The 3rd Conference of the Polish Society on Relativity

Lectures

Jan Ambjørn
Title: CDT and Minisuperspace
Abstract: CDT is a theory of quantum geometry. In the most recent phase diagram for CDT we might have a continuum limit along a phase transition line separating a phase with isotropy and homogeneity from one where these symmetries are broken. Approaching the transition line from the so-called phase C, minisuperspace might be an excellent approximation to certain aspects of the universe even when it has Planck size. I try to use the minisuperspace framework of CDT to "understand" the Big Bang and origin of time and space by invoking W3-symmetry.

Michał Artymowski
Title: Inflation, Scalar-Tensor Theories and LQC
Abstract: In my talk I will present how to obtain cosmic inflation in the framework of scalar-tensor theory. I will focus on maximally flat inflationary potentials and on the influence of LQC on the initial conditions for inflation.

Iwo Białynicki-Birula
Title: From Uncertainty Relations to Fluctuations of Geometry in a Hot Universe
Abstract: Uncertainty relations are a trade mark of quantum physics. Most of the time they appear in their rudimentary form: $\Delta x \Delta p \geqslant \hbar/2$. However, the consequences of uncertainty relations reach much farther. In particular, the uncertainty relations imply the fluctuations of the electromagnetic field that have an observable effect: the Lamb shift. In my talk I will show that analogous phenomena can be predicted for the gravitational field. They result in fluctuations of geometry.

Andrzej Borowiec
Title: Palatini Cosmological Models à la Starobinsky
Abstract: We discuss Starobinsky cosmological model in a framework of Palatini gravity. It appears that such approach provides on the one hand very good agreement with the present day experimental data as well as an internal inflationary mechanism driven by type III freeze singularity on the other hand. A dynamical system analysis indicates similarity to LCDM model for the late times while singular inflation takes place before recombination epoch. The talk is based on recent papers with A. Stachowski, M. Szydlowski and A. Wojnar.

Piotr Chruściel
Title: Past Limit of the Trautman-Bondi Mass
Abstract: Klainerman and Nicolo have shown that the past limit of the Trautman-Bondi mass is the ADM mass for a restricted class of initial data sets. In this talk I will outline a new proof of the result for very general initial data.

Adam Chudecki
Title: Congruences of Null Strings and Their Relation with Weyl Tensor and Traceless Ricci Tensor
Abstract: 4-dimensional complex and real spaces equipped with congruences of totally null, geodesic and self-dual (SD) 2-surfaces are considered. The properties of such congruences are discussed. It appeared that the existence of the congruences of null strings has influence on Petrov-Penrose types of Weyl spinor and on traceless Ricci tensor as well. Spaces equipped with two such foliations are called para-Hermite spaces. In such spaces traceless Ricci tensor is completely determined via geometrical objects which describe the properties of these congruences. The possible algebraic types of traceless Ricci tensor in para-Hermite spaces are discussed. Spaces with Weyl spinor of the type II or I can admit even richer structure: three or four complementary congruences of SD null strings. Some explicit metrics of such spaces are presented and their properties are discussed.

Daniel Nathan Coumbe
Title: Some Recent Results in Euclidean Dynamical Triangulations
Abstract: We study the non-perturbative formulation of quantum gravity defined via Euclidean dynamical triangulations (EDT) in an attempt to make contact with Weinberg's asymptotic safety scenario. We find that a fine-tuning may be necessary in order to recover semiclassical behavior. After introducing and fine-tuning a non-trivial local measure term, in principle we find no barrier to taking a continuum limit, and we find evidence that four-dimensional, semiclassical geometries are recovered at long distance scales in the continuum limit. We also find that the spectral dimension at short distance scales is consistent with $3/2$, a value that could resolve the tension between asymptotic safety and the holographic entropy scaling of black holes.

Mariusz Dąbrowski
Title: Singularities and Cyclic Universes
Abstract: I will discuss various types of singularities which are possible within the framework of simple isotropic and homogeneous cosmologies. Then I will present what conditions are necessary to remove, weaken or exchange the nature of these singularities. Finally, I will discuss some proposals to construct the cyclic models of the universe which can be connected by standard and non-standard singularities.

