Fachverband Gravitation und Relativitätstheorie (GR) gemeinsam mit der Astronomischen Gesellschaft e.V. (AG)

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Dieses Jahr hat sich unser Fachverband das Schwerpunktsthema *Gravitation und Raumfahrt* gewählt. Neben den wie üblich breit gestreuten Themen der Beiträge, die sich auf Haupt- und Kurzvorträgen sowie Poster verteilen, werden wir einen Plenarvortrag von Dr. Fritz Merkle (OHG AG Bremen) über die technologischen Herausforderungen des europäischen Navigationsystems GALILEO hören sowie einen Festvortrag von Prof. Hansjörg Dittus (DLR) über die Faszination der Raumfahrt, die mittlerweile eine Brücke zwischen Fundamentalphysik und Alltagsanwendungen bildet. Darüberhinaus werden wir an zwei Symposien zu den Themen *Fundamental Physics in Space (SYPS)* bzw. *Cosmic Censorship* teilnehmen. Besondes hingewisen sei auch auf einen Informationsvortrag zum Thema *Funding Programmes der DFG*, in dem sich Dr. Stephan Krückeberg (DFG) am Dienstag vor dem Begrüßungsabend gezielt an junge Forscher in der Frühphase ihrer Karriere wenden wird.

Übersicht der Hauptvorträge und Fachsitzungen

(Hörsäle: SFG 0140 (Fachsitzungen), SFG 0150 (parallele Fachsitzungen, Poster), SFG 2030 (Diskussionsraum))

Hauptvorträge

GR 1.1	Mo	8:30– 9:10	SFG 0140	**The Shadow of Black Holes. An Analytic Description** — •Arne Grenzebach
GR 4.1	Di	8:30– 9:10	SFG 0140	**Observations of binary black hole coalescence events by LIGO** — •Badri Krishnan
GR 8.1	Mi	8:30– 9:10	SFG 0140	**Radio pulsars – unique gravity laboratories in space** — •Norbert Wex
GR 8.2	Mi	9:10– 9:50	SFG 0140	**MICROSCOPE: The first space-based test of the Weak Equivalence Principle in orbit** — •Stefanie Bremer
GR 12.1	Do	8:30– 9:10	SFG 0140	**Relatively complicated? Teaching general relativity at different levels** — •Markus Pössel
GR 13.1	Do	14:00–14:40	SFG 0140	**Quantum matter determines the underlying gravity theory** — •Frederic P. Schuller
GR 15.1	Do	16:30–17:10	SFG 0140	**The Nambu-Goto string as an effective field theory and its semiclassical limit** — •Jochen Zahn

Hauptvorträge des fachübergreifenden Symposiums SYCC

Das vollständige Programm dieses Symposiums ist unter SYCC aufgeführt.

SYCC 1.1	Mo	16:30–17:00	HS 1010	**Determinism, strong cosmic censorship, and the strength of singularities inside black holes** — •Jan Sbierski
SYCC 1.2	Mo	17:00–17:30	HS 1010	**Quasi-stationary collapse scenarios support cosmic censorship** — •Reinhard Meinel
SYCC 1.3	Mo	17:30–18:00	HS 1010	**Approaching the Event Horizon of the Galactic Center Black Hole** — •Frank Eisenhauer
SYCC 1.4	Mo	18:00–18:30	HS 1010	**48 Years of Cosmic Censorship, and Still We Do Not Know What It Is** — •Erik Curiel

Hauptvorträge des fachübergreifenden Symposiums SYPS

Das vollständige Programm dieses Symposiums ist unter SYPS aufgeführt.

SYPS 1.1	Mi	14:00–14:30	SFG 0140	**Magnetospheric Physics – Basic Processes and Open Questions** — •Antonius Otto
SYPS 1.2	Mi	14:30–15:00	SFG 0140	**GRACE/GRACE-FO and LAGEOS/LARES in Geodesy, Earth Observation and Relativity** — •Rolf König
SYPS 1.3	Mi	15:00–15:30	SFG 0140	**LISA and LISA Pathfinder** — •Gerhard Heinzel
SYPS 1.4	Mi	15:30–16:00	SFG 0140	**Promises and challenges of Gaia astrometry** — •Sergei Klioner

Fachsitzungen

GR 1.1–1.5	Mo	8:30–10:30	SFG 0140	**Schwarze Löcher 1**
GR 2.1–2.1	Mo	11:45–12:30	HS 2010	**Plenarvortrag Silke Britzen**
GR 3.1–3.6	Mo	14:00–16:00	SFG 0140	**Schwarze Löcher 2**
GR 4.1–4.5	Di	8:30–10:30	SFG 0140	**Klassische Allgemeine Relativitätstheorie 1**
GR 5.1–5.1	Di	11:45–12:30	HS 2010	**Plenarvortrag Fritz Merkle**
GR 6.1–6.6	Di	14:00–16:00	SFG 0140	**Relativistische Astrophysik**
GR 7.1–7.6	Di	16:30–18:00	SFG 0140	**Klassische Allgemeine Relativitätstheorie 2**
GR 8.1–8.4	Mi	8:30–10:30	SFG 0140	**Experimentelle Tests 1**
GR 9.1–9.3	Mi	16:30–17:30	SFG 0140	**Experimentelle Tests 2**
GR 10.1–10.5	Mi	16:30–18:10	SFG 0150	**Alternative Ansätze**
GR 11.1–11.3	Mi	17:30–18:30	SFG 0140	**Gravitationswellen**
GR 12.1–12.5	Do	8:30–10:30	SFG 0140	**Didaktische Aspekte der Relativitätstheorie**
GR 13.1–13.6	Do	14:00–15:55	SFG 0140	**Grundlegende Probleme und allgemeiner Formalismus**
GR 14.1–14.10	Do	14:00–16:00	SFG 0150	**Postersitzung**
GR 15.1–15.5	Do	16:30–18:30	SFG 0140	**Quantenaspekte der Gravitation und vereinheitlichender Theorien 1**
GR 16.1–16.6	Fr	8:30–10:30	SFG 0140	**Quantenaspekte der Gravitation und vereinheiltichender Theorien 2**
GR 17.1–17.4	Fr	11:00–12:00	SFG 0140	**Kosmologie**
GR 18.1–18.2	Fr	12:00–12:30	SFG 0140	**Numerische Relativitätstheorie**

Mitgliederversammlung Fachverband Gravitation und Relativitätstheorie

Donnerstag 12:45–13:45 Raum SFG 0140 (Imbiss wird gestellt)

- Bericht des Fachverbandsleiters
- Verschiedenes

GR 1: Schwarze Löcher 1

Zeit: Montag 8:30–10:30 Raum: SFG 0140

Hauptvortrag GR 1.1 Mo 8:30 SFG 0140

The Shadow of Black Holes. An Analytic Description — •Arne Grenzebach — ZARM, Universität Bremen

Black holes are perhaps the most intriguing objects in Astrophysics. Due to the strong gravity and the resulting deflection of light, the black hole will cast a shadow. I will introduce an analytic geometrical way to construct the black hole's shadow whose shape varies in different space-times. The resulting formulas describe the boundary of the shadow for the general Plebański-Demiański class of stationary, axially symmetric type D solutions of the Einstein-Maxwell equations seen by an observer at arbitrary position. Furthermore, the shadow-plots can be compared with those of a moving observer. An observed image of the shadow would be a strong evidence for the existence of black holes. Thus, the upcoming high-resolution observations of the Galactic center, will reveal whether the center of our Milky Way hosts a black hole.

GR 1.2 Mo 9:10 SFG 0140

Shadow of a distorted black hole with a quadrupole moment — •Efthimia Deligianni — ZARM - University of Bremen, Germany

The No-Hair-Theorem has shown that astrophysical black holes are to be described by two parameters, namely their mass and spin. For these black holes the shadow has been well described.

However, if there is an external matter structure around the black hole, e.g. an external galaxy, then the structure induces a quadrupole moment. It is interesting to investigate in how far the shadow of such a deformed black hole varies from the Schwarzschild- or Kerr-case.

In this talk I will present our results for the shadow of a black hole with a quadrupole moment.

GR 1.3 Mo 9:30 SFG 0140

Shadow of a Kerr black hole in a plasma — •Volker Perlick[1] and Oleg Yu. Tsupko[2] — [1]ZARM, Universität Bremen, 28359 Bremen — [2]Space Research Institute of the Russian Academy of Sciences, Profsoyuznaya 84/32, Moscow 117997, Russia

We consider light propagation in a plasma around a Kerr black hole. The plasma is assumed to be pressureless ("cold") and non-magnetised. We find the necessary and sufficient condition on the plasma electron density that guarantees separability of the Hamilton-Jacobi equation for the light rays (i.e., that guarantees existence of a Carter constant). For all cases where this separability condition is satisfied, we give an analytical formula for the boundary curve of the shadow of the Kerr black hole. The general results will be illustrated with several examples of specific plasma electron densities. The perspectives of actually observing the influence of the plasma on the shadow will be discussed.

GR 1.4 Mo 9:50 SFG 0140

The Meissner Effect of generic black holes — •Norman Gürlebeck[1,2] and Martin Scholtz[3] — [1]ZARM, University of Bremen, Am Fallturm, 28359 Bremen — [2]DLR Institute of Space Systems, 28359 Bremen, Germany — [3]Institute of Theoretical Physics, Charles University, V Holesovickach 2, 180 00 Praha 8, Czech Republic

Black holes are important astrophysical objects describing an end state of stellar evolutionm, which are observed frequently. There are theoretical predictions that Kerr black holes with high spins expel magnetic fields. However, Kerr black holes are pure vacuum solutions, which do not include accretion disks, and additionally previous investigations are mainly limited to weak magnetic fields. We show here in full general relativity that generic rapidly spinning black holes including those deformed by accretion disks or other matter still expel even strong magnetic fields. Analogously to a similar property of superconductors, this property is called Meissner effect.

