Titles and Abstracts

Mini-Courses

Michael Bordag
Universität Leipzig

Casimir effect

Abstract: These lectures provide an introduction to the Casimir effect covering a range from *Nullpunktsenergie* to modern applications.

1. Nullpunktsenergie and Casimir effect – an introduction
   - historical aspects
   - Casimir's work
   - attraction vs. repulsion
2. Divergences, renormalization and heat kernel expansion
   - vacuum energy and effective action
   - zeta functional regularization
   - heat kernel expansion
3. Scattering approach (generalized Lifshitz formula)
   - arbitrary geometry
   - beyond PFA
   - low temperature expansion and Drude problem
4. Application to graphene
   - QED: photon in (3+1) and electron in (2+1) dimensions
   - Casimir effect for graphene
   - surface modes

Salvatore Capozziello
Università di Napoli "Federico II"

Mathematical and physical foundations of extended theories of gravity

Abstract: Extended Theories of Gravity have recently attracted a lot of interest in order to explain the observed cosmic acceleration and clustering phenomena at Galactic and extragalactic scales. Very likely, what we call "dark matter" and "dark energy" are nothing else but signals of the breakdown of General Relativity at large scales and could be interpreted as "geometric effects". Furthermore, Solar System experiments and some peculiar astrophysical phenomena (e.g. magnetars, extremely massive neutron stars and so on) do not exclude the possibility that such theories could give observable effects also at ultraviolet scales. We review the physical and mathematical foundations of such an approach and discuss the main results related with it.

Claus Kiefer
Universität zu Köln

Quantum gravity – A mini-course

Abstract: In this mini-course, I shall give an introduction to the main (non-string) approaches to quantum gravity. In the first lecture, I present the motivations for dealing with this topic and present the general problems. In the second lecture, I discuss covariant approaches with particular emphasis on path-integral quantization (including dynamical triangulation). In the third lecture, I discuss canonical approaches including quantum geometrodynamics and loop quantum gravity. In my last lecture, I apply these approaches to cosmology and to the physics of black holes.

References: C. Kiefer, *Quantum Gravity*, third edition (Oxford 2012);
C. Kiefer, Conceptual Problems in Quantum Gravity and Quantum Cosmology, *ISRN Math.Phys.* 2013 (2013) 509316, freely available online under http://dx.doi.org/10.1155/2013/509316 or under arXiv:1401.3578 [gr-qc].

Nicola Napolitano
INAF - Osservatorio Astronomico di Capodimonte

Dark Matter from galaxy to galaxy cluster scales

Abstract: I will biefly illustrate the evidence of Dark Matter in different astrophysical systems from dwarf galaxies to massive clusters using different techniques (dynamics, lensing, Xrays) and discuss the results in the context of theoretical predictions from cosmological simulations.

Talks

Manuel Asorey
Universidad de Zaragoza

Topological entropy and renormalization group flows

Abstract: New developments on global properties of the renormalization group flow in different space-time dimensions unveiled the existence of several entropic functions that are monotonic along the RG flow. The results are known as c-theorem, a-theorem, F-theorem, etc. With especial interest we will focus on odd dimensional spaces where new entropic conjectures based on the holonomy entropy have been recently formulated.

Eugênio R. Bezerra de Mello
Universidade Federal da Paraíba

Induced fermionic current in the cosmic string spacetime

Abstract: In this talk, we consider a charged massive fermionic quantum field in the cosmic string spacetime and in the presence of a magnetic field confined in a cylindrical tube of finite radius. Three distinct configurations for the magnetic field are taken into account: (i) a cylindrical shell of radius a, (ii) a magnetic field proportional to $1/r$ and (iii) a constant magnetic field. In these three cases, the axis of the infinitely long tube coincides with the cosmic string. Our main objective is to calculate the induced azimuthal fermionic current density outside the tube. In order to do that, we explicitly construct the normalized wave-functions for each case, and use the summation method to develop our analysis. We show that the induced current is decomposed into a part corresponding to a zero-thickness magnetic flux in addition to a core-induced contribution. The latter presents specific form depending on the magnetic field configuration considered. The zero-thickness contribution depends only on the fractional part of the ration of the magnetic flux inside the tube by the quantum one, while the core-induced contribution depends on the total magnetic flux inside the tube, and consequently, it is not a periodic function of the flux.

