Gravitation and Relativity Division
Fachverband Gravitation und Relativitätstheorie (GR)

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The award of the Physics Nobel-Prize 2017 for the first direct detection of gravitational-waves and, in particular, the most recent observation (GW170817) of such waves from an inspiral of a binary-system of neutron stars, will naturally set the focus of this year's annual meeting of our division. We will dive straight into the heart of the matter with three main talks by renowned experts on Monday afternoon; so be there in time! The AKjDPG has organized a tutorial on gravitational waves on Monday morning, which in that context is especially recommended to all younger and/or non-expert participants. In addition, there will be an interdisciplinary Symposium on recent observational and theoretical developments in gravity. Another innovation in our division is that posters will now be not only presented at the poster session, but kept for display throughout the whole week for further examination and discussion. This is part of our general call for stronger support of didactical and educational efforts. Finally I wish to mention the many other talks on observational and theoretical aspects, with quite a substantial part on Quantum Gravity/Cosmology, especially our plenary talk by Claudia de Rahm on the possibility of a consistent theory of "massive gravity" and its possible observational signatures.

Overview of Invited Talks and Sessions

(Lecture room NW-Bau - HS3 and Phys-SR-SE1; Poster Phys-SR-SE2)

Plenary talk of GR

PV IX	Do	9:00– 9:45	Z6 - HS 0.004	**How Light is Gravity ?** — •Claudia de Rham

Invited talks

GR 1.1	Mo	16:00–16:50	NW-Bau - HS3	**The Physics Nobel Prize 2017: Gravitational Waves** — •Bernd Brügmann
GR 1.2	Mo	16:50–17:40	NW-Bau - HS3	**The gravitational wave detection of a binary neutron star merger: expectations, surprises, and prospects** — •Jochen Greiner
GR 1.3	Mo	17:40–18:30	NW-Bau - HS3	**Neutron star mergers and the begin of multi-messenger astrophysics** — •Stephan Rosswog
GR 2.1	Di	11:00–11:45	NW-Bau - HS3	**Die Physik von Gravitationswellendetektoren** — •Ronny Nawrodt
GR 2.2	Di	11:45–12:30	NW-Bau - HS3	**Searching for continuous gravitational waves from spinning neutron stars: status and outlook** — •Reinhard Prix
GR 5.1	Mi	11:00–11:45	NW-Bau - HS3	**Formation of Double Neutron Stars and their Merger Rates** — •Thomas Tauris
GR 5.2	Mi	11:45–12:30	NW-Bau - HS3	**Accretion-Driven Growth of Super-Massive Black Holes** — •Wolfgang J. Duschl
GR 7.1	Mi	16:30–17:10	NW-Bau - HS3	**Teaching about gravitational waves** — •Markus Pössel
GR 7.2	Mi	17:10–17:50	NW-Bau - HS3	**Visualizing relativistic effects in a non-relativistic model** — •Thomas Filk
GR 9.1	Do	11:00–11:45	NW-Bau - HS3	**Constructive QFT Approach to Quantum Gravity** — •Thomas Thiemann

GR 10.1	Do	11:45–12:30	NW-Bau - HS3	**A test of the gravitational redshift using Galileo satellites 5 and 6** — •Sven Herrmann, Felix Finke, Olga Kichakova, Claus Lämmerzahl, Meike List, Benny Rievers
GR 13.1	Do	16:30–17:15	NW-Bau - HS3	**Theoretical aspects of relativistic geodesy** — •Dennis Philipp

Tutorial of AKjDPG: Gravitational Waves

See AKjDPG for the full program of the tutorial.

AKjDPG 1.1	Mo	9:00–10:30	Z6 - HS 0.001	**Gravitational Waves - Theory and Observation** — •Claus Kiefer
AKjDPG 1.2	Mo	11:00–11:45	Z6 - HS 0.001	**Detecting gravitational waves** — •Markus Pössel
AKjDPG 1.3	Mo	11:45–12:30	Z6 - HS 0.001	**Numerical simulations of black hole and neutron star systems** — •Bernd Brügmann

Invited talks in the interdisciplinary symposium SYGR

See SYGR for the full program of the symposium.

SYGR 1.1	Di	14:00–14:30	Z6 - HS 0.004	**New horizons in gravity** — •Lavinia Heisenberg
SYGR 1.2	Di	14:30–15:00	Z6 - HS 0.004	**Binary neutron stars: Einstein's richest laboratory** — •Luciano Rezzolla
SYGR 1.3	Di	15:00–15:30	Z6 - HS 0.004	**Search for Dark Matter** — •Christian Weinheimer
SYGR 1.4	Di	15:30–16:00	Z6 - HS 0.004	**From QFT on curved spacetimes to effective quantum gravity** — •Kasia Rejzner

Sessions

GR 1.1–1.3	Mo	16:00–18:30	NW-Bau - HS3	**Most recent developments in gravitational waves and relativistic astrophysics**
GR 2.1–2.2	Di	11:00–12:30	NW-Bau - HS3	**Gravitational waves I**
GR 3.1–3.8	Di	16:30–19:10	NW-Bau - HS3	**Alternative theories of gravity and general formalism**
GR 4.1–4.5	Di	16:30–18:10	Phys-SR-SE1	**Gravitational waves II**
GR 5.1–5.2	Mi	11:00–12:30	NW-Bau - HS3	**Relativistic astrophysics I**
GR 6.1–6.6	Mi	14:00–16:00	NW-Bau - HS3	**Relativistic astrophysics II**
GR 7.1–7.2	Mi	16:30–17:50	NW-Bau - HS3	**Didactical aspects of relativity**
GR 8.1–8.15	Mi	18:00–19:30	Phys-SR-SE2	**Poster session (permanent)**
GR 9.1–9.1	Do	11:00–11:45	NW-Bau - HS3	**Quantum Gravity I**
GR 10.1–10.1	Do	11:45–12:30	NW-Bau - HS3	**Experimental tests I**
GR 11.1–11.6	Do	14:00–16:00	NW-Bau - HS3	**Black Holes**
GR 12.1–12.5	Do	14:00–15:40	Phys-SR-SE1	**Alternative approaches**
GR 13.1–13.8	Do	16:30–19:35	NW-Bau - HS3	**Classical GR**
GR 14	Do	19:45–20:45	NW-Bau - HS3	**General assembly of the Gravitation and Relativity Division**
GR 15.1–15.6	Fr	9:00–10:30	NW-Bau - HS3	**Quantum Gravity II**
GR 16.1–16.9	Fr	11:00–13:15	NW-Bau - HS3	**Quantum Gravity III**
GR 17.1–17.1	Fr	9:00– 9:20	Phys-SR-SE1	**Experimental tests II**
GR 18.1–18.3	Fr	9:20–10:20	Phys-SR-SE1	**Cosmology**
GR 19.1–19.2	Fr	11:00–11:40	Phys-SR-SE1	**Numerical relativity**

General assembly of the Gravitation and Relativity Division

Thursday 19:45–20:45 Building NW, Room HS3

- Report by the chairperson
- Election of new chairperson
- Election of new advisory board
- Presentation of books authored by members
- Miscellaneous

GR 1: Most recent developments in gravitational waves and relativistic astrophysics

Zeit: Montag 16:00–18:30 Raum: NW-Bau - HS3

Hauptvortrag GR 1.1 Mo 16:00 NW-Bau - HS3

The Physics Nobel Prize 2017: Gravitational Waves — •Bernd Brügmann — University of Jena

Albert Einstein predicted gravitational waves already hundred years ago as a consequence of his newly formulated theory of general relativity. In highly publicized news, the LIGO/Virgo collaboration announced in 2016 the first direct detection of a gravitational wave signal, and in the end of 2017 the Nobel Prize for Physics was awarded "for decisive contributions to the LIGO detector and the observation of gravitational waves". There is excellent evidence that the first signals correspond to the inspiral and merger of two black holes. Most recently, the first gravitational waves from the collision of two neutron stars have been detected. In this talk we give an overview of the theory and the numerical methods that allow the prediction and analysis of gravitational wave signals. Part of the success story are great advances in numerical general relativity that allow us to simulate binaries with increasing levels of complexity, providing models that explain the observed gravitational wave signals.

Hauptvortrag GR 1.2 Mo 16:50 NW-Bau - HS3

The gravitational wave detection of a binary neutron star merger: expectations, surprises, and prospects — •Jochen Greiner — Max-Planck-Institute for Extraterrestrial Physics, Garching, Germany

On August 17, 2017, Advanced LIGO & Virgo detected gravitational waves from a binary neutron star merger. A short-duration gamma-ray burst was detected in temporal coincidence by the INTEGRAL and Fermi satellites. A few hours later, an optical/NIR transient was found which turned out to be compatible with the predictions of a kilonova, powered by the radioactive decay of heavy r-process nuclei produced in the merger. I will give an overview of the observational results of this event which will go down in history as the start of multi-messenger gravitational wave astronomy. I will contrast the original expectations with the actual findings, and will spend most of the time on the mismatches, i.e. the new questions which emerged.

Hauptvortrag GR 1.3 Mo 17:40 NW-Bau - HS3

Neutron star mergers and the begin of multi-messenger astrophysics — •Stephan Rosswog — The Oskar Klein Centre, Department of Astronomy, Stockholm University

Neutron star mergers had long been suspected to produce gravitational wave "chirps", gamma ray bursts and produce heavy elements via the rapid neutron capture process. While overall convincing, all these conjectures were based on indirect arguments and none was proven directly. This changed on August 17, 2017: a gravitational wave signal from a merging neutron star binary was detected, closely followed by a short gamma-ray burst and week-long transients accross the electromagnetic spectrum coming from the radioactive decay of freshly synthesised r-process elements. In this talk I will give an overview over these recent developments.

GR 2: Gravitational waves I

Zeit: Dienstag 11:00–12:30 Raum: NW-Bau - HS3

Hauptvortrag GR 2.1 Di 11:00 NW-Bau - HS3

Die Physik von Gravitationswellendetektoren — •Ronny Nawrodt — Friedrich-Schiller-Universität Jena, AG Fachdidaktik der Physik und Astronomie, August-Bebel-Str. 4, 07743 Jena

Der direkte Nachweis von Gravitationswellen im Jahre 2015 war ein großer Meilenstein der Physik. Bereits die ersten Detektionen konnten zahlreiche astrophysikalische Fragestellungen zu Schwarzen Löchern bzw. Neutronensternen klären und führten im Jahr 2017 zum Nobelpreis für Physik. Die Detektion von Gravitationswellen ist der Beginn der Gravitationswellenastronomie, die ein völlig neues Beobachtungsfenster ins Weltall eröffnet. Der Vortrag gibt einen Überblick über die experimentellen Grundlagen moderner Gravitationswellendetektoren. Es wird gezeigt, wie man mit hochauflösenden Michelson-Interferometern die von Gravitationswellen verursachte relative Längenänderung von weniger als 10^{-21} nachweisen kann. Als Ausblick werden Konzepte für zukünftige Detektoren und deren wissenschaftliches Potential vorgestellt.