GR 1.5 Mo 10:10 SFG 0140

Rotating non-singular black holes — •Roman Smit and Piero Nicolini — Frankfurt Institute for Advanced Studies (FIAS), Frankfurt am Main, Germany

A variety of non-singular spherically symmetric black hole solutions have been found in the past. Their energy momentum tensor is usually an anisotropic perfect fluid with a dark-energy-like equation of state ($p=-\rho$) for the radial pressure.

Historically, the Kerr-Newman solution was found by applying a complexification algorithm – the Newman-Janis algorithm – to the Reissner-Nordstroem solution.

I will show how to modify and apply this algorithm to the known spherical non-singular black holes to obtain rotating non-singular black holes.

GR 2: Plenarvortrag Silke Britzen

Zeit: Montag 11:45–12:30 Raum: HS 2010

Plenarvortrag GR 2.1 Mo 11:45 HS 2010

What matter(s) at the Event Horizon? Radio Interferometry at highest resolution — •S. Britzen[1], A. Zensus[1], C. Fendt[2], A. Eckart[3,1], and V. Karas[4] — [1]MPI Radioastronomie, Bonn — [2]MPI Astronomie, Heidelberg — [3]I. Physikalisches Institut, Universität zu Köln — [4]Astronomical Institute of the Academy of Sciences, Prague

M87 is the central elliptical galaxy in the Virgo cluster and at a distance of 16.7 Mpc the second closest active black hole to our galaxy. The bright jet and counter-jet have been studied intensively in all wavelength regimes (radio to TeV). Most detailed information for this show-case jet has been obtained in the radio regime with increasing observing frequencies and resolution in recent years. This source is a prime object to be studied in exquisite detail with the high-angular resolution radio imaging provided by the Event Horizon Telescope project (EHT) observations since it promises to allow a direct view on the jet launching process itself.

I will present our most recent results based on an analysis of 16 years of radio interferometric monitoring data which reveal for the first time details concerning the physical processes of the jet loading of M87. I will discuss the implications for the jet launching mechanism. In addition, I will present the current status of the EHT-observations to image the photon sphere around the event horizon of M87 (and Sgr A*) and possible tests of General Relativity (GR).

GR 3: Schwarze Löcher 2

Zeit: Montag 14:00–16:00 Raum: SFG 0140

GR 3.1 Mo 14:00 SFG 0140

Charged, Rotating Black Objects in Einstein-Maxwell-Dilaton Theory in $D \geq 5$ — Burkhard Kleihaus[1], •Jutta Kunz[1], and Eugen Radu[2] — [1]University of Oldenburg, Germany — [2]University of Aveiro, Portugal

We study black objects with non-spherical horizon topology in $D \geq 5$ dimensions, which possess $k+1$ angular momenta of equal magnitude, where $0 \leq k \leq \lfloor \frac{D-5}{2} \rfloor$. These black objects describe black rings ($k=0$) and black ringoids ($k>0$). We endow the vacuum solutions with charge by employing the Kaluza-Klein construction with an appropriate value of the dilaton coupling constant.

GR 3.2 Mo 14:20 SFG 0140

Geodesics in the 5D Myers-Perry-AdS spactime and applications to AdS/CFT — •Saskia Grunau and Hendrik Neumann — Carl von Ossietzky Universität Oldenburg

The five-dimensional Myers-Perry-Anti-de-Sitter spacetime describes a black hole which is characterized by its mass, two independent rotation parameters and the negative cosmological constant. In the context of AdS/CFT it can be associated with a four dimensional conformal field theory on the boundary. Here we study the 5D Myers-Perry-AdS spactime using geodesics. Therefore we derive the equations of motion and solve them in terms of the Weierstraß functions. We analyze the geodesic motion in detail and give a list of all possible orbits. Furthermore we discuss the appliction of geodesics in the AdS/CFT correspondence. In particular, geodesics can be related to two-point correlators.

GR 3.3 Mo 14:40 SFG 0140

Analytic solutions of the geodesic equation for $U(1)^2$ dyonic rotating black holes — •Kai Flathmann and Saskia Grunau — Institut für Physik, Universität Oldenburg, D- 26111 Oldenburg, Germany

In this talk we present the equations of motion of test particles and light of the six parameter $U(1)^2$ dyonic rotating black hole family and its solutions. One special feature of this spacetime is the 2-dimensional curvature singularity, which shape varies from ring singularities to toroidal like structures. The equations of motion can be derived from the Hamilton-Jacobi equation and are solved in terms of derivatives of the hyperelliptic Kleinian σ function. We use parametric diagrams and effective potentials to characerize the radial and latitudinal motion and present a list of possible orbit types.

GR 3.4 Mo 15:00 SFG 0140

Hairy black holes in the general Skyrme model — •Olga Kichakova[1], Yakov Shnir[2], Christoph Adam[3], and Andrzej Wereszczynski6[4] — [1]University of Oldenburg, Germany — [2]BLTP, JINR, Dubna, Russia — [3]Santiago de Compostela University, Spain — [4]Jagiellonian University, Poland

We study the existence of hairy black holes in the generalized Einstein-Skyrme model. It is proven that in the BPS model limit there are no hairy black hole solutions, although the model admits gravitating (and flat space) solitons. Furthermore, we find strong evidence that a necessary condition for the existence of black holes with Skyrmionic hair is the inclusion of the Skyrme term L_4. As an example, we show that there are no hairy black holes in the $L_2 + L_6 + L_0$ model and present a new kind of black hole solutions with compact Skyrmion hair in the $L_4 + L_6 + L_0$ model.

GR 3.5 Mo 15:20 SFG 0140

Magnetized AdS black holes and solitons in Einstein-Maxwell-Chern-Simons theory — •Jose Luis Blazquez-Salcedo — Oldenburg University, Oldenburg, Germany

In this talk we present a new class of AdS black holes and solitons in D=5 Einstein-Maxwell-Chern-Simons theory. These objects are cohomogeneity-1 solutions, which asymptotically approach an AdS_5 space-time. The black holes are characterized by their mass, equal magnitude angular momenta, electric charge, and the magnitude of the magnetic potential at the AdS boundary. The solitons appear as deformations of the magnetized AdS background. We investigate the connection between the black holes and the solitons and we study how their thermodynamic properties change under this transition.

GR 3.6 Mo 15:40 SFG 0140

First steps in calculating supermassive objects (black holes) using TOV equation — •Jürgen Brandes — Karlsruhe, Germany

Lorentz interpretation (LI of GRT) predicts supermassive objects without event horizon and therefore they are different from black holes of classical GRT [1]. Possibly, these differences become observable by the Event Horizon Telescope and BlackHoleCamp projects. To assist this process, supermassive objects are calculated using the TOV equation which has no singularities if LI of GRT is applicated. The talk discusses the first steps and can be followed on www.grt-li.de.

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

GR 4: Klassische Allgemeine Relativitätstheorie 1

Zeit: Dienstag 8:30–10:30 Raum: SFG 0140

Hauptvortrag GR 4.1 Di 8:30 SFG 0140

Observations of binary black hole coalescence events by LIGO — •Badri Krishnan — Max-Planck-Institute for Gravitational Physics, Callinstr. 38, 30167 Hannover

The advanced LIGO detectors have observed two binary black hole coalescence events with high significance: GW150914 on September 14, 2016 and GW 151226 on December 16, 2016. These detections enable us, for the first time, to probe the properties of black holes in full non-linear general relativity. In this talk I will summarize these events and other results from the first observational run of the Advanced LIGO detectors. In particular, I will discuss the significance of the events, some properties of the binary black holes observed, implications for fundamental Physics and future prospects.

GR 4.2 Di 9:10 SFG 0140

Recent analytic results for spin effects of black hole binaries — •Jan Steinhoff — Albert Einstein Institute Potsdam

Black holes binaries are the most prominent source for current gravitational wave observatories. Spin effect are expected to be important in particular for long waveforms, as demonstrated by the event GW151226. This talk discusses recent analytic results for spin effects of black hole binaries. The leading order spin effects in the post-Newtonian approximation can be summed to all orders in spin, leading to a connection between spin effects in comparable mass binaries and test body motion in Kerr spacetime. Furthermore, spin effects were computed to fourth order in the post-Newtonian approximation. We give an outlook how these recent results can improve models for spin effects in the strong-field regime. For these investigations it turns out to be useful to understand the choice of a center of the black holes as a gauge symmetry in a point-particle action.

GR 4.3 Di 9:30 SFG 0140

The gravitational compass: Mapping of the gravitational field in General Relativity — •Dirk Puetzfeld — ZARM, Uni Bremen

In General Relativity, the comparison of clocks, as well as the measurement of the mutual accelerations between the constituents of a swarm of test bodies, is of direct operational significance. We show how a suitably prepared set of clocks and test bodies can be used to extract all components of the gravitational field. In particular, we comment on the role of the underlying reference frame in the determination of suitable clock and test body setups.

