The 14th International Conference on Gravitation, Astrophysics and Cosmology (ICGAC14)

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National Central University, Jhongli, Taiwan

Abstracts

1 Classical Gravity, GR Extensions

(Tue1) David Kubiznak (Perimeter Institute, Canada) Researcher

"Is there a Gauss-Bonnet gravity in four dimensions?"

We comment on the recently introduced Gauss-Bonnet gravity in four dimensions. We argue that although the naive $D \to 4$ limit of the Gauss-Bonnet gravity does not work, a well-defined theory is obtained by generalizing a conformal trick employed by Mann and Ross to obtain a limit of the Einstein gravity in $D = 2$ dimensions. This yields a scalar-tensor theory of the Horndeski type that can also be obtained by dimensional reduction methods. Some properties and solutions of this theory in four and three dimensions will be discussed.

(Tue2) Ling Jun Wang (University of Tennessee at Chattanooga, USA) Professor

"Unification of Gravitational and Electromagnetic Fields"

It has been a long dream of physicists to unify all the fundamental forces. It has not been very successful. The classical unification theories of Hermann Weyl, Arthur Eddington, Theodor Kaluza and Albert Einstein all have fundamental problems one way or another. The modern efforts along quantum field approach are not successful either. The Grand Unification The Theory of Everything (TOE) requires an unbelievably high Plank energy scale and an accelerator larger than the solar system. It is absolutely beyond our reach. It has been realized that general relativity is incompatible with quantum mechanics [1]. Recently, we have developed a theory with mathematical rigor to unify the gravitational and the electromagnetic forces strictly within the classical framework by generalizing Newton's law of gravitation to include a dynamic term inferred from the Lorentz force of electromagnetic interaction [2]. An entire dynamic theory including a wave equation of gravitation is developed without any additional ad hoc hypothesis. The wave equation and its solution naturally solve the mystery of action-at-distance. One of the exciting discoveries is that the inverse square law of the static and the dynamic forces is the result of the conservation of mass (Gauss's Law) and the total momentum (Wang's Law). The gravitational force and the electromagnetic force are thus unified in the sense that these two forces and their propagation can be described by exactly the same set of equations.

REFERENCES

1. Randall, L., Warped Passages: Unraveling the Universe's Hidden Dimensions. (Ecco. ISBN 0-06-053108-8. 2005).

2. Wang, L.J., Unification of Gravitational and Electromagnetic fields, Physics Essays, 31, No. 1, 2018.

(Wed1) Vesselin Gueorguiev (Institute for Advanced Physical Studies, USA) Researcher

"The Scale Invariant Vacuum Theory as viable Cosmology Model"

Recent studies in applying the Weyl's original gauge symmetry idea within the framework of the Weyl's Integrable Geometry to modern observational data in cosmology has resulted in the Scale Invariant Vacuum (SIV) paradigm. A sequence of papers by Prof. Andre Maeder has shown that SIV is a viable contender to standard LamdaCDM model see [1] for recent review. It has been also shown that the growth of the density perturbations of the early universe can be modeled within SIV without the need of dark matter [2]. Furthermore, SIV has been able to explain the asymptotic limit of the Radial Acceleration Relation (RAR) in Dwarf Spheroidals better than MOND and Dark Matter models [3]. An overview of the SIV results will be summarized and discussed subject to the time constraints of the workshop.

[1] Universe 2020, 6 (3), 46

[2] Physics of the Dark Universe 25 (2019) 100315

[3] MNRAS 492 (2) February 2020, Pages 2698-708

(Wed7) Muhammad Sharif (University of the Punjab, Pakistan) Professor

"Effects of Charge on Gravastars in Modified Theory of Gravitation"

In this talk, we study the effects of charge on a peculiar stellar object, known as gravastar in curvature-matter coupling gravity. This stellar object is also known as an alternative to a black hole and is expressed by three different domains named (i) the interior domain, (ii) the intermediate shell and (iii) the exterior domain. In the interior domain, we assume that pressure is equal to negative energy density which leads to the existence of a repulsive force on the spherical shell. The intermediate shell consists of ultra-relativistic plasma and pressure which shows a direct relation with energy density and counterbalances the repulsive force applied by the interior domain. The exterior vacuum spherical domain is taken to be the de Sitter spacetime illustrated by the Reissner-Nordstrom metric. We conclude that non-singular solutions of charged gravastar with various physical properties such as length, energy, entropy and equation of state parameter are physically consistent.

(Wed8) James Nester (National Central University, Taiwan) Professor

"Quasi-local gravitational energy"

The specification of energy for gravitating systems has been an unsettled issue since Einstein proposed his pseudotensor. It has been considered to be ill defined, having no proper local density. Energy-momentum is now considered to be quasi-local (associated with a closed 2-surface). We have been investigating quasi-local proposals (including pseudotensors) that can be approached from the Lagrangian-Noether-Hamiltonian perspective. There are two ambiguities: (i) many possible expressions, (ii) they all depend on some non-dynamical structure, e.g., a reference frame on the boundary of the dynamical region. The Hamiltonian perspective gives a handle on both problems, clarifying their physical significance. It led us to a remarkable discovery: with an isometric Minkowski reference a large class of expressions—namely all those that agree to linear order with the Einstein pseudotensor's Freud superpotential (equivalently, with our preferred quasi-local expression)—give a common quasi-local energy value. With a best-matched reference on the boundary this value is the (non-negative!) Wang–Yau mass. Similarly, for a constant curvature isometric reference (de Sitter or anti-de Sitter) we found that a large class of expressions—namely all those that agree with the Abbot-Deser superpotential (equivalently, with our preferred quasi-local expression) to linear order—have a common quasi-local energy value. Thus, we have discovered that with an isometric reference there is a unique quasi-local energy.

(Wed9) Sinya Aoki (Yukawa Institute for Theoretical Physics, Kyoto U., Japan) Professor

"Local energy density and conserved energy in general relativity"

How to define a local energy density has been a long-standing issue in general relativity from its beginning. There exist many different definitions for the total energy but without defining a local energy density. We give a simple and precise definition of a conserved charge from covariantly conserved currents in general relativity, which enables us to define local energy density from an energy momentum tensor for matter in general relativity. Applying our formalism to blackholes, we can reproduce usual black hole masses, which justifies the interpretation that the energy of the blackhole is given by the matter energy at the origin. Next, applying our definition to a compact star, we find that there exists a correction to the known mass formula associated with Oppenheimer-Volkoff equation. We also give some comparisons with conventional methods such as the ADM mass, the Komar energy.

(Wed10) Dmitry Gal'tsov (Moscow State University, Russia) Professor

"Successive dualities, NEC violation and singularities"

We discuss reinterpretation of classical singularities of GR in the context of non-minimal scalar-tensor theories (STT) disformally dual to Einstein-minimal scalar theory. Two such theories can be considered successively dual, if each of them is dual to the same third theory. This opens a way to test the strength of NEC violation in two STT constructing exact solutions dual to a singular GR solution. The NEC violation makes the metric in the STT frames better behaved and possibly nonsingular. Using successive duality of two NEC violating STTs, we show that desingularization is stronger in derivatively coupled STT compared with the case on non-derivative coupling

(Wed11) Sebastian Bahamonde (University of Tartu, Estonia) Postdoc

"Solar System Tests in Modified Teleparallel Gravity"

In this talk, I will present different Solar System tests in a modified Teleparallel gravity theory based on an arbitrary function $f(T,B)$ which depends on the scalar torsion T and the boundary term B. I will first give an overview about Teleparallel theories which are based on choosing a manifold with a zero curvature but non-zero torsion. Then, I will show new perturbed spherically symmetric solutions around Schwarzschild in Teleparallel gravity. For each solution, I will show different Solar System tests such as the perihelion shift, deflection of light, Cassini experiment, Shapiro delay and the gravitational redshift. Finally, I confront these computations with different known experiments from these Solar System tests to put different bounds on the mentioned models.

(Wed12) Konstantinos Dialektopoulos (Yangzhou University, China) Postdoc

"Can Horndeski gravity be recast in the Teleparallel framework?"

Teleparallel gravity is an alternative, but equivalent to General Relativity, description of gravitational interactions. As in the curvature framework, also in the teleparallel one, there have been many studies that include scalar field(s). Horndeski gravity is the most general scalar tensor theory of gravity, with a single scalar field, leading to second order equations of motion. However, most of this action is constrained from gravitational waves. In this talk, I will discuss whether or not the theory can survive in the teleparallel framework. Spoiler: It does!

(Wed13) Takafumi Kokubu (Hunan Normal University, China) Postdoc

"High energy collision without fine tuning: Acceleration and multiple collisions of shells in a bound system"

High energy collision of massive body is investigated without fine tuning. We study multiple collisions of two spherical concentric shells in a gravitationally bound system and calculate the center of mass energy between the shells. We solve the equation of motions for two shells without imposing any fine tuning of the initial parameters. In this bound system, the shells collide many times and these motions are highly nontrivial due to chaotic behavior of the shells. Consequently, the center of mass energy for each collision varies nontrivially and even reach almost its theoretical upper limit. We confirm that a significant proportion of the theoretical limit is automatically achieved during multiple collisions without fine tuning. At the same time, we also study shell ejection from the system after some collisions. If the initial shell's energy is large enough, multiple collisions may cause one shell to accumulate energy so that it escapes to infinity, even if two shells are initially confined in the system. The ejection is caused by multiple collisions inducing nontrivial energy transfer between the shells. The relation between the maximum center of mass energy and the energy transfer causing the shell ejection is also discussed.

