift falls around the lower end of the theoretically predicted mass range for HMBHs. We further discuss physical consequences of various types of black holes in the universe.

References:

[1] Lian, Lou, 2014, Monthly Notices of the Royal Astronomical Society, Volume 438, Issue 2, p.1242-1255, Relativistic self-similar dynamic collapses of black holes in general polytropic spherical clouds (Advance access publication December 20, 2013).

[2] Lou, Lian, 2012, Monthly Notices of the Royal Astronomical Society, Volume 420, Issue 3, pp. 2147-2161, Three dimensional hydrodynamic instabilities in stellar core collapses.

[3] Lou, Jiang, 2008, Monthly Notices of the Royal Astronomical Society Letters, Volum 391, Issue 1, L44-L48, Supermassive Black Holes in Galactic Bulges

Hong **Lu** *(BNU)*, Beijing, China

Black Holes — the First 99 Years

August, 11, 08:30 – 09:15, Main Conference Hall

It has been 99 years since Schwarzschild constructed his eponymous solution in Einstein's theory of gravity. It is suprising that exact solutions can exist in such a nonlinear theory. In this talk, we shall review the tremendous progress made in the past 99 years, focusing on exact local solutions. We also discuss the current problems and possible future directions.

Kei-ichi **Maeda** *(WU)*, Tokyo, Japan

Scientific Opening

August, 10, 09:45 – 10:00, Main Conference Hall

Jérôme **Martin** *(IAP)*, Paris, France

How well can future CMB missions constrain cosmic inflation?

August, 13, 11:00 – 11:30, Main Conference Hall

We study how the next generation of Cosmic Microwave Background (CMB) measurement missions (such as EPIC, LiteBIRD, PRISM and COrE) will be able to constrain the inflationary landscape in the hardest to disambiguate situation in which inflation is simply described by single-field slow-roll scenarios. Considering the proposed PRISM and LiteBIRD satellite designs, we simulate mock data corresponding to five different fiducial models having values of the tensor-to-scalar ratio ranging from 10^{-1} down to 10^{-7}. We then compute the Bayesian evidences and complexities of all Encyclopaedia Inflationaris models in order to assess the constraining power of PRISM alone and LiteBIRD complemented with the Planck 2013 data. Within slow-roll inflation, both designs have comparable constraining power and can rule out about three quarters of the inflationary scenarios, compared to one third for Planck 2013 data alone. However, we also show that PRISM can constrain the scalar running and has the capability to detect a violation of slow roll at second order. Finally, our results suggest that describing an inflationary model by its potential shape only, without specifying a reheating temperature, will no longer be possible given the accuracy level reached by the future CMB missions.

Jérôme **Martin** *(IAP)*, Paris, France

Observing Inflationary Reheating

August, 13, 09:15 – 10:00, Main Conference Hall

Reheating is the epoch which connects inflation to the subsequent hot big-bang phase. Conceptually very important, this era is, however, observationally poorly known. We show that the current Planck satellite measurements of the cosmic microwave background (CMB) anisotropies constrain the kinematic properties of the reheating era for most of the inflationary models. This result is obtained by deriving the marginalized posterior distributions of the reheating parameter for about 200 models of slow-roll inflation. Weighted by the statistical evidence of each model to explain the data, we show that the Planck 2013 measurements induce an average reduction of the posterior-to-prior volume by 40%. Making some additional assumptions on reheating, such as specifying a mean equation of state parameter, or focusing the analysis on peculiar scenarios, can enhance or reduce this constraint. Our study also indicates that the Bayesian evidence of a model can substantially be affected by the reheating properties. The precision of the current CMB data is therefore such that estimating the observational performance of a model now requires incorporating information about its reheating history.

Yongge **Ma** *(BNU)*, Beijing, China

Black Hole Entropy in Loop Quantum Gravity

August, 14, 13:30 – 14:00, Main Conference Hall

The statistical origin of black hole entropy is the great mystery which has be explored by any quantum gravity theory. The quasi-local notion of isolated horizon was proposed in order to formulate the horizon of a black hole by phase space functions which can be quantized [1]. We can consider the isolated horizon as an inner boundary of a four-dimensional asymp- totically flat spacetime region. Because of the isolated horizon condition, it turns out that, with different gauge choices, the boundary degrees of freedom can be described either by a SU(2) Chern-Simons theory with punctures [2] or by a SO(1,1) BF theory with sources [3]. In both cases the entropy of the isolated horizon can be calculated in the framework of loop quantum gravity. The leading order contributions of the microscop- ical degrees of freedom are both proportional to the area of the horizon, while the sub-leading quantum corrections are different for different ap- proaches. The BF theory description of the boundary degrees of freedom is applicable in arbitrary dimensions of spacetime.