Marco Cariglia
Universidade Federal de Ouro Preto & Università degli Studi di Camerino

Symmetries of black holes

Abstract: In modern physics the symmetry analysis, both classical and quantum, of a system takes a central and illuminating role. Black holes are no exception and display a range of a priory unexpected symmetries. In the first part of the talk I will discuss the extension to higher dimensions of the 'miraculous' properties of the Kerr black hole: the Kerr-NUT-(A)dS family of rotating black holes possesses a tower of Killing-Yano forms that guarantee integrability of a number of important equations in the background: geodesic, Hamilton-Jacobi, Klein-Gordon, spinning particle, Dirac, stationary string, tensor gravitational perturbations. The relevant symmetries here are in the phase space of the excitation evolving in the fixed background. In the second part of the talk I will describe Hamiltonian symmetries of the damped harmonic oscillator, that have an application to the quasinormal modes of the black holes themselves.

Alberto Cattaneo
Universität Zürich

BV-BFV theories on manifolds with boundary and general relativity

Abstract: According to Segal and Atiyah, quantum field theories should be thought of as appropriate functors from a version of the cobordism category. I will describe how this has to be reformulated if one plans to work in perturbation theory, and in particular, how the bulk Batalin-Vilkovisky formalism has to be matched with the boundary Batalin-Fradkin-Vilkovisky formalism. I will then discuss the case of general relativity, both in the Einstein-Hilbert and in the Palatini formalisms.

Júlio C. Fabris
Universidade Federal do Espírito Santo

A new approach to scalar-tensor theories

Abstract: The scalar-tensor theories have been since long time an alternative to the General Relativity theory. However, the observational constraints, either at cosmological or local levels, reduce these theories to configurations very near to the GR ones. The possibility to obtain important new effects at cosmological level, keeping untouched the success at local level, can be obtained by using screening mechanisms. A different approach, which can open new possibilities, can be implemented by considering the scalar field as an external field, not subjected to the variational principle. We discuss this new approach in the cosmological context.

Gilberto M. Kremer
Departamento de Física, Universidade Federal do Paraná

Analysis of some gravitational problems with the Boltzmann equation

Abstract: One of the problems analyzed here refers to Jeans instability. The search for structure formation from gas clouds is an old subject that goes back to 1902 when Jeans used the system of phenomenological equations of mass and momentum densities together with the Poisson equation and showed that small perturbations in the mass density, pressure, velocity and gravitational potential in a static background with wavenumber smaller than the Jeans wavenumber could evolve with time. In terms of balance of forces the fluctuations can grow in time if the inwards directed gravitational force is larger than the outwards directed internal pressure of the gas. Jeans theory describes the gravitational instability of self-gravitating systems by searching for conditions that small perturbations can grow and leads to a collapse of the system. It was formulated before the knowledge of the Universe expansion and one has to take into account the Jeans "swindle", which imposes that the Poisson equation is valid only for the perturbations, since the background solution of constant mass density, pressure, gravitational potential and vanishing velocity satisfy the balance equations of mass and momentum densities, but not the Poisson equation. Here the dynamics of self-gravitating fluids is analyzed within the framework of a collisionless Boltzmann equation in the presence of gravitational fields and Poisson equation. The equilibrium distribution function takes into account the expansion of the Universe and a pressureless fluid in the matter dominated Universe. Without invoking Jeans "swindle" a dispersion relation is obtained by considering small perturbations of the

equilibrium values of the distribution function and gravitational potential. The collapse criterion, which happens in an unstable region where the solution grows exponentially with time, is determined from the dispersion relation.

The other problem concerns the analysis of self-gravitating systems of ideal gases in the post-Newtonian approximation. We obtain the equilibrium relativistic distribution function (the so-called Maxwell-Jüttner distribution function) at first order in the post-Newtonian approximation within the framework of general relativity. Taking into account the aforesaid distribution function, we compute the particle four-flow and energy-momentum tensor. We focus on the search of static solutions for the gravitational potentials with spherical symmetry. In doing so, we obtain the density, pressure and gravitational potential energy profiles in terms of dimensionless radial coordinate by solving the aforesaid equations numerically. Due its physical relevance, we also find the galaxy rotation curves using the post-Newtonian approximation. We join two different kinds of static solutions in order to account for the linear regime near the center and the typical flatten behavior at large radii as well.