(Wed14) Pradyumn Sahoo (Birla Institute of Technology & Science-Pilani, India) Professor

"A non-singular bounce in $f(R,T)$ gravitation"

The present discussion is devoted to the study of bouncing cosmology in $f(R,T)$ modified gravity where we presume $f(R,T) = R+2lambdaT$, $lambda$ being the model parameter. We will discuss here a novel parametrization of Hubble parameter which is apt in representing a successful bouncing scenario and simultaneously generate viable estimates of $a_0(t)$, $q_0(t)$, $H_0(t)$ and t_0. We proceed to present a complete analysis of the proposed bouncing model by studying the Hubble slow roll parameters, energy conditions and stability against linear homogeneous perturbations in flat space-time. We also delineate bouncing cosmology for the proposed model by employing Quintom matter. The present article further communicate for the first time that violation of energy-momentum materialize for both the contracting and expanding universes except for the bouncing epoch with energy flow directed away and into the matter fields for the contracting and expanding universe respectively. We further present a thorough investigation about the feasibility of the proposed bouncing scenario against first and generalized second law of thermodynamics. We found that the proposed bouncing scenario obeys the laws of thermodynamics for the constrained parameter space of $lambda$. The manuscript conclude after investigating the viability of the proposed bouncing model in non minimal $f(R,T)$ gravity where $f(R,T) = R+\chi RT$.

(Wed15) Jackson Levi Said (University of Malta, Malta) Professor

"Teleparallel Extensions to Cosmological Models"

LCDM continues to be supported by a large number of observational tests at cosmological, galactic and solar system scales. However, as observational measurements become ever more precise certain aspects of this model have resulted in large observational tensions such as in the H0 tension and the growing fSigma8 tension, among others. One alternative is to revisit the foundations of standard gravity (curvature based models of gravity) and consider an exchange of the Levi-Civita connection with its teleparallel analog (torsion based gravity). Under a particular choice of Lagrangian, this can be shown to be dynamically equivalent to LCDM called the teleparallel equivalent of general relativity (TEGR). However, the theories formed beyond TEGR are entirely novel and only limit to the standard gravity modifications of LCDM in some settings. While some of these extensions can limit to their curvature analog, the other way is not possible since teleparallel gravity is naturally lower order in derivative terms. In this presentation, the best motivated extensions of TEGR will be introduced together with recent constraints from recent cosmological observations. Current constraints have been shown to effective constraint literature models. The possible use of model-independent approaches to reconstructing gravitational models from cosmological data will also be discussed.

(Thu14b) Zhi-Bang Yao (Sun Yat-sen University, China) Student

"Spatially covariant gravity theories with two tensorial degrees of freedom"

Within the general framework of spatially covariant theories of gravity, we study the conditions for having only the two tensorial degrees of freedom. Generally, there are three degrees of freedom propagating in the theory, of which two are tensorial and one is of the scalar type. Through a detailed Hamiltonian analysis, we find two necessary and sufficient conditions to evade the scalar type degree of freedom. The first condition implies that the lapse function-extrinsic curvature sector must be degenerate. The second condition ensures that the dimension of the phase space at each spacetime point is even, so that the scalar type degree of freedom is eliminated completely. We also compare our results with the previous studies, and apply our formalism to a simple example, in which the Lagrangian is quadratic in the extrinsic curvature.

(Thu15a) Shota Yanai (Tokyo University of Science, Japan) Student

"Compact, charged boson-stars, -shells in the CP^N gravitating nonlinear sigma model"

Q-balls are non-topological solitons that appear in certain nonlinear complex scalar field models. The scalar field models with standard kinetic terms and V-shaped potential gives rise to compact Q-balls. When they couple with gravity, (compact) boson-stars arise. We study compact Q-balls (-shells) and compact boson-stars (boson-shells) in nonlinear sigma model with CP^N target space. The models with odd integer $N(=2n+1)$ and suitable potential can be parametrized by N-th complex scalar fields and they support compact solutions. For $n = 0, 1$ the solutions form Q-ball while $n \geq 2$ they always have shell structure. We find the new U(1) gauged compact Q-balls(-shells) and their gravitating solutions. The interior of the shell-like solutions can be empty space or harbor a black hole or a naked singularity.

(Thu15b) Hrishikesh Chakrabarty (Fudan University, China) Student

"Black hole bounce and birth of a baby universe"

We present a dynamical toy model for an expanding universe inside a black hole. The model is built by matching a spherically symmetric collapsing matter cloud to an expanding Friedmann-Robertson-Walker universe through a phase transition that occurs in the quantum-gravity dominated region, here modeled with semi-classical corrections at high density. The purpose of the model is to suggest a possible reconciliation between the observation that black holes are well described by the classical solutions and the fact that the theoretical resolution of space-time singularities leads to a bounce for the collapsing matter.

(Thu16a) Jinzhao Wang (ETH, Switzerland) Student

"Outer entropy = Bartnik-Bray quasilocal mass"

Entropy and energy are found to be closely tied on our quest for quantum gravity. We point out an interesting connection between the recently proposed outer entropy, a coarse-grained entropy defined for a compact spacetime domain motivated by the holographic duality, and the Bartnik-Bray quasilocal mass long known in the mathematics community. In both scenarios, one seeks an optimal spacetime fill-in of a given closed, connected, spacelike, codimension-two boundary. We show that for an outer-minimizing mean-convex surface, the Bartnik-Bray inner mass matches exactly with the irreducible mass corresponding to the outer entropy. The equivalence implies that the area laws derived from the outer entropy are mathematically equivalent as the monotonicity property of the quasilocal mass. It also gives rise to new bounds between entropy and the gravitational energy, which naturally gives the gravitational counterpart to Wall's ant conjecture. We also observe that the equality can be achieved in a conformal flow of metrics, which is structurally similar to the Ceyhan-Faulkner proof of the ant conjecture. We compute the small sphere limit of the outer entropy and it is proportional to the bulk stress tensor as one would expect for a quasilocal mass.

2 Classical and Quantum Cosmology

(Thu1) Jong-Ping Hsu (University of Massachusetts Dartmouth, USA) Professor

"Correlations of Hubble's Law and the Future of the Universe Based on the Strong Cosmological Principle and Yang-Mills Gravity"

We discuss dynamic models for the beginning, expansion and future of the universe based on a strong cosmological principle suggested by Yang-Mills gravity in flat spacetime. The results imply a correlation between Hubble's 'linear' law and the initial and final states of the universe. We derive a relativistic equation of motion for galaxies from the cosmic Okubo action, which involves a time-dependent effective metric tensor $G_{\mu\nu}(t)$. The strong cosmological principle states that $G_{\mu\nu}(t) = \eta_{\mu\nu} A^2(t)$ for all time. In HHK model with $A(t) = \alpha t^{1/2}$, the solution of Okubo's equation implies the initial mass run away velocity $\dot{r}(0)$ to be the speed of light c, which resembles a detonation. Such an initial state is also associated with a finite radius $r_o > 0$, infinite cosmic redshift and a finite deceleration. And the future of the universe is characterized by $r(\infty) \to \infty$ and $\dot{r}(\infty) \to 0$ with zero redshift. A distant galaxy satisfies the usual Hubble's law $\dot{r}(t) \approx H(t)r(t), H(t) = \dot{A}(t)/A(t)$, and has a constant 'cosmic momentum' $p = MA(t)\dot{r}(t)/1 - \dot{r}(t)/c$. We also discuss a model with a strict Hubble's linear relation $\dot{r}(t) \approx \text{const.} \times r(t)$ in the non-relativistic approximation. This model gives a 'silent' beginning: $\dot{r}(t) = 0, \ddot{r}(t) \to \infty$ as $t \to 0$; and final radius $r(t) \to \infty$, final velocity, $\dot{r}(t) \to$ the speed of light, $\ddot{r}(t) \to 0$ as $t \to \infty$. In all models with the strong cosmological principle, a distant galaxy has a constant cosmic momentum and Hubble's recession velocities are predicted to have an upper limit, i.e., the speed of light, as measured in an inertial frame.

(Thu2) Nikodem Poplawski (University of New Haven, USA) Professor

"Big Bounce and inflation from spin and torsion"

The conservation law for the total (orbital plus spin) angular momentum of a Dirac particle in the presence of gravity requires that spacetime is not only curved, but also has a nonzero torsion. The coupling between the spin and torsion in the Einstein-Cartan theory of gravity generates gravitational repulsion at extremely high densities, which should prevent a singularity in a black hole and may create there a new, closed, baby universe. We show that such a universe may form when a particular function of the scale factor and temperature is greater than some threshold, and that the universe can undergo one or more nonsingular bounces. We also show that quantum particle production caused by an extremely high curvature near a bounce, and creating enormous amounts of matter, can generate a finite period of inflation. This scenario has only one parameter, does not depend significantly on the initial conditions, does not involve hypothetical scalar fields, avoids eternal inflation, and predicts plateau-like inflation that is supported by the Planck observations of the cosmic microwave background. This scenario also suggests that our Universe may have originated from a nonsingular Big Bounce in a black hole existing in another universe.

(Thu3) Sujoy Modak (Universidad de Colima, Mexico) Professor

"New geometric and field theoretic aspects of radiation dominated early universe"

Radiation dominated (RD) stage is believed to succeed the inflationary stage of the early universe. In this talk, we shall show that the RD stage has a novel geometric feature which allows us to construct some aspects of quantum field theory in a rigorous manner. We shall introduce a new vacuum state (the "T" vacuum) for the massless scalar fields and show that it is not only well behaved, but also give radiation due to particle creation when looked upon from the cosmological/comoving observer's frame. A comparison of this study with the well known Unruh effect will also be presented. Finally, we shall discuss the future problems and potential importance of this discovery.