GR 4.4 Di 9:50 SFG 0140

The relativistic geoid — •Dennis Philipp, Dirk Puetzfeld, Eva Hackmann, Volker Perlick, and Claus Lämmerzahl — ZARM, University of Bremen, Germany

We construct a relativistic geoid based on a time-independent redshift potential, which foliates the spacetime into isochronometric surfaces. This relativistic potential coincides with the acceleration potential for isometric congruences. Known Newtonian and post-Newtonian results are recovered in the respective limits. Being fully relativistic, this notion of a geoid can also be applied to neutron stars.

By definition, this relativistic geoid can be determined by a congruence of Killing observers equipped with standard clocks by comparing their frequencies. The redshift potential gives the correct result also for frequency comparison through optical fiber links as long as the fiber is at rest w.r.t. the congruence.

We give explicit expressions for the relativistic geoid in the Kerr spacetime and the Weyl class of spacetimes. To investigate the influence of higher order mass multipole moments we compare the results for the Schwarzschild case to those obtained for the Erez-Rosen and q-metric spacetimes.

GR 4.5 Di 10:10 SFG 0140

Friedmann-like initial data for an inhomogeneous universe with black holes — •Michael Fennen[1] and Domenico Giulini[1,2] — [1]ZARM, Universität Bremen — [2]ITP, Universität Hannover

The very successful standard model of cosmology is based upon the cosmological principle stating that the Universe is homogeneous and isotropic. This is only true on the largest scales so that we are aiming for a model that takes the inhomogeneous structure on smaller scales into account. For this reason we consider the initial data of a closed vacuum space-time filled with black holes at the moment of maximal expansion. Since we do not expect that every configuration of black holes leads to a Friedmann-like time evolution, we present a new simple criterion for these black hole configurations such that the initial data is similar to a spherical Friedmann dust universe in some sense.

GR 5: Plenarvortrag Fritz Merkle

Zeit: Dienstag 11:45–12:30 Raum: HS 2010

Plenarvortrag GR 5.1 Di 11:45 HS 2010

Satellites for the European GALILEO Navigation System — •Fritz Merkle — OHB SE, Bremen, Germany

The GALILEO Navigation Satellite System is Europe's equivalent to and interoperable with the US GPS navigation system. In its final configuration the system will consist of 24 plus 6 spare operational satellites in Medium Earth Orbit at an altitude of 23222km. Key elements of the satellite payloads are the ultra-high precision clocks. Each satellite is equipped with two Rubidium Atomic Frequency Standards and two Passive Hydrogen Masers with short term stabilities in the range of 5E-14 to 5E-15, respectively. Flying two technologies provides a high degree of reliability and redundancy. By today 18 Galileo Satellites are deployed in space and early operation of GALILEO has been announced recently. The challenge of designing and manufacturing the satellites has to take into account that the satellites have to be delivered in a cadence of one satellite every six weeks. Additionally, there is the challenge of providing for these precision timing instruments the appropriate physical environment inside the satellite platform, taking into account a minimum lifetime of 12 years and this under considerations of economy. Another set of 2 times 4 satellites will be launched in 2018 and 2019. 8 to 12 more satellites are currently in the procurement phase by the European Commission. In its final implementation GALILEO system with Full Operation will provide several satellite-only services, including the Open Service, the Safety-of-Life Service with very high integrity, the Commercial Service with improved accuracy, and the Public Regulated Service with controlled and encrypted access. In addition GALILEO will support the search and rescue service as a European contribution to the international COSPAS-SARSAT co-operative. This presentation will introduce GALILEO and the physical and entrepreneurial challenges of navigation satellites.

GR 6: Relativistische Astrophysik

Zeit: Dienstag 14:00–16:00 Raum: SFG 0140

GR 6.1 Di 14:00 SFG 0140

The gravitomagnetic clock effect — •Eva Hackmann and Claus Lämmerzahl — ZARM, Universität Bremen

In General Relativity the rotation of a gravitating object causes purely relativistic effects on the motion of orbiting test particles, which are often referred to as frame dragging or gravitomagnetic effects. Here we will discuss a frame dragging effect on clocks first introduced by Cohen and Mashoon (Phys. Lett. A 181, 353 (1993)) as the difference in proper time as measured by two clocks, one on a prograde and one on a retrograde equatorial circular orbit, after a revolution of 2π. A generalisation of this effect to arbitrary geodesic motion of the two clocks allows to consider much more general settings. In particular, we will discuss this effect for two pulsars orbiting Sagittarius A*, the supermassive black hole in the center of our galaxy.

GR 6.2 Di 14:20 SFG 0140

Analytic model for relativistic dust accretion onto a Kerr-Newman black hole — •Kris Schroven, Eva Hackmann, and Claus Lämmerzahl — Zarm, Universität Bremen, Bremen, Germany

We will discuss analytically a stationary axis symmetric accretion fl ow of dust-like particles on a Kerr-Newman black hole. Even though the particles are treated to be non interacting, we will expect them to form, if charged, a plasma. Streamlines are expressed by the equations of motion of charged test particles in Kerr-Newman space time. The corresponding density field, created by charged and uncharged particles, is calculated numerically. This model provides a good way to present the in influence of the specific angular momentum and the specific charge of the black hole and test particles on the course of the accretion flow and density field. Furthermore the influence on the location of the outer and inner edge of the formed accretion disc can be discussed within this model.

GR 6.3 Di 14:40 SFG 0140

Gravitational waves and rotational properties of hypermassive neutron stars from binary mergers — •Matthias Hanauske[1,2], Luciano Rezzolla[1,2], and Horst Stöcker[1,2,3] — [1]Institut für Theoretische Physik, Max-von-Laue-Straße 1, Frankfurt, Germany — [2]Frankfurt Institute for Advanced Studies, Ruth-Moufang-Straße 1, Frankfurt, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

One hundred years after Albert Einstein developed the field equations of general relativity and predicted the existence of gravitational waves (GWs), these curious spacetime-ripples have been observed from a pair of merging black holes by the LIGO detectors. As GWs emitted from merging neutron star binaries are on the verge of their first detection, it is important to understand the main characteristics of the underlying merging system in order to predict the expected GW signal. Based on a large number of numerical-relativity simulations of merging neutron star binaries, the emitted GW and the interior structure of the generated hypermassive neutron stars (HMNS) have been analyzed in detail. This talk will focus on the internal and rotational HMNS properties and their connection with the emitted GW signal. Especially, the appearance of the hadron-quark phase transition in the interior region of the HMNS and its conjunction with the spectral properties of the emitted GW will be addressed. arXiv:1611.07152

GR 6.4 Di 15:00 SFG 0140

Simulating generic binary neutron star mergers — •Tim Dietrich[1], Sebastiano Bernuzzi[2], Bernd Bruegmann[3], Maximiliano Ujeviv[4], and Wolfgang Tichy[5] — [1]Max Planck Institute for Gravitational Physics, Albert Einstein Institute, D-14476 Golm, Germany — [2]DiFeST, University of Parma, and INFN Parma I-43124 Parma, Italy — [3]Theoretical Physics Institute, University of Jena, 07743 Jena, Germany — [4]Centro de Ciencias Naturais e Humanas, Universidade Federal do ABC, 09210-170, Santo Andre, Sao Paulo, Brazil — [5]Department of Physics, Florida Atlantic University, Boca Raton, FL 33431 US

Binary neutron star mergers are associated with a variety of observable phenomena in the gravitational and electromagnetic spectra. We investigate binary neutron stars in the last milliseconds before and after their merger with full 3D numerical simulations. We explain how we access previously unaccessible regions of the binary neutron star parameter space, e.g. spinning and high mass ratio setups, and we discuss first simulations with generic setups. We also show that recent upgrades allow us to improve the accuracy of the simulation and decrease the phase error of the obtained gravitational waveforms. With this updates our waveforms can be used for validating and improving semi-analytical waveform models.

GR 6.5 Di 15:20 SFG 0140

Carter constant and Killing tensors for fluids — •Vojtěch Witzany — ZARM, Universität Bremen, Germany

One of the surprises of the "golden age of general relativity" was the fact that the space-time of an isolated spinning black hole, the Kerr space-time, has an unexpected non-explicit symmetry which manifests itself in the existence of a Killing(-Yano) tensor and the integrability of a number of equations for test fields. In this talk we report on the generalization of the concept of a Killing tensor and the corresponding integral of motion, the Carter constant, to perfect-fluid flows in the Kerr space-time.

One notable result is the fact that every Killing tensor in a metric conformally related to the Kerr metric can be understood as a fluid-Killing tensor in a barotropic flow. We construct explicitly a class of such fluid-Killing tensors and demonstrate their applicability in the case of a family of stiff-fluid solutions.

GR 6.6 Di 15:40 SFG 0140

White Dwarfs in Scalar-Tensor-Theory — •Kevin Eickhoff, Burkhard Kleihaus, and Jutta Kunz — Institut für Physik, Universität Oldenburg, D- 26111 Oldenburg, Germany,

Scalar-Tensor Theory (STT) can give rise to new branches of compact objects, which exhibit spontaneous scalarization, as first observed for neutron stars. In scalarized objects the mass-radius relation can strongly deviate from the one found in General Relativity. Here we investigate whether scalarization can also occur in white dwarfs. We employ a STT with function $A(\varphi) = e^{\frac{\beta}{2}\varphi^2}$, and vary the coupling constant β for the scalar field φ. We discuss the dependence of the mass-radius relation and the presence of scalarization on the strength of the coupling β.