Hauptvortrag GR 2.2 Di 11:45 NW-Bau - HS3

Searching for continuous gravitational waves from spinning neutron stars: status and outlook — •Reinhard Prix — Albert-Einstein-Institut, Callinstr. 38, 30167 Hannover

Continuous gravitational waves (CWs) emitted from spinning deformed neutron stars are still awaiting their first detection. In this talk I will describe the current status of searches for CWs in data from the Advanced LIGO and Virgo detectors, and I will attempt to sketch a future outlook. Two relevant questions are: Can we reasonably expect a CW detection in the near future, and what (astro-)physical insights can we gain from a detection of CWs (or from its absence)?

GR 3: Alternative theories of gravity and general formalism

Zeit: Dienstag 16:30–19:10 Raum: NW-Bau - HS3

GR 3.1 Di 16:30 NW-Bau - HS3

Effective action model of dynamically scalarizing binary neutron stars — Noah Sennett, Lijing Shao, and •Jan Steinhoff — Albert Einstein Institute Potsdam

Gravitational waves can be used to test general relativity (GR) in the highly dynamical strong-field regime. Scalar-tensor theories of gravity are natural alternatives to GR that can manifest nonperturbative phenomena in neutron stars (NSs). One such phenomenon, known as dynamical scalarization, occurs in coalescing binary NS systems. Ground-based gravitational-wave detectors may be sensitive to this effect, and thus could potentially further constrain scalar-tensor theories. This type of analysis requires waveform models of dynamically scalarizing systems; in this work we devise an analytic model of dynamical scalarization using an effective action approach. For the first time, we compute the Newtonian-order Hamiltonian describing the dynamics of a dynamically scalarizing binary in a self-consistent manner. Despite only working to leading order, the model accurately predicts the frequency at which dynamical scalarization occurs. In conjunction with Landau theory, our model allows one to definitively establish dynamical scalarization as a second-order phase transition. We also connect dynamical scalarization to the related phenomena of spontaneous scalarization and induced scalarization; these phenomena are naturally encompassed into our effective action approach.

GR 3.2 Di 16:50 NW-Bau - HS3

Generalized scalar-torsion theories of gravity — •Manuel Hohmann — Universität Tartu, Tartu, Estland

Teleparallel gravity theories, which attribute gravity to the torsion of spacetime instead of curvature, have gained growing attention in the last years, in particular due to their recently developed Lorentz covariant formulation. The fundamental fields of these theories are a tetrad and a flat spin connection. A straightforward extension to teleparallel gravity, which provides for possible explanations for the observed accelerating phases in cosmology, is obtained by coupling one or several scalar fields to torsion. Here we discuss the properties of a general class of such scalar-torsion theories. We show how local Lorentz invariance is naturally achieved through their covariant formulation, and study a class of theories which is invariant under conformal transformations of the tetrad field. We also discuss the resulting cosmological dynamics.

GR 3.3 Di 17:10 NW-Bau - HS3

Teleparallel theories of gravity in analogy to (non-linear) theories of electrodynamics — Manuel Hohmann, Laur Järv, Martin Krssak, and •Christian Pfeifer — Laboratory for theortical physics, University of Tartu, Tartu, Estonia

The teleparallel formulation of gravity theories reveals close structural analogies to electrodynamics, which are more hidden in their usual formulation in terms of the curvature of spacetime. In this talk I will demonstrate how every locally Lorentz invariant teleparallel theory of gravity with second order field equations can be understood as built from a gravitational field strength and excitation tensor which are related to each other by a gravitational constitutive relation. This construction is analogous to the axiomatic formulation of theories of electrodynamics, where different theories are distingusihed by an electromagnetic constitutive relation which expresses the electromagnetic excitation in terms of the electromagnetic field strength. The advantage of this approach to gravity is that the field equations for different models all take the same compact form and general results can be obtained.

To demonstrate the strength of our approach I will present the general teleparalel gravitational field equations in this language and display constitutive laws for previously studied teleparallel theories of gravity, including the teleparallel equivalent of general relativity and so called f(T)-models.

GR 3.4 Di 17:30 NW-Bau - HS3

Spontaneous Scalarization of Rotating Ellis Wormholes — •Xiao Yan Chew, Burkhard Kleihaus, and Jutta Kunz — Institut of Physics, University of Oldenburg, Carl-von-Ossietzky-Straße 9-11, 26129 Oldenburg

Scalar–tensor theory is one of the alternative theories of gravity. We consider the spinning generalization of the Ellis wormhole in this theory. Similar to other compact objects such as neutron stars and boson stars, these spinning wormholes also exhibit the phenomenon of spontaneous scalarization. The domain of existence of these scalarized wormholes is determined and their properties are investigated.

GR 3.5 Di 17:50 NW-Bau - HS3

Friedmann equations for gravity underlying birefringent electrodynamics — •Maximilian Düll and Nils Fischer — Universität Heidelberg

In recent years, it has become clear how quantizable matter fields determine the gravitational theory of the spacetime on which those matter fields live. This procedure - the gravitational closure of matter field equations - in the end boils down to finding the gravitational action as a solution of a set of partial differential equations that have been constructed from the prescribed matter dynamics. In this talk, we will show how appropriate symmetry assumptions - namely spatial homogeneity and isotropy - greatly simplify this problem of finding the appropriate gravitational action. We will illustrate the procedure with two explicit examples - the standard case of Friedmann-Robertson-Walker cosmology for a metric spacetime and cosmology for a spacetime with possible birefringence in vacuum.

GR 3.6 Di 18:10 NW-Bau - HS3

Gravitational field equations following from a bi-metric matter theory — •Udo Beier — Friedrich-Alexander Universität Erlangen-Nürnberg, Erlangen, Deutschland

Given any quantizable matter action, it is possible to determine the gravitational Lagrangian for the underlying geometry. This procedure is called gravitational closure and is equivalent to solving a set of partial differential equations, the so-called gravitational closure equations.

I will present how one performs the procedure of gravitational closure for a simple bi-metric matter theory, namely two Klein-Gordon fields that couple to two separate metric fields.

Using the deceptively simple matter model as input, I will show how one practically solves the ensuing gravitational closure equations perturbatively. The resulting action and linearized gravitational field equations will then be interpreted and compared to previous proposals in the literature.

GR 3.7 Di 18:30 NW-Bau - HS3

Pre-metric two-form gravity — •Florian Wolz — Friedrich-Alexander-Universität, Erlangen, Deutschland

Within the constructive gravity program it was shown that predictive and quantizable matter field theories pose such strong conditions on the underlying geometry that its Lagrangian is completely determined. Building on this program efforts have been made to derive the Lagrangian of pre-metric geometry.

After both, the weak field limit and the symmetry reduced case of birefringent cosmology, were successfully derived, in this talk we now employ a first order formulation of pre-metric geometry constructed with 2-forms in order to obtain an exact solution of the pertinent gravitational closure equations.

GR 3.8 Di 18:50 NW-Bau - HS3

Supermassive objects (black holes) calculated using the Tolman Oppenheimer Volkoff (TOV) equation — •Jürgen Brandes — Karlsruhe, Germany

Lorentz interpretation of general relativity (LI of GRT) predicts supermassive objects without event horizon and therefore different from black holes of classical GRT [1], [2]. These differences should become observable by the Event Horizon Telescope and Black Hole Cam projects during 2018. To assist the evaluation of the observational results, supermassive objects are calculated using the TOV equation regarding the different arguments of classical GRT and LI of GRT.

Classical GRT and LI of GRT use the same formulas and make (nearly) the same experimental predictions. So, gravitational waves and all the other well-known relativistic experiments are predicted in the same manner [1], [2] but the one important exception are black holes with and supermassive objects without event horizon.

[1] J. Brandes, J. Czerniawski: *Spezielle und Allgemeine Relativitätstheorie für Physiker und Philosophen - Einstein- und Lorentz-Interpretation, Paradoxien, Raum und Zeit, Experimente*, 4. Aufl. 2010, [2] Website www.grt-li.de.

GR 4: Gravitational waves II

Zeit: Dienstag 16:30–18:10 Raum: Phys-SR-SE1

GR 4.1 Di 16:30 Phys-SR-SE1

Waveform modeling for gravitational wave astronomy — •Harald Pfeiffer — Max Planck Institute for Gravitational Physics (Albert Einstein Institute)

The past two years have witnessed the advent of gravitational wave (GW) astronomy led by the spectacular observations of binary black holes and binary neutron stars by the LIGO and Virgo detectors. GW astronomy relies on knowledge of the gravitational waveforms for a variety of tasks: To design search strategies to detect gravitational waves; to measure masses, spins and tidal parameters of the coalescing compact objects; and also to test general relativity and to search for signatures of physics beyond classical general relativity.

This talk elucidates the interplay between GW astronomy and waveform modeling. We will present new waveform models, and will discuss validation studies to ensure that the recent GW observations are not biased by waveform model deficiencies. Particular emphasis will be paid to numerical relativity simulations, the only means to compute the gravitational waves emitted during the genuinely nonlinear and dynamic late inspiral and merger phase of compact object binaries.

GR 4.2 Di 16:50 Phys-SR-SE1

Enhancing the Optical Spring in Gravitational-Wave Detectors via Intra-Cavity Optical-Parametric Amplification — •Mikhail Korobko[1], Farid Ya. Khalili[2,3], and Roman Schnabel[1] — [1]Institut für Laserphysik und Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Moscow State University, Department of Physics, Moscow 119992, Russia — [3]Russian Quantum Center, Skolkovo 143025, Russia

Over the past two years Advanced LIGO and Advanced Virgo gravitational wave detectors have made several observations of gravitational waves from merging binary black holes and binary neutron stars. Extending the detection range and increasing the number of events requires a higher sensitivity of the detectors, that is mainly limited by the quantum radiation pressure and shot noise in the current design. One of the ways to improve the sensitivity is to use the optical spring effect, where detuning the optical cavity from its resonance causes the electromagnetic fluctuations to create a position-dependent force on the detector mirrors. This additional force gives a rise to a resonant enhancement in sensitivity for some gravitational wave frequency. We investigate the use of an optical parametric amplification to enhance this effect. We discuss how the frequency of this resonance can be tuned dynamically, matching the signal frequency of a signal, thus achieving a significant and broadband enhancement in sensitivity. We show that this all-optical control of the optical spring can be a versatile way of shaping the sensitivity in future gravitational-wave detectors.

GR 4.3 Di 17:10 Phys-SR-SE1

Signatures of alternative models of gravity in the gravitational waves: the quasi-normal modes of compact objects — •Jose Luis Blazquez-Salcedo — University of Oldenburg, Oldenburg, Germany

We study the ring-down phase of gravitational waves emitted from compact objects, such as neutron stars and black holes. We consider alternative models of gravity, e.g., Einstein-Gauss-Bonnet-dilaton theory, Scalar-Tensor theory, etc. The properties of the ring-down of these objects are studied using the quasi-normal mode formalism. This allow us to calculate how the theory characterises the properties of the ring-down in each case. We compare with the standard General Relativity results, which give us possible signatures of the alternative models of gravity in the gravitational wave emission.