References:

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Guillermo Antonio **Mena Marugan** *(IEM, CSIC)*, Madrid, Spain

Gauge Invariant Perturbations in Quantum Cosmology

August, 14, 11:00 – 11:30, Main Conference Hall

We consider cosmological perturbations around FLRW spacetimes minimally coupled to a scalar field and present a formulation designed to preserve covariance. The perturbations are described in terms of Mukhanov-Sasaki gauge invariants, linear perturbative constraints, and variables canonically conjugate to them. This set is completed into a canonical one for the entire system, including the homogeneous degrees of freedom. We find the global Hamiltonian constraint of the model, in which the contribution of the homogeneous sector is corrected with a term which can be identified as the Mukhanov-Sasaki Hamiltonian. We then explain how to quantize the system respecting covariance and how to extract the evolution of the primordial scalar perturbations.

References:

[1] L. Castello Gomar, M. Martin-Benito, and G. A. Mena Marugan, *Gauge-Invariant Perturbations in Hybrid Quantum Cosmology*, JCAP (2015) [accepted for publication] [arXiv:1503.03907].

Hermann **Nicolai** *(AEI)*, Golm, Germany

Approaches to quantum gravity – a brief survey for non-specialists (2)

August, 15, 08:30 – 09:00, Main Conference Hall

Constructing a consistent theory of quantum gravity that also unifies gravity with the other interactions is perhaps the greatest challenge of modern theoretical physics. In this talk I will review some of the currently favored approaches towards this goal at an introductory level.

Hermann **Nicolai** *(AEI)*, Golm, GERMANY

Approaches to quantum gravity – a brief survey for non-specialists (1)

August, 12, 09:15 – 10:00, Main Conference Hall

Constructing a consistent theory of quantum gravity that also unifies gravity with the other interactions is perhaps the greatest challenge of modern theoretical physics. In this talk I will review some of the currently favored approaches towards this goal at an introductory level.

Sousuke **Noda** *(Nagoya-U)*, Nagoya, JAPAN

Wave Optics in Kerr spacetime and Black Hole Shadows

August, 11, 16:00 – 16:20, Main Conference Hall

We aim to obtain the shadow of the Kerr black hole using wave optics. For this purpose, we formulate wave optics in Kerr spacetime with Green function [1] and consider wave scattering problem. Then we discuss the interference pattern and how to reconstruct the image of a point source from the scattered wave. This is the extension of the analysis for Schwarzschild spacetime [2].

References:

[1] H. Yang, F. Zhang, A. Zimmerman and Y. Chen, *"Scalar Green function of the Kerr spacetime"*, Phys. Rev. D **89(6)**, (2014) 064014.

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Nobuyoshi **Ohta** *(Kinki Univ.)*, Higashi-Osaka City, JAPAN

Asymptotic Safety and Quantum Gravity

August, 14, 11:30 – 12:00, Main Conference Hall

We construct a novel functional renormalization group equation for gravity which encodes the gravitational degrees of freedom in terms of general function of the scalar curvature. We use a new parametrization of the metric which avoids unphysical singularity. We show that there are ultraviolet fixed points essential for Asymptotic Safety. We study if this approach may be used to determine possible UV completion of gravitational theory and the result may be something that drives inflation of the universe. We also discuss gauge-independence of our results.

References:

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Miok **Park** *(KIAS)*, Seoul, Korea, Republic of

Holography without SUSY and GR

August, 12, 11:30 – 12:00, Main Conference Hall

SUSY plays an essential role in construction of AdS/CFT [1]. SUSY, however, has not been proved yet up to in 8 TeV regime in LHC, and so either a direct experimental proof for AdS/CFT conjecture is hard to perform. The important feature of AdS/CFT is that a strongly coupled system in gauge theory can correspond to a weakly coupled system in gravity theory. This property has extended the AdS/CFT duality to a broader regime, which is gravity/gauge duality or holography without SUSY such as AdS/QCD or AdS/CMT. These new challenges open up an experimental possibility to prove the gravity/gauge duality. In this relaxed holography, the same symmetry in gravity and gauge theory is considered, but more foundational theoretical construction for duality has not been done. Nonetheless, one has observed some plausible corresponding phenomena of CMT to gravity. In this 100 years of general relativity anniversary meeting, I will focus on mechanisms of gravity side and introduce how the gravitational mechanism is interpreted in CMT via the holography picture, which have been intensively and broadly studied for a decade. I will mention the Casimir energy that is dual to the negative energy of AdS Soliton [2], a holographic superconductor that is dual to a hairy black hole which is generated by a phase transition from RN-AdS black hole at a low temperature and in which the perturbation can be analysed by a linear response theory [3,4], and Lifshitz spacetime that is inspired by quantum criticality and can realise a holographic renormalisation flow [5,6,7].