Maciej Dunajski
Title: Projective Surfaces and Einstein Metrics
Abstract: Given a projective structure on a surface N, I shall explain how to canonically construct a neutral signature Einstein metric with non-zero scalar curvature on the total space M of a certain rank 2 affine bundle M over N. The homogeneous Einstein metric corresponding to the flat projective structure on RP^2 is the non-compact real form of the Fubini-Study metric on $M = SL(3,R)/GL(2,R)$. There are many new non-homogeneous examples.

Michał Eckstein
Title: Causality in Almost Commutative Space-Times
Abstract: Drawing from the mathematical richness of non-commutative geometry, I will introduce the concept of an almost commutative space-time and show that it admits a sensible notion of causality. The latter does not affect classical causal relations in the space-time component, but it does induce highly non-trivial constraints on the "motion" in the "inner space". I will illustrate the general concept on a simple model and relate the outcomes to a relativistic quantum effect – the Zitterbewegung.

Janusz Garecki
Title: Canonical Superenergy and Angular Supermomentum Complexes in General Relativity and Some of Their Applications
Abstract: Many years ago we have introduced into GR the canonical superenergy and angular supermomentum tensors by using special averaging of the differences of the canonical energy-momentum and angular momentum. The averaging was performed in Riemann normal coordinates. About four years ago we have observed that these tensors can also be obtained in simpler way by using the canonical superenergy and angular supermomentum complexes. Such complexes can be introduced into GR in a natural way starting from canonical energy-momentum and angular momentum complexes. We define the canonical superenergy and angular supermomentum complexes and then, we apply them to analyze of a closed system, Trautman's radiative spacetimes, and Friedman universes.

Kristina Giesel
Title: Reduced Loop Quantization with 4 Klein-Gordon Scalar Fields
Abstract:

Jakub Gizbert-Studnicki
Title: Phase Structure of Causal Dynamical Triangulations Model in 4D
Abstract: I will discuss a quantum gravity model defined by Causal Dynamical Triangulations. Identification of the phase structure and order of the phase transitions is a first step in the quest for a continuum limit of CDT where, following the asymptotic safety conjecture, the resulting theory of quantum gravity becomes nonperturbatively renormalizable. I will present the recently updated CDT phase diagram and discuss geometric properties of the new bifurcation phase. I will also briefly describe the impact of topology on CDT phase structure.

Andrzej Görlich
Title: Causal Dynamical Triangulations with Toroidal Topology
Abstract: Causal Dynamical Triangulations (CDT) is a background independent approach to quantum gravity which introduces a lattice regularization. In the case of spherical spatial topology, a universe with geometry of a four-sphere emerges dynamically in the so-called de Sitter phase. Imposing toroidal spatial topology changes this picture significantly and the average spatial volume profile becomes constant. Although no background geometry is put in by hand, also in the case of toroidal spatial topology the full quantum theory of CDT is able to identify a classical background geometry with superimposed quantum fluctuations. We determine the effective action, by measuring the covariance matrix of spatial volume fluctuations, and compare it with a minisuperspace GR action where only the scale factor is kept as dynamical variable. We discuss the impact of spatial topology in 3+1 dimensional CDT.

Zbigniew Haba
Title: Diffusive DM/DE Interaction
Abstract: We assume that particles of the dark matter and the inflaton interact with an infinite environment of particles and fields. The interaction under the Markovian approximation, leads to a diffusive energy exchange with the particles and fields of the current cosmological models. The environment is interpreted as the dark energy. Einstein equations lead to a prediction of the DM/DE ratio and determine the inflaton energy density. It is shown that the diffusive interaction gives a relation between the diffusion constant, the temperature and the cosmological term.

David Hilditch
Title: Dual Foliation Formulations of General Relativity
Abstract: When solving general relativity numerically we must use a formulation of the field equations for which the resulting PDE problem is well-posed. Building such a good formulation usually requires making a coordinate choice. This leads to statements like 'gauge freedom in general relativity is the choice of coordinates'. The latter two facts have long bothered me, because one of the first lessons in relativity is that coordinates should in some sense not matter. In my talk I will explain the solution to my earlier confusion. Time permitting I will also describe ongoing work to exploit this solution for practical purposes.