(Thu4) Naritaka Oshita (Perimeter Institute, Canada) Postdoc

"Hawking-Moss transition catalyzed by a black hole"

Static oscillating bounces in Schwarzschild de Sitter spacetime are investigated. The oscillating bounce with many oscillations gives a super-thick bubble wall, for which the total vacuum energy increases while the mass of the black hole decreases due to the conservation of Arnowitt-Deser-Misner (ADM) mass. We show that the transition rate of such an "up-tunneling" consuming the seed black hole is higher than that of the Hawking-Moss transition. This novel picture could shed light on the initial condition problem for inflation, provided that the inflationary universe is metastable due to the Higgs metastability and/or landscape structure.

(Thu5) Shun-Pei Miao (National Cheng Kung University, Taiwan) Professor

"Fine Tuning Problems with Cosmological Coleman-Weinberg Potentials"

Cosmological Coleman-Weinberg potentials are quantum corrections to the effective potential of the inflaton which result from coupling it to ordinary matter in order make re-heating efficient. These corrections are problematic for inflation because they are not Planck-suppressed and tend to make the potential too steep. Therefore they must be subtracted off by additions to the classical action. Unfortunately, they cannot be completely subtracted off. Although they go over to the Coleman-Weinberg form in the flat space limit, their actual form on de Sitter background is the 4th power of the Hubble parameter times a complicated function of the coupling constant times the ratio of the inflaton to the Hubble parameter. On a general inflationary background they are not even local functions of the geometry, whereas the allowable subtractions consist of algebraic functions of the inflaton and the Ricci scalar. We discuss the disturbing results from the best possible local subtraction schemes. This talk is based on arXiv:1506.07306, 1806.02533, 1908.03814 and 1908.05558.

(Thu6) Yuichiro Tada (Nagoya University, Japan) Postdoc

"Manifestly covariant theory of stochastic inflation"

The stochastic approach to inflation can non-perturbatively treat the superhorizon fluctuations as the classical random noise to go beyond the standard perturbative QFT approach. I first review how this approach enables us to calculate the observable curvature perturbations in a non-perturbative way and how it can be implemented in a numerical program. I then describe the covariance of the stochastic theory and the discretization scheme of the stochastic noise, which are important both theoretically and practically. Mathematically the stochastic noise can be discretized in an arbitrary manner, but we reveal the physically motivated discretization, which ensures the covariance of the stochastic theory on the inflatons' target manifold.

(Thu7) Xun Xue (East China Normal University, China) Professor

"Spatial Curvature and Large Scale Lorentz Violation"

The tension between the Hubble constant obtained from the local measurements and cosmic microwave background (CMB) measurements motivated us to consider the cosmological model beyond standard model based on such as the large scale Lorentz violation model with non-vanishing spatial curvature. The degeneracy among spatial curvature, cosmological constant and cosmological contortion distribution makes the model viable in describing the known observation date. We got some constrains on the spatial curvature by the comparison of the relation between measured distance modulus and redshift with the expected one, evolution of matter density over time and evolution of effective cosmological constant. The performance of large scale Lorentz violation model with non-vanishing spatial curvature under these constrains is discussed.

(Thu8) Chopin Soo (National Cheng Kung University, Taiwan) Professor

"Cosmic time and reduced phase space of General Relativity"

In an ever-expanding spatially closed universe, the fractional change of the volume is the preeminent intrinsic time interval to describe evolution in General Relativity. The expansion of the universe serves as a subsidiary condition which transforms Einstein's theory from a first class to a second class constrained system. The Hamiltonian constraint is solved by eliminating the trace of the momentum in terms of the other variables, and spatial diffeomorphism symmetry is tackled explicitly by imposing transversality. A reduced physical Hamiltonian for intrinsic time evolution of the two physical d.o.f. emerges. Freed from the first class Dirac algebra, deformation of the Hamiltonian constraint is permitted, and natural extension of the Hamiltonian while maintaining spatial diffeomorphism invariance leads to a theory with Cotton-York term as the ultraviolet completion of Einstein's theory.

(Thu9) Hoi Lai Yu (Academia Sinica, Taiwan) Professor

"Intrinsic Time Quantum Gravity"

Prompting the ever expansion of a spatially closed universe to become a fundamental principle in cosmology, therefore, the close universe's fractional changes in volume being the intrinsic time; we shall discuss, (1) the physical contents of General Relativity as a system of second class constraints, and (2) the physical canonical phase space functional integral of General Relativity plus its quantum ultra-violet completion with the Cotton-York tensor.

(Wed3a) Yun Hao (University of Massachusetts Dartmouth, USA) Student

"Motions of Light Rays and Galaxies in Cosmic Scales with the Cosmological Principle"

We derive a relativistic equation of motion for light rays and galaxies from the cosmic Okubo action, S_{Ok}, which involves a purely time-dependent effective metric tensor $G_{\mu\nu}(t)$. It is derived from Yang-Mills gravity in flat space-time and the large scale limit. We discuss the laws of motion in cosmos with and without the cosmological principle based on inertia frames. For inertial frames, Yang-Mills gravity and cosmological principle lead to the non-vanishing components $G_{00} \propto G_{kk} \propto t^{1/2}, k = 1, 2, 3$, for matter dominated universe. The solution of Okubo's equation $G_{\mu\nu}(t)\partial_\mu S \partial_\nu S - m^2 = 0, [S \equiv S_{Ok}, G_{\mu\lambda}(t)G^{\lambda}{}_{\nu}(t) = \delta_{\mu\nu},]$ implies the initial mass run away velocity $\dot{r}(0)$ to be an effective speed of light, which resembles a 'bang'. The effective speed of light in super-macroscopic cosmos is determined by the equation $G_{\mu\nu}(t)dx^\mu dx^\nu = 0$. The motion of light rays and the cosmic redshift involving non-inertial light source are described by the Okubo equation with $m = 0$. In all models with the cosmological principle, the cosmic Okubo actions lead to a constant 'cosmic momentum' and imply an upper limit for all recession galaxies, as measured in an inertial frame.

(Wed3b) Yusuke Mikura (Nagoya University, Japan) Student

"Conformal inflation in the metric-affine geometry"

Systematic understanding for classes of the inflationary models is investigated from a viewpoint of the local conformal symmetry and explicit breaking of the global symmetry in the framework of the metric-affine geometry. The metric-affine geometry is a generalization of the Riemannian one adopted in the ordinary General Relativity. There the affine connection is an independent variable of the metric rather than given by the Levi-Civita connection as its function. Thanks to this independency, the metric-affine geometry can preserve the local conformal symmetry in each term of the Lagrangian contrary to the Riemannian geometry, and then the local conformal invariance can be compatible with much more kinds of global symmetries. As simple examples, we consider the two-scalar models with the broken SO(1,1) and the broken O(2), leading to the well-known α-attractor and natural inflation respectively.

(Wed4a) Qi Li (East China Normal University, China) Student

"The Effective Potential Originating from Swampland and the Non-trivial Brans-Dicke Coupling"

The effective vacuum energy density contributed by the non-trivial contortion distribution and the bare vacuum energy density can be viewed as the energy density of the auxiliary quintessence field potential. We find that the negative bare vacuum energy density from string landscape leads to a monotonically decreasing quintessence potential while the positive one from swampland leads to the meta stable or stable de Sitter like potential. Moreover, the non-trivial Brans-Dicke like coupling between quintessence field and gravitation field is necessary in the latter case.

3 Dark Matter and Dark Energy

(Tue11) Keiko Nagao (Okayama University of Science, Japan) Researcher

"Directional direct detection of light dark matter"

In directional detection experiment of dark matter, both the recoil energy and direction are expected to be detected. Recently a possibility that light dark matter whose mass is O(1-0.01) GeV can be constrained in ordinary direct detection due to cosmic ray acceleration had been pointed out. In this talk, detectability of this kind of cosmic-ray accelerated dark matter in the directional detection will be discussed.

(Tue12) Naoya Kitajima (Tohoku University, Japan) Researcher

"Primordial Black Holes from QCD Axion Bubbles"

In this talk, I show a scenario in which a strong Peccei-Quinn (PQ) symmetry breaking in the early universe results in large inhomogeneities of the initial QCD axion field value, leading to the formation of very dense axion bubbles. Some of the axion bubbles subsequently collapse into primordial black holes (PBHs). The spatially homogeneous part of the QCD axion explains dark matter of the universe, while the PBHs arising from the axion bubbles can explain the LIGO events or the seed of supermassive black holes. Interestingly, the mass of PBH is determined by the axion decay constant; for $f_a = 10^{17}(10^{16})$ GeV, the PBH mass is heavier than about $10(10^4)M_\odot$. In addition, axion miniclusters are also formed from the axion bubbles more abundantly than PBHs, and their masses are expected to be heavier than in the usual scenario based on the spontaneous breaking of the PQ symmetry after inflation.