References:

[1] J. M. Maldacena, *The Large N limit of superconformal field theories and supergravity*, Int. J. Theor. Phys. **38**, 1113 (1999) [Adv. Theor. Math. Phys. **2**, 231 (1998)] [hep-th/9711200]

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Patrick **Peter** *(IAP)*, Paris, France

Bouncing cosmologies

I will give a review of bouncing cosmological models that have been proposed as alternatives to inflation [1].

References:

[1] D. Battefeld and P. Peter, A Critical Review of Classical Bouncing Cosmologies, Phys. Rep. 571 (2015) 1.

Grasiele **Santos** *(Sapienza)*, Roma, Italy

Scalar Perturbations in a Friedmann-like metric with non-null Weyl Tensor

August, 13, 16:00 – 16:30, Main Conference Hall

In a previous work [1] the authors have solved the Einstein equations of General Relativity for a class of metrics with constant spatial curvature, where it was found a non vanishing Weyl tensor in the presence of a primordial magnetic field with an anisotropic pressure component. Here [2], we perform the perturbative analysis of this model in order to study the gravitational stability under linear scalar perturbations. For this purpose, we take the Quasi-Maxwellian formalism of General Relativity as our framework [3], which offers a naturally covariant and gauge-invariant approach to deal with perturbations that are directly linked to observational quantities. We then compare this scenario with the perturbed dust-dominated Friedmann model emphasizing how the growth of density perturbations is enhanced in our case.

References:

[1]E. Bittencourt, J. M. Salim and G. B. Santos, *Gen. Rel. Grav.* **46**, 1790 (2014). [gr-qc/1402.3121]

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[3] G. F. R. Ellis, *Relativistic Cosmology*, *Proceedings of the International School of Physics 'Enrico Fermi'*, Course 47: General relativity and cosmology, 104, Academic Press, NewYork and London (1971); Reprinted in *Gen. Rel. Grav.* **41** 581 (2009).

Kazunari **Shima** *(SIT)*, Fukaya, Japan

New Einstein-Hilbert type action with nonlinear symmetry and unity of Nature

August, 14, 16:30 – 17:00, Main Conference Hall

Adopting specific and unstable (Riemann) space-time inspired by nonlinear representation of SUSY(NLSUSY) and following the *geometric* arguments of Einstein general relativity(GR) principle, we obtain NLSUSY invariant Einstein-Hilbert type action *nonlinear supersymmetric general relativity (NLSUSYGR)* equipped with the cosmological term. NLSUSYGR would break down spontaneously to ordinary Riemann space-time and NG fermion and gives a new paradigm for the SUSY unification of space-time and matter with the robust SUSY breaking mechanism, where the standard model(SM) of the low energy particle physics emerges in the true vacuum of NLSUSYGR as the effective theory composed of NG fermion. NLSUSYGR scenario bridges naturally the cosmology and the low energy particle physics and gives new insights into unsolved problems of GR, SM and mysterious relations among them, e.g. the space-time dimension *four*, the dark energy density, the neutrino mass, the three-generations structure of quarks and leptons, the chirality, etc., which continues naturally to the present big bang cosmology scenario. We would like to explain the basic idea and discuss new physical and mathematical perspectives with some details.

References:

[1] K. Shima and M. Tsuda, *Particle Astrophysics of Nonlinear Supersymmetric Genaral Relativity*, Fortschr. Phys. 57, 698(2009). References therein. Proceedings of Fourth EU RTN Workshop *Constituents, Fundamental Forces and Symmetries of the Universe*, 11-17 September, 2008, Varna, Bulgaria, ed. D. Luest, and V. Dovrev.

[2] K. Shima, *New Einstein-Hilbert Action for Unity of Nature*, Fortschr. Phys. 50, 717(2002). Proceedings of Symposium *100 Years Werner Heisenberg-Works and Impact*, 26-30, September, 2001, Bamberg, Germany, ed. D. Papenfuss, D. Luest and W. Schleich.

Tetsuya **Shiromizu** *(Nagoya)*, Nagoya, Japan

Positive mass theorem as a principle

August, 11, 11:30 – 12:00, Main Conference Hall

To explain the current accelerating expansion of the Universe, one often thinks of introduction of dark energy models and/or modifications of gravitational theory. I will discuss the role of positive mass in such theories and see that the form of a certain theory compatible with positive mass is strongly limited. Therefore, as imposed in linearized theory, one may be able to adopt the positive mass as a new additional principle to construct the theory for dark energy/modified gravity. For such theories, stability will be automatically guaranteed in kinematical sense. This talk is based on Refs. [1] and [2].

References:

[1] M. Nozawa and T. Shiromizu, *Modeling scalar fields consistent with positive mass*, Phys. Rev. D89 (2014), 023011.