GR 7: Klassische Allgemeine Relativitätstheorie 2

Zeit: Dienstag 16:30–18:00 Raum: SFG 0140

GR 7.1 Di 16:30 SFG 0140

Rotating Excited Boson Stars — •Lucas Gardai Collodel, Burkhard Kleihaus, and Jutta Kunz — University of Oldenburg

We investigate axially symmetric, rotating boson stars which are radially excited. These objects exist only for a limited range of the field's frequency. Given different coupling strengths with gravity we determine its domain of existence, as well as the frequency dependence behaviour of the star's parameters, which is then compared with the non-excited case. The circular orbit's tangential velocity of test particles around such objects is also analysed in order to determine if their existence offers a good alternative for dark matter at the galactic scale.

GR 7.2 Di 16:45 SFG 0140

Spinning Wormholes in Scalar-Tensor Theories — •Burkhard Kleihaus, Xiao Yan Chew, and Jutta Kunz — Carl von Ossietzky Universität Oldenburg

Wormholes are solutions of the Einstein equations discribing spacetimes with two asymptotically flat regions connected by a throat. A textbook example is the Ellis wormhole supported by a scalar phantom field. Although this solution is known since a long time in the static case, the stationary rotating generalizations have been found only recently.

Here we present stationary rotating wormholes in Scalar-Tensor theories. We show that certain Scalar-Tensor theories allow for spontaneously scalarized wormholes. We discuss their domain of existence and their physical properties. Especially we compare the solutions in the Einstein frame and in the Jordan frame. Whereas global charges like mass and angular momentum are similar in both frames, the geometric properties can be very different. E.g. wormholes which possess a single throat in the Einstein frame can possess a double throat in the Jordan frame.

GR 7.3 Di 17:00 SFG 0140

Properties of Rotating Ellis Wormholes — •Xiao Yan Chew, Burkhard Kleihaus, and Jutta Kunz — Institut of Physics, University of Oldenburg, D-26111, OLdenburg, Germany

Wormholes are regular solutions of the Einstein equation. They describe spacetimes with two asymptotically flat regions connected by a throat. A classical example is the static Ellis wormhole which is supported by a phantom scalar field. The stationary rotating generalization of the Ellis wormhole with symmetrical properties has been found and discussed recently.

Here we consider the non-symmetric rotating Ellis wormholes. We present their mass formulae, and discuss the geometry of the throat and ergoregion. We show that the limiting configurations of these wormholes are the extremal Kerr black holes. Furthermore, the geodesics of these wormholes are analyzed and we demonstrate that they possess bound orbits.

GR 7.4 Di 17:15 SFG 0140

Five-dimensional wormholes at the core of rotating boson stars — •Sarah Kahlen, Burkhard Kleihaus, and Jutta Kunz — Carl von Ossietzky Universität, Oldenburg

We consider rotating wormhole spacetimes in five dimensions whose throat is immersed in bosonic matter. They represent boson star like configurations with non-trival topology supported by a phantom field. We discuss their physical properties and point out an unexpected richness of configurations. We also present their geometrical features like the existence of single throat and double throat wormholes. We show, that rotation can stabilize these systems.

GR 7.5 Di 17:30 SFG 0140

Parametrized post-Newtonian limit of ghost-free bimetric massive gravity — •Manuel Hohmann — Physikalisches Institut, Universität Tartu, Estland

We consider the unique action of ghost-free massive gravity with two metric tensors and a coupling potential. In our setting we allow for two different types of matter, both modelled as perfect fluids, coupled to their corresponding metrics. Since there is no direct, non-gravitational interaction between these two matter sectors, they mutually appear dark, and can hence be interpreted as dark and visible matter.

Here we focus on the gravitational interaction both within each sector and between the sectors in the parametrized post-Newtonian (PPN) limit. We derive the PPN parameters of the theory and discuss their consistency with observations in the solar system.

GR 7.6 Di 17:45 SFG 0140

Weyl-invariant extension of the Metric-Affine Gravity — •Zahra Altaha Motahar — Oldenburg University, Oldenburg, Germany

Metric-affine geometry provides a non-trivial extension of the general relativity where the metric and connection are treated as the two independent fundamental quantities in constructing the space-time (with non-vanishing torsion and non-metricity). We study the generic form of action in this formalism, and then construct the Weyl-invariant version of this theory. It is shown that in Weitzenbock space, the obtained

Weyl-invariant action can cover the conformally invariant teleparallel action. Finally the related field equations are obtained in the general case.

GR 8: Experimentelle Tests 1

Zeit: Mittwoch 8:30–10:30 Raum: SFG 0140

Hauptvortrag GR 8.1 Mi 8:30 SFG 0140
Radio pulsars – unique gravity laboratories in space — •Norbert Wex — Max-Planck-Institut für Radioastronomie, Bonn, Germany

The discovery of the Hulse-Taylor binary pulsar in 1974 has opened up a completely new field of experimental gravity. In two aspects, pulsars have taken precision gravity tests qualitatively beyond the weak-field slow-motion regime of the Solar system: They provided the first experimental evidence for the existence of gravitational waves, and they allowed for the first time to test the gravitational interaction of strongly self-gravitating bodies. To date, we know several radio pulsars that can be utilized for precise measurements of different gravitational phenomena in a strong-field context. In particular, the so-called 'Double Pulsar' has more than lived up to our early expectations. In many aspects, pulsar experiments are also complementary to present and upcoming gravity experiments with terrestrial gravitational-wave observatories.

The talk gives an introduction to gravity tests with radio pulsars, highlights some of the most important results, and gives a brief outlook into the future of this exciting field of experimental gravity.

Hauptvortrag GR 8.2 Mi 9:10 SFG 0140
MICROSCOPE: The first space-based test of the Weak Equivalence Principle in orbit — •Stefanie Bremer[1], Meike List[1], Benny Rievers[1], Hanns Selig[1], and Manuel Rodrigues[2] — [1]ZARM, University of Bremen, Bremen, Germany — [2]ONERA, The French Aerospace Lab, Palaiseau, France

After more than 15 years of planning, developing, building, and testing, MICROSCOPE has finally been launched in April 2016. After the commissioning phase, scientific measurements started in December and are planned to be continued at least for 18 month. The goal of this satellite 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}.

Developed, built and now operated by the French space agency CNES, MICROSCOPE is the first satellite in a low Earth orbit using a drag-free attitude control system. This technology forms the foundation for the scientific payload T-SAGE, developed and built by ONERA. The payload comprises two differential accelerometers, each containing two test masses. Due to the drag-free system non-gravitational disturbances are cancelled out thus allowing the test masses to follow a pure gravitational orbit. The accurate analysis of the test mass motion will finally result in a quantity of η.

First scientific results are expected in June 2017. This talk will summarize MICROSCOPE's road to space and highlight some features of the challenging data analysis procedure.

GR 8.3 Mi 9:50 SFG 0140
Testing the gravitational redshift with Galileo satellites 5 and 6 — •Sven Herrmann, Felix Finke, Daniela Knickmann, Claus Lämmerzahl, Meike List, and Benny Rievers — ZARM, Center of Applied Space Technology and Microgravity, University Bremen

The satellites Galileo 5 and 6 of the European GNSS launched in August 2014 have not reached their targeted circular orbit at around 22.000 km height. Instead, their orbits possess an eccentricity of about 0.16 and the satellites undergo a change in height of about 8000 km 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) and ESA (GREAT), we have started an activity to analyze the clock and orbit data from these two Galileo satellites, to investigate whether an improved test over the result from Vessot and Levines GPA experiment can be obtained. Here we report on the current status of our data analysis and give an outlook on the achievable accuracy of this test.

GR 8.4 Mi 10:10 SFG 0140
Atom-chip gravimetry with Bose-Einstein condensates — •Martina Gebbe[1], Sven Abend[2], Matthias Gersemann[2], Hauke Müntinga[1], Holger Ahlers[2], Wolfgang Ertmer[2], Ernst M. Rasel[2], Claus Lämmerzahl[1], and The QUANTUS Team[1,2,3,4,5,6] — [1]ZARM, Uni Bremen — [2]Institut für Quantenoptik, LU Hannover — [3]Institut für Physik, HU Berlin — [4]Institut für Quantenoptik, Uni Ulm — [5]Institut für angewandte Physik, TU Darmstadt — [6]Institut für Physik, JGU Mainz

Due to their small spatial and momentum width ultracold Bose-Einstein condensates (BEC) or even delta-kick collimated (DKC) atomic ensembles are very well suited for high precision atom interferometry. We generate such an ensemble in a miniaturized atom-chip setup where BEC generation and delta-kick collimation can be performed in a fast and reliable way. Using the chip as retroreflector we have realized a compact gravimeter and determined local gravitational acceleration g with an accuracy of $10^{-5}\,g$ limited by seismic noise. We demonstrate that the device's sensitivity can be enhanced with the help of an optical lattice to relaunch the atoms. Our atom-chip gravimeter opens up the way for compact and robust portable sensors that are interesting for various applications. This work is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) due to an enactment of the German Bundestag under grant numbers DLR 50WM1552-1557 (QUANTUS-IV-Fallturm).

GR 9: Experimentelle Tests 2

Zeit: Mittwoch 16:30–17:30 Raum: SFG 0140

GR 9.1 Mi 16:30 SFG 0140
Updates on the Drift Mode Experiment on LISA Pathfinder — •Sarah Paczkowski on behalf of the LPF collaboration — Albert-Einstein-Institut, Max-Planck-Institut für Gravitationsphysik und Universität Hannover, 30167 Hannover, Germany

The LISA Pathfinder (LPF) satellite mission is a technology demonstrator for a gravitational wave observatory in space, called LISA. LPF was launched on December 3rd 2015 and is expected to operate until May 31st 2017.