(Tue13) Tetsutaro Higaki (Keio University, Japan) Professor

"Note on a solution to domain wall problem with the Lazarides-Shafi mechanism in axion dark matter models"

Axion is a promising candidate of dark matter. After the Peccei-Quinn symmetry breaking, axion strings are formed and attached by domain walls when the temperature of the universe becomes comparable to the QCD scale. Such objects can cause cosmological disasters if they are long lived. As a solution for it, the Lazarides-Shafi mechanism is often discussed through introduction of a new non-Abelian (gauge) symmetry. We study this mechanism in detail and show configuration of strings and walls. Even if Abelian axion strings with a domain wall number greater than 1 are formed in the early universe, each of them is split into multiple Alice axion strings due to a repulsive force between the Alice strings even without domain wall. When domain walls are formed as the universe cools down, a single Alice string can be attached by a single wall because a vacuum is connected by a non-Abelian rotation without changing energy. Even if an Abelian axion string attached by domain walls is created due to the Kibble Zurek mechanism at the chiral phase transition, such strings are also similarly split into multiple Alice strings attached by walls in the presence of the domain wall tension. Such walls do not form stable networks since they collapse by the tension of the walls, emitting axions.

(Tue14) Sungwook E Hong (University of Seoul, Korea) Researcher

"Revealing the Local Cosmic Web by Deep Learning"

Eighty per cent of the matter in the Universe is in the form of dark matter that comprises the skeleton of the large-scale structure called the Cosmic Web. As the Cosmic Web dictates the motion of all matters in galaxies and inter-galactic media through gravity, knowing the distribution of dark matter is essential for studying the large-scale structure. However, as dominated by dark matter and warm-hot inter-galactic media, both of which are hard to trace, the detailed structure of the Cosmic Web is unknown. Here we show that we can reconstruct the Cosmic Web from the galaxy distribution using the convolutional-neural-network based deep-learning algorithm. We find the mapping between the position and velocity of galaxies and the Cosmic Web using the results of the state-of-the-art cosmological galaxy simulations, Illustris-TNG. We confirm the mapping by applying it to the EAGLE simulation. Finally, using the local galaxy sample from Cosmicflows-3, we find the dark-matter map in the local Universe. We anticipate that the local dark-matter map will illuminate the studies of nature of dark matter and the formation and evolution of the Local Group. High-resolution simulations and precise distance measurements to local galaxies will improve the accuracy of the dark-matter map.

(Tue15) Goverdhan Khadekar (RTM Nagpur University, India) Professor

"Scalar fields Reconstruction of Viscous Power Law Entropy Corrected Holographic Dark Energy"

In this work we study the non flat FRW universe filled with an interacting viscous power law corrected holographic dark energy (PLECHDE) model with the quintessence, tachyon, k-essence and dilaton scalar filed model in the framework of Einstein general theory of relativity. We obtain equation of state parameter of the interacting viscous PLECHDE and then construct both dynamic and potential of these scalar filed models, according to the evolutionary behavior of the interacting viscous PLECHDE model.

(Thu11b) Sung Mook Lee (Yonsei University, Korea) Student

"Primordial Black Holes in Higgs-R^2 Inflation as a Whole Dark Matter"

Primordial black holes are produced in a minimal UV extension to the Higgs inflation with an included R^2 term. We show that for parameters consistent with Standard Model measurements and Planck observation results lead to $M_{\rm PBH} \in (10^{-17}, 10^{-15}) M_\odot$ primordial black holes with significant abundance, which may consist the majority of dark matter.

(Thu16b) Yiyi Zhu (University of Massachusetts Lowell) Student

"The Role of Non-Relativistic Neutrinos in Dark Matter"

According to the theory proposed by Lee and Yang in 1955, apart from four fundamental interactions, we derive a new force in a generalized U(1) group based on the conservation law of the lepton number. It is called as the lepton force. It turns out to be a constant force between two point lepton charges. However, in our mathematical model, the size of objects cannot be neglected. For convenience, we model the universe as a gigantic sphere with uniform lepton charges (carried by the electrons in atoms). We calculate the effective force of this sphere on a point lepton charge pf a neutrino. Our calculations show that we may consider the lepton charges of the gigantic sphere as concentrated at the center of the sphere. The new force formula is linear and will increase as the distance increases. Based on the hadron decay result, the number of neutrinos are much more than the numbers of protons and electrons which are the main particles of the observable universe. However, it is difficult to detect neutrinos in nature. This result suggests that our hypothesis may be consistent with observation of dark matter. The only problem is that energy of the original neutrinos is too high so that they cannot make up dark matter. But dark matter can consists of non-relativistic neutrinos. We can obtain the lepton potential with the lepton force. Based on the energy conservation law, neutrinos will move slower as the distance increases. And according to the simulation result, neutrinos will cold down to non-relativistic particles even stop somewhere inside the observable universe.

4 Black Holes, Wormholes

(Tue3) Bogeun Gwak (Dongguk University - Seoul Campus, Korea) Professor

"Kerr-Sen Black Hole and Weak Cosmic Censorship Conjecture"

We investigate the weak cosmic censorship conjecture for Kerr-Sen black holes by a charged scalar field. When the fluxes of the scalar field are assumed to transfer its conserved quantities to the black hole, extremal and near-extremal black holes cannot be over-spun and over-charged in their first-order variations.

(Tue4) Dong-han Yeom (Pusan National University, Korea) Professor

"Before the Page time: maximum entanglements or the return of the monster?"

The entropy of Hawking radiation is approximately equal to the maximum of entanglement entropy if a black hole is in a state before the Page time, i.e., when the entropy of Hawking radiation is smaller than the entropy of the black hole. However, if there exists a process generating smaller entanglements rather than maximal entanglements, the entropy of Hawking radiation will become smaller than the maximum of the entanglement entropy before the Page time. If this process accumulates, even though the probability is small, the emitted radiation can eventually be distinguished from the exactly thermal state. In this paper, we provide several interpretations of this phenomenon: (1) information of the collapsed matter is emitted before the Page time, (2) there exists a firewall or a non-local effect before the Page time, or (3) the statistical entropy is greater than the areal entropy; a monster is formed. Our conclusion will help resolve the information loss paradox by providing groundwork for further research.

(Tue5) Shih-Yuin Lin (National Changhua University of Education, Taiwan) Professor

"A nearly black star may look like a 2D membrane"

A nearly black, gravitationally intense star of semi-transparent, spherical, massive shell containing a few pointlike light sources inside would be perceived not like a three-dimensional ball for a localized observer outside the shell in terms of the affine or binocular distance. As the radius of the spherical shell approaches the Schwarzschild radius, the perceived distance between the front and rear surfaces of the shell would go to zero, while the images of most of the interior emitters would squeeze around the shell surfaces in terms of the affine or binocular distance. So, the Schwarzschild black hole formed from the star would be thought of as a two-dimensional membrane for the observers who can only measure the binocular distance and/or affine distance. However, the depth information of a point source inside the nearly black star can still be resolved in terms of the radar or luminosity distance, which needs the knowledge about the radar signals or standard candles sent in earlier by the observer outside the star. This suggests that at late times of gravitational collapse the area law of the entropy would dominate over the volume law for outside observers due to the loss of the knowledge about the ingoing probes earlier.

(Tue6) Shinji Mukohyama (YITP, Kyoto U, Japan) Professor

"Black holes in scalar-tensor theory"

After reviewing the EFT approach to scalar-tensor theories, I will revisit the issue of strong coupling of perturbations around stealth solutions, i.e. backgrounds with the same forms of the metric as in general relativity but with non-trivial configurations of the scalar field. In particular I will argue that a controlled detuning of the degeneracy condition, which is called scordatura, renders the perturbations weakly coupled without changing the properties of the stealth solutions at astrophysical scales. Finally, I will explore the possibility to use disformal field redefinitions to investigate new regions of the solution space of scalar tensor theories, and present new hairy black holes solutions beyond the stealth sector.

(Tue7) Nobuyuki Sakai (Yamaguchi University, Japan) Professor

"Exotic Gravitating Objects"

To identify observationally exotic gravitating objects such as wormholes, braneworld blackholes, boson stars and global monopoles, we theoretically investigate their microlensing phenomena and shadows.

(Tue8) Shoichi Kawamoto (National Tsing Hua University, Taiwan) Researcher

"Charged rotating BTZ black holes in noncommutative space and torsion gravity"

We consider charged rotating BTZ black holes in noncommutative space using a Chern-Simons theory formulation of (2+1)-dimensional gravity. The noncommutativity between the radial and the angular variables is introduced through the Seiberg-Witten map for gauge fields, and the deformed geometry to the first order in the noncommutative parameter is derived. It is found that the deformation also induces nontrivial torsion, and Einstein-Cartan theory appears to be a suitable framework to investigate the equations of motion. Though the deformation is indeed nontrivial, the deformed and the original Einstein equations are found to be related by a rather simple coordinate transformation.

(Tue9) Michael Good (Nazarbayev University, Kazakhstan) Professor

"Radiation from an inertial mirror horizon"

The purpose of this study is to investigate radiation from asymptotic zero acceleration motion where a horizon is formed and subsequently detected by an outside witness. A perfectly reflecting moving mirror is used to model such a system and compute the energy and spectrum. The trajectory is asymptotically inertial (zero proper acceleration)-ensuring negative energy flux (NEF), yet approaches light-speed with a null ray horizon at a finite advanced time. We compute the spectrum and energy analytically.

(Tue10) Che-Yu Chen (LeCosPA, National Taiwan University, Taiwan) Postdoc

"Regular black hole interior spacetime supported by three-form field"

In this talk, we show that a minimally coupled 3-form endowed with a proper potential can support a regular black hole interior. The singularity is replaced with a Nariai-type spacetime, whose topology is $dS_2 \times S_2$, in which the radius of the 2-sphere is constant, so as the interior continues to expand indefinitely, the geometry becomes essentially compactified. The 2-dimensional de Sitter geometry appears despite the negative potential of the 3-form field. Such a dynamical compactification could shed some light on the origin of de Sitter geometry of our Universe, exacerbated by the Swampland conjecture. In addition, we show that the spacetime is geodesically complete. The geometry is singularity-free due to the violation of the null energy condition.