GR 4.4 Di 17:30 Phys-SR-SE1

Astrophysical Gravitational Waves in Conformal Gravity — •Patric Hölscher[1], Chiara Caprini[2], and Dominik Schwarz[1] — [1]Bielefeld University, Germany — [2]Laboratoire Astroparticule et Cosmologie, Paris, France

We investigate gravitational radiation from binary systems in Conformal Gravity (CG) and Massive Conformal Gravity (MCG). These theories have achieved interesting results, like fitting galaxy rotation curves without dark matter.

For the linearised theory it turns out that the metric is given by the sum of a massless and a massive spin-2 field. Calculating the decay of the orbital period of binary systems for different mass regimes, our results show that CG and MCG with a small mass for the massive spin-2 field cannot explain the decay of the orbital period via gravitational radiation. But for MCG in the case of a large mass, the decrease of the orbital period is in agreement with current data. Additionally, this theory seems very interesting since it has a correct limit to General Relativity and is renormalizable.

GR 4.5 Di 17:50 Phys-SR-SE1

A new interpretation of Gravitational Waves — •Norbert Sadler — Norbert Sadler ;Wasserburger Str. 25a; 85540 Haar

It can be shown that the Gravitational Waves result from a local linear, longitudinal, energy-desity oscillation between the middle energy-density of the universe,from 4/9 proton energy equivalence per one meter and the proton radius.

At fusion of two Black-Holes as well as two Neutron-Stars the Exceptional E8 Symmetry Group, especially the 57 dimensional object and the space structure will be stimulated and extended along the directional density oscillation.

The E8-Symmetry Group replaces the Spacetime!

The plain gravity channel-waves can be shown as real wave functions of the gravitative and the electromagnetic interactions as well of the Hubble-Vortex.

2*Pi*alfa(Gravitation)=alfa(QED)*(Ho X Ho).

Further Information: www.cosmology-harmonices-mundi.com

GR 5: Relativistic astrophysics I

Zeit: Mittwoch 11:00–12:30 Raum: NW-Bau - HS3

Hauptvortrag GR 5.1 Mi 11:00 NW-Bau - HS3

Formation of Double Neutron Stars and their Merger Rates — •Thomas Tauris — AIfA, University of Bonn — MPIfR

In recent years, the discovery rate of the exotic double neutron star (DNS) systems has increased rapidly. The coming decade will even greatly enhance the number of both radio pulsar DNS systems, with the completion of the Square Kilometre-Array, and DNS mergers from detections of high frequency gravitational waves using LIGO/Virgo. This calls for a new investigation of the formation and evolution of DNS systems. In this talk, I will summarize the beautiful journey of binary stars leading to the production of DNS systems and discuss their key parameters. This includes correlations between spin period, orbital period and eccentricity, based on theoretical modelling. I discuss NS masses and present Monte Carlo simulations of supernovae (SNe) to extrapolate the pre-SN stellar properties and probe the explosions. Finally, I will discuss the merger-rate densities of DNS systems and double black hole systems in the local Universe and compare with LIGO/Virgo detections.

Hauptvortrag GR 5.2 Mi 11:45 NW-Bau - HS3

Accretion-Driven Growth of Super-Massive Black Holes — •Wolfgang J. Duschl — Astrophysik Kiel, Christian-Albrechts-Universität zu Kiel, Leibnizstr. 15, 24118 Kiel, Germany

The first super-massive black holes (SMBHs) with masses of the order of a billion solar masses in the nuclei of galaxies are observed at redshifts of 7.5, corresponding to an age of the Universe of around 700 million years. In my talk, I will first show how such large amounts of mass can be accreted into black holes within sufficiently short periods of time, and will, in particular, discuss the importance of self-gravity of the accreting material for a sufficiently fast accretion. The second part will be devoted to the question of how in the near future details of this accretion process can be used as tracers of physics in strong gravitational fields.

GR 6: Relativistic astrophysics II

Zeit: Mittwoch 14:00–16:00 Raum: NW-Bau - HS3

GR 6.1 Mi 14:00 NW-Bau - HS3

Accretion disks around compact objects with mass quadrupole — •Claus Lämmerzahl — ZARM, University of Bremen, Am Fallturm, 28359 Bremen

Compact massive objects like rotating neutron stars possess axially symmetric mass multipoles. We describe thick accretion disks in such axially symmetric space-times and discuss the modifications compared to accretion disks around Black Holes.

GR 6.2 Mi 14:20 NW-Bau - HS3

Geometrically thick fluid tori parametrisations — •Pavel Jefremov and Vojtěch Witzany — ZARM, Universität Bremen

In this talk I investigate various new solution for the geometrically thick toroidal perfect fluid configurations orbiting a stationary and axisymmetric black hole. These solutions are constructed by demanding that the velocity field of the orbiting fluid be expressed analytically through the parameter(s) of the resulting configuration. The well-known analytical solutions such as Polish Doughnuts with constant angular momentum and the Fishbone-Moncrief tori are then recovered as special cases of the resulting more general family of solutions.

GR 6.3 Mi 14:40 NW-Bau - HS3

The exact propagation delay in pulsar timing — Arnab Dhani[1,2,3] and •Eva Hackmann[3] — [1]Pennsylvania State University — [2]Indian Institute of Technology Roorkee — [3]ZARM, Universität Bremen

Pulsar timing offers the possibility to test the theory of gravity in the strong field regime. Particularly promising laboratories for such tests are pulsar–black hole binaries. In such a system it is therefore of paramount importance to accurately model the effects of General Relativity. Here we present an exact analytical calculation for the relativistic propagation delay of the signal of a pulsar orbiting a supermassive black hole. We use this result to test the accuracy of the usually employed post–Newtonian approximation methods.

GR 6.4 Mi 15:00 NW-Bau - HS3

Equilibrium of a charged perfect fluid around a Kerr black hole in a dipole magnetic test field: Role of the spin — •Kris Schroven, Audrey Trova, Eva Hackmann, and Claus Lämmerzahl — University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen, Germany

Analytical descriptions of accretion discs - such as the thick disc model- can help to deepen the understanding of the physics involved in this structures. Here, we will analytically discuss the structures formed by a charged ideal fluid, surroundling a rotating black hole (BH) with a magnetic dipole test-field. These formed structures are then influenced by the balance between the gravitational and magnetic forces. The test field will be oriented along the spin-axis. Furthermore rigid rotation of the fluid around the BH is assumed. We will focus on how the black hole spin influences the structure and position of the equilibrium configurations of the fluid. We will see, that the black hole spin plays a crucial role in the existence of equilibrium configurations of the fluid along the spin axis.

GR 6.5 Mi 15:20 NW-Bau - HS3

Equilibrium of charged perfect fluid around a Kerr black hole: role of the spin — •Audrey Trova[1], Kris Schroven[1], Jiří Kovář[2], Petr Slaný[2], Vladimir Karas[3], and Eva Hackmann[1] — [1]University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen, Germany — [2]Institute of Physics, Faculty of Philosophy and Science, Silesian University in Opava Bezručovo nám. 13, CZ-746 01 Opava, Czech Republic — [3]Astronomical Institute, Academy of Sciences, Boční II, CZ-141 31 Prague, Czech Republic

Studies of equilibrium of toroidal structures of a perfect fluid are important to understand the physics of accretion disks. Here, we are presenting an analytical approach for the equilibrium of charged-perfect fluid surrounding a rotating black hole, embedded in an asymptotically large scale uniform magnetic field. The vertical and radial structure of the torus are influenced by the balance between the gravitational and the magnetic force. Following our previous study of rotating charged test fluid around a non rotating black hole, this time, we show that according to the spin of the black hole the area of existence of such structures change. In this work, we focus our attention on orbiting structures in permanent rigid rotation. We prove, in this rotating case also, the existence of equilibrium configurations in the equatorial plane and on the polar axis such as charged polar clouds. Moreover, we show that the rotation of the black hole has a crucial role in the existence of such structures.

GR 6.6 Mi 15:40 NW-Bau - HS3

Fermi LAT limit on evaporation of individual primordial black holes — •Dmitry Malyshev[1], Christian Johnson[2], Steven Ritz[2], and Stefan Funk[1] — [1]ECAP, Erlangen, Germany — [2]Santa Cruz University, USA

Primordial black holes (PBH) with masses below approximately 10^{15} g are expected to emit gamma rays with energies above a few tens of MeV, which can be detected by the Fermi Large Area Telescope (LAT). Previous searches for PBHs have focused on either short timescale bursts or the contribution of PBHs to the isotropic gamma-ray emission. We show that, in case of individual PBHs, the Fermi LAT is most sensitive to PBHs with temperatures near 16 GeV, which it can detect out to a distance of about 0.03 pc. These PBHs would appear as potentially moving point sources. We develop a new algorithm to detect the proper motion of a gamma-ray PS, and apply it to unassociated PS in the third Fermi-LAT source catalog (3FGL). None of unassociated PS with spectra consistent with PBH evaporation show significant proper motion. The derived 99% confidence limit on PBH evaporation rate in the vicinity of the Earth is similar to the limits obtained with ground-based gamma-ray observatories.

GR 7: Didactical aspects of relativity

Zeit: Mittwoch 16:30–17:50 Raum: NW-Bau - HS3

Hauptvortrag GR 7.1 Mi 16:30 NW-Bau - HS3

Teaching about gravitational waves — •Markus Pössel — Haus der Astronomie / Max-Planck-Institut für Astronomie, Heidelberg

Over the past few years, gravitational waves have captured the imagination of the general public and, specifically, of pupils and of university-level students world-wide. This makes gravitational waves an attractive subject for teaching. But their grounding in general relativity also makes gravitational waves a challenging subject to teach. In this talk, I explore different ways of teaching about gravitational waves at the undergraduate and at the high school level, using concepts from Newtonian physics as well as models, analogies, and visualizations.

Hauptvortrag GR 7.2 Mi 17:10 NW-Bau - HS3

Visualizing relativistic effects in a non-relativistic model — •Thomas Filk — Institute of Physics, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

A chain of harmonically coupled pendula in a gravitational field is a classical Newtonian system. However, in a continuum limit, where the discreteness of the chain can be neglected, the equations of motion of this system become Lorentz invariant. Therefore, all non-trivial solutions of this system (solitons, breathers) behave like relativistic objects: there is a maximal speed of propagation and the solutions show Lorentz contraction and time-dilation when in motion (with the proper Lorentz factor and the speed of light replaced by the speed of wave propagation along the chain). Intrinsically, i.e. when the “clocks” and “rulers” of the system are used, this becomes a Lorentz invariant relativistic system. Extrinsically, i.e. for an external observer, it remains to be Newtonian.