Orest Hrycyna
Title: A New Generic Cosmological Scenario Without Singularity
Abstract: Dynamical systems methods are used to investigate dynamics of a cosmological model with the non-minimally coupled scalar field and a potential function. Performed analysis distinguishes the values of the non-minimal coupling constant parameter $\frac{3}{16} \leqslant \xi < \frac{1}{4}$, which from the other side correspond to conformal coupling in a higher dimensional theory of gravity. Using observational data coming from distant supernovae type Ia, the Hubble function $H(z)$ measurements and information coming from the Alcock-Paczyński test we find cosmological constraints on the non-minimal coupling constant ξ between the scalar curvature and the scalar field. Evolutional scenario under investigations do not depend on a specific choice of initial conditions and is free from this degeneracy as opposed to the seminal Starobinsky scenario.

Mikołaj Korzyński
Title: Optical Properties of the Black Hole Lattices
Abstract: I will discuss the optical properties of the cubic black hole lattices, investigated using numerical means.

Jerzy Kowalski-Glikman
Title: Symmetries of Flat Quantum Spacetime
Abstract: By applying loop quantum gravity techniques to 2+1 gravity with a positive cosmological constant Λ, we show how the local gauge symmetry of the theory, encoded in the constraint algebra, acquires the quantum group structure of $SO_q(4)$, with $q = \exp(i\hbar\Lambda\sqrt{2\kappa})$. By means of an Inonu-Wigner contraction of the quantum group bi-algebra, keeping κ finite, we obtain the kappa-Poincaré algebra of the flat quantum space-time symmetries. The talk is based on arXiv:1606.03085.

Andrzej Krasiński
Title: Blueshifts in the Lemaitre-Tolman and Quasi-Spherical Szekeres Models
Abstract: In Lemaitre-Tolman models that have non-constant Big Bang (BB) function, null geodesics emitted *radially* from the BB reach every observer with infinite blueshift (i.e. $z = -1$). These blue-shifted rays have several properties in common with the observed gamma-ray bursts. The quasi-spherical Szekeres (QSS) models have in general no symmetry, so there are no radial directions in them. However, in axially symmetric QSS models with nonconstant BB numerical calculations show that very strong blue-shifts can appear on those rays that intersect every space of constant time on the symmetry axis. In general QSS models with nonconstant BB, numerical calculations show that two preferred directions exist, on which blueshifts are equally strong. Astrophysical applications of these results will be briefly discussed.

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

Jerzy Lukierski
Title: Kappa-Deformations – Historical Remarks and Recent Developments
Abstract: In short historical perspective I shall recall some results from nineties and show further how kappa-deformed symmetries inspired DSR (Doubly or Deformed Special Relativity) approach. As new developments I shall show how to describe quantum-covariant kappa-deformed phase spaces by passing from Hopf algebras to Hopf algebroids and finally I will describe the kappa-deformations of (super)string target spaces.

Ilkka Mäkinen
Title: Time Evolution in Deparametrized Models of Loop Quantum Gravity
Abstract: Deparametrization, i.e. the use of a matter field as a relational, physical time variable, is a possible approach towards a satisfactory formulation of the dynamics of loop quantum gravity. In my talk I will describe the construction of concrete models of loop quantum gravity in which the role of the time variable is played by a free Klein-Gordon field or an irrotational dust field. I will also show some numerical examples of time evolution of simple states of quantum geometry in these models.

Tomasz Miller
Title: Causality for Probability Measures
Abstract: In a joint work with M. Eckstein we propose and study the extension of the causal precedence relation onto the space of Borel probability measures on a given spacetime M. I will illustrate the concept with several characterizations, which are all equivalent if the causal properties of M are sufficiently robust. I will briefly present thus developed formalism, which draws from the optimal transport theory, and discuss its possible applications in the study of causality in quantum theory.

Anna Nakonieczna
Title: Multidimensional Dynamics of the Brane-Dilaton Black Hole System
Abstract: Interactions among black holes and branes could have been relevant in the early stages of the evolution of the Universe. Primordial black holes could have formed out of matter density perturbations, while phase transitions in the cooling Universe may have resulted in an occurrence of extended topological defects. There can exist two types of static configurations within the brane-black hole system. The first one corresponds to the brane which intersects the event horizon, the second one represents unlinked objects. In the case of an extremal black hole, the former does not form. Our research was devoted to examining the dynamical behavior of the brane-dilaton black hole system. The evolution of a brane of a nonzero initial velocity was traced with respect to the position of a black hole. The dynamics was described in multiple dimensions and for various values of parameters of the theoretical setup.