(Wed2) Angel Rincon (Pontifical Catholic University of Valparaíso, Chile) Postdoc

"Scale-dependent black holes"

In this talk, we will review the current status of a special kind of black holes inspired by asymptotic safety. In particular, we will investigate how certain well known black hole quantities suffer changes in light of the scale-dependent scenario, which is based on the running of the coupling constants of the theory.

(Fri10) Sung-Won Kim (Ewha Womans University, Korea) Professor

"Creation and Annihilation of Wormhole in Matter-Dark Energy Universe"

We considered the evolution of the wormhole throat in the universe with dust or/and dark energy. We adopt a quasilocal definition of a wormhole throat on a spacelike hypersurface, since these spacetimes are not asymptotically flat. This throat is coincide with a bifurcating trapping horizon or be located in the trapped region. In a matter-dominated universe, wormhole throat appears with cosmological horizon and it disappears with cosmological horizon in dark energy universe. We also find the condition of the matter distribution for the existence of the wormhole throat.

(Wed4b) Keisuke Nakashi (Rikkyo University, Japan) Student

"Observability of the innermost stable circular orbit in a near-extremal Kerr black hole"

We consider the escape probability of a photon emitted from the innermost stable circular orbit (ISCO) of a rapidly rotating black hole. As an isotropically emitting light source on a circular orbit reduces its orbital radius, the escape probability of a photon emitted from it decreases monotonically. The escape probability evaluated at the ISCO also decreases monotonically as the black hole spin increases. When the dimensionless Kerr parameter a is at the Thorne limit $a = 0.998$, the escape probability from the ISCO is 58.8%. In the extremal case $a = 1$, even if the orbital radius of the light source is arbitrarily close to the ISCO radius, which coincides with the horizon radius, the escape probability remains at 54.6%. We also show that such photons that have escaped from the vicinity of the horizon reach infinity with sufficient energy to be potentially observed because Doppler blueshift due to relativistic beaming can overcome the gravitational redshift. Our findings indicate that signs of the near-horizon physics of a rapidly rotating black hole will be detectable on the edge of its shadow. Ref: Phys.Rev.D 101 (2020) 4, 044044.

(Wed5a) Yasutaka Koga (Rikkyo University, Japan) Student

"Photon surfaces as pure tension shells: Uniqueness of thin shell wormholes"

A joined spacetime (JST) is a spacetime constructed from two spacetimes by thin-shell formalism. Z2-symmetric JSTs with a pure-tensional thin shell have been extensively investigated in literatures in the context of wormholes, brane worlds, and baby universes. In this talk, we see that if such a Z2-symmetric pure-tensional JST (Z2PTJST) is Lambda-vacuum, the thin shell must be on a photon surface, a hypersurface which geometrically generalizes a photon sphere, of the original two spacetimes. In particular, in the case of vacuum wormholes, i.e. vacuum and asymptotically flat Z2PTJSTs, we prove the uniqueness theorem of the spacetimes by applying Cederbaum's photon sphere uniqueness theorem to the problem. Our theorem states that the original two spacetimes constituting the JST are Schwarzschild spacetimes of equal masses and the thin shell is on the radius $r = 3M$, the photon sphere of the spacetimes. The talk is based on [Phys. Rev. D 101, 104022 (2020)].

(Wed5b) Colin MacLaurin (University of Queensland, Australia) Student

"3-Volumes of a black hole"

In relativity, physical measurements are relative to the observer. For Schwarzschild spacetime I present spatial measurements including 3-dimensional volume, relative to a congruence of observers. The observer 4-velocities are parametrised by kinetic energy and angular momentum, as determined from Killing vector fields in the usual way. The volume integral is over the local 3-spaces orthogonal to the 4-velocity at each point, which form a geometric "distribution" not integrable to a submanifold in general. The broader motivation is conceptual understanding, with applications to spacetime splitting and physical interpretation of arbitrary fields on spacetime.

(Wed6a) Kapil Chandra (Bastar University, India) Student

"Does Hawking predict the correct temperature of black hole"

In our study of the validity of Hawking's predicted radiation temperature of a black-hole, we found that the calculated temperature is another form of Zeldovich's expression for the cosmological constant. We reasoned that as Zeldovich predicted the extreme value of cosmological constant thus Hawking might have also predicted an extreme temperature. However, the actual temperature might be something different. This result implies that all predictions based on Hawking's radiation temperature might be incorrect.

(Wed6b) Yawar Hussain Khan (National Institute of Technology Srinagar, India) Student

"Culetu regular black hole with asymptotically Minkowski core, its remnants and stability"

In this work we present the remnants of Culetu black hole. The black hole is regular everywhere and rather having usual de-sitter core, the core is asymptotically Minkowskian. We first derive expression for the remnant size for different values of mass and charge parameters, m and q respectively. The stability of remnants is analyzed in presence of thermal fluctuations and we observe that the thermal fluctuations tend to increase the entropy at the horizon radius which is exactly the remnant radius.

(Thu10a) Hsu-Wen Chiang (LeCosPA, National Taiwan University, Taiwan) Student

"Generic 3-species model for unitary black hole evolution"

We extend the results in Hotta et al. (arXiv:1706.07520) by showing that the presence of a channel from the black hole interior to the exterior, no matter the form or strength, is enough for the recovery of page curve.

(Thu10b) Yu-Hsien Kung (LeCosPa, National Taiwan University, Taiwan) Student

"Modification to the Hawking temperature of a dynamical black hole by a flow-induced supertranslation"

One interesting proposal to solve the black hole information loss paradox without modifying either general relativity or quantum field theory, is the soft hair, a diffeomorphism charge that records the anisotropic radiation in the asymptotic region. This proposal, however, has been challenged, given that away from the source the soft hair behaves as a coordinate transformation that forms an Abelian group, thus unable to store any information. To maintain the spirit of the soft hair but circumvent these obstacles, we consider Hawking radiation as a probe sensitive to the en- tire history of the black hole evaporation, where the soft hairs on the horizon are induced by the absorption of a null anisotropic flow, generalizing the shock wave considered in [1, 2]. To do so we introduce two different time-dependent extensions of the diffeomorphism associated with the soft hair, where one is the backreaction of the anisotropic null flow, and the other is a coordinate trans- formation that produces the Unruh effect and a Doppler shift to the Hawking spectrum. Together, they form an exact BMS charge generator on the entire manifold that allows the nonperturbative analysis of the black hole horizon, whose surface gravity, i.e. the Hawking temperature, is found to be modified. The modification depends on an exponential average of the anisotropy of the null flow with a decay rate of 4M, suggesting the emergence of a new 2-D degree of freedom on the horizon, which could be a way out of the information loss paradox.

(Thu11a) Igor Bogush (Moscow State University, Russia) Student

"Kaluza-Klein dyons: regular and singular"

We generated new asymptotically (locally) flat static solutions of Kaluza-Klein theory with Newman-Unti-Tamburino (NUT) parameter and independent scalar charge, extending the previously known results. Generally, these solutions can be represented by a nondegenerate charge matrix in the coset matrix approach. The corresponding four-dimensional metrics generalize Fisher solution and contain naked singularities. Regular black holes belong to the case of degenerate charge matrix, and we explore the most general such solutions endowed with the NUT parameter. Solving the degeneracy constraint equation, we found three branches of the dilaton charge as a function of other charges corresponding to three classes of solutions. One of them contains previously known regular KK black holes. Two other generically are singular. Contrary to the Einstein-Maxwell theory, the overcharged solutions can not be converted to wormhole adding NUT, while the 5D solutions still contain (non-traversable) wormholes. We analyze the geodesic structure, including the behavior inside the chronology boundary around the Misner string of Nutty KK dyons.

5 Strings, Branes, Higher Spin Fields and Quantum Gravity

(Fri2) Robert Mann (University of Waterloo, Canada) Professor

"Holographic Complexity and Thermodynamic Volume"

I describe the first investigation of the holographic complexity conjectures for rotating black holes. Exploiting a simplification that occurs for equal-spinning odd dimensional black holes, we uncover a relationship between the complexity of formation and the thermodynamic volume associated with the black hole. This result reduces to known expressions when the spin vanishes, and suggests that it is thermodynamic volume and not entropy that governs the complexity of formation in both the Complexity Equals Volume and Complexity Equals Action proposals. Assuming the validity of a conjectured inequality for thermodynamic volume, our result suggests the complexity of formation is bounded from below by the entropy for large black holes.

(Fri3) Mitsutoshi Fujita (Sun Yat-Sen University, China) Researcher

"Kibble-Zurek Scaling in a Holographic p-wave Superconductor"

We study the Kibble-Zurek mechanism in a 2d holographic p-wave superconductor model with a homogeneous source quench on the critical point. We derive, on general grounds, the scaling of the Kibble-Zurek time, which marks breaking-down of adiabaticity. It is expressed in terms of four critical exponents, including three static and one dynamical exponents. Via explicit calculations within a holographic model, we confirm the scaling of the Kibble-Zurek time and obtain the scaling functions in the quench process. We find the results are formally similar to a homogeneous quench in a higher dimensional holographic s-wave superconductor. The similarity is due to the special type of quench we take. We expect differences in the quench dynamics if the condition of homogeneous source and dominance of critical mode are relaxed.