This model cannot only be used to demonstrate relativistic effects in the classroom, but it also shows nicely how Einstein’s interpretation of relativity comes about when the measuring devices are considered as part of the system. And it emphasizes the usefullnes of changing perspectives.

GR 8: Poster session (permanent)

Zeit: Mittwoch 18:00–19:30 Raum: Phys-SR-SE2

GR 8.1 Mi 18:00 Phys-SR-SE2

Frequency Spectrum of an Optical Resonator in Curved Spacetime — Dennis Rätzel[1], •Fabienne Schneiter[2], Daniel Braun[2], Tupac Bravo[1], Richard Howl[1], Maximilian P. E. Lock[3,1], and Ivette Fuentes[4,1] — [1]Faculty of Physics, University of Vienna, Boltzmanngasse 5, 1090 Vienna, Austria — [2]Institut für Theoretische Physik, Eberhard-Karls-Universität Tübingen, 72076 Tübingen, Germany — [3]Imperial College, Department of Physics, SW7 2AZ London, United Kingdom — [4]School of Mathematical Sciences, University of Nottingham, University Park, Nottingham NG7 2RD, UK

We study the effect of a gravitational field and proper acceleration on the frequency spectrum of an optical resonator, both when the resonator is considered to be rigid or deformable. The resonator is modeled as a rod of matter with two attached mirrors at its ends, or as a dielectric rod whose ends function as mirrors. We derive expressions for the frequency spectrum, which is defined through the runtime of light pulses sent back and forth between the mirrors by an observer. For a deformable resonator, the frequency spectrum depends on the speed of sound in the rod supporting the mirrors. The speed of sound approaching infinity corresponds to the assumption of Born rigidity, and the speed of sound approaching the speed of light corresponds to the assumption of a relativistic concept of rigidity. The results may be used for measuring gravitational fields or accelerations based on frequency shifts, and are not limited to weak gravitational fields.

GR 8.2 Mi 18:00 Phys-SR-SE2

Relativistic Interactive Flight Simulation — •Stephan Preiss — Institut für Physik, Universität Hildesheim

First-person visualizations can be used as virtual laboratories where relativistic scenes are explored and relativistic phenomena like length contraction, time dilation and aberration of light are directly observable. We developed an interactive relativistic flight simulation to show these effects. Next to static objects, the simulation also includes objects that move at constant speed, accelerate uniformly or rotate constantly. With this tool, we are able to address the common difficulties in the understanding of the special theory of relativity by creating scenes treating twin and ladder paradoxa.

GR 8.3 Mi 18:00 Phys-SR-SE2

partially massless and self duality in three dimensions — •daniel galviz[1] and adel khoudeir[2] — [1]Universität Bonn, Nussallee 12, D-53115 Bonn, Germany — [2]Centro de Física Fundamental, Departamento de Física, Facultad de Ciencias, Universidad de Los Andes, Merida 5101, Venezuela

Partially massless in three dimensions is revisited and its relationship with the self-dual massive gravity is considered. The only mode of the partially massless is shown explicitly through of an action for a scalar field on (A)dS background. This fact can be generalized to higher dimensions. This degree of freedom is altered when a triadic Chern-Simons is introduced, giving rise to the self dual massive gravity on (A)dS background. We present another physical system with partially massless symmetry and its connection with topologically massive gravity is discussed.

GR 8.4 Mi 18:00 Phys-SR-SE2

Scalarization of neutron stars with realistic equations of state — •Zahra Altaha Motahar, Jose Luis Blazquez-Salcedo, Burkhard Kleihaus, and Jutta Kunz — Oldenburg University

Neutron stars are one of the most mysterious but interesting objects in the universe. Due to their compactness and high ensity, we can take them as an ideal laboratory to test alternative theories of gravity. In addition, studying neutron stars can improve our limited knowledge of properties and the physics of nuclear matter in such a high density inside these compact objects.

We demonstrate the effect of scalarization on static and slowly rotating neutron stars implementing various realistic Equations Of State (EOSs). Beside polytropic EOS and some EOSs considering pure nuclear matter, and pure quark matter, particularly we include several EOSs describing nuclear matter with hyperons and hybrid matter for the first time in this context.

We investigate the onset of scalarization, for these different EOSs presenting a universal relation for the critical coupling parameter versus the compactness. We then recognize that the most significant universal (independent of the EOS) feature of the onset and the magnitude of the scalarization, is the correlation with the value of the the gravitational potential at the center of the star. We also analyze the moment-of-inertia–compactness relations and confirm universality for the nuclear matter, hyperon and hybrid equations of state.

GR 8.5 Mi 18:00 Phys-SR-SE2

Flying through a Kerr black hole – Visualizations — •Thomas Reiber — Universität Hildesheim

We use a maximal analytic extension of Kerr spacetime, which offers an interesting topology. An observer in it can pass through event horizons to reach distant asymptotically flat parts of the spacetime. To illustrate what an observer moving through a Kerr black hole would observe, a general relativistic ray tracer is used to calculate videos of the observers view for different geodesic movements of the observer.

GR 8.6 Mi 18:00 Phys-SR-SE2

Sektormodelle gekrümmter Raumzeiten — •Corvin Zahn und Ute Kraus — Universität Hildesheim

Die Allgemeine Relativitätstheorie beschreibt die Welt als vierdimensionale Lorentz-Mannigfaltigkeit. Um die Bewegung von Teilchen oder die Ausbreitung von Licht zu untersuchen ist es oft ausreichend, einen zweidimensionalen Unterraum bestehend aus der Zeit- und einer Raumkoordinate zu betrachten.

Zur anschaulichen Darstellung solcher Unterräume, deren Geometrie i. A. nicht die Minkowski-Geometrie ist, haben wir Anschauungsmodelle entwickelt. Sie basieren auf der im Regge-Kalkül verwendeten koordinatenfreien, nur auf messbaren Abständen beruhenden Beschreibung der Raumzeit.

In diesem Beitrag werden Beispiele solcher Sektormodelle vorgestellt: Raumzeiten von Schwarzen Löchern, Neutronensternen, Gravitationswellen und dem expandierenden Universum.

GR 8.7 Mi 18:00 Phys-SR-SE2

Satellite Dynamics and Formation Flight Simulator: Design, Analysis, and Optimization of future geodesy missions — Takahiro Kato, Wöske Florian, Rievers Benny, and •List Meike — ZARM, Universität Bremen, Am Fallturm 2, 28359 Bremen

Observations in satellite gravimetry depend on accurate modeling techniques for (I) an interpretation of measured data and the characterization of perturbations, (II) mission analysis, design and optimization and (III) tests of data evaluation procedures.

The need for an improvement of the modeling of system and environment in particular for satellite gravimetry is motivated by a range of complex questions and tasks.

The focus of the development lies on the implementation of an accurate dynamics model of the satellite under external perturbations, as well as the internal coupling effects (noises) on the measurement.

GR 8.8 Mi 18:00 Phys-SR-SE2

MICROSCOPE: A space mission to test the Weak Equivalence Principle — Stefanie Bremer, Meike List, •Benny Rievers, and Hanns Selig — ZARM, Universität Bremen, Am Fallturm 2, 28359 Bremen

On the 25th of April the French space mission MICROSCOPE was launched. After the successful commissioning phase, scientific measurements started in December 2016 and are planned to be continued at least until January 2018. The goal of the MICROSCOPE mission is ambitious: The Weak Equivalence Principle is being tested with a precision never achieved before yielding the determination of the Eötvös parameter η with an accuracy of 10-15. Here we show details on the orbit and system modeling as well as on some aspects of data analysis.

GR 8.9 Mi 18:00 Phys-SR-SE2

Circular motion in NUT space-time — •Pavel Jefremov and Volker Perlick — ZARM, Universität Bremen

We investigate characteristic imprints of the gravitomagnetic charge and the Manko-Ruiz constant on circular geodesics and perfect fluid tori motion in NUT (Newman-Unti-Tamburino) metric. For the perfect fluid case we consider the Polish Doughnuts model which is widely used in modelling of accretion flows. We find that the shape of the rotational configurations is qualitatively changed due to the presence of the gravitomagnetic charge and compare thermodynamical parameters of the tori for different values of the parameters of the metric.

GR 8.10 Mi 18:00 Phys-SR-SE2

Relativistic accretion of charged dust in Kerr-Newman spacetime — •Kris Schroven, Eva Hackmann, and Claus Lämmerzahl — University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen, Germany

We use an analytical model to describe the accretion of a dilute collisionless plasma onto a rotating and charged black hole (BH). By assuming continuous injection of particles at the spherical shell, and by treating the BH and accretion disk as passive sinks of particles, the dicsussed model becomes stationary. The model may serve as a toy model for plasma feeding an accretion disk around a charged and rotating BH. Our main focus lies on the discussion of the influence of a very small BH net charge on the plasma accretion. We can demonstrate that, within our model, already a vanishingly small BH charge may in general have a non-negligible effect on the plasma's motion. Furthermore, we argue that the inner and outer edges of the forming accretion disk strongly depend on the charge of the accreted plasma.

The resulting possible configurations of accretion disks are analyzed in detail.

GR 8.11 Mi 18:00 Phys-SR-SE2

Relativistic geodesy: the geoid and leveling — •Dennis Philipp — ZARM, Universiät Bremen

We give a definition of the relativistic geoid in terms of the redshift potential, which exists for any isometric congruence of observers. Our definition yields the well known (post-)Newtonian notions in the respective limit, and it applies to any celestial object no matter how strong the gravitational field is. Mathematically, the definition of the geoid in terms of a redshift potential is equivalent to a definition in terms of an acceleration potential, and we use this equality to explore the field of relativistic leveling. The definitions are visualized by specific examples for analytically known simple spacetimes, and we show the influence of certain properties of the gravitational field, such as the gravitomagnetic parameter, on the results.

GR 8.12 Mi 18:00 Phys-SR-SE2

Galilean relativity with the relativistic gamma factor. — •Osvaldo Domann — Stephanstr. 42, D- 85077 Manching

SR as derived by Einstein is the product of an approach of 1905 when the interactions between light and the measuring instruments were still not well understood. SR is a rough undifferentiating heuristic mathematical approach which ignores the origin of the constancy of light speed in inertial frames, arriving to wondrous results about time and space. With the findings made during the last 100 years by experimentalists, a critical revision of Einstein's theoretical approach is more than overdue. Based on these findings, a theoretical approach is presented which takes into consideration the interactions between light and optical lenses and electric antennas of the measuring instruments, explaining why always 'c' is measured in the frame of the instruments. The approach treats relativity as a speed problem with absolute time and space variables, resulting equations of Galilean relativity multiplied with the gamma factor. More at www.odomann.com

GR 8.13 Mi 18:00 Phys-SR-SE2

The Question of Dark Energy — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

Dark energy is considered to be one of the great mysteries of present-day physics. From measurements of the motion of type Ia supernovae, it has been concluded that the universe is undergoing accelerated expansion. To explain this acceleration, the universe is assumed to be filled with some type of ("dark") energy.