Peter M. Lavrov
Tomsk State Pedagogical University

Effective action with composite fields and Clairaut-type equations

Abstract: It is noted that the Legendre transformations in the standard formulation of quantum field theory have the form of functional Clairaut-type equations. It is shown that in presence of composite fields the Clairaut-type form holds after loop corrections are taken into account. A new solution to the functional Clairaut-type equation appearing in field theories with composite fields is found.

Oliver F. Piattella
Universidade Federal do Espírito Santo

Lensing in the McVittie metric

Abstract: Does cosmology affect the bending of light caused by a compact object such as a black hole? I present some contradictory answers to this question and offer my own perspective based on the study of null geodesics in the McVittie metric.

Rudnei O. Ramos
Universidade do Estado do Rio de Janeiro

The little inflaton that is hot

Abstract:

Inflation occurring in a radiation environment and at the same time having the inflaton sustaining the radiation bath throughout the inflationary dynamics characterizes warm inflation models in general. However, having warm inflation in a regime where it is directly coupled to the radiation fields has proved for a long time to be a challenge. In this talk I discuss a well-motivated model from particle physics that can successfully achieve this and where inflation can occur at a finite temperature $T > H$ that is sustained by dissipative effects. The inflaton field corresponds to a pseudo-Nambu Goldstone boson of a broken gauge symmetry. Similarly to "Little Higgs" scenarios for electroweak symmetry breaking, this model allows to have the inflaton directly coupled to only a few radiation fields, in fact only two additional fields. The flatness of the inflaton potential is protected against both quadratic divergences and the leading thermal corrections. There are yet non-local dissipative effects naturally present that are able to sustain a nearly-thermal bath of light particles despite the accelerated expansion of the Universe. I discuss the modifications to the primordial spectrum of curvature and tensor perturbations induced by dissipative and thermal effects, showing a simple realization consistent with CMB observations using a simple quartic renormalizable potential for the inflaton.

Ilya L. Shapiro
Universidade Federal de Juiz de Fora

Superrenomarlizable models of quantum gravity

Abstract: Abstract: The main difficulty of perturbative quantum gravity (QG) in 4d is the conflict between renormalizability and unitarity. The simplest version of QG is based on General Relativity and is non-renormalizable. One can construct renormalizable and even superrenormalizable versions of QG by introducing higher derivatives, but then one has to deal with the unphysical higher derivative massive ghosts. At the same time polynomial superrenormalizable versions of QG have certain attractive features, such as unambiguous and exactly calculable beta-functions and possible Lee-Wick type unitarity in case when all extra poles are complex. The non-polynomial models of QG have no ghosts at the tree level, but taking loop corrections into account one meets infinite amount of ghost-like complex states. In the IR one can prove that the modified Newton limit in all these models is singularity-free.

Alessandro Spallicci
Université d'Orléans

Non-Maxwellian electromagnetism implications on astrophysical and cosmological scales

Abstract: Our understanding of the universe at large and small scales relies largely on electromagnetic observations. As photons are the messengers, fundamental physics has a concern in testing their properties, including the absence of mass. The double nature of light (particle and wave) together with the Heisenberg's uncertainty rule suggest that we indeed test the macroscopic effects due to potentially massive quantum particles rather than the mass of a single photon or graviton. Recent determinations of photon mass upper limits *[Bonetti L., Ellis J., Mavromatos N.E., Sakharov A.S., Sarkisyan-Grinbaum E.K.G., Spallicci A.D.A.M., 2016. Photon mass limits from Fast Radio Bursts, Phys. Lett. B, 757, 548. arXiv:1602.09135 [astro-ph.HE]; Retin A., Spallicci A.D.A.M., Vaivads A., 2016. Solar wind test of the de Broglie-Proca's massive photon with Cluster multi-spacecraft data, to appear in Astropart. Phys., arXiv:1302.6168 [hep-ph]]* put into some question the Particle Data Group (PDG) accepted limits. In parallel a collaboration with the Centro Brasileiro de Pesquisas Físicas *[Bonetti L., dos Santos Filho L.R., Helayl-Neto J.A., Spallicci A.D.A.M., 2016, to be submitted]* in Rio de Janeiro, appears to indicate the emergence of massive photons – à la Carroll-Field-Jackiw – from Supersymmetry and Lorentz invariance breaking. The speaker is part of a collaboration aiming at detecting very low radio frequencies, wherein massive photons induce larger time delays, through a swarm of nano-satellites *[Bentum M.J, Bonetti L., Spallicci A.D.A.M., 2016, to be submitted]* to be possibly launched by the European Space Agency. The delays are easily derived by the de Broglie-Proca Lagrangian. Another line of work concerns the insurgence of different frequency shifts according to their polarisation in very strong magnetic fields, as magnetars *[Perez-Bergliaffa S., Bonetti L., Spallicci A., 2016, submitted]*, dealt in the Heisenberg-Euler formalism. This latter work was carried out as French Chair at the Universidade do Estado do Rio de Janeiro. Finally, how all this may impact the propagation of photons at the astrophysical or cosmological scale will be addressed.