[2] M. Nozawa and T. Shiromizu, *Positive mass theorem in extended supergravities*, Nucl.Phys. B887 (2014) 380-399.

Vera Georgievna **Sinitsyna** *(FIAN)*, Moscow, Russian Federation

TeV gamma-ray emission from region of Perseus Cluster: NGC 1275 and GK Per

August, 10, 16:40 – 17:00, Main Conference Hall

The Perseus cluster of galaxies with the central galaxy NGC 1275 is ideally suitable both for studying the physics of relativistic jets from Active Galactic Nuclei and for revealing the feedback role of the central galaxy. We presented the results of fifteen-year-long observations of the AGN NGC 1275 at energies 800 GeV - 40 TeV discovered by the SHALON telescope in 1996. Having analyzed the SHALON data, we have determined such characteristics of NGC 1275 as the spectral energy distributions both, central part related to AGN core and extended structures around NGC 1275 and images at energies > 800 GeV for the first time. The data obtained at very high energies, namely the images of the galaxy and its surroundings, and the flux variability indicate that the TeV γ-ray emission is produced by a number of processes: in particular, part of this emission is generated by relativistic jets in the nucleus of NGC 1275 itself. Whereas, the presence of an extended structure around NGC 1275 is evidence of the interaction of cosmic rays and magnetic fields generated in the jets at the galactic center with the gas of the Perseus cluster.

Recently, unique data on GK Per (Nova 1901) TeV γ-ray emission were obtained with SHALON experiment for the first time. The analysis of SHALON observation data revealed the main TeV-emission region coinciding with the position of central source of GK Per and the weak emission of shell, that is also observed in X-ray by Chandra.

Vera Yurievna **Sinitsyna** *(FIAN)*, Moscow, Russian Federation

The results of 20-year observations of Cygnus Region at TeV energies

August, 10, 16:20 – 16:40, Main Conference Hall

The twenty-year-long studies of the Cygnus Region at energies 800 GeV - 100 TeV by SHALON telescope are presented in this paper. The results of long-term observations of the Cyg X-3 binary at energies 800 GeV - 85 TeV detected by SHALON in 1995y are presented with images, integral spectra and spectral energy distribution. The 4.8 hour orbital modulation of TeV γ-ray emission of Cyg X-3 was found in SHALON data. The folded TeV γ-ray light curve by SHALON has the similar shape and position of maxima as the folded MeV light curve by Fermi LAT. During the all observation period of Cyg X-3 with SHALON 6 significant flux increases were detected at energies above 0.8 TeV. The last two significant increase of flux have detected in May 2009 and October 2011, which is correlated with flaring activity at lower energy range of X-ray and/or at observations of Fermi LAT. Earlier, in 1997, 2003 and 2006 a comparable increase of the flux over the average value was also observed. In general, the correlation of Radio, soft X-ray and TeV energy γ-ray fluxes is traced since 1996y. The variability of very high-energy γ-radiation and correlation of radiation activity in the wide energy range can provide essential information on the particle mechanism production up to the very high energies as well as can help to solve the problem of rising of the highly relativistic jets in this high-mass binary system.

Additional to Cyg X-3 study data on the TeV sources of Cygnus Region, namely γCygni SNR was obtained with SHALON. The analysis of TeV γ-ray arrival directions reveal two emission regions in γCygni SNR: the main at the South-East part of SNR shell and second one at North. The main contribution of energy flux gives the SE region of SNR shell. Also, TeV γ-ray emission regions correlate with the NW and SE parts of the shell visible in the radio energies by Canadian Galactic Plane Survey.

Alexei **Starobinsky** *(RAS)*, Moscow-Chernogolovka, Russian Federation

Cosmology and gravitation: do we need to go beyond Einstein?

August, 15, 09:00 – 09:30, Main Conference Hall

I discuss if there exists any need now to go beyond the two famous Einstein's contributions to gravity: his general theory of relativity and a cosmological constant, and when such necessity may appear in future.

Alexei **Starobinsky** *(RAS)*, Moscow-Chernogolovka, Russian Federation

Inflation: properties, viable models and perspectives of further research

August, 13, 08:30 – 09:15, Main Conference Hall

Present knowledge about physical properties of an inflationary stage in the early Universe (curvature, its rate of change, inflaton mass, etc.) which follows from the latest observational data is reviewed, models producing the best fit to these data are listed and directions of future research are discussed. It is argued that the measured value of the slope $n_s - 1$ of the primordial spectrum of scalar (density) perturbations, under some natural additional assumptions, implies small, but not too small amount of quantum primordial gravitational waves generated during inflation, $r > 10^{-3}$, similar to that in the original $R + R^2$ inflationary model (1980). Local features in the CMB temperature anisotropy power spectrum in the multipole range $\ell = (20 - 40)$ are of interest, too, and may point to some new physics during inflation.