(Fri4) Jia-Rui Sun (Sun Yat-Sen University, China) Professor

"On the emergence of gravitational dynamics from tensor networks"

Tensor networks are powerful techniques that widely used in condensed matter physics. Recently, it is shown that they can generate the anti-de Sitter (AdS) geometry by using the entanglement renormalization approach. However, whether the dynamical connections can be found between the tensor network and the gravity is an important unsolved problem. In this talk, we will introduce a novel approach to integrate ideas from tensor networks, entanglement entropy, canonical quantization of quantum gravity and the holographic principle and argue that the bulk gravitational dynamics can be generated from a tensor network if the wave function of the latter satisfies the Wheeler-DeWitt equation, which indicates a connection between the boundary Schrodinger equation and the bulk Wheeler-DeWitt equation.

(Fri5) Vishnu Rajagopal (University of Hyderabad, India) Researcher

"Kappa deformed oscillator algebra and Unruh effect"

The kappa-deformed space time is a Lie algebraic type non-commutative-space-time that comes naturally in the study of quantum gravity. Here we study the quantisation of scalar field theory in kappa-deformed space-time. Construction of Lagrangians in the kappa deformed space-time do not lead to unique answers and hence we use kappa deformed equations of motion for the quantisation. Adopting a quantisation scheme that uses only field equations, we derive the quantisation rules for deformed scalar theory, starting from the kappa-deformed equations of motion. This scheme allows two choices; (1) a deformed commutation relation between the field and its adjoint which leads to usual oscillator algebra, (2) an undeformed commutation relation between field and its adjoint leading to a deformed oscillator algebra. This deformed oscillator algebra is used to derive modification to Unruh effect in the kappa-deformed space-time.

(Fri6) Chiranjeeb Singha (Indian Institute of Science Education and Research, India) Researcher

"Hamiltonian-based derivation of the Hawking effect"

In order to achieve a Hamiltonian-based canonical derivation of the Hawking effect, one usually faces multiple hurdles. Firstly, spacetime foliation using Schwarzschild time does not lead to hyper-surfaces which are always spacelike. Secondly, the null coordinates which are frequently used in the covariant approach, do not lead to a true matter Hamiltonian. In order to overcome these difficulties, We have introduced a new set of near-null coordinates which allows one to perform an exact canonical derivation of the Hawking effect. However, there too one faces the difficulty of having to deal with non-vanishing matter diffeomorphism generator as the spatial decomposition involves a non-zero shift-vector. Then we have introduced a new set of coordinates that allows one to perform an exact canonical derivation of the Hawking effect without having to deal with matter diffeomorphism generator. These derivations open up an avenue to explore the Hawking effect in the framework of different canonical quantization methods such as the polymer quantization.

(Fri7) Homa Shababi (Sichuan University, China) Postdoc

"The Minimal Length Uncertainty and the Tsallis statistical mechanics"

In this presentation, we study the thermodynamics of quantum harmonic oscillator in the Tsallis framework and in the presence of a minimal length uncertainty. The existence of the minimal length is motivated by various theories such as string theory, loop quantum gravity, and black-hole physics. We analytically obtain the partition function, probability function, internal energy, and the specific heat capacity of the vibrational quantum system for $1 < q < \frac{3}{2}$ and compare the results with those of Tsallis and Boltzmann-Gibbs statistics without the minimal length scale.

(Fri8) Hiroyuki Takata (Tomsk State Pedagogical University, Russia) Researcher

"Fronsdal like Lagrangian for continuous spin by BRST method"

Continuous spin filed theory is described by infinite number of fields with different spin. It includes real parameter μ of mass dimension, that is called continuous spin parameter. μ is a quantum number classifying representation of Poincare group other than mass or spin. Lagrangian for continuous spin field theory has been studied by different ways. We use so called BRST method to construct Lagrangian for continuous spin filed, that is well developed method for free higher spin field theory. By technical reason, we start from fields with spinor indices, find Lagrangian in four dimension by BRST method, convert it to that with vector indices and then rewrite with double traceless fields. It is an explicit Lagrangian in arbitrary spacetime dimension for integer spin with continuous spin parameter μ. It clearly becomes Fronsdal Lagrangian for massless higher spin field when $\mu \to 0$.

(Fri9) Michael A. Ivanov (Belarus State University of Informatics and Radioelectronics, Belarus)

"Different expectations about quantum gravity"

The desire to quantize general relativity to unify it with quantum mechanics gave not very much up to now; some predicted effects lie very far in the Planck scale to be observed in the foreseeable future. The situation is different in the model of low-energy quantum gravity by the author where some known effects (such as the cosmological redshift) may be interpreted as results of the interaction of gravitons with photons or bodies. The Newton constant G may be computed in the model that makes it principally underlying for general relativity. Important features of the model and some possibilities to verify it at present are discussed here.

6 Extra Dimensions and Variation of Constants

7 Experimental Studies of Gravity and Fundamental Physics Space Projects

(Mon14) Cosimo Bambi (Fudan University, China) Professor

"Testing general relativity with black holes using X-ray observations"

Einstein's theory of general relativity was proposed over 100 years ago and has successfully passed a large number of observational tests in weak gravitational fields. However, the strong field regime is still largely unexplored, and there are many modified and alternative theories that have the same predictions as Einstein's gravity for weak fields and present deviations only when gravity becomes strong. Astrophysical black holes are ideal laboratories for testing gravity in the strong field regime. In this talk, I will present the XSPEC models relxill_nk and nkbb, which are designed for testing the metric around black holes by fitting, respectively, the reflection and the thermal component of the accretion disk. I will also show current constraints on possible new physics from the analysis of a few sources with these models.

(Mon15) Ignazio Ciufolini (University of Salento, Italy) Professor

"Tests of General Relativity and frame-dragging using the LARES and LARES 2 satellites"

Dragging of inertial frames, or frame-dragging, is an intriguing phenomenon predicted by General Relativity. The weak equivalence principle is at basis of General Relativity and other viable theories of gravitation. LARES (LAser RElativity Satellite) is a laser-ranged satellite successfully launched February 13, 2012. LARES 2 is a new generation laser-ranged satellite ready for launch in fall-winter 2020. We describe the accurate tests of frame-dragging and a test of the equivalence principle achieved with LARES and the very accurate tests of frame-dragging and General Relativity achievable with LARES 2

8 Gravitational Waves

(Mon1) Michael Landry (LIGO Hanford Observatory/Caltech, USA) Researcher

"Colliding black holes and neutron stars: latest results from LIGO and Virgo"

On Mar 27, 2020, the LIGO Scientific and Virgo Collaborations suspended their third observation run (O3), a search for gravitational waves (GWs) of astrophysical origin. Beginning Apr 1, 2019 and running 11 months (plus one month off for detector improvements), LIGO and Virgo interferometers recorded 56 unretracted triggers, corresponding to an average rate of one likely GW signal every six days, before suspending operations owing to the global pandemic. The majority of these triggers correspond to mergers of binary black holes. Some candidates may be binary neutron star mergers, others black hole-neutron star collisions. Published O3 detections to date include GW190425, a heavy binary neutron star merger; GW190412, an asymmetric mass binary black hole coalescence with measurable imprints of higher multipoles in the data; and GW190814, a merger of a black hole and a mass-gap object. In this talk we review detector performance in O3 and summarize novel detections published to date. We sketch the pathway to O4, slated to commence in early 2022, and prospects for future detections.

(Mon2) Nobuyuki Kanda (Osaka City University, Japan) Professor

"Status of KAGRA"

KAGRA is laser interferometric gravitational wave detectors that constructed in Kamioka-mine, Japan. It is employing cryogenic mirror, 3km long baseline, and underground site to archive a high sensitivity. KAGRA collaboration consists of about 300 international researchers. We would like to report a status of current commissioning of detectors, plan for the observation, data analysis and scientific target of KAGRA.

(Mon3) Wei-Tou Ni (National Tsing Hua University, Taiwan) Professor

"Gravitational Wave Detection in Space: the Present Outlook"

Gravitational wave (GW) detection in space is aimed at low frequency band (100 nHz - 100 mHz; i.e., nicro-Hz band and milli-Hz band) and middle frequency band (100 mHz - 10 Hz). In this paper, we present an overview on the sensitivity, the sources, orbit design, basic orbit configuration, angular resolution, orbit optimization, deployment, time-delay interferometry and payload concept of the current proposed GW detectors in space under study. The detector proposals under study have arm length ranging from 100 km to 1.3×10^9 km (8.6 AU) including (a) Solar orbiting detectors – AMIGO, ASTROD-GW (ASTROD [Astrodynamical Space Test of Relativity using Optical

Devices] optimized for GW detection), BBO (Big Bang Observer), DECIGO (DECi-hertz Interferometer GW Observatory), ESA AMIGO, Folkner's Mission Concept, LISA (LISA [Laser Interferometer Space Antenna]), TAIJI etc. (in Earth-like solar orbits), Mu-Aries (in Mars-like solar orbits) and Super-ASTROD (in Jupiter-like solar orbits); (b) Earth orbiting detectors – B-DECIGO and TIANQIN ...

(Mon4) Ziren Luo (Chinese Academy of Sciences, China) Researcher

"A brief introduction to Taiji and Taiji-1 satellite"

Chinese Space-borne Gravitational Wave Detection Program "Taiji" is to detect the gravitational wave (GW) within the frequency band between 0.1mHz and 1Hz. The GW sources in such frequency band offer a brand new approach to study our universe. The technologies related to Taiji program are so challenging that Taiji have to take three steps, "single satellite", "double satellites" and "three satellites" to achieve the final objectives. The "single satellite" mission, called Taiji-1, is now successfully launched, and the first run of on-orbit testing is completed. A brief introduction to the Taiji mission and Taiji-1's first round results is given.