Winfried Zimdahl
Universidade Federal do Espírito Santo

Inhomogeneities and backreaction in cosmology

Abstract:

Based on the Lemaître-Tolman-Bondi (LTB) metric we discuss features of the dynamics of the simplest inhomogeneous bang-time models. These configurations are shown to describe either local humps or local voids. Recent SNIa data are reproduced by a local hump with an extension of almost 2 Gpc or a local void for which we obtain a best-fit scale of about 30 Mpc. In the second part of the talk we demonstrate that backreaction of inhomogeneities within Buchert's formalism may result in an effective viscous pressure of the cosmic medium. The use of an effective metric with a time-dependent curvature radius allows us to calculate the luminosity distance of the backreaction model. This quantity is different from its counterpart for a "conventional" spatially flat bulk viscous fluid universe. Both expressions are tested against SNIa data with only marginally different results for the distance-redshift relation and in accordance with the ΛCDM model.

Short communications

Ljudmila Bordag
University of applied sciences Zittau/Görlitz

Optimization problem for a portfolio with an illiquid asset: Lie group analysis

Abstract: Management of a portfolio that includes an illiquid asset is an important problem of modern mathematical finance. One of the ways to model illiquidity among others is to build an optimization problem and assume that one of the assets in a portfolio cannot be sold until a certain finite, infinite or random moment of time. This approach arises a certain amount of models that are actively studied at the moment.

Working in the Merton's optimal consumption framework with continuous time we consider an optimization problem for a portfolio with an illiquid, a risky and a risk-free asset. Our goal in this paper is to carry out a complete Lie group analysis of PDEs describing value function and investment and consumption strategies for an portfolio with an illiquid asset that is sold in a random moment of time with a prescribed liquidation time distribution. Study of optimization problems with an illiquid asset leads to three dimensional non-linear Hamilton-Jacobi-Bellman (HJB) equations. Such equations are not only tedious for analytical methods but are also quite challenging form a numeric point of view. To reduce the three-dimensional problem to a two-dimensional one or even to an ODE one uses some substitutions, yet the methods used to find such substitutions are rarely discussed by the authors.

We find the admitted Lie algebra for a certain class of liquidation time distributions in cases of HARA and log utility functions and formulated theorems for these cases. We use them to obtain corresponding reductions. Several of these substitutions were used in other papers before and other ones are new to our knowledge. This method gives us the possibility to provide a complete set of non-equivalent substitutions and reduced equations.

Cristine Nunes Ferreira
Instituto Federal de Educação, Ciência e Tecnologia Fluminense

Discussion about the black hole with a global monopole

Abstract: In this work we will discuss the modified General Relativity Theory where the torsion and the curvature are gauge fields. We find the exact metric solution of a black hole in a region that contains a global monopole considering that both torsion and curvature are non-vanishing. The metric is composed of a Schwarzschild solution and two gauge correction terms r^{-1} and r^2. We will also discuss the explicit expressions for the local thermodynamic quantities of the black hole as a function of the event horizon. The parameter describing the monopole and the measurable corrections due to the torsion gauge theory modifications of the General Relativity will also be discussed here. In this work, we will also contrast our results against the $f(R)$ theory.