However, there is a very unspectacular explanation for these measurements if we follow the Lorentzian relativity rather than the relativity of Einstein.

In the Lorentzian relativity space is not expanding but always fixed and the stars and the galaxies are moving physically through this stable space. Inflation is in this view not a change of the space but a change of the speed of light c. And instead of a slowly expanding space one has to assume a slow decrease of the speed of light.

If in this view the speed of light was higher in the past there is a simple solution. Because if this higher c of the early times is inserted into the Doppler equation to determine the speed of the stars from their red shift, this will yield higher speeds for early stars. So there is no acceleration.

GR 8.14 Mi 18:00 Phys-SR-SE2

Possible experimental proof of Lorentz interpretation (LI) of GRT — •Jürgen Brandes — Karlsruhe, Germany

LI of GRT is a rational variation of classical GRT. Nobel Prize winner Kip S. Thorne accepts both, the curved spacetime paradigm of classical GRT and the flat spacetime paradigm of LI of GRT. "Is spacetime really curved? Isn't it conceivable that spacetime is actually flat, but the clocks and rulers with which we measure it . . . are actually rubbery?" and his answer is: "Yes." [2]. Normally, there is no difference in the predictions of relativistic experiments of both interpretations. The great exception: within LI of GRT "black holes" have no event horizon and they are degenerate objects of arbitrary mass from which light waves can escape. The poster shows details of the calculations of these supermassive objects using the Tolman Oppenheimer Volkoff (TOV) equation. The differences to classical GRT shall become observable by the "Event Horizon Telescope" and "Black Hole Cam" project within 2018.

[1] J. Brandes, J. Czerniawski: *Spezielle und Allgemeine Relativitätstheorie für Physiker und Philosophen - Einstein- und Lorentz-Interpretation, Paradoxien, Raum und Zeit, Experimente*, 4. Aufl. 2010, [2] Website www.grt-li.de.

GR 8.15 Mi 18:00 Phys-SR-SE2

Dark Matter Problem solved by Modified Gravitation — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

Dark matter is one of the great mysteries in physics today.

There are fundamentally two possible solutions: (1) types of particle may exist which are presently undetected and which provide the missing contribution to the gravitational field; (2) the theory of gravity put forward by Newton and Einstein, which relates gravitation to mass and energy, may be at fault.

For the second alternative, a working ansatz is available. If the Lorentzian interpretation of relativity is extended to the field of general relativity, i.e. to gravitation, this results in a different causality for gravity. Gravity is no longer caused by mass but is instead a side effect of other forces. So every elementary particle contributes to the field independently of its mass. In this case, photons and neutrinos play a prominent role.

Taking the thoroughly investigated rotating galaxy NGC 3198 as an example of this approach, it can be shown that the result for the value of the field as well as its spatial distribution fits the measurements quite precisely.

On the other hand, the search for specific particles as an explanation for this phenomenon has not yielded any hint of their existence up to now.

GR 9: Quantum Gravity I

Zeit: Donnerstag 11:00–11:45 Raum: NW-Bau - HS3

Hauptvortrag GR 9.1 Do 11:00 NW-Bau - HS3

Constructive QFT Approach to Quantum Gravity — •Thomas Thiemann — FAU Erlangen-Nuernberg

It is well known that canonical quantisation of Quantum Field Theories (QFT) on Minkowski space can be rephrased as a problem in constructive QFT, namely the construction of a rigorous path integral measure on a space of Euclidian fields obeying the Osterwalder-Schrader (OS) axioms. From such a measure the canonical QFT (Hilbert space, vacuum, dynamics) can be recovered by OS reconstruction. The measure theoretic approach opens access to Wilsonian renormalisation techniques that can be used in order to derive a consistent continuum theory from a naively quantised version.

In this talk we review elements of this framework and explain how it can be applied to canonical Quantum Gravity (QG). We close by discussing applications thereof in a particular incarnation of canonical QG called Loop Quantum Gravity (LQG).

GR 10: Experimental tests I

Zeit: Donnerstag 11:45–12:30 Raum: NW-Bau - HS3

Hauptvortrag GR 10.1 Do 11:45 NW-Bau - HS3

A test of the gravitational redshift using Galileo satellites 5 and 6 — •Sven Herrmann, Felix Finke, Olga Kichakova, Claus Lämmerzahl, Meike List, and Benny Rievers — ZARM, Center of Applied Space Technology and Microgravity, University Bremen

The European GNSS satellites Galileo 5 and 6 launched in August 2014 have not reached their targeted circular orbit at around 22.000 km height. Instead, their orbits now possess an eccentricity of about 0.16 and the satellites' height changes periodically about 8000 km during each orbit. While this is of some disadvantage for navigation purposes it offers a unique possibility to perform a precise test of the gravitational redshift predicted by General Relativity. Thus, with support from DLR (RELAGAL project) and ESA (GREAT project), we have conducted an analysis of the clock and orbit data from these two satellites to investigate whether an improved test over the result from Vessot and Levines GPA experiment can be obtained. Here we present the results of this analysis covering approximately 3 years of data and give an outlook on further possible improvements of this test.

GR 11: Black Holes

Zeit: Donnerstag 14:00–16:00 Raum: NW-Bau - HS3

GR 11.1 Do 14:00 NW-Bau - HS3

Solitons and Black Holes in 5d Einstein-Maxwell-Chern-Simons Theory — Jose Luis Blazquez-Salcedo[1], •Jutta Kunz[1], Francisco Navarro-Lerida[2], and Eugen Radu[3] — [1]Universität Oldenburg, Germany — [2]Universidad Complutense de Madrid, Spain — [3]Universidade de Aveiro, Portugal

We consider black holes in 5-dimensional Einstein-Maxwell-Chern-Simons (EMCS) theory in the presence of a negative cosmological constant. These possess equal-magnitude angular momenta and a nontrivial magnetic field at spatial infinity. Their boundary metric corresponds to the product of time and a squashed 3-dimensional sphere. The black holes are then described by their mass, angular momenta, electric charge, magnetic flux, and squashing parameter. Under certain conditions globally regular solitonic configurations are approached. Supersymmetric solutions arise as well.

GR 11.2 Do 14:20 NW-Bau - HS3

On the Present Ability to Test Theories of Gravity via Black-Hole Shadows — •Yosuke Mizuno[1], Ziri Younsi[1], Christian Fromm[1], Oliver Porth[1], Mariafelicia De Laurentis[1], Hector Olivares[1], Heino Falcke[2], Michael Kramer[3], and Luciano Rezzolla[1] — [1]Institut für Theoretische Physik, Goethe Universität, Frankfurt am Main, Germany — [2]Department of Astrophysics/IMAPP, Radboud University Nijmegen, Nijmegen, The Netherlands — [3]Max-Planck-Institut für Radioastronomie, Bonn, Germany

Upcoming sub-millimetre VLBI images of Sgr A* carried out by the Event-Horizon-Telescope Collaboration (EHTC) are expected to provide critical evidence for the existence of this supermassive black hole. In this work we assess our present ability to use EHTC images to determine if they correspond to a Kerr black hole as predicted by Einstein's theory of general relativity or to a black hole in alternative theories of gravity. To this end, we perform GRMHD simulations and use GRRT calculations to generate synthetic shadow images of a magnetised accretion flow onto a Kerr black hole. In addition, and for the first time, we perform GRMHD simulations and GRRT calculations for a dilaton BH, which we take as a representative solution of an alternative theory of gravity. Taking into account the configuration of the VLBI observing array from the 2017 EHTC campaign, we find that it could be extremely difficult to distinguish between black holes from different theories of gravity, thus highlighting that great caution is needed when interpreting BH images as tests of general relativity.

GR 11.3 Do 14:40 NW-Bau - HS3

The shadow of a collapsing dark star — Stefanie Schneider and •Volker Perlick — ZARM, U Bremen, 28359 Bremen

According to general relativity a black hole is seen as a black disc against a bright backdrop of light sources. This black disc is usually called the "shadow" of the black hole. A US-led coordinated project known as the Event Horizon Telescope, in partnership with a European project known as the BlackHoleCam, is under way to actually observe the shadow of the black hole candidates at the centre of our own galaxy and at the centre of M87. For theoretical considerations of the shadow, the black hole is usually considered as eternal, i.e., as existing in a time-independent state forever. Here we ask the question of how the shadow comes about in the course of time if a black hole is formed by gravitational collapse. We consider the simplest model of a gravitational collapse, assuming that the collapsing "star" is a dark ball of dust.

GR 11.4 Do 15:00 NW-Bau - HS3

Light propagation near a black hole distorted by an external quadrupole moment — •Efthimia Deligianni — ZARM, Universität Bremen

For isolated and stationary black holes analytical descriptions of the shadow already exist. Surrounding such a black hole with an external matter distribution, e.g. an external galaxy, leads to deformation of the spacetime – we speak of distorted black holes. Consequently, the shadow of such black holes deviates from the Schwarzschild- or Kerr-case.

In this talk I will present our progress in analytically describing this distorted shadow. In particular, I will discuss the photon region of a black hole under the influence of an external quadrupolar gravitational field.

GR 11.5 Do 15:20 NW-Bau - HS3

The zeroth law in quasi-homogeneous thermodynamics and black holes — Alessandro Bravetti[1], •Christine Gruber[2,4], Cesar Lopez-Monsalvo[3], and Francisco Nettel[2] — [1]IIMAS, UNAM, Mexico City, Mexico — [2]ICN, UNAM, Mexico City, Mexico — [3]UAM, Mexico City, Mexico — [4]University of Oldenburg, Germany

Motivated by black holes thermodynamics, we consider the zeroth law of thermodynamics for systems whose entropy is a quasi-homogeneous function of the extensive variables. We show that the generalized Gibbs-Duhem identity and the Maxwell construction for phase coexistence based on the standard zeroth law are incompatible in this case. We argue that the generalized Gibbs-Duhem identity suggests a revision of the zeroth law which in turns permits to reconsider Maxwell's construction in analogy with the standard case. The physical feasibility of our proposal is considered in the particular case of black holes.

GR 11.6 Do 15:40 NW-Bau - HS3

Horizon Wave Function in Quantum-Modified Black Hole Models — Andrea Giugno[1], Andrea Giusti[1,2,3], Piero Nicolini[4,5], and •Michael Florian Wondrak[4,5] — [1]Arnold Sommerfeld Center, Ludwig-Maximilians-Universität München, München, Germany — [2]Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy — [3]INFN, Sezione di Bologna, Bologna, Italy — [4]Frankfurt Institute for Advanced Studies (FIAS), Frankfurt am Main, Germany — [5]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität Frankfurt, Frankfurt am Main, Germany

From a physical viewpoint, matter takes up a finite, nonvanishing volume. There are no point-like objects. This raises the question in which cases a given matter distribution describes a quantum particle or alternatively a (quantum) black hole.