Łukasz Nakonieczny
Title: Classical Gravity and the Quantum One-Loop Effective Action the Higgs Case
Abstract: Motivated by the possibility of the instability of the Standard Model vacuum at the high energy scale, we investigated an influence of the gravitational field associated to this scale on the subject. To translate the energy scale to the curvature we used a standard cosmological model. As a tool of the trade we chose the heat kernel approach to obtain the one-loop effective action for the Higgs sector. Further investigations revealed that the classical gravitational field will contribute, in the lowest nontrivial order, terms proportional to the squares of the Riemman and Ricci tensors to the one-loop effective potential. These terms may be regarded as new contributions to the running of the Higgs quartic coupling which influence its behavior in the high energy/curvature region.

Jan Ostrowski
Title: Mass Function of Galaxy Clusters in Relativistic Inhomogeneous Cosmology
Abstract: Modern cosmological model (LCDM) relies strongly on the assumption of isotropy and homogeneity of the Universe. The difficulties arise when this assumption is applied to Einstein equation. This is problematic, since in general, the Einstein tensor built from the averaged metric is not equal to the averaged stress-energy tensor. In this context, the discrepancy between these quantities is called "the backreaction" and has been a subject of scientific debate among cosmologists and relativists for more than 20 years. In my talk I will present one of the methods to tackle this problem, i.e. the Buchert scalar averaging, together with its applications, including the cosmological mass function of galaxy clusters.

Mandar Patil
Title: Can We Use Gravity to Produce Ultra-High Energy Cosmic Rays and Neutrinos?
Abstract: Origin of ultra-high energy cosmic rays and neutrinos remains an enigma. All proposed mechanisms use electromagnetic interaction to accelerate changed particles. We propose for the first time, a mechanism that exclusively makes use of gravity, rather than the electromagnetic forces. We show that it is possible to generate ultra-high energy particles in the overspinning Kerr geometry transcending Kerr bound by a small amount. We compute spectrum of the ultra-high energy particles and argue that its shape could serve as a powerful probe of particle physics. By solving the constraint equations in numerical relativity we show that the overspinning Kerr geometry could occur in the gravitational collapse scenario. It was also argued by Horava that overspinning spacetimes could be realized in the context of string theory. We also speculate on the other spacetime geometries where a similar acceleration mechanism could be at work.

Włodzimierz Piechocki
Title: Addressing the Issue of Quantum Spikes
Abstract: At the classical approach to spacetime singularities leads to a simplified dynamics in which spatial derivatives become unimportant compared to time derivatives, and thus each spatial point essentially becomes uncoupled from its neighbors. This uncoupled dynamics leads to sharp features (called "spikes") as follows: particular spatial points follow an exceptional dynamical path that differs from that of their neighbors, with the consequence that in the neighborhood of these exceptional points the spatial profile becomes ever more sharp. Spikes are consequences of the BKL-type oscillatory evolution towards generic singularities of spacetime. Do spikes persist when the spacetime dynamics are treated using quantum mechanics? To address this question, we treat a Hamiltonian system that describes the dynamics of the approach to the singularity and consider how to quantize that system. We argue that this particular system is best treated using an affine quantization approach (rather than the more familiar methods of canonical quantization) and we set up the formalism needed for this treatment.

Roman Plyatsko
Title: Antigravity Effects in General Relativity
Abstract: Effects of the strong repulsion which acts on a highly relativistic spinning particle and are caused by the spin-gravity coupling in Schwarzschild's background are considered using the Mathisson-Papapetrou equations.

Istvan Racz
Title: The Many Faces of the Constraints in General Relativity
Abstract: In this talk the constraint equations for smooth spaces satisfying Einstein's equations will be considered. It is shown that, regardless whether the primary space is Riemannian or Lorentzian, the constraints can always be put into the form of an evolutionary system comprised either by a first order symmetric hyperbolic system and a parabolic equation or, alternatively, by a strongly hyperbolic system subsided by an algebraic relation. The (local) existence and uniqueness of solutions to these evolutionary systems is also shown verifying thereby that the proposed evolutionary approach provides a viable alternative to the apparently unique conformal method.

Tomasz Rembiasz
Title: Magnetorotational Instability in Core-Collapse Supernovae
Abstract: Magnetorotational instability (MRI) is one of the most promising agents significantly amplifying magnetic fields in (resulting from rapidly rotating progenitors) core-collapse supernovae (CC-SNe). The initial phase of the MRI (of the exponential growth) is well understood, however its exact termination mechanism remains unknown. In this talk, we present our newest results clearly indicating that the MRI, given CC-SN conditions, is terminated by the parasitic Kelvin-Helmholtz instability. This allows us to set the limit on the maximum magnetic field amplification by the MRI.