The aim of LPF is to show that the required level of free-fall needed for gravitational wave observation with LISA, is achievable. The acceleration of a drag-free test mass (TM) is measured with respect to a reference TM which is on the same axis, and therefore has to be constantly actuated. This is slightly different from the LISA case, so the drift mode, or free-flight, experiment allows us to mimic the LISA scenario on LPF by replacing the constant actuation with periodic force impulses and times without actuation. The drift mode experiment is also an important cross-check for our standard measurements with constant actuation. However, this comes at the cost of introducing quasi-parabolic motion of the reference mass and periodic data gaps into the data analysis.

Here, we report on the analysis and the results of the drift mode experiment on LPF.

GR 9.2 Mi 16:50 SFG 0140
A laser actuated cantilever to search for deviations from gravity in the nanometre length scale — •Helena Schmidt, Lars Andresen, Helmut Wolff, and Ludger Koenders — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Although gravity has been well tested on several length scales, some unified theories predict deviations for the region below 1 mm. Some of the newer theories are the *Domestic Axion* hypothesis by Dvali and Funcke and a ghost-free quantum gravity by Edholm et al. (2016).

We present a method to search for such deviations in the nanometre length scale. Below 1 μm, the electrostatic and the Casimir force are by some magnitudes stronger than the gravitational force. To distinguish these forces, we designed a new cantilever made of fused silica. Utilizing the cantilever with the frequency modulation AFM technique it is feasible to measure these forces with sufficient accuracy to set new constraints for possible deviations of gravity. We are going to present first experimental results.

GR 9.3 Mi 17:10 SFG 0140

BOOST: A Test of Special Relativity — •Lisa Wörner[1], Thilo Schuldt[2], Norman Gürlebeck[1], Arne Grenzebach[1], Markus Krutzik[3], Thijs Wendrich[4], Nadan Jha[4], Domenico Geradi[5], Ulrich Johann[5], Claus Braxmaier[1,2], and the BOOST collaboration[1,2,3,4,5] — [1]ZARM, University of Bremen — [2]DLR — [3]Humboldt University Berlin — [4]Leibniz University Hanover — [5]Airbus Defense and Space

BOOST is a mission that aims at testing the foundations of Special Relativity. The centre piece of BOOST is a Kennedy-Thorndike experiment [1] mounted on a satellite. It is dedicated to detect a potential boost dependence of the speed of light by comparing a length reference (i.e. a highly stable optical resonator) with a molecular frequency reference. Likewise experiments have been performed on Earth. The current best Earth-bound test has been performed by Tobar et al. [2] in 2010, being able to determine the Kennedy-Thorndike coefficient with an accuracy of $4\ 10^{-8}$. By operating a state-of-the-art experimental setup in space for a duration of two years that accuracy could theoretically be improvement to $1\ 10^{-10}$. With the restrictions induced by the choice of orbit and the achievable stability of the in-build clocks an improvement of the accuracy in the order of two orders of magnitude seems realistic.

[1] R.J. Kennedy, E.M. Thorndike, Physical Review, 42 (1932) 400-418. [2] M.E. Tobar, et al., Physical Review D, 81 (2010) 022003.

GR 10: Alternative Ansätze

Zeit: Mittwoch 16:30–18:10 Raum: SFG 0150

GR 10.1 Mi 16:30 SFG 0150

The color of stars vs. the time dilation — •Shukri Klinaku — University of Prishtina, Kosovo

In 1842 Christian Doppler explaining the color of binary stars found the "wave-length Doppler effect". The "frequency Doppler effect" is also well-known. Analogously, we can successfully define the "energy Doppler effect", and the "time Doppler effect". We know that the color of stars changes for the observer on Earth, while for an observer in frame of reference on the star doesn't change. So the increasing and decreasing of frequency; the extension and contraction of wavelength; the increasing and decreasing of radiation energy; and the period dilation and period contraction are symmetric and they are dependent on relative velocity between the velocity of light (c) and velocity of its source (v). Thus if we want to express these changes (color, frequency, wavelength or radiation energy) in terms of time, then we use the "time Doppler effect", that means the change of the period of receiving signals. In other words, the time interval in the frame of moving source within n periods of emission (nTs) is quite equal to the time interval in the frame of observer on Earth which contains the same number n of the same periods: n(To + Ts v/c), where the second term in the sum inside brackets represents the time within which the first signal (from n signals) arrives to the observer. The story about the "length contraction" and "time dilation" overs here. The most tragic moment in all modern physics is the misinterpretation of the change of wavelength as "length contraction" and the misinterpretation of the change of periods as "time dilation".

GR 10.2 Mi 16:50 SFG 0150

Gravity Based on Lorentz's instead of Einstein's Theory of General Relativity — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

Einstein developed his theory of relativity as a purely geometric system. In contrast to his approach, Hendrik Lorentz developed a physics-related relativity. However, Lorentz had to make some assumptions which were considered very speculative at the time, and so he had little chance of holding his ground against Einstein's geometry. In the meantime, however, the Lorentzian approach conforms to our understanding of physics. It exhibits great advantages, physically and with respect to understandability, compared to Einstein's.

Lorentz in his day only developed special relativity. However general relativity can also be developed based on Lorentz's physics-related approach. The result is a theory which fulfils all known proofs for Einstein's GRT and is in addition much easier to handle: no 4-dimensional Riemannian geometry is needed; school mathematics is sufficient. And the big open problems of dark matter and dark energy have solutions corresponding to a straightforward physical explanation and complying fully with other physical domains.

Further Info: www.ag-physics.org/gravity

GR 10.3 Mi 17:10 SFG 0150

Eine analytisch begründete Ursache der Gravitation — •Hans Körber — Kiel, Deutschland

Eine fast triviale Feststellung: Atome (und Moleküle) wirken in ihrer Umgebung elektrisch nicht neutral, weil sich ihre Elektronen und Protonen nicht am selben Ort befinden und sich diese zudem auf verschiedenen Radien bewegen. Die auf Bohrschem Radius (bzw Vielfachem davon) kreisenden Elektronen erzeugen wesentlich größere magnetische Momente als die ums Baryzentrum mitbewegten Protonen. Jedes Atom (und Molekül) besitzt daher einen magnetischen Dipol. In riesigen Feldansammlungen sind die extrem vielen Einzeldipole isoliert betrachtet zumeist chaotisch ausgerichtet und in der Summe daher unmagnetisch. Doch zu anderen Feldanhäufungen richten sich einige, genügend Dipole wegen der Fernwirkung aus, so daß die Feldhaufen (Substanzen) einander magnetisch anziehen: Sie gravitieren miteinander - es ist eine Schwerkraft vorhanden. „Es ziehen sich Massen an." Nähern sich die Substanzen, nimmt die Zahl der zueinander ausgerichteten Dipole zu. Die „Gravitationskonstante" ist somit keine.

GR 10.4 Mi 17:30 SFG 0150

Galilean relativity with 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 approach which omits 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. Relativity is treated as a speed problem with absolute time and space variables resulting equations of Galilean relativity multiplied with the Gamma factor. GR is the theory of gravitation of the SM and is based on time and space distortions and consequently a revision is also needed. An approach is also presented for gravitation based on the reintegration of migrated electrons and positrons to their nuclei. More at www.odomann.com

GR 10.5 Mi 17:50 SFG 0150

The gravitation and the Theory of Everything. — •Norbert Sadler — Wasserburger Str. 25a ; 85540 Haar

It can be shown that the algebra of the Exzeptional E8- Symmetry Group is an appropriate, dynamic gauge symmetry and that the gravitation can be understood as curvature of the entropy S(Univ.) of the universe.

From these findings there will be first disclosed a Theory of Everything T.O.E. in which the gravitaion, the cosmic Order-Parameter as well as the elementary particles are correctly described and understood.

The Theory of Everything:

alfa(gravitation) x (E8 x E8)=(S(Univ.) x S(Univ.)). with: Algebra(E8)=8.61x10**17; S(Univ.)=0.00664.

Acording to the above T.O.E. the curvature of the four dimensional spacetime of the ART is replaced by the curvarture of the entropy of the universe S(Univ.). There is no four dimensional spacetime and therefore are no problems with the singularities.

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

GR 11: Gravitationswellen

Zeit: Mittwoch 17:30–18:30 Raum: SFG 0140

GR 11.1 Mi 17:30 SFG 0140

Beating the standard sensitivity-bandwidth limit of cavity-enhanced interferometers with internal squeezed light generation — •Mikhail Korobko[1], Lisa Kleybolte[1], Stefan Ast[2], Haixing Miao[3], Yanbei Chen[4], and Roman Schnabel[1] — [1]Institut für Laserphysik und Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Institut für Gravitationsphysik, Leibniz Universität Hannover and Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Callinstraße 38, 30167 Hannover, Germany — [3]Institute of Gravitational Wave Astronomy, University of Birmingham, Birmingham B15 2TT, United Kingdom — [4]Caltech CaRT, Pasadena, California 91125, USA

The shot-noise limited sensitivity of cavity-enhanced interferometric measurement devices, such as gravitational-wave detectors, can be improved by increasing the cavity finesse, given the fixed light power inside the detector. This comes at a price of proportional reduction of the detection bandwidth. It is possible to overcome this standard sensitivity-bandwidth limit using non-classical correlations in the light field. Here, we investigate the internal squeezing approach, where the parametric amplification process creates a non-classical correlation directly inside the interferometer cavity. We analyse the limits of the approach theoretically, and measure 36% increase in the sensitivity-bandwidth product compared to the classical case. To our knowledge this is the first experimental demonstration of improving the sensitivity-bandwidth product using internal squeezing.