Kentaro **Tanabe** *(KEK)*, Tsukuba, Japan

The Large D limit of General Relativity

August, 11, 14:00 – 14:30, Main Conference Hall

The spacetime dimension D is a dimensionless parameter of General Relativity. Considering the $1/D$ expansion of General Relativity with the infinite limit of D, we find the gravity is dramatically simplified but its non-trivial structure still remains at the limit. This simplification occurs since the expansion parameter $1/D$ introduces the separation of scales in the theory naturally such as r_0 and r_0/D where r_0 is a black hole radius. Using this simplification we can solve various problem of the gravity in analytic way. In this talk I will review some basic properties of the gravity at large D based on the paper [1], and next I will give recent progress of large D gravity as the effective theory [2,3].

References:

[1] R. Emparan, R. Suzuki and K. Tanabe, "The large D limit of General Relativity," JHEP **1306**, 009 (2013) [arXiv:1302.6382].

[2] R. Emparan, T. Shiromizu, R. Suzuki, K. Tanabe and T. Tanaka, "Effective theory of Black Holes in the 1/D expansion," arXiv:1504.06489.

[3] R. Suzuki and K. Tanabe, "Stationary black holes: Large D analysis," arXiv:1505.01282.

Speakers

Takahiro **Tanaka** *(Kyoto Univ.)*, Kyoto, Japan

Testing modified gravity by gravitational waves

August, 10, 10:00 – 10:45, Main Conference Hall

Binary compact objects are the source of gravitational waves whose waveforms are studied theoretically most in detail. The comparison of future observations with the theoretical templates will give us a unique test of the strong gravity regime of general relativity. Then, the natural questions will be what kind of modified gravity models are still viable as antitheses of general relativity and what kind of modifications can be detected by gravitational waves. I'll review these issues, including my personal opinions.

Andrew **Tolley** *(CWRU)*, Cleveland, United States

On the Uniqueness of Einstein-Hilbert action in Massive Gravity

August, 14, 10:30 – 11:00, Main Conference Hall

In the last few years a remarkable number of uniqueness theorems have shown that the Einstein-Hilbert action is the unique kinetic term for a massive graviton that ensures five propagating degrees of at all scales. This holds even when diffeomorphism invariance is broken and applies to all multi-gravity theories. Coupled with the known unique family of mass terms, this extends to the massive from the massless theory the well known uniqueness theorems for the form of interacting spin-2 fields and shows that Einstein-Hilbert gravity emerges without the need to assume diffeomorphism invariance or geometry.

David **Tong** *(Cambridge)*, Cambridge, United Kingdom

Black Holes and Conductivity

August, 11, 13:30 – 14:00, Main Conference Hall

I'll review progress in using gauge gravity duality to extract lessons for charge transport in strongly interacting quantum field theories.

Jean **Trân Thanh Vân** *(ICISE)*, Quy Nhơn, Viet Nam

Welcome at ICISE

August, 10, 08:30 – 08:45, Main Conference Hall

Roland **Triay** *(CPT-AMU)*, Marseille, France

Closing

August, 15, 09:30 – 09:45, Main Conference Hall

Shinji **Tsujikawa** *(TUS)*, Shinjuku, Japan

Effective field theory approach to modified gravity with applications to inflation and dark energy

August, 13, 13:30 – 14:00, Main Conference Hall

The effective field theory (EFT) of cosmological perturbations is a useful framework to deal with the low-energy degrees of freedom present for inflation and dark energy [1].

This approach accommodates a wide range of modified gravitational theories such as Horndeski theories, Gleyzes-Langlois-Piazza-Vernizzi theories, and Hořava-Lifshitz gravity. Expanding the action up to quadratic order in the perturbations and imposing conditions for the elimination of spatial derivatives higher than second order, we obtain the Lagrangian of curvature perturbations and gravitational waves with a single scalar degree of freedom. The resulting second-order Lagrangian is exploited for computing the scalar and tensor power spectra generated during inflation up to next-to-leading order in slow-roll [2].

Under the so-called disformal transformation, we show that it is possible to transform to the Einstein frame in which the tensor power spectrum is of the same form as that in General Relativity (GR). We also study the evolution of matter density perturbations and the effective gravitational coupling in the EFT framework [3] and construct a dark energy model in which the gravitational interaction is weaker than that in GR for the perturbations relevant to large-scale structures.

References:

[1] S. Tsujikawa, "The effective field theory of inflation/dark energy and the Horndeski theory," Lect. Notes Phys. **892**, 97 (2015) [arXiv:1404.2684 [gr-qc]]; R. Kase and S. Tsujikawa, "Effective field theory approach to modified gravity including Horndeski theory and Hořava-Lifshitz gravity," Int.J. Mod.Phys.D **23**, 1443008 (2015) [arXiv:1409.1984 [hep-th]].