(Mon5) Yi-Ming Hu (Sun Yat-sen University, China) Professor

"Science with the TianQin observatory"

In this talk, we aim to provide a comprehensive coverage to the scientific potential with the TianQin observatory, concentrating on the astrophysical perspective. The proposed TianQin gravitational wave observatory is aiming to detect gravitational wave signals in the millihertz frequency band, through the method of space-borne laser interferometry. In total, three satellites will be launched, each following a geocentric orbit, with an orbital altitude of about one hundred thousand kilometers. We will discuss TianQin's expected detection ability on sources ranging from massive black hole binary mergers, extreme mass ratio inspirals, Galactic binary white dwarves, stellar mass binary compact objects inspirals, as well as stochastic gravitational wave background.

(Mon6) Eduard Larranaga (Universidad Nacional de Colombia, Colombia) Professor

"Waveform produced by a particle coupled with a scalar field plunging into a static spherically symmetric black hole"

In this work, we consider a particle linearly coupled to a scalar field to calculate the radiation produced when it plunge into a static and spherically symmetric black hole from slightly below the innermost stable circular orbit.

(Mon7) Kei-ichi Maeda (Waseda University, Japan) Professor

"Hierarchical Triplet System and Gravitational Waves"

We study a hierarchical triple system with the Kozai–Lidov (KL) mechanism, which causes periodic exchange between eccentricity of an inner binary and relative inclination due to the existence of a nearby third body. We calculate the cumulative shift of periastron time of a binary pulsar by the emission of gravitational waves. The KL mechanism will bend the evolution curve of the cumulative shift when the eccentricity becomes large. We also analyze features of the wave from a hierarchical triple system undergoing KL oscillations. The waveform changes its shape in time because of oscillation of the eccentricity. When the eccentricity is small, the waveform is a sinusoidal shape modulated by a tertiary companion, while it becomes one with sharp peaks near periastron point when the eccentricity gets large. We examine the time variation of the characteristic strain curve, which may appear in the observable range of space detectors such as LISA when the eccentricity becomes large via the KL oscillations. Once we find this GWs event, it will repeat every KL oscillation cycle.

(Mon8) Hayato Motohashi (Kogakuin University, Japan) Professor

"Primordial black holes from canonical single field inflation"

With the direct detection of gravitational waves from binary black hole mergers and the continuing lack of direct detection of WIMPs, interest in primordial black holes (PBHs) as candidates for dark matter (DM) has recently received renewed attention. In this talk I will focus on the possibility to generate PBHs as DM from canonical single field inflation, for which the standard slow-roll approximation must be violated by at least O(1) in order to enhance the curvature power spectrum within the required number of efolds between CMB scales and PBH mass scales. I will discuss specific models of single-field inflation to generate PBHs consistent with LIGO events.

(Mon9) Xian Gao (Sun Yat-sen University, China) Professor

"Propagation of the gravitational waves in a cosmological background"

We investigate the propagation of the gravitational waves in a cosmological background. Based on the framework of spatially covariant gravity, we derive the general quadratic action for the gravitational waves. The spatial derivatives of the extrinsic curvature and the parity-violating terms are systematically introduced. Special attention is paid to the propagation speed of the gravitational waves. We find that it is possible to make the two polarization modes propagate in the same speed, which may differ from that of the light, in the presence of parity-violating terms in the action. In particular, we identify a large class of spatially covariant gravity theories with parity violation, in which both the polarization modes propagate in the speed of light. Our results indicate that there are more possibilities in the framework of spatially covariant gravity in light of the propagation speed of the gravitational waves.

(Mon10) Chan Park (NIMS, Korea) Postdoc

"Observations of Gravitational Waves by Gauge-Invariant Measures of Light"

Gravity influences the light described by a scalar field (phase) and a vector field (polarization). We provide a covariant description of how gravitational waves affect the phase and polarization of light without introducing any coordinates or bases. Unfortunately, perturbations of the phase and the polarization are not gauge invariant, which means that they cannot be measured in the laboratory. Defining various gauge-invariant measures of light perturbation to observe gravitational waves, we explain the working principle of detectors; e.g., Michelson interferometers and pulsar timing arrays. In addition, we explore the possibility of developing a new scheme for gravitational-wave detection by measuring the polarization of light. We expect that our analysis will not only deepen our understanding of gravitational-wave observations, but also be useful in designing new detectors.

(Mon11) Shaoqi Hou (Wuhan University, China) Postdoc

"Gravitational memory effects and Bondi-Metzner-Sachs symmetries in scalar-tensor theories"

The relation between gravitational memory effects and Bondi-Metzner-Sachs symmetry of the asymptotically flat spacetimes is studied in the scalar-tensor theory. For this purpose, the solutions to the equations of motion near the future null infinity are obtained in the generalized Bondi-Sachs coordinates with a suitable determinant condition. It turns out that the Bondi-Metzner-Sachs group is also a semi-direct product of an infinitesimal dimensional supertranslation group and the Lorentz group as in general relativity. There are also degenerate vacua in both the tensor and the scalar sectors in the scalar-tensor theory. The supertranslation relates the vacua in the tensor sector, while in the scalar sector, it is the Lorentz transformation that transforms the vacua to each other. So there are the tensor memory effect similar to the one in general relativity, and the scalar memory effect, which is new. The evolution equations for the Bondi mass and angular momentum aspects suggest that the null energy fluxes and the angular momentum fluxes across the null infinity induce the transition among the vacua in the tensor and the scalar sectors, respectively.

(Mon12) Dong-Hoon Kim (Seoul National University, Korea) Researcher

"Light Perturbed by Gravitational Waves"

Light undergoes perturbation as gravitational waves pass by. This can be shown by solving Maxwell's equations in a spacetime perturbed by gravitational waves. It can be further shown that a perturbation of light due to gravitational waves leads to a delay of the photon transit time. A simple application of this principle is presented with regard to the detection of gravitational waves via a pulsar timing array.

(Mon13) Shi Pi (Kavli IPMU, Japan) Postdoc

"An analytical formula for induced gravitational waves with a finite-width peak"

I will talk about the stochastic gravitational wave (GW) background induced by the primordial scalar perturbation with the spectrum having a lognormal peak of width Δ at $k = k_*$. An analytical formula for the GW spectrum Ω_{GW} is introduced for both narrow ($\Delta \ll 1$) and broad ($\Delta > 1$) peaks. For narrow peaks, a broken power law from k^3 to k^2 is found in the infrared region to the peak, while the broken frequency marks the width of the peak by $f_b/f_p \approx \sqrt{3}\Delta$. For broad peaks, the main part of Ω_{GW} is a lognormal peak with a smaller width $\Delta/\sqrt{2}$.

(Thu12a) Joseph Gais (Chinese University of Hong Kong, Hong Kong) Student

"Echoes of the Gravitational Atom: A Novel Probe of the Scalar Ultralight Boson"

Scalar ultralight bosons, a promising dark matter candidate, will form a bosonic cloud around a rotating black hole via superradiant instabilities. The bosonic cloud + rotating black hole system is known as a "gravitational atom" with quantum numbers analogous to that of a hydrogen atom. If such a gravitational atom exists, it alters the effective potential of the gravitational-wave propagation around the black hole of the system, adding a potential peak at a radius determined by the boson mass in addition to the Kerr potential peak at the light ring. We argue that this additional potential will lead to echoes of gravitational waves in the ringdown of a gravitational atom, where gravitational waves reflect between the Kerr and bosonic cloud potentials. Applying our model to the gravitational wave event GW150914, we are able to place an upper bound on the ultralight boson mass of 7.3×10^{-12} eV in a single gravitational wave event.

(Thu12b) Mark Ho-Yeuk Cheung (Chinese University of Hong Kong, Hong Kong) Student

"Ringdown Spectroscopy of Rotating Black Holes Pierced by Cosmic Strings"

Multiple gauge theories predict the presence of cosmic strings with different mass densities $G\mu/c^2$. We derive an equation governing the perturbations of a rotating black hole pierced by a straight, infinitely long cosmic string along its axis of rotation and calculate the quasinormal-mode frequencies of such a black hole. We then carry out parameter estimation on the first detected gravitational-wave event, GW150914, by hypothesizing that there is a string piercing through the remnant, yielding a constraint of $G\mu/c^2 < 3.8 \times 10^{-3}$ at the 90% confidence interval with a comparable Bayes factor with an analysis for a Kerr black hole without a string. In contrast to existing studies which focus on the mutual intersection of cosmic strings, or the cosmic string network, our work focuses on the intersection of a cosmic string with a black hole, with characteristics which can be identified in binary coalescence signals.

(Thu13a) Rafia Sarwar (Institute of Space Technology, Islamabad, Pakistan) Student

"Event Rates of Extreme Mass Ratio Inspirals (EMRIs) and Intermediate Mass Ratio Inspirals (IMRIs) in Milky Way Galaxy"

Numerous galaxies host a massive black hole (MBH) in their galactic nuclei enclosed by dense stellar population. Extreme mass-ratio inspirals (EMRIs) and intermediate mass-ratio inspirals (IMRIs) are the most compelling sources of gravitational radiation detectable by laser interferometer space antenna (LISA) that will have the capability to observe the entire sky probe the gravitational Universe. EMRIs and IMRIs are the prime sources for LISA encompasses the whirling of COs, typically stellar-mass black holes (BH), neutron stars (NS), white dwarfs (WD) and intermediate-mass black holes (IMBH) with diminishing mass ratio and prolonged cycles, emitting gravitational radiations lasting for several years. We investigate the dependence of signal-to-noise ratios (SNRs) to parameters and make inferences regarding the properties of Galactic EMRIs. Constraining the intrinsic parameters of the analytical kludge (AK) waveform model, we employ the well-calibrated stellar properties of the MBH to extrapolate the scaling relation that contemplates fiducial fit for back-of-envelop computations of SNRs. Additionally, we enumerate the averaged probability of 1.43 EMRI events to occur in Milky Way (MW) hosting a MBH, by employing the known astrophysical stellar dynamics of stellar population near the MBH and considering the detector's sensitivity.