GR 11.2 Mi 17:50 SFG 0140

Astrophysical Gravitational Waves in Conformal Gravity — •Patric Hölscher[1], Chiara Caprini[2], and Dominik Schwarz[1] — [1]Bielefeld University, Bielefeld, Germany — [2]Astroparticle and Cosmology laboratory, Paris, France

We investigate the gravitational radiation from binary systems in Conformal Gravity and Massive Conformal Gravity. Therefore, we derive the inhomogeneous linearized field equations for the metric which are given by a massive Klein-Gordon equation.

To calculate the radiated energy we follow the standard method by deriving an expression for the gravitational energy-momentum tensor. In order to explain the decrease of the orbital period of binary systems we use data from the analysis of galaxy rotation curves and from the well-measured binary system PSRJ1012+5307.

Our result is that there is nearly no decrease of the orbital period. This means that gravitational radiation is not effective and there has to be another mechanism to explain the shrinkage of the orbital period of binary systems.

GR 11.3 Mi 18:10 SFG 0140

Quasinormal modes of perturbed black holes in Einstein-dilaton-Gauss-Bonnet gravity — Jose Luis Blazquez-Salcedo[1], Caio F. B. Macedo[2], Vitor Cardoso[3], Valeria Ferrari[4], Leonardo Gualtieri[5], •Fech Scen Khoo[6], Jutta Kunz[7], and Paolo Pani[8] — [1]University of Oldenburg, Oldenburg, Germany — [2]Universidade de Lisboa, Lisboa, Portugal — [3]Universidade de Lisboa, Lisboa, Portugal — [4]Sapienza Universita di Roma, Sezione INFN Roma1, Roma, Italy — [5]Sapienza Universita di Roma, Sezione INFN Roma1, Roma, Italy — [6]Jacobs University, Bremen, Germany — [7]University of Oldenburg, Oldenburg, Germany — [8]Sapienza Universita di Roma, Sezione INFN Roma1, Roma, Italy

We will discuss the gravitational waves emitted by distorted black holes in a gravity theory that extends general relativity to include the coupling of a scalar field (dilaton) and the topological Gauss-Bonnet invariant which is second order in curvature. We will be focusing in this talk on the quasinormal modes which are most relevant for the ringdown phase of the gravitational waves, where we explore the linear mode stability of the black holes against axial and polar perturbations.

GR 12: Didaktische Aspekte der Relativitätstheorie

Zeit: Donnerstag 8:30–10:30 Raum: SFG 0140

Hauptvortrag GR 12.1 Do 8:30 SFG 0140

Relatively complicated? Teaching general relativity at different levels — •Markus Pössel — Haus der Astronomie und Max Planck Institut für Astronomie, MPIA-Campus, Königstuhl 17, 69117 Heidelberg

Can a bowling ball in a rubber sheet properly represent Einstein's description of gravity? Is space really expanding in an expanding universe? In an interferometric gravitational wave detector, do light waves play the role of a ruler?

Simplifications and analogies are unavoidable whenever teaching Einstein's theory of general relativity to a wider audience, such as undergraduate students, high school students, or the general public. The talk presents examples for such simplifications and analogies at different levels, including a critical discussion of misleading examples and potential pitfalls.

GR 12.2 Do 9:10 SFG 0140

Empirical exploration of spacetimes with bundles of light rays — •Thomas Müller — Haus der Astronomie / MPIA, Heidelberg

Studying the trajectories of light rays around black hole spacetimes is a standard task in an introductory course to general relativity. Based on this knowledge, students can already implement a simple ray tracing algorithm to visualize how a black hole geometrically distorts the Milky Way background.

For more advanced explorations of how curved spacetime influences light, a whole bundle of light rays has to be traced. This can be realized for example by additionally integrating the Jacobian equation and the equation for the parallel transport of a Sachs basis. In this talk I discuss how interactive visualization of these bundles can help to empirical explore gravitational lensing effects in different spacetimes.

GR 12.3 Do 9:30 SFG 0140

General Theory of Relativity on the Computer - An Interactive Lecture — •Matthias Hanauske — Institut für Theoretische Physik, Max-von-Laue-Straße 1 — Frankfurt Institute for Advanced Studies, Ruth-Moufang-Straße 1, Frankfurt, Germany

The concept, the content and the implementation of an interactive lecture held at the Goethe University in SS2016 will be discussed in this talk. The main focus of the course is general relativity theory as well as the imparting of special programming knowledge, whereby the lecture took place in the PC pool of the institute and the students should apply the learned concepts directly during the lecture. In the first part of the course, students learn the use of computer algebra systems (Maple and Mathematica). Various applications of the Einstein and geodetic equations were implemented in Maple, quasi-analytic calculations were carried out and corresponding solutions were calculated and visualized. The second part of the course focused on the numerical calculation of neutron stars and white dwarfs using a C/C++ program. In addition, the basic concepts of parallel programming were introduced and an MPI and OpenMP version of these programs where created. In the third part of the course, time-dependent numerical simulations of GR were carried out using the Einstein Toolkit. (For more information, see http://fias.uni-frankfurt.de/~hanauske/VARTC/)

GR 12.4 Do 9:50 SFG 0140

Derivation of the Deflection of Light near a Mass from Huygen's Principle — •Carmesin Hans-Otto — Gymnasium Athenaeum, 21680 Stade, Harsefelder Straße 40 — Studienseminar Stade, Bahnhodstraße 5, 21682 Stade — Universität Bremen, Fachbereich 1, Pf 330440, 28334

In the vicinity of a mass the space time is curved. As a consequence the wavelength of light is relatively short near the mass. So the wave front exhibits Huygen's elementary waves with relatively small radius near the mass. Consequently the wave front moves towards the mass and the light is deflected. From this I derive the formula for the deflection of light near a mass.

GR 12.5 Do 10:10 SFG 0140

Big Bang Observation and Theory at School — •Hans-Otto Carmesin — Gymnasium Athenaeum, 21680 Stade, Harsefelder Straße 40 — Studienseminar Stade, Bahnhodstraße 5, 21682 Stade — Universität Bremen, Fachbereich 1, Pf 330440, 28334

Students discovered the age of the universe by their own and understood the observation by elementary methods.

Students of age 12 and older took photographs with an 11 inch telescope at the school observatory. With these photographs, the students achieved an overview of the visible universe and concluded the Big Bang. In an alternative observation the students determined the age of the universe spectroscopically.

The students modelled the expansion of the universe with Newtonian cosmology and with quantum gravity.

GR 13: Grundlegende Probleme und allgemeiner Formalismus

Zeit: Donnerstag 14:00–15:55 Raum: SFG 0140

Hauptvortrag GR 13.1 Do 14:00 SFG 0140

Quantum matter determines the underlying gravity theory — •Frederic P. Schuller — Department of Physics, Friedrich-Alexander University Erlangen-Nuremberg, Staudtstr. 7, 91058 Erlangen

How much choice does one have in postulating gravitational dynamics? Virtually none, if one has already decided on quantizable equations of motion for all matter fields that populate the spacetime.

The mechanism is quite simple. Geometry and matter must share the same initial data surfaces, in order to allow for a common evolution. But this inevitably injects the principal polynomial of the matter dynamics into the constraint algebra of viable dynamics for the geometry. And since the constraint algebra can then be written as a linear functional differential equation for the gravitational Lagrangian, the latter can be determined constructively. In fact, the gravitational Lagrangian is uniquely determined, up to constants of integration.

Finding the gravitational dynamics that support given matter field equations thus amounts to no more, and no less, than solving a linear system of differential equations. The technicalities behind this assertion are subtle, but utterly physical. Interestingly, there is no theoretical constraint whatsoever that restricts one to a metric background, which opens up unexpected avenues for the construction of modified matter theories on refined background geometries.

We will close by demonstrating how the mechanism works in practice and point out a type of physical questions that was previously inaccessible, but can now be addressed and answered.

GR 13.2 Do 14:40 SFG 0140

Tonti diagrams for the teleparallelism theory of gravity (TG) and for the Poincaré gauge theory (PG) — •Friedrich W. Hehl[1] and Enzo Tonti[2] — [1]Universität zu Köln and University of Missouri, Columbia — [2]Università degli Studi di Trieste

One of us, over the past decades, developed a general classification program for classical and relativistic theories in physics, such as, e.g., for particle dynamics, electromagnetism, the mechanics of deformable media, fluid mechanics, thermodynamics etc. [1]. Here we will display for the first time the corresponding diagrams (i) for the teleparallelism theory of gravity, see [2], as well as (ii) for the Poincaré gauge theory, see [3]. Interrelationships between both diagrams of (i) and (ii) are discussed. [1] E. Tonti, *The Mathematical Structure of Classical and Relativistic Physics,* A general classification diagram (Birkhäuser-Springer, New York, 2013). [2] Y. Itin, Yu. N. Obukhov, J. Boos, and F. W. Hehl, Local and linear premetric teleparallel theory of gravity: Tonti diagram, constitutive tensor, gravitational waves, in preparation (2016/17). [3] M. Blagojević and F. W. Hehl (eds.), *Gauge Theories of Gravitation: A Reader with Commentaries* (Imperial College Press,London, 2013).