[2] S. Tsujikawa, "Disformal invariance of cosmological perturbations in a generalized class of Horndeski theories," JCAP **1504**, 043 (2015) [arXiv:1412.6210 [hep-th]].

[3] A. De Felice, K. Koyama and S. Tsujikawa, "Observational signatures of the theories beyond Horndeski," arXiv:1503.06539 [gr-qc] (JCAP to appear); S. Tsujikawa, "Possibility of realizing weak gravity in redshift-space distortion measurements," arXiv:1505.02459 [astro-ph.CO].

Filippo **Vernizzi** *(IPhT)*, Gif-sur-Yvette, France

A unifying description of dark energy

August, 13, 10:30 – 11:00, Main Conference Hall

The present accelerated expansion of the Universe has greatly stimulated theorists' creativity. Currently, there are so many dark energy scenarios, each leading to a different phenomenology, that it will be hard to compare their predictions with the observations of future surveys, such as Euclid. I will review an approach to describe dark energy and modified gravity models under a unifying framework. I will explain how to translate any existing or future model into this description and address their theoretical consistency. Finally, I will discuss the link with observations and show that this approach provides the most efficient way to confront theoretical models with current and future cosmological observations.

Thuan **Vo Van** *(VINATOM)*, Hoan Kiem, Viet Nam

Lepton mass hierarchy in the light of time-space symmetry with microscopic curvatures

August, 11, 16:40 – 17:00, Main Conference Hall

A cylindrical model of gravitational geometrical dynamics with time-like extra-dimensions leads to a microscopic geodesic description of the curved space-time. Due to interaction of a Higgs-like cosmological potential with individual space-time fluctuations, the original time-space symmetry is spontaneously broken, inducing a strong time-like curvature and a weak space-like deviation curve. Consequently, the physical time of 4D space-time is defined to consist of a longitudinal linear component and a transverse curvature; the two time-like extra-dimensions are made explicit in terms of the quantum wave function and the proper time variable. As a result, the basic Klein-Gordon-Fock equation of a free massive elementary particle is derived, which implies a duality between the quantum mechanics equation and a microscopic geodesic description of general relativity. Consequently, the Heisenberg indeterminism is able to link directly with time-space curvatures. Moreover, extending the time-like curvatures to a higher order than one of the basic cylindrical configuration, we found reasonable mass ratios of all charged leptons. In the light of time-space symmetry, a new attempt is proposed to clarify the mass hierarchy of neutrinos and, accordingly, the absolute neutrino masses may be seen based on neutrino oscillation differences of mass squares. This solution opens an opportunity for experimental verification of the proposed model.

The first part of this talk is based on [1] and [2]. The first attempt to apply the model for charged leptons has been presented recently at the 27th Rencontres de Blois ”Particle Physics and Cosmology”, Chateau Royal de Blois, France, May 31 - June 05, 2015 (http://blois.in2p3.fr/2015/).

References:

[1] Vo Van Thuan, *Revealing extradimensions*, IJMPA. 24 (2009) 3545.

[2] Vo Van Thuan, *From microscopic gravitational waves to the quantum indeterminism*, arXiv:1507.00251[gr-qc]2015.

Edward **Wilson-Ewing** *(AEI)*, Potsdam-Golm, Germany

Bouncing universes in loop quantum cosmology

August, 14, 14:00 – 14:30, Main Conference Hall

High precision observations of the cosmic microwave background provide strong constraints on the dynamics of the early universe and raise the hope that it may be possible to detect quantum gravity effects. In this talk, I will consider realizations of the ekpyrotic [1] and matter bounce [2,3] scenarios in loop quantum cosmology, where scale-invariant perturbations are generated in a contracting Friedmann space-time which later bounces due to quantum gravity effects. I will show how it is possible to explicitly calculate the evolution of the perturbations across the non-singular bounce and discuss what conditions are necessary for scale-invariance to be preserved. I will also explain how loop quantum cosmology can affect observational quantities; one such effect is a damping of the amplitude of tensor modes.

References:

[1] E. Wilson-Ewing, *Ekpyrotic loop quantum cosmology*, JCAP **1308** (2013) 015, [arXiv:1306.6582 [gr-qc]].

[2] E. Wilson-Ewing, *The Matter Bounce Scenario in Loop Quantum Cosmology*, JCAP **1303** (2013) 026, [arXiv:1211.6269 [gr-qc]].

[3] Y.F. Cai and E. Wilson-Ewing, *A ΛCDM bounce scenario*, JCAP **1503** (2015) 006, [arXiv:1412.2914 [gr-qc]].