To address this issue, one can compare the Schwarzschild radius with the width of the matter distribution which is typically of the order of the Compton wavelength. If the Schwarzschild radius is larger, one can speak of a black hole. A more refined ansatz to determine the character of a matter distribution is offered by the horizon wave function. It allows for the horizon radius to take on a range of values and yields the probability of being a black hole. In this talk we discuss modifications in the realm of quantum-modified black hole models.

GR 12: Alternative approaches

Zeit: Donnerstag 14:00–15:40 Raum: Phys-SR-SE1

GR 12.1 Do 14:00 Phys-SR-SE1

Gravity Based on Lorentzian Relativity — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

When relativity was introduced, around 1900, two fundamentally different approaches were under discussion. The earlier one was proposed by Lorentz / Larmor and based on physical processes: contraction was deduced from the known contraction of fields in motion, dilation from an assumed oscillation in particles with a velocity c. At the time, however, this approach was considered very speculative since the understanding of particles and matter was very sketchy and did not support this interpretation.

Einstein's approach, which assumed specific properties of the abstract notions of space and time and which was based on a principle rather on physical laws, was therefore more easily accepted.

In the meantime, though, the approach proposed by Lorentz / Larmor is fully supported by our knowledge of physics. Hence, not only can special relativity be based on known physics but so too can general relativity, i.e. gravity. If we use the known facts of the reduction of c in a gravitational field and the mentioned properties of elementary particles, all results and facts of relativistic gravity can be deduced by using Euclidian geometry and basic mathematics rather than principles.And the big open problems of dark matter and dark energy have solutions corresponding to a straightforward physical explanation.

For further Info: www.ag-physics.org .

GR 12.2 Do 14:20 Phys-SR-SE1

Galilean relativity with the relativistic gamma factor. — •Osvaldo Domann — Stephanstr. 42, D- 85077 Manching

SR as derived by Einstein is the product of an approach of 1905 when the interactions between light and the measuring instruments were still not well understood. SR is a rough undifferentiating heuristic mathematical approach which ignores the origin of the constancy of light speed in inertial frames, arriving to wondrous results about time and space. With the findings made during the last 100 years by experimentalists, a critical revision of Einstein's theoretical approach is more than overdue. Based on these findings, a theoretical approach is presented which takes into consideration the interactions between light and the optical lenses and electric antennas of the measuring instruments, explaining why always 'c' is measured in the frame of the instruments. The approach treats relativity as a speed problem with absolute time and space variables, resulting equations of Galilean relativity multiplied with the gamma factor. More at www.odomann.com

GR 12.3 Do 14:40 Phys-SR-SE1

Gravitation as a physical interaction of subatomic particles instead of a geometrical space-time curvature. — •Osvaldo Domann — Stephanstr. 42, D- 85077 Manching

GR is the theory of gravitation of the SM. It is a mathematical approach from 1915, based on the representation of subatomic particles as isolated entities in space, arriving to the wondrous concept of space-time curvature. GR resists all intents of integration into a unified field theory and is not compatible with quantum mechanics. An approach is presented for a gravitation theory that is based on the representation of a subatomic particle (SP) as a focal point of rays of Fundamental Particles (FPs) that go from infinite to infinite, FPs where the energy of the subatomic particle is stored as rotations defining angular momenta. With this representation all SPs interact permanently through the angular momenta of their FPs, according to the Mach principle that postulates that physical laws are determined by the large-scale structure of the universe. The approach explains gravitation as the result of the physical reintegration of migrated electrons and positrons to their nuclei. It allows the derivation of all four known forces from one field and is compatible with QED. No wondrous concepts are used. More at www.odomann.com

GR 12.4 Do 15:00 Phys-SR-SE1

Kann auf das Gravitationsfeld nicht doch das Bewegungsprinzip angewendet werden? — •Karl-Herbert Darmer — Meyertwiete 7, 22848 Norderstedt

Braucht die Geometrie der Allgemeinen Relativitätstheorie die Absolute Konstanz der Lichtgeschwindigkeit als Grundvoraussetzung? Die Geometrie der Lorentztransformationen braucht sicher keine absolute Konstanz der Lichtgeschwindigkeit! Wer sich so etwas seltsames vorstellen kann wie die Dunkle Materie, die keine weitere Eigenschaft hat, als die Lücke der Formeln zu füllen, der sollte auch in der Lage sein, sich ein Gravitationsfeld vorzustellen, das gebildet wird aus den Gravitationsfeldern der Masseteilchen, das auf diese zurückwirkt, zu dem sich die Lichtphotonen mit Lichtgeschwindigkeit bewegen und das keine weiteren materiellen Eigenschaften hat.

Wer sich das Gravitationsfeld als Gummimatte vorstellen kann, über die Kugeln rollen und abhängig von ihrem Gewicht unterschiedliche Dellen verursachen, der stellt sich ein Feld vor auf das das Bewegungsprinzip angewendet werden kann. Man kann Nadeln in die Gummimatte stecken und egal wie sich die Kugeln bewegen, bleiben die Nadeln an der selben Stelle stecken. Auch das ist nur eine relative Bewegung, den die Matte selbst könnte sich bewegen.

Wenn man das Bewegungsprinzip auf das Gravitationsfeld zulässt und es als Medium sieht, gibt es Lösungen für die zu schnell rotierenden Galaxien, die auch ohne Dunkle Materie auskommen. Weiteres dazu unter www.darmer.de/dpg2018.

GR 12.5 Do 15:20 Phys-SR-SE1

Das Janusgesicht der Determination — •Helmut Hille — Fritz-Haber-Straße 34, 74081 Heilbronn

Die Geschichte der Physik ist immer auch ein Teil der Geistesgeschichte und des Zeitgeistes. Davor schützen auch keine wissenschaftlichen Beweise, deren Interpretation oft genug dem Zeitgeist und den mit ihm verbundenen Erwartungen unterliegen, die bedient sein wollen. Anhand der Auffassung von Trägheit zeige ich, was seit der Antike die mehr oder weniger unbewusste Motivation der jeweiligen Vorstellung dieser wichtigen Eigenschaft von Materie ist und warum es heute wichtig ist, sich endlich ehrlich zu machen und die Dinge so zu sehen, wie sie sind. Schon Augustinus warnte: "Wer immer etwas hinter die Dinge zu sehen versucht, sieht am Ende die Dinge selber nicht mehr."

GR 13: Classical GR

Zeit: Donnerstag 16:30–19:35 Raum: NW-Bau - HS3

Hauptvortrag GR 13.1 Do 16:30 NW-Bau - HS3

Theoretical aspects of relativistic geodesy — •Dennis Philipp — ZARM, Universität Bremen

General Relativity is at present the best available theory of gravity, as its predictions have been verified by all previously conducted experiments and observations. The technological capabilities for gravitational measurements on Earth and in its vicinity recently improved dramatically. Therefore, relativistic effects become increasingly important in modern relativistic geodesy. Although at present usually the first order post-Newtonian approximation of GR is sufficient, this may not be correct for specific applications and for future and contemporary high-precision geodetic measurements. We review results for high-precision relativistic orbit modeling, the analytic description of the (gravitational) redshift between satellites and Earth-bound clocks, relativistic leveling, and the definition of the relativistic geoid. In addition, we outline how methods and concepts from relativistic geodesy can be applied to astrophysics of compact objects and vice versa.

GR 13.2 Do 17:15 NW-Bau - HS3

Building a Hamiltonian for spinning bodies in curved spacetime — •Vojtěch Witzany — ZARM, Universität Bremen, Am Fallturm 2, 28359 Bremen, Germany

The motion of bodies smaller than the curvature scale of the background space-time can be effectively described by a multipolar formalism. Several Hamiltonians for this mode of motion were proposed, but they lack generality and theoretical foundation. In this talk, I show how to construct a set of fundamental Poisson brackets and a Hamiltonian for the multipolar body from its governing field theory.

GR 13.3 Do 17:35 NW-Bau - HS3

The gravitational clock compass — •Dirk Puetzfeld — ZARM, Uni Bremen

We show how a suitably prepared set of clocks can be used to extract all components of the gravitational field in the context of General Relativity. Conceptual differences between the clock compass and the standard gravitational compass, which is based on the measurement of the mutual accelerations between the constituents of a swarm of test bodies, are highlighted. Particular attention is paid to the construction of the underlying reference frame.

GR 13.4 Do 17:55 NW-Bau - HS3

Static Orbits in Rotating Spacetimes — •Lucas Gardai Collodel, Burkhard Kleihaus, and Jutta Kunz — Institut für Physik, Universität Oldenburg, Postfach 2503 D-26111 Oldenburg, Germany

We show that under certain conditions an axisymmetric rotating spacetime contains a ring of points in the equatorial plane, where a particle at rest with respect to an asymptotic static observer remains at rest in a static orbit. We illustrate the emergence of such orbits for boson stars. Further examples are wormholes, hairy black holes and Kerr-Newman solutions.

GR 13.5 Do 18:15 NW-Bau - HS3

Wormholes Immersed in Rotating Matter — Christian Hoffmann[1], Theodora Ioannidou[2], Sarah Kahlen[1], •Burkhard Kleihaus[1], and Jutta Kunz[1] — [1]Institut für Physik, Universität Oldenburg, Germany — [2]Aristotle University of Thessaloniki, Thessaloniki, Greece

We demonstrate that rotating matter sets the throat of an Ellis wormhole into rotation, allowing for wormholes which possess full reflection symmetry with respect to the two asymptotically flat spacetime regions. We analyse the properties of this new type of rotating wormholes and show that the wormhole geometry can change from a single throat to a double throat configuration. We further discuss the ergoregions and the lightring structure of these wormholes.

GR 13.6 Do 18:35 NW-Bau - HS3

Cosmological constant is a conserved charge — •Kamal Hajian — Institute for Research in Fundamental Sciences (IPM), Tehran, Iran

Cosmological constant can be considered as the on-shell value of a top form in gravitational theories. The top form is the field strength of a gauge field, and the theory enjoys a gauge symmetry. After reviewing a short history of cosmological constant, we will show that cosmological constant in this context is the charge of global part of the gauge symmetry, and is conserved irrespective of the dynamics of the metric and other fields. In addition, we will introduce its conjugate chemical potential, and prove the generalized first law of thermodynamics which includes variation of cosmological constant as a conserved charge. At the end, we will discuss how our new term in the first law is related to the volume-pressure term. This talk is based on the paper arXiv:1710.07904 in collaboration with Dmitry Chernyavsky.

GR 13.7 Do 18:55 NW-Bau - HS3

Einstein and the Ether — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

The development of the theory of relativity is closely connected to the development of the view of the ether. At the time when several variants of the theory of relativity were being discussed (around 1900), the corresponding understanding of the phenomenon ether played a crucial role.