Luciano Rezzolla
Title: The Physics and Astrophysics of Merging Neutron-Star Binaries
Abstract: I will argue that if black holes represent one the most fascinating implications of Einstein's theory of gravity, neutron stars in binary system are arguably its richest laboratory, where gravity blends with astrophysics and particle physics. I will discuss the rapid recent progress made in modeling these systems and show how the inspiral and merger of a binary system of neutron stars is more than a strong source of gravitational waves. Indeed, while the gravitational signal can provide tight constraints on the equation of state for matter at nuclear densities, the formation of a black-hole-torus system can explain much of the phenomenology of short gamma-ray bursts, while the the ejection of matter during the merger can shed light on the chemical enrichment of the universe.

Giacomo Rosati
Title: Planck-Scale Modified Spacetime Symmetries and Propagation of IceCube GRB-Neutrinos
Abstract: I give a short review of how quantum-gravity-induced modifications of relativistic symmetries may affect the propagation of ultrarelativistic particles. The approach I follow will be based on the hypothesis that an effective description of quantum spacetime may exhibit some kind of Planck-scale-governed non-commutativity. I focus then on our recent results (arXiv:1605.00496) on how IceCube data might be manifestations of such quantum-gravity-modified laws of propagation for neutrinos. The scenarios of interest for this kind of analysis are characterized by a correlation between the energy of an observed neutrino and the difference between the time of observation of that neutrino and the trigger time of a GRB.

Boudewijn Roukema
Title: First Steps Towards Scalar-Averaged Cosmological N-Body Simulations
Abstract: In the standard approach to modeling cosmological structure formation, the formation of galaxies, filaments and voids is assumed to follow Newtonian gravity and to be decoupled from the Einstein equation that is applied, independently, at cosmological scales to spatial sections of rigid comoving, spatially constant scalar curvature. Some initial steps in joining the RAMSES (Cecill) and DTFE(GPL) codes together in order to develop a self-consistent, scalar-averaged simulation code will be presented.

Pradyumn Kumar Sahoo
Title: Kaluza-Klein Dark Energy Model in the Form of Wet Dark Fluid in $f(R,T)$ Gravity
Abstract: A five dimensional Kaluza-Klein space time is considered with wet dark fluid (WDF) source in the framework of $f(R,T)$ gravity, where R is the Ricci scalar and T is the trace of the energy-momentum tensor proposed by Harko et al. (Phys. Rev. D **84**, 024020,(2011)). A new equation of state in the form of WDF has been used for dark energy (DE) component of the universe. It is modeled on the equation of state $p = \omega(\rho - \rho^{*})$ which can be describing a liquid, for example water. The exact solutions to the corresponding field equations are obtained for power law and exponential law of the volumetric expansion. The geometrical and physical parameters for both the models are studied.

Tilman Sauer
Title: Einstein, Hilbert, and the Genesis of General Relativity
Abstract: The respective roles of Albert Einstein and David Hilbert in the creation of the general theory of relativity have been discussed extensively in the historical literature. In the talk, I will review the discovery of the gravitational field equations with a particular

focus on the role of mathematics and mathematical heuristics in this discovery.

Katarzyna Senger
Title: Gravity with Higher Order Lagrangians
Abstract: We study higher-order theories of gravity arising from an invariant Lagrangian $L(j^k g, j^h \Phi)$, depending on k-th order jets of the metric g and on h-th order jets of the matter field(s) Φ. We start with the meaningful and yet non-trivial case $k = 3$ in the absence of matter field(s), then we derive a general formula for any value of k and for the case with matter field(s).

Olga Sergijenko
Title: Observational Constraints on Tensor Perturbations in Cosmological Models with Dynamical Dark Energy
Abstract: We constrain the contribution of tensor-mode perturbations in the models with dynamical dark energy considering various inflation scenarios. The dark energy is assumed to be a minimally coupled classical scalar field with barotropic equation of state. The used datasets include Planck-2015 data on CMB anisotropy and lensing, BICEP2/Keck Array data on B-mode polarization, BAO from SDSS and 6dFGS, power spectrum of galaxies from WiggleZ, weak lensing from CFHTLenS and SN Ia data from the JLA compilation. We also investigate the uncertainties of reconstructed potential of the scalar field dark energy.