Masahide **Yamaguchi** *(TITECH)*, Tokyo, Japan

Galilean Creation of the Inflationary Universe

August, 11, 14:30 – 15:00, Main Conference Hall

It has been pointed out that the null energy condition can be violated stably in some non-canonical scalar-field theories. This allows us to consider the Galilean Genesis scenario in which the universe starts expanding from Minkowski spacetime and hence is free from the initial singularity. We use this scenario to study the early-time completion of inflation, pushing forward the recent idea of Pirtskhalava *et al.* We present a generic form of the Lagrangian governing the background and perturbation dynamics in the Genesis phase, the subsequent inflationary phase, and the graceful exit from inflation, as opposed to employing the effective field theory approach. Our Lagrangian belongs to a more general class of scalar-tensor theories than the Horndeski theory and Gleyzes-Langlois-Piazza-Vernizzi generalization, but still has the same number of the propagating degrees of freedom, and thus can avoid Ostrogradski instabilities. We investigate the generation and evolution of primordial perturbations in this scenario and show that one can indeed construct a stable model of inflation preceded by (generalized) Galilean Genesis.

Jun'ichi **Yokoyama** *(RESCEU)*, Bunkyo-ku, Japan

Gravitational Waves from the Early Universe

August, 10, 11:30 – 12:00, Main Conference Hall

The gravitational wave is a useful probe in cosmology which carries information of the early Universe all the way up to the inflationary epoch. There a number of possible production mechanisms of gravitational waves in the early Universe such as: (i) quantum tensor perturbation generated during inflation, (ii) gravitational waves generated by second-order perturbation of density fluctuations, (iii) those generated by bubble collision after first-order phase transitions, (iv) those created by self-ordering of multi-component scalar fields after a global symmetry breaking, and (v) gravitational from topological defects, especially from oscillating cosmic strings. I will talk about some of the above production mechanisms and discuss their implications to cosmology of the early Universe, in particular, the possibility to determine thermal history using the power spectrum of gravitational waves.

Hirotaka **Yoshino** *(KEK)*, Tsukuba, Japan

Axion Bosenova and Gravitational Waves

August, 10, 15:30 – 16:00, Main Conference Hall

String theories suggest possible existence of many axionic scalar fields with tiny masses. If there is a scalar field with a mass whose Compton wavelength is comparable to astrophysical black holes (BHs), it extracts BH rotation energy via *superradiant instability* and forms an axion cloud. In this talk, I clarify the dynamics of an axion cloud caused by its nonlinear self-interaction and the property of gravitational wave emission from this system by numerical simulations. The nonlinear self-interaction intermittently causes violent phenomena called *bosenovae*, during which burst-like gravitational waves are emitted. A BH-axion system can be regarded as a "gravitational wave geyser" in our universe.

References:

[1] H. Yoshino and H. Kodama, *"Bosenova and Axiverse,"* arXiv:1505.00714 [gr-qc].

[2] H. Yoshino and H. Kodama, *"Probing the string axiverse by gravitational waves from Cygnus X-1,"* Prog. Theor. Exp. Phys. (2015) 061E01 [arXiv:1407.2030 [gr-qc]].

[3] H. Yoshino and H. Kodama, *"Bosenova collapse of axion cloud around a rotating black hole,"* Prog. Theor. Phys. **128**, 153 (2012)

Posters

Miftahul **Hilmi** *(ITB)*, Bandung, Indonesia

Cosmic Dynamics with Quintessence as Dark Energy Model

Various models of dark energy have been proposed to explain cosmic acceleration. Quintessence is one of dark energy models in the form of a scalar field. With its Lagrangian that takes a form of kinetic component and its potential, it is possible for this scalar field to drive late-time cosmic acceleration.

In this work, cosmic dynamics with the presence of a quintessence has been derived. I will start by reviewing about phase plane analysis of a model with exponential potential [1]. After that, cosmic dynamics for the case of non-exponential potential is derived. In the case of non-exponential potential, there will be a tracker solution that attract other trajectories to a common evolutionary path [2].

In addition, I will discuss about reconstruction of quintessence from observations, starting from reconstruction of the field potential, to the evolution of its equation of state. I will also review about statefinder parameters [3] that can be used to distinguish any dark energy models from cosmological constant. Finally, (w_ϕ, w'_ϕ) plane as a classification of quintessence models is discussed.

References:

[1] E. J. Copeland, A. R. Liddle and D. Wands, *Exponential potentials and cosmological scaling solutions*, Phys. Rev. D 57 (1998) 4686 [gr-qc/9711068].

[2] L. Amendola and S. Tsujikawa, Dark Energy: Theory and Observations, Cambridge University Press, Cambridge U.K. (2010), pg. 145.