(Thu13b) Alberto Mangiagli (University of Milano - Bicocca, Italy) Student

"Merger rate of stellar black hole binaries above the pair-instability mass gap"

In current stellar evolutionary models, the occurrence of pair-instability supernovae plays a key role in shaping the resulting black hole (BH) mass distribution, preventing the formation of remnants between about [60, 120] solar masses. We develop an approach to describe BHs beyond the pair-instability mass gap, by convolving the initial mass function and star formation rate with the metallicity evolution across cosmic time and SEVN, a code to evolve single stars up to $M < 350$ solar masses. Under the ansatz that the underlying physics of binary formation does not change beyond the gap, we then construct the cosmic population of merging BH binaries. We found that LIGO/Virgo at design sensitivity will detect between $\approx [0.4, 7]$ events per year with both mass components above the gap, considering the most pessimistic and optimistic scenario. Similarly, the expected rate for third generation ground-based detectors, like Einstein Telescope, ranges between [10, 460] events per year. Moreover, at lower frequencies, LISA can individually detect these binaries in their early inspiral. The number of multiband events, i.e. merging in less than four years, is expected to be in the range [1, 20]. While ET will detect all these events, LIGO/Virgo is expected to detect $< 50\%$ of them. Finally the unresolved systems are expected to contribute to the stochastic background in the LISA band. We estimate that this background may be in principle detected with a signal-to-noise ratio between ≈ 2.5 and ≈ 80. Our work has been accepted for publication: A. Mangiagli et al., ApJL 883, L27

9 Numerical Relativity

(Fri12) Xiaoyi Xie (University of Southampton, United Kingdom) Postdoc

"Instabilities in neutron-star post-merger remnants"

Using nonlinear, fully relativistic, simulations we investigate the dynamics and gravitational wave signature associated with instabilities in neutron star post-merger remnants. For simplified models of the remnant we establish the presence of an instability in stars with moderate $T/|W|$, the ratio between the kinetic and the gravitational potential energies. Detailed analysis of the density oscillation pattern reveals a local instability in the inner region of the more realistic differential rotation profile. We apply Rayleigh's inflection theorem and Fjørtoft's theorem to analyze the stability criteria concluding that this inner local instability originates from a shear instability close to the peak of the angular velocity profile, and that it later evolves into a fast-rotating $m = 2$ oscillation pattern. We discuss the importance of the presence of a co-rotation point in the fluid, its connection with the shear instability, and comparisons to the Rossby Wave and Papaloizou Pringle Instabilities considered in the wider literature.

10 Relativistic Astrophysics

(Fri1) Marcelo Rubio (IATE-OAC, UNC, Argentina) Postdoc

"A numerical scheme for solving the relativistic dissipative fluid equations"

We present a numerical scheme that implements the set of conservation laws governing the dynamics of ultra-relativistic dissipative fluids. Motivated by a divergence-type hydrodynamic theory previously developed, we comment on the difficulties that appear in the implementation, and discuss some preliminary results and future perspectives. This is a work in collaboration with Prof. Oscar Reula.

(Fri13) Sousuke Noda (Yangzhou University, China) Postdoc

"Blandford-Znajek process as Alfvénic superradiance"

Blandford-Znajek process has been widely discussed as an energy extraction process to explain the engine of astrophysical jets. In that process, the rotational energy of a black hole is extracted by electromagnetic fields around it in the form of the Poynting flux. While, other energy extraction mechanisms from a black hole are known such as Penrose process and superradiance (wave scattering with amplification). In this talk, I will demonstrate that the Blandford-Znajek process can be understood as the long wavelength limit of superradiance for Alfvén waves (Alfvénic superradiance).

(Fri14) Yun-Long Zhang (YITP, Kyoto University, Japan) Postdoc

"Gravitational Waves and Possible Fast Radio Bursts from Axion Clumps"

The axion objects such as axion mini-clusters and axion clouds around spinning black holes induce parametric resonances of electromagnetic waves through the axion-photon interaction. In particular, it has been known that the resonances from the axion with the mass around 10^{-6} eV may explain the observed fast radio bursts (FRBs). Here we argue that similar bursts of high frequency gravitational waves, which we call the fast gravitational wave bursts (FGBs), are generated from axion clumps with the presence of gravitational Chern-Simons (CS) coupling. The typical frequency is half of the axion mass, which in general can range from kHz to GHz. We also discuss the secondary gravitational wave production associated with FRB, as well as the possible host objects of the axion clouds, such as primordial black holes with typical masses around 10^{-5} solar masses. Future detections of FGBs together with the observed FRBs are expected to provide more evidence for the axion. [arxiv: 2003.10527]

(Fri15) Remo Ruffini ((1) ICRA, Dipartimento di Fisica, Sapienza Universit'a di Roma, Roma, Italia (2) ICRANet, Piazza della Repubblica 10, Pescara, Italia (3) ICRANet-Rio, Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil (4) Universit'e de Nice Sophia Antipolis, Nice, France (5) INAF, Rome, Italy) Professor

"The geodesic motion of S2 and G2 as a test of the fermionic dark matter nature of our galactic core"

The S-stars motion around the Galactic center implies that the central gravitational potential is dominated by a compact source, Sagittarius A* (Sgr A*), with a mass of about $4 \times 10^6 M_\odot$, traditionally assumed to be a massive black hole (BH). Particularly important for this hypothesis, and for any alternative model, is the explanation of the multiyear, accurate astrometric data of the S2 star around Sgr A*, including the relativistic redshift which has been recently verified. Another relevant object is G2, whose most recent observational data challenge the massive BH scenario: its post-pericenter radial velocity is lower than the expectation from a Keplerian orbit around the putative massive BH. This scenario has traditionally been reconciled by introducing a drag force on G2 by an accretion flow. Alternatively to the central BH scenario, we here demonstrate that the observed motion of both S2 and G2 is explained in terms of the dense core - diluted halo fermionic dark matter (DM) profile, obtained from the fully relativistic Ruffini-Argüelles-Rueda (RAR) model. It has been already shown that for fermion masses $48 - 345$ keV, the RAR-DM profile accurately fits the rotation curves of the Milky Way halo. We here show that the solely gravitational potential of such a DM profile, for a fermion mass of 56 keV, explains: 1) all the available time-dependent data of the position (orbit) and line-of-sight radial velocity (redshift function z) of S2; 2) the combination of the special and general relativistic redshift measured for S2; 3) the currently available data on the orbit and z of G2; and 4) its post-pericenter passage deceleration without introducing a drag force. For both objects, we find that the RAR model fits better the data than the BH scenario: the mean of reduced chi-squares of the time-dependent orbit and z data are, for S2, $\langle\bar{\chi}^2\rangle_{\rm S2,RAR} \approx 3.1$ and $\langle\bar{\chi}^2\rangle_{\rm S2,BH} \approx 3.3$ and, for G2, $\langle\bar{\chi}^2\rangle_{\rm S2,RAR} \approx 20$ and $\langle\bar{\chi}^2\rangle_{\rm G2,BH} \approx 41$. If we look at the fit of the corresponding z data, while for S2 we find comparable fits, i.e, $\bar{\chi}^2_{z,\rm BAR} \approx 1.28$ and $\bar{\chi}_{z,\rm BH} \approx 1.04$, for G2 only the RAR model can produce an excellent fit of the data, i.e. $\bar{\chi}^2_{z,\rm RAR} \approx 1.0$ and $\bar{\chi}^2_{z,\rm BH} \approx 26$. In addition, the critical mass for gravitational collapse of a degenerate 56 keV-fermion DM core into a BH is $\sim 10^8 M_\odot$. This result may provide the initial seed for the formation of the observed central supermassive BH in active galaxies, such as M87.

(Thu14a) Rajeev Singh (Institute of Nuclear Physics Polish Academy of Sciences, Poland) Student

"Heavy-Ion Collisions and Fluid Dynamics"

Measurements made recently by the STAR collaboration show that the Lambda hyperons produced in relativistic heavy-ion collisions are subject to global spin polarization with respect to an axis coincident with the axis of rotation of the produced matter. Recently formulated formalism of relativistic hydrodynamics with spin, which is a generalization of the standard hydrodynamics, is a natural tool for describing the evolution of such systems. This approach is based on the conservation laws and the form of the energy-momentum tensor and spin tensor postulated by de Groot, van Leeuwen, and van Weert (GLW). Using Bjorken symmetry we show how this formalism may be used to determine observables describing the polarization of particles measured in the experiment.

11 White Dwarfs, Neutron Stars and Gamma Ray Bursts

(Fri11) Gregory Vereshchagin (ICRANet, Italy) Professor

"Diffusive photospheres and thermal emission in early afterglows of gamma-ray bursts"

I will review the theory of photospheric emission from relativistic outflows. It will be shown how he measurement of observed characteristics of gamma-ray bursts can be used to determine initial radii of their outflows as well as their Lorentz factors. I will argue that in some cases there is evidence of radiative diffusion process as the origin of observed thermal components in the spectra of gamma-ray bursts. Observational properties of diffusive photospheres will be discussed.

12 Applied Relativity