Tomasz Smołka
Title: Hamiltonian Dynamics in Asymptotically Kerr Spacetimes. Examination of Quasilocal Mass in Kerr Spacetime
Abstract: We present a variational formula which leads to a Hamiltoniam dynamics in the space of general-relativistic initial data sets with asymptotically Kerr ends. In Kerr spacetime, we examine selected surfaces: rigid spheres (with constant external curvature) and round spheres (with a constant 2-dimensional curvature scalar). We expose angular momentum in an asymptotical series.

Leszek Sokołowski
Title: Degrees of Freedom and Lagrangians Explicitly Depending on the Weyl Tensor
Abstract: The recent revival of interest in alternative gravity theories is based on the apparent accelerated expansion of the Universe. The simplest modification of GR consists in employing Lagrangians being arbitrary functions of the curvature tensor. The case of L depending solely on the Ricci tensor and scalar is physically relatively clear. If the Lagrangian explicitly depends on the Weyl tensor it is difficult to assign degrees of freedom to the tensor. We argue that in a viable theory of gravity the L should be free of the Weyl tensor.

Adam Szereszewski
Title: Kundt's Metrics with Special Properties
Abstract: The structure of vacuum Einstein's field equations for Kundt's metrics will be described. If part of these equations are satisfied then the remaining can be reduced to linear system. This observation can be used to generate new solutions from old ones. It is especially interesting to apply this method to four-dimensional spacetimes foliated by the non-expanding horizons.

Yuri Taistra
Title: One-Way Solutions of Maxwell Equation in Kerr Metric

Abstract: We obtain in analytic form one-way solutions of Maxwell equation in Kerr metric and analyze their physical consequences.

Tomasz Trześniewski
Title: Nonlinear Field Space Theory and Quantum Gravity
Abstract: Phase spaces with nontrivial geometry appear in different approaches to quantum gravity and can also play a role in other areas of theoretical physics. However, so far such phase spaces have only been considered for particles or strings (i.e. sigma models). We propose an extension of the usual field theory to the framework of fields with nonlinear phase space of field values, which generally means nontrivial topology or geometry. In order to explore this idea we construct a prototype scalar field with the spherical field phase space and study its quantized version with the help of perturbative methods. As the result we obtain a variety of predictions that are known from the quantum gravity research, including algebra deformations, generalization of the uncertainty relations, shifting of the vacuum energy and renormalization of the charge and speed of propagation of field excitations. The applicability of such a model can be tested in, e.g., the description of primordial cosmological perturbations.

Piotr Waluk
Title: Degrees of Freedom of Weak Gravitational Field on a Spherically Symmetric Background
Abstract: When dealing with a gauge theory one needs to identify the true physical degrees of freedom of the model. We present a construction of reduced ADM data for the Cauchy problem for linearized gravity on a Kottler background (i.e. spherically symmetric vacuum solution with cosmological constant) – the whole information can be contained within four gauge-invariant scalar functions on the initial surface. This is a generalization of earlier results by J. Jezierski and J. Kijowski for Minkowski and Schwarzschild backgrounds.

Naqing Xie
Title: Quasi-Local Mass Integrals and the Total Mass
Abstract: On asymptotically and asymptotically hyperbolic manifolds, by evaluating the total mass via the Ricci tensor, we show that the limits of certain Brown-York type and Hawking type quasi-local mass integrals equal the total mass of the manifold in all dimensions. This is a joint work with P. Miao and L.F. Tam.

Posters

Victor E. Ambrus
Title: Non-Equilibrium Effects Induced by Quantum Corrections in Rigidly-Rotating Thermal States
Abstract: Using quantum field theory at finite temperature, quantum corrections to the stress-energy tensor (SET) obtained using kinetic theory for rigidly-rotating flows at thermal equilibrium on Minkowski space. The corrections become dominant near the speed-of-light surface (SOL), where the SET diverges. The quantum-induced non-equilibrium part can be decomposed using the Eckart frame, revealing the presence of a heat flux in the case of the Dirac field. In the case of the Klein-Gordon field, analytic methods can be used to extract the finite part of the otherwise infinite thermal expectation value (t.e.v.) of the SET, which gives rise to a heat flux and a pressure deviator in the Eckart frame. Furthermore, the Landau frame is not well-defined in the vicinity of the SOL for the Klein-Gordon field, while for the Dirac field, the Landau energy is always less than the energy in the Eckart frame.