GR 13.3 Do 14:55 SFG 0140

(A)dS at low and high velocity — •Lukas Brunkhorst — ZARM, Universität Bremen

From the standpoint of the Relativity postulate, Minkowski spacetime has two limiting cases: the Galilean and the Carrollian one. These arise if one is concerned with phenomena whose dynamics are either slow when compared with the speed of light or closely approaching it, respectively, and are geometrically represented by a degenerating of the metric and its inverse. It is of conceptual as well as practical interest to introduce gravity into these mathematically peculiar, though physically meaningful situations, which has been done for the Galilean case in terms of Newton-Cartan theory. We discuss the constant curvature spaces, with emphasis on the Carrollian case, by viewing them as the limits of de Sitter and Anti de Sitter spacetime.

GR 13.4 Do 15:10 SFG 0140

Treating the Einstein-Hilbert action as a higher derivative theory: what can be learnt from this? — •Branislav Nikolic — Institute for Theoretical Physics, Cologne, Germany

The Einstein-Hilbert action is a first order theory — by an appropriate partial integration, it can be put into a form exhibiting up to first time derivatives of the metric in the canonical formulation. Here, we investigate some of the consequences that arise if the action is treated as a second order theory. It is shown, in particular, that information about a broken conformal symmetry can be exhibited if we introduce extrinsic curvature as an independent variable — a procedure usual for genuine second order theories; in the original formulation, this is not easily obtainable. We also discuss implications and further examples.

GR 13.5 Do 15:25 SFG 0140

Some results of canonical gauge theory of gravity — •Johannes Münch[1,2], Jürgen Struckmeier[1,3], Matthias Hanauske[1], Johannes Kirsch[2], David Vasak[2], and Horst Stöcker[1,2,3] — [1]Goethe Universität, Frankfurt am Main, Deutschland — [2]Frankfurt Institute for Advanced Studies (FIAS), Frankfurt am Main, Deutschland — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Deutschland

In analogy to SU(N)-gauge theories, the goal was set to also derive gravity as a gauge theory. This presentation shows how to deduce a gauge theory - in particular the relevant coupling terms - in the extended Hamiltonian formalism of field theory. The gauge group is formed by diffeomorphisms. The corresponding gauge transformations are formulated as canonical transformations in the Hamiltonian theory. It remains freedom in choosing a dynamic term, which represents the free theory of gravity. Thus, a special dynamic term is being discussed. The term refers to a linear combination of a quadratic and a linear term in the canonical momentum corresponding to the gauge field. In this way a modification to Einstein's equations occurs. Conformities and deviations of the solutions compared to Einstein's theory are being discussed.

GR 13.6 Do 15:40 SFG 0140

Matter Ordered by Quantum Phase Fields: Emergent Gravity in a Dynamic Universe — •Ingo Steinbach — Ruhr-University Bochum

The question of quantum gravity is approached from a new point of view. The phase field concept, which is successfully applied in certain condensed matter problems [Steinbach & Pezzolla, Physica D, 1999], will be generalized to a quantum phase field concept. It is applicable to matter in general, formulated in terms of a variational principle. The new concept [I. Steinbach, Z. Naturforschung A, to be published] has energy as the only fundamental substance. Different states of energy are ordered by a discrete set of quantum phase fields. The dual elements of matter, mass and space, are described as volume- and gradient-energy contributions of the set of fields, respectively. Time and space are formulated as background-independent dynamic variables. The evolution equations of the fields and the wave-function of the universe are derived in quasi-static approximation. Gravitational interaction emerges from quantum fluctuations in finite space. Application to a large number of fields predicts scale separation in space and repulsive action of masses distant beyond a marginal distance. The predicted marginal distance is compared to the size of the voids in the observable universe.

GR 14: Postersitzung

Zeit: Donnerstag 14:00–16:00 Raum: SFG 0150

GR 14.1 Do 14:00 SFG 0150

Relativistic Effects in Spectroscopic Binary Stars - Paving the way to precise stellar mass determinations — •Vanessa Fahrenschon[1,2,3], Roberto Saglia[2,1], and Luca Pasquini[3] — [1]University Observatory Munich, Ludwig-Maximilians-Universität München, Germany — [2]Max Planck Institute for extraterrestrial Physics, Garching, Germany — [3]European Southern Observatory, Garching, Germany

High-resolution spectroscopy is one of the most powerful tools of modern observational astrophysics. With the incorporation of new measurement and calibration techniques, e.g. laser frequency combs, precisions will soon reach the 1m/s level and allow for direct measurements of relativistic effects in nearby stellar systems.

In this work, radial velocities (RVs) of double-lined spectroscopic binaries (SB2s) are used to detect periodic redshifts due to special and general relativistic effects. Simulations of all expected redshift contributions, depending on the binary system's parameters, are presented. A comparison with state-of-the-art measurements is made to show the necessity to take relativistic effects into account in the future.

Due to the availability of more RV curve fit parameters in SB2 systems than in other systems, it will soon be possible to determine the masses of both stellar components separately in a very precise way. This can be done without having to use additional information from astrometry or other measurements, making this a very important tool for all fields of astrophysics.

GR 14.2 Do 14:00 SFG 0150

Sector models of a plane gravitational wave — Ute Kraus and •Corvin Zahn — Universität Hildesheim

We present sector models that visualize the properties of a plane gravitational wave. These include the spatial curvature and the motion of free particles within the wave.

Sector models can provide an intuitive understanding of the intrinsic geometry of curved spaces or spacetimes. They are built by dividing curved space or spacetime into small blocks with Euclidean or Minkowski geometry respectively.

GR 14.3 Do 14:00 SFG 0150

Relativistic Interactive Flight Simulation — •Stephan Preiss — Universität Hildesheim

To visualize relativistic phenomena like length contraction, time dilation and the aberration of light in an interactive simulation, we construct a virtual world with a drastically reduced speed of light. This was done in an interactive flight simulator developed by Christoph Keller. Here, the observer can move at relativistic velocities and sees the resulting images that are calculated with ray tracing methods. This program was now extended to support a surround view environment (CAVE).

GR 14.4 Do 14:00 SFG 0150

Visualizing a Rotating Black Hole — •Thomas Reiber — Universität Hildesheim

The Kerr solution of the Einstein field equation describes the spacetime around a rotating Black Hole. It can be extended over the event horizons to connect distant regions of spacetime. Ray tracing in the maximal analytic extension of Kerr spacetime is used to calculate the view of an observer in the interior region of a black hole.

GR 14.5 Do 14:00 SFG 0150

Black hole conserved charges via "solution phase space method" — •Kamal Hajian and Mohammad Mehdi Sheikh-Jabbari — Institute for Research in Fundamental Sciences (IPM), Tehran, Iran

I will present a method for calculating black hole conserved charges associated with exact symmetries in the context of covariant gravitational theories. The method is called "solution phase space method," and is based on covariant phase space formulation of charges. Introducing the notion of "solution phase space", which is the phase space built by family of solutions parametrized by some free parameters, one can calculate the mass, angular momentum, electric charge, and entropy of a given black hole, by a single formulation, in any dimension, and with any asymptotics. Moreover, the codimension-2 surfaces of integration are almost relaxed to be chosen arbitrarily in the bulk. We have applied the formulation to find conserved charges and first law(s) of thermodynamics for the Kerr-dS black holes, unifying them with the Kerr and Kerr-AdS black holes. Refs. for more details: "Phys.Rev. D93, (2016), 4, 044074, arXiv:1512.05584", and "Gen.Rel.Grav. 48, (2016), no.8, 114, arXiv:1602.05575".

GR 14.6 Do 14:00 SFG 0150

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 this measurement. There are indications that the speed of light 'c' was higher in the past. If this higher value is inserted into the Doppler equation to determine the speed from red-shifts, higher speeds are found for early stars. So there is no acceleration.

Mainstream physics objects to this, however, arguing that according to Einstein's theory of relativity, c has always been the known constant. However, this is not clearly stated by Einstein.

A variation of c will also explain the so called phenomenon of cosmological inflation in a very straight way. The underlying horizon problem, i.e. the apparent logical connection of parts of our universe far apart from each other can be the consequence of a very high 'c' at early times. There is no need for any other explanation.

GR 14.7 Do 14:00 SFG 0150

Galilean relativity with 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 approach which omits 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. Relativity is treated as a speed problem with absolute time and space variables resulting equations of Galilean relativity multiplied with the gamma factor. GR is the theory of gravitation of the SM and is based on time and space distortions and consequently a revision is also needed. An approach is also presented for gravitation based on the reintegration of migrated electrons and positrons to their nuclei. More at www.odomann.com

GR 14.8 Do 14:00 SFG 0150

Lorentz interpretation of GRT - comments, possible experimental proof — •Jürgen Brandes — Karlsruhe, Germany

Ludwig Neidhart reviewed book [1] and recommends it even to those who are critical against Lorentz interpretation (LI) of GRT: "Auch wer dem Standpunkt der Autoren kritisch gegenübersteht, wird es mit Gewinn lesen können, weil ...[2]". The well-known gravitational physicist Kip S. Thorne accepts the two standpoints as correct, the curved spacetime paradigm or classical GRT and the flat spacetime paradigm or LI of GRT. He asks: "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]. The poster presents these ideas and the first steps in calculating supermassive stellar objects (black holes) using TOV equation. Application of this equation on neutron stars and black holes using LI of GRT leads to results different from classical GRT possibly testable by astronomical observations of these stars and galactic centers.