[3] V. Sahni, T. D. Saini, A. A. Starobinsky and U. Alam, *Statefinder – a new geometrical diagnostic of dark energy*, JETP Lett. 77 (2003) 201 [astro-ph/0201498].

Yasusada **Nambu** *(Nagoya Univ.)*, Nagoya, Japan

Twisted wave front of scattering waves by Kerr black hole

The orbital angular momentum (OAM) of photons can be produced by a scattering of the Kerr black hole [1,2]. However, reasons why the OAM of photons is generated by the Kerr black hole seems not to be clarified completely. In this poster, we investigate a mechanism of generating OAM of photons in a gravitational lensing system using the wave optics and explain why the Kerr black hole can produce the OAM of photons.

References:

[1] M. Anselmino, M. Harwit, *Photon orbital angular momentum in astrophysics*, Astrophys. J. 597, 1266 (2003) [astrop-ph/0307430].

[2] H. Yang and M. Casals *Wavefront twisting by rotating black holes: orbital angular momentum generation and phase coherence detection* Phys. Rev. D 90, 023014 (2014) [arXiv:1404.0722].

Hoang Vu **Nguyen** *(IOP, VAST)*, Hà Noi, Viet Nam

Hawking radiation and black hole evaporation

Consider the vacuum near the black hole as thermal bath, and using the thermal equilibrium and Euclidean time (imaginary time). We obtain the Hawking temperature of black hole and after that we will research the evaporation of the different types of black holes.

References:

[1] S.W.Hawking *Particle creation by the black hole*, Commun. math. Phys.43, 199-220 (1975).

[2] S.W.Haking, *Black Hole explosions*, Nature 248, 30 , (1974).

[3] A.Zee *Quantum field theory in a nutshell 2nd edition* Princeton University Press, 2006

[4] Maulik K.Parlik, Frank Wilczeck *hawking radiation as tunneling* Physical Review Letters Vol 85, Num 43, 5042-5045

Rahul **Nigam** *(BITS Pilani)*, Hyderabad, India

Black Hole Decay in String Theoy

Vera Georgievna **Sinitsyna** *(FIAN)*, Moscow, Russian Federation

EBL measurements through the TeV gamma-ray spectra of Low- and High-red shifted AGN at z=0.0179 to z=2.979

The detection of the very high energy γ-ray sources at red-shifts from z = 0.018 to z = 2.979 with SHALON telescopes gives an opportunity to constrain the Extragalactic Background Light (EBL) density, as the TeV γ-rays can be absorbed due to interaction of low-energy photons of EBL. So, based on the modification of γ-ray spectra of the proximate and distant metagalactic sources with influence of EBL one can reconstruct the cosmological history of EBL. Spectral energy distributions of EBL constrained from observations of NGC1275 (z=0.0179), Mkn421 (z=0.031), Mkn501 (z=0.034), Mkn180 (z=0.046), 3c382 (z=0.0578), 4c+31.63 (z=0.295), OJ 287 (z=0.306), 3c454.3 (z=0.859), 4c+55.17 (z=0.896), 1739+522 (z=1.375), B2 0242+43 (z=2.243) and B2 0743+25(z=2.979) together with data from measurements and models are presented. Also, the results of the extragalactic source observation are presented with integral spectra, images and spectral energy distributions for each of sources at energies above 800 GeV.

The detection of TeV γ-ray sources at high red-shifts is the evidence of less average spectral density of Extragalactic Background Light and thus the less star formation rate at early evolution stage, than it is previously believed. Also, the possible explanation of the detected very high energy gamma-emission from the distant AGNi is the re-scattering of primary TeV-photons on the Dark Matter particles, so called WISP - weakly interacting slim particles. The axion-like particles has been considered to be a candidate for such weakly interacting slim particles.

Marcus **Werner** *(YTP)*, Kyoto, Japan

A geometrical approach to gravitational lensing magnification

The recent discoveries of strongly lensed type Ia supernovae yielded the first direct measurements of image magnifications in gravitational lensing (e.g., [1]). As magnification is thus becoming an important observable, it is also desirable to gain a better theoretical understanding of this concept beyond its usual formulation in the quasi-Newtonian approximation. This poster describes how the standard definition of gravitational lensing magnification may be generalized to Lorentzian spacetimes, and shows how this definition can be interpreted geometrically in terms of the van Vleck determinant and the exponential map (based on [2]).

References:

[1] R. Quimby, M. C. Werner, M. Oguri, et al., *Extraordinary magnification of the ordinary type Ia supernova PS1-10afx*, Astrophys. J. 768 (2013) L20 (5pp)

[2] A. B. Aazami and M. C. Werner, *Magnification in gravitational lensing via the exponential map*, forthcoming (2015)

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