Victor E. Ambrus
Title: Rigidly Rotating Maxwell-Juttner States on Spherically Symmetric Space-Times Using the Tetrad Formalism
Abstract: A general framework for the study of rigidly-rotating thermal states governed by the Boltzmann equation on space-times with central symmetry is presented. The topology of the Killing horizons (i.e. the speed-of-light surface, as well as the event horizon) associated with rigidly-rotating observers is presented. Using the tetrad formalism, the transport coefficients (bulk viscosity, shear viscosity and heat diffusivity) are analyzed when the Marle model is used for the collision term. We specialize our results to the maximally-symmetric spaces (Minkowski, de Sitter and anti-de Sitter), as well as to the static black hole space-times (Schwarzschild and Reissner-Nordstrom black holes). Reference: arXiv:1605.07043 [hep-th].

Alek Bedroya
Title: QFT Corrections to Black Holes
Abstract: We consider the Back Reaction of QFT fluctuations reflected in trace anomaly on Schwarzschild and Reisner Nordstrom Black holes. The Schwarzschild BH develops an internal horizon which turns out to be the limit of inner Horizon of RN black hole when its charge vanishes. This puts a lower limit of mass of the black holes which corresponds to the extremal limit of the Schwarzschild case with zero temperature and no Hawking radiation. We also find the modification of Mass Charge relation for RN case to avoid naked singularity as a modification to the standard relation $Q = M$ for the extremal case. Furthermore we study thermodynamics of the BH solutions and the modifications due to trace anomaly.Finally we study the effect of QFT trace anomaly on the collapse of a spherically symmetric shell and show that the singularity does not form. The collapse stops at a finite radius, the bounce radius as also expected from quantum gravity considerations.

Hristu Culetu
Title: Semiclassical Corrections to a Regularized Schwarzschild Metric
Abstract: A version of the Schwarzschild metric to be valid in microphysics is proposed. The source fluid is anisotropic with $p_r = -\rho$ and fluctuating tangential pressures. At large distances with respect to the Compton wave length associated to the source particle, they do not depend on the mass m of the source and everywhere depend on $\hbar$ and the velocity of light c but not on the Newton constant G. The particle may be a black hole for $m >> m_P$ only and when $m = m_P$ it becomes an extremal black hole. The WEC is violated when $r < r_0/2 = \hbar/emc$ due to the negative tangential pressures.

Wojciech Kulczycki
Title: The Gravitational Waves in Cosmology and the Huygens Principle
Abstract: The linearized Einstein equations describing the gravitational wave in Regge-Wheeler gauge for cosmological background have been obtained and analyzed. Their consistency has been proven and the wave equation for axial and polar modes obtained. The question of the influence of the metric perturbations on the matter has been investigated as well as the conditions of the fulfillment of the Huygens principle in dependence on the size of the initial support of the gravitational wave. The numerical calculations have been carried out for both dust and de Sitter universe.

Daniel Nemeth
Title: Minimal Configuration in CDT Quantum Gravity
Abstract: Numerical methods are playing an important role in the modern time's science, without them many approaches and results would be unreachable. To understand the structure and behavior of the lattice-based systems (like CDT) one can use random walks via Monte Carlo simulations and measure some reasonable observables with the help of it. The recent research in CDT has shown that the choice of topology of the spacetime matters, and under toroidal condition we found an interesting behavior of the system. After letting the system shrink, instead of reaching the minimal triangulation surprisingly it became smaller. This small system still keeps the attributes of the toroidal condition.

Ramin Zahedi
Title: On the Mathematical Origin of the Fundamental Field Equations of Physics: a New Axiomatic Quantization Approach
Abstract: This article is a summary of an expanded version of my previous publication. In this article I present a new axiomatic approach based on the ring theory and Clifford algebras. Using this (primary) mathematical approach a unique set of the general relativistic (single-particle) wave equations are derived directly. These equations are shown to correspond to certain massive forms of the laws governing the fundamental forces of nature, including the Gravitational, Electromagnetic (Maxwell) and Nuclear (Yang-Mills) field equations, and also the (half-integer spin) single-particle wave equations such as the Dirac equation. In particular, based on the definite mathematical structure of the relativistic wave equations derived, it is proven that the universe cannot have more than four space-time dimensions.