Special relativity can be treated comparatively well with or without reference to an ether. The situation is, however, more complicated in the case of general relativity. In contrast to Einstein, his colleagues Ernst Mach and Hendrik Lorentz, who were very familiar with Einstein's view, tended to regard the ether as an unavoidable assumption in this context.

We will present both sides of the argument and discuss the possible conclusions in the light of our present knowledge of physics.

More info: Ludwik Kostro, Einstein and the Ether, Apeiron 2000.

GR 13.8 Do 19:15 NW-Bau - HS3

Gedanken zu $\mathbf{E = m \cdot c^2}$ — •Helmut Hille — Fritz-Haber-Straße 34, 74081 Heilbronn

Ich halte Einsteins berühmte Gleichung für seine größte Leistung, insofern sie den Materiebegriff erweitert hat, ob sie nun quantitativ zutreffend ist oder nicht. Sie war eine kühne Vorausschau auf Atom- und Wasserstoffbomben und hätte eigentlich als Warnung dienen können, die Büchse der Pandora nicht zu öffnen. Ich frage hier nach dem Ursprung dieser mächtigen Energie und sehe sie als einen weiteren Beweis dafür an, dass unser Kosmos aus einem gemeinsamen Ereignis hervorgegangen ist, das wir in Deutschland etwas mythisch verklärt Urknall nennen.

GR 14: General assembly of the Gravitation and Relativity Division

Zeit: Donnerstag 19:45–20:45 Raum: NW-Bau - HS3

Duration 60 min.

GR 15: Quantum Gravity II

Zeit: Freitag 9:00–10:30 Raum: NW-Bau - HS3

GR 15.1 Fr 9:00 NW-Bau - HS3

Renormalizable and unitary quantum theory of gravity — •Christian Steinwachs[1], Andrei Barvinsky[2,3], Diego Blas[4], Mario Herrero-Valea[5], and Sergey Sibiryakov[4,5,6] — [1]Albert-Ludwigs-Universität, Freiburg, Germany — [2]Lebedev Physics Institute, Moscow, Russia — [3]Tomsk State University, Tomsk, Russia — [4]Theoretical Physics Department, CERN, Geneva, Switzerland — [5]École Polytechnique Fédérale, Lausanne, Switzerland — [6]Institute for Nuclear Research of the Russian Academy of Sciences, Moscow, Russia

In the construction of a quantum theory of gravity there seems to be a fundamental conflict between renormalizability, unitarity and Lorentz invariance. All these properties are considered as indispensable features of a quantum field theory. Giving up Lorentz invariance as a fundamental principle allows to construct a renormalizable and unitary quantum theory of gravity. Recently, for the first time, the one-loop beta functions have been calculated for this theory in 2+1 dimensions, suggesting that the theory is asymptotically free. I summarize recent progress and discuss the new challenges one is faced with when extending this theory to the physically relevant case of 3+1 dimensions.

GR 15.2 Fr 9:15 NW-Bau - HS3

Semiclassical approximation to quantum geometrodynamics of Weyl-Einstein gravity and emergence of classical Einstein gravity — Claus Kiefer and •Branislav Nikolic — Institute for Theoretical Physics, Zülpicher Straße 77a, 50937 Cologne, Germany

It is known that a semiclassical approximation to the quantum geometrodynamics based on the Einstein-Hilbert action gives, to the highest order, classical Einstein gravity, while the following order gives the quantum field theory on curved spacetimes in the Schrödinger picture, which is a desirable result. In addition, higher derivative classical theories of gravity are being investigated as alternatives to or extensions of General Relativity. If one wants to study quantum gravity via quantum geometrodynamics, it is natural to investigate whether such alternative theories emerge in the semiclassical approximation to their corresponding quantum gravity theories. We study a particular theory of Weyl-Einstein gravity, in which the Einstein-Hilbert action is extended to include the quadratic Weyl tensor term. It is shown that an appropriate semiclassical approximation, motivated by the method of perturbative constraints, does not lead to the classical Weyl-Einstein gravity, but to the classical Einstein equations. Signatures of the Weyl-tensor term appear in the following order, where a modified functional Schrödinger equation emerges. We discuss the implications of these results.

GR 15.3 Fr 9:30 NW-Bau - HS3

Quantum gravitational correction from the Wheeler-DeWitt equation — Chrsitian Steinwachs and •Matthijs van der Wild — Physikalisches Institut, Universität Freiburg, Germany

In recent years, inflationary scalar field models with a strong non-minimal coupling to gravity have gained much attention.

In particular, the model of non-minimal Higgs inflation, where the inflaton field is identified with the Standard Model Higgs field, allows for a unified description of cosmology and particle physics.

We perform the canonical quantization of a general scalar-tensor theory and derive the first quantum gravitational corrections following from a semi-classical expansion of the Wheeler-DeWitt equation.

We discuss how a strong non-minimal coupling affects these corrections and give a brief estimate of their possible impact on cosmological observations.

GR 15.4 Fr 9:45 NW-Bau - HS3

Quantum properties of $f(R)$ gravity — •Michael Ruf and Christian Steinwachs — Physikalisches Institut, Albert-Ludwigs Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany

We present the one-loop counterterms in $f(R)$ gravity for an arbitrary background manifold. This extends previous results in $f(R)$ gravity, which were limited to spaces of constant curvature. The calculation can be most efficiently performed by a combined use of the background field method and the heat kernel approach. Compared to similar calculations in higher derivative theories of gravity, the main technical difficulty of $f(R)$ theory is related to the special degenerate structure of the principal symbol of the fluctuation operator, which prevents the straightforward application of standard techniques. We discuss a new method which allows to reduce the problem to the evaluation of known functional traces. Our result has important applications in cosmology and black hole physics and allows to study the quantum equivalence between $f(R)$ gravity and its reformulation as a scalar-tensor theory.

GR 15.5 Fr 10:00 NW-Bau - HS3

Black Holes within the Asymptotically Safe Scenario of Quantum Gravity — •Dennis Stock — University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen

We study the effects of quantum gravity on black hole geometries within the set-up of asymptotically safe quantum gravity. Under the assumption that leading order quantum effects are taken into account, by promoting Newton's and the cosmological constant to scale-dependent functions, we arrive at a quantum-improved metric for Schwarzschild-(A)dS and Kerr-(A)dS. Different constructions, to relate the momentum scale within the FRG-formalism to a length scale, are discussed using numerical as well as analytical methods. Depending on parameters such as the mass and angular momentum of the black hole, the quantum-improved black holes can display a different number of horizons to their counterparts in general relativity. Further results addressed include the Penrose diagrams, the investigation of the central curvature singularity via the Kretschmann scalar, and the Hawking temperatures, together with the implications for the endpoint of the black hole evaporation process.

GR 15.6 Fr 10:15 NW-Bau - HS3

Quantum signatures of area-metric deviations from a metric — •Roberto Tanzi — University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen

The most general theory of electrodynamics with linear field equations introduce a new geometry, the area metric, that regulates the propagation of light rays and massive particles instead of the usual Lorentzian metric. In the majority of the experimental situations, the area metric is expected to be a small perturbation around a metric background. In this perturbative case, the concerning quantum theory of electrodynamics can be shown to be renormalizable and can be used to compute various fundamental processes.

I will show that, when one combines the results of these quantum electrodynamics with the dynamics of an area-metric perturbation, the anomalous magnetic moment of the electron, the cross sections of Bhabha scattering, and the hyperfine splitting of the hydrogen pick up a dependence on the position. This way, measurements of the position dependence of these quantities provide a new channel to investigate area-metric deviations from a metric spacetime.

GR 16: Quantum Gravity III

Zeit: Freitag 11:00–13:15 Raum: NW-Bau - HS3

GR 16.1 Fr 11:00 NW-Bau - HS3

Pre-inflation from the multiverse and its effect on the cosmic microwave background — Mariam Bouhmadi-López[1,2], •Manuel Krämer[3], João Morais[1], and Salvador Robles-Pérez[4,5] — [1]Department of Theoretical Physics, University of the Basque Country UPV/EHU, Bilbao, Spain — [2]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain — [3]Instytut Fizyki, Uniwersytet Szczeciński, Szczecin, Poland — [4]Instituto de Física Fundamental, CSIC, Madrid, Spain — [5]Estación Ecológica de Biocosmología, Medellín, Spain

We present two models of constructing a multiverse in the third quantization formalism, which results from a quantum-field-theoretical formulation of the Wheeler–DeWitt equation. In the first model based on eternal inflation, this formalism converts the eternally inflating universe into an ensemble of sub-universes that exhibit a distinctive pre-inflationary phase. Assuming that our observable universe is represented by such a sub-universe, we calculate the effect of the pre-inflationary phase onto the primordial scalar power spectrum and find that there is a suppression of power on the largest scales followed by a bump leading to an enhancement. In order to get a sizable effect for the suppression to explain the observed quadrupole anomaly in the CMB, the bump is enhanced too much to be compatible with the CMB data. In the second model, which involves an explicit quantum interaction between the sub-universes, we obtain a different pre-inflationary phase that better fits the CMB data and might even lead us towards an explanation of the CMB quadrupole discrepancy.

GR 16.2 Fr 11:15 NW-Bau - HS3

Dimensional flow of spacetime in lattice path integrals — •Johannes Thürigen — Humboldt-Universität zu Berlin

In many approaches to quantum gravity the spectral dimension has proven to be a very informative observable to understand the properties of quantum geometries. Calculating this quantity is a particular challenge for a spacetime as given by a Lattice gauge theories such as Spin foam models. Here I will present new results on a flow of the spectral dimension from D = 4 in the IR to a smaller value in the UV for superpositions of lattice geometries. These results can be applied to restricted Spin Foam models and shed new light on their renormalization properties.

GR 16.3 Fr 11:30 NW-Bau - HS3

Constraints on Non-Commutative SpaceTime using CMB Data in Coherent State approach — •Dipanshu Gupta[1,2] and Piero Nicolini[1,2] — [1]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [2]Goethe Universität Frankfurt am Main, Frankfurt am Main, Germany

From the seminal work of Witten and Seiberg, it has been shown that noncommutativity is inherent in String Theory and a good low energy approximation for fields. We try to constrain the length scale of noncommutativity of spacetime using a new power spectrum of CMB Anisotropy derived using the Coherent State approach to noncommutativity instead of Star-Product approach in widespread literature. This formalism has many advantages, one of which is the preservation of Lorentz Invariance. We compute this new power spectrum and compare it with available data from CMB Experiments to put a new bound on the noncommutative parameter.

GR 16.4 Fr 11:45 NW-Bau - HS3

Spectral Dimension in Quantum Gravity and p-branes — •Marco Knipfer — Frankfurt Institute for Advanced Studies, Frankfurt am Main — Institute for Theoretical Physics, Goethe University Frankfurt, Frankfurt am Main

At the Planck scale the Universe is expected to suffer from wild quantum fluctuations. The latter can turn a classical spacetime from a smooth manifold to a sort of fractal. Fractals can have dimensions that differ from the standard topological dimension. A possible definition of the dimension of a fractal is offered by the concept of spectral dimension. Such a dimension is a measure of the dimensionality by inspecting how a particle diffuses on the spacetime manifold. An interesting feature is that most theories of quantum gravity have a scale dependant spectral dimension which approaches two at the Planck scale. We give an overview of the spectral dimension in different theories of quantum gravity and models incorporating quantum gravity effects. We also give a calculation of the spectral dimension when the diffusive processes is described in terms of p-branes by employing the quenched mini-superspace bosonic p-brane propagator.

GR 16.5 Fr 12:00 NW-Bau - HS3

Probability for primordial black holes in a lower dimensional universe — •Athanasios Tzikas — Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany

In recent years, many theoretical evidence illustrate the possibility that our universe may started as an effective lower dimensional spacetime before it became the 4-dimensional universe that we live today. Based on the Hartle-Hawking No-Boundary-Proposal and the mechanism of Spontaneous Dimensional Reduction, we present a possible history of a lower dimensional universe connected to the spontaneous production of primordial black holes.

GR 16.6 Fr 12:15 NW-Bau - HS3

Integrable Classical and Quantum Cosmological Models with Liouville Field — Alexander Andrianov[1,4], Chen Lan[2], Oleg Novikov[1], and •Yi-Fan Wang[3] — [1]Saint-Petersburg State University, Ulyanovskaya str. 1, Petrodvorets, Sankt-Petersburg 198504, Russland — [2]ELI-ALPS Research Institute, Budapesti út 5, H-67228 Szeged, Ungarn — [3]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, D-50937 Köln, Deutschland — [4]Institut de Ciències del Cosmos, Universitat de Barcelona, Martí i Franquès 1, E-08028 Barcelona, Spanien

A method is proposed for the exact integration of homogeneous cosmological models with a Liouville field , which is a scalar field with an exponential potential. The key of the method is to use an integral of motion to eliminate the lapse function as the redundant degree of freedom. Applying this method, equations of implicit curves as classical solutions in minisuperspace are derived in closed-form. From these, a direct correspondence with the Wheeler–DeWitt quantum cosmological theory is obtained.

The completeness and orthogonality of cosmological wave functions in the quantum context are carefully reconsidered, so is the Hermiticity of the phantom model, which leads to the exceptional result of a discrete spectrum.

The physical wave packets are established based on two definitions of norm, one is Schrödinger, the other is introduced from techniques of pseudo-Hermitian quantum mechanics. Numerical results of both cases are given and discussed.

GR 16.7 Fr 12:30 NW-Bau - HS3

Explanation of Cosmic Inflation by Gravitation — •Hans-Otto Carmesin[1,2,3] and Matthias Carmesin[4] — [1]Universität Bremen, Fachb. 1, Pf. 330440, 28334 Bremen — [2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — [3]Gymnasium Athenaeum, Harsefelder Str. 40, 21680 Stade — [4]Universität Göttingen, Fak. f. Physik, 37077 Göttingen

From the Cosmic Microwave Background CMB the flatness problem and the horizon problem arose. An extraordinarily rapid increase of distances in the early universe, the Cosmic Inflation, was proposed as a possible solution by Guth in 1981, whereby suggested mechanisms for such an increase have been criticized (Steinhardt: Scientific American 2011). We propose a theory that explains the Cosmic Inflation by only one fundamental force: Gravitation (Carmesin, H.-O.: Vom Big Bang bis heute mit Gravitation, Model for the Dynamics of Space. Berlin: Verlag Dr. Köster 2017.). Our theory additionally applies quantum physics, contains no fit parameter, applies fundamental constants only, namely the constant of gravitation G, the velocity of light c and the Planck constant h. We discover a sequence of dimensional phase transitions at critical densities. Our results are in excellent quantitative agreement with observations, namely the critical density, the duration of cosmic inflation, the temperature fluctuations and the factor of increase correspond to the CMB and the flatness and horizon problems are solved.

GR 16.8 Fr 12:45 NW-Bau - HS3

Quantum gravity without additional theory - Compatibility of Schwarzschild metric and quantum mechanics — •René Friedrich — Strasbourg

The current notion of spacetime depends on three assumptions which are in contradiction to special relativity and to the Schwarzschild metric, and this is the reason why the quantization of spacetime cannot work. Instead, the key to quantum gravity is the abandon of these three assumptions and the limitation of the notion of spacetime to its actual role, by the means of three insights:

1. Spacetime is not continuous, in particular not in spacelike direction, and thus it cannot be quantized.
2. For the solution of fundamental problems of physics about time, we must consider the notion of proper time instead of the coordinate time of spacetime.
3. Gravitation may be represented by Schwarzschild metric not only as the curved spacetime, but alternatively also as gravitational time dilation in absolute, uncurved space. From these three insights are following the characteristics of quantum gravity. The result: Gravity appears within quantum mechanics in the form of gravitational time dilation.

GR 16.9 Fr 13:00 NW-Bau - HS3

From condensed matter to quantum gravity: Quantum effects between neutron stars — •Johanna Karouby — Munich area, Germany

The 2017 Nobel Prize has been attributed to three pioneers in the discovery of gravitational waves. Historically, on September 14, 2015 the LIGO (Laser Interferometer Gravitational-Wave Observatory) experiment observed the first ever measured gravitational wave signal. The signals observed by LIGO come from pairs of coalescing black holes and more recently also from neutron stars! In this talk, I will present the computation of an exact quantum correction to the gravitational potential between a pair of polarizable objects such as neutron stars. I will show the case of two distant bodies and compute a quantum force from their induced quadrupole moments due to two graviton exchange. The effect is in close analogy to the Casimir-Polder and London-van der Waals forces between a pair of atoms from their induced dipole moments due to two photon exchange. The new effect is computed from the shift in vacuum energy of metric fluctuations due to the polarizability of the objects. I will present the computation for the potential energy at arbitrary distances compared to the wavelengths in the system, including the far and near regimes. In the far distance, or retarded, regime, the potential energy takes on a particularly simple form. Finally, I will provide estimates of this effect when applied to neutron stars.

GR 17: Experimental tests II

Zeit: Freitag 9:00–9:20 Raum: Phys-SR-SE1

GR 17.1 Fr 9:00 Phys-SR-SE1

The Gravitational Field of a Laser Beam of Gaussian Profile — •Fabienne Schneiter[1], Dennis Rätzel[2], and Daniel Braun[1] — [1]Institut für Theoretische Physik, Eberhard-Karls-Universität Tübingen, 72076 Tübingen, Germany — [2]Faculty of Physics, University of Vienna, Boltzmanngasse 5, 1090 Vienna, Austria

We investigate the gravitational properties of light for the case of a laser beam with Gaussian profile. Such Gaussian beams are approximate solutions of the Helmholtz equation valid under the condition of small beam divergence. We start from an expansion of the vector potential in orders of the divergence angle and derive the perturbation of the spacetime metric induced by the beam and the corresponding spacetime curvature to the same order. Calculating the geodesics, we analyze the motion of massive test particles at rest as well as the motion of test rays of light. The results are compared to well-known cases such as the infinitely thin beam of light first investigated in the seminal paper by Tolman et al.

GR 18: Cosmology

Zeit: Freitag 9:20–10:20 Raum: Phys-SR-SE1

GR 18.1 Fr 9:20 Phys-SR-SE1

Turn back time: Gaussianising the late-time matter density field — •Cora Uhlemann — DAMTP, University of Cambridge

Since the matter distribution in the early universe is nearly perfectly Gaussian, one can extract almost all of the statistical information from the two-point correlation function of densities. However, the growth of structures over time causes significant deviations from Gaussianity which arise due to the nonlinear dynamics of gravitational clustering. This complicates the analysis of late-time observables such as the galaxy distribution extracted from large-scale structure surveys. I will explain how one can infer a gaussianising transformation from recent theoretical insights into the statistics of densities in spheres. This Gaussianisation maps the late-time density to an almost Gaussian field which is in better correspondence to the linear density field - hence essentially turns back time.

GR 18.2 Fr 9:40 Phys-SR-SE1

Scale Invariant Inflation — •Anirudh Gundhi — Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany

The inflationary scenario is one of the most natural mechanisms to account for the high precision measurements of the cosmic microwave background radiation. However, in order to fit these observations, it either suffers from assigning arbitrary scalar field potentials (like in chaotic inflation) or a large number of free parameters (like in some string theory motivated multifield models). The challenge remains to come up with a physically motivated model which has just the right number of free parameters to fit the observations completely. We will see that Higgs-Starobinsky inflation is one such candidate. Its Lagrangian is obtained uniquely by demanding scale invariance and avoiding Ostrogradsky instability. With this physical constraint, one ends up with three free parameters and no ambiguity in the scalar field potential. Although Starobinsky inflation fits all the observations to a good precision, this model has the freedom to fit the scalar to tensor ratio better if in future a more accurate measurement is made. The focus of the talk will also be on overcoming some of the non-trivial aspects of having a curved field space metric, while working in the Einstein frame, to compute the inflationary observables.

GR 18.3 Fr 10:00 Phys-SR-SE1

Dirac's Large Numbers in Einstein-Dicke Cosmology — •Alexander Unzicker — Pestalozzi-Gymnasium München

The Large Number Hypothesis reflects a tantalizing observation that, according to Dirac, suggests 'a deep relation between cosmology and atomic physics'. It is shown that Diracs Hypotheses directly follow from a version of general relativity developed by Dicke (1957) that closely matches a precursor theory of general relativity by Einstein (1911) based on variable speed of light. Tragically, Dirac, Dicke and Einstein were unaware of the far-reaching similaritiy of their respective approaches.

GR 19: Numerical relativity

Zeit: Freitag 11:00–11:40 Raum: Phys-SR-SE1

GR 19.1 Fr 11:00 Phys-SR-SE1

Solving Binary Neutron Star Initial Data by Hyperbolic Relaxation — •Hannes Rüter and Bernd Brügmann — Friedrich Schiller University Jena, Germany

A short review will be given on the algorithm and the properties of the hyperbolic relaxation method [arXiv:1708.07358]. We discuss its achievements and challenges in the application to binary neutron star initial data and present results obtained by employing the pseudo-spectral numerical relativity code bamps.

GR 19.2 Fr 11:20 Phys-SR-SE1

Electromagnetic counterparts to binary neutron star mergers, simulations and facts — •Antonios Nathanail — Institut für Theoretische Physik, Goethe Universität Frankfurt, Frankfurt, Germany

We will review some basic facts achieved in the last years, by simulations of binary neutron star systems in numerical relativity. We will focus especially on electromagnetic counterparts to GW radiation, in light of the recent detection of GRB170817 and its follow up observations. We will discuss the possibility of the absence of a jet and present arguments that all observables can be accounted to a quasi isotropic explosion produced by the merger. We will further present results of the head on collision of magnetized neutron stars, which can be viewed as a first step in understanding electromagnetic radiation from the merger of a binary system.