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

GR 14.9 Do 14:00 SFG 0150

Derivation of the Schwarzschild metric from Special Relativity — •Carmesin Hans-Otto — Gymnasium Athenaeum, 21680 Stade, Harsefelder Straße 40 — Studienseminar Stade, Bahnhodstraße 5, 21682 Stade — Universität Bremen, Fachbereich 1, Pf 330440, 28334

The well known Schwarzschild metric is derived with especially few assumptions: A falling object increases its velocity v. So its energy is increased by the Lorentz factor. Due to the conservation of energy, the energy must decrease by another factor that describes the energy due to gravitation. A formula for this factor is derived. From this expression the blue-shift of a falling photon is obtained. The Schwarzschild metric is derived as a consequence.

GR 14.10 Do 14:00 SFG 0150

Where Einstein had failed: New Physics - logic and experimental checks — •Claus Birkholz — Seydelstr. 7, D-10117 Berlin

Einstein's bottom-up approach to GR by differential geometry prevented him from identifying its 4 invariants: He just succeeded in presenting an incomplete subset of its 2nd-order invariant giving rise to his detailed metric, while his energy-momentum tensor had been left on the level of a rough suggestion. The rest of parameters, which he arbitrarily subsumed under his cosmological "constant", then, had become a matter of enduring speculation.

The higher invariants got lost completely. The specific situation of time to stop running at the event horizon and reversing its sign, there, is not supported by Lagrangians of the variation calculus. With decreasing angular momentum, heavy mass will increase. This is the Dark-Matter phenomenon missing in Einstein's truncated version. The interior of a black hole is free of singularities. Leptons turn out to be composed structures.

Based on how an experimentalist is collecting data, the poster outlines a more realistic top-down construction giving a "ToE" - with Quantum Gravity, the 4-dimensionality of space-time, chiral "internal" substructures (of a GUT), the quark confinement, the composition of leptons, and the individual values of coupling constants being outputs resulting from theory. Einstein's curvilinear metric is fully quantised.

By calculating the fine-structure constant, its resulting deviation of only 0.08% (theory from experiment) is confirming the ToE details entering.

GR 15: Quantenaspekte der Gravitation und vereinheitlichender Theorien 1

Zeit: Donnerstag 16:30–18:30 Raum: SFG 0140

Hauptvortrag GR 15.1 Do 16:30 SFG 0140

The Nambu-Goto string as an effective field theory and its semi-classical limit — •Jochen Zahn — Institut für Theoretische Physik, Universität Leipzig

The Nambu-Goto string, being purely geometrical and exhibiting diffeomorphism invariance, can be seen as a toy model for (quantum) gravity. I present an effective field theory approach to its quantization, based on perturbation theory around non-trivial classical solutions. It employs the BRST formalism (to deal with diffeomorphism invariance) and renormalization methods developed for QFT on curved space-times. It can be seen as the string theory analog of perturbative quantum gravity. Using rotating classical solutions as the starting point of perturbation theory, one can compute semi-classical corrections to the energy.

Several deviations from standard quantum strings are found. For example, the theory is consistent, as an effective field theory, for any dimension of the target space. Furthermore, the semi-classical limit of standard quantum strings does not coincide with that of our perturbative approach. The origin of these deviations will be briefly discussed.

The talk is partly based on joint work with D. Bahns and K. Rejzner.

GR 15.2 Do 17:10 SFG 0140

Quantum properties of theories with anisotropic scaling — •Christian F. Steinwachs[1], Andrei O. Barvinsky[2,3], Diego Blas[4], Mario Herrero-Valea[5], Dmitry V. Nesterov[2], Guillem Perez-Nadal[6], and Sergey M. Sibiryakov[4,5,7] — [1]Physikalisches Institut, Albert-Ludwigs Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany — [2]Theory Department, Lebedev Physics Institute, Leninskii Pr. 53, Moscow 119991, Russia — [3]Department of Physics, Tomsk State University, Lenin Ave. 3 6, Tomsk 634050, Russia — [4]CERN Theory Division, CH-1211 Geneva 23, Switzerland — [5]Institut de Théorie des Phénomènes Physiques, EPFL, CH-1015 Lausanne, Switzerland — [6]Departamento de Física, Universidad de Buenos Aires, Ciudad Universitaria, pabellón 1 (1428) Buenos Aires, Argentina — [7]Institute for Nuclear Research of the Russian Academy of Sciences

We discuss the quantum properties of theories with an anisotropic scaling of space and time. Such theories break fundamental Lorentz invariance in the UV. New techniques have to be applied to analyze general renormalization properties and to perform explicit calculations – among them a non-local gauge fixing procedure. We present a method how calculations of quantum divergences in a non-covariant theory can be related to the well known heat kernel technique for covariant theories and discuss the application of this technique to the model of Hořava-Lifshitz gravity.

GR 15.3 Do 17:30 SFG 0140

Hawking radiation: Comparison of pure-state and thermal description — •Yi-Fan Wang and Claus Kiefer — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln

We present the power spectral densities for a quantum field in the background of a Schwarzschild black hole and compare the cases of the field being in a pure state and in the usual thermal state. In the low-energy regime the densities strongly differ, while at high energies they practically coincide. We define a distance measure between the resulting two density operators and evaluate it assuming an UV cutoff and discrete field energy levels. We find that the distance is exponentially small with respect to the number of the levels as well as the ratio of the cutoff and the Hawking temperature. We finally discuss the operational meaning of a vanishing distance.

GR 15.4 Do 17:50 SFG 0140

Singularity avoidance in Kantowski-Sachs quantum cosmology — •Nick Kwidzinski — Institute for Theoretical Physics, University of Cologne, 50937 Cologne, Germany

We study the classical and quantum cosmology of Kantowski-Sachs universes. Special attention will be given to the singularities that occur in these models and their resolution in the corresponding quantum models. Quantization is performed within the minisuperspace approximation of quantum geometrodynamics.

GR 15.5 Do 18:10 SFG 0140

Planck-scale-modified dispersion relations in homogeneous and isotropic spacetimes — •Christian Pfeifer — ITP Uni Hanover, Hanover Deutschland

Last year I presented how one can understand dispersion relations covariantly as level sets of a Hamilton function on the point particle phase space of spacetime. In this talk I will demonstrate how one obtains the most general homogeneous and isotropic dispersion relation and how this allows us to study a specific Planck-Scale deformation of Friedman-Lemaître-Robertson-Walker (FLRW) geometry. This deformation has the property that it is locally identical to the κ-Poincaré dispersion relation studied extensively in quantum gravity phenomenology. Studying the motion of particles subject to such Hamiltonian we derive the redshift and lateshift as observable consequences of the Planck-scale deformed FLRW universe.

This talk is based on the article: https://arxiv.org/abs/1612.01390

GR 16: Quantenaspekte der Gravitation und vereinheiltichender Theorien 2

Zeit: Freitag 8:30–10:30 Raum: SFG 0140

GR 16.1 Fr 8:30 SFG 0140

Tensor Galileons and Gravity — •Peter Schupp[1], Fech Scen Khoo[1], Athanasios Chatzistavrakidis[2], and Diederik Roest[2] — [1]Jacobs University Bremen — [2]University of Groningen

When does an action functional lead to field equations which contain only second derivatives of the corresponding field? For a symmetric 2-tensor (i.e. a metric) the answer to this question are Lovelock invariants, including the Einstein-Hilbert action and the Gauss-Bonnet term. For scalar fields a similar role is played by Galileons. We extend these results to mixed-symmetry tensors, introducing an index free formulation based on Grassmannian variables. We find that (1,1)-tensor Galileons describe linearized Lovelock gravity in any dimension.

GR 16.2 Fr 8:50 SFG 0140

Towards apparent convergence in asymptotically safe quantum gravity — Tobias Denz[1], Jan M. Pawlowski[1,2], and •Manuel Reichert[1] — [1]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Deutschland — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung mbH, Planckstr. 1, 64291 Darmstadt, Deutschland

The asymptotic safety scenario in gravity is accessed within the systematic vertex expansion scheme for functional renormalisation group flows. In the present work this expansion scheme includes propagators, the graviton three-point function and, for the first time, the graviton four-point function. This provides us with a closed flow equation for the graviton propagtor: all vertices and propagators involved are deduced by their own flows. In terms of a covariant operator expansion the current approximation gives access to Λ, R, R^2 as well as $R^2_{\mu\nu}$ and higher derivative operators. We find a UV fixed point with three attractive and two repulsive directions, thus confirming previous studies on the relevance of the first three operators. In the infrared we find trajectories that correspond to classical general relativity and further show non-classical behaviour in some fluctuation couplings. We also find signatures for the apparent convergence of the systematic vertex expansion. This opens a promising path towards finally establishing asymptotically safe gravity in terms of apparent convergence.

GR 16.3 Fr 9:10 SFG 0140

Generalized Uncertainty Principle Modified Black Holes in Large Extra Dimensions — •Marco Knipfer[1,2], Maximiliano Isi[3], Sven Köppel[1,2], Roman Smit[1,2], Jonas Mureika[4], and Piero Nicolini[1,2] — [1]Frankfurt Institute for Advandced Studies (FIAS), Frankfurt am Main, Germany — [2]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, Frankfurt am Main, Germany — [3]Physics Department, California Institute of Technology, Pasadena, CA 91125 — [4]Department of Physics, Loyola Marymount University, Los Angeles, CA

Thought Experiments show that General Relativity announces its own breakdown at the Planck Scale where a Theory of Quantum Gravity is needed. It is widely believed that Quantum Gravity will change some features of Black Holes like: 1) The singularity in the center of a Schwarzschild Black Hole, 2) the diverging (1/M) Hawking temperature and the evaporation endpoint. I will show modifications to the Schwarzschild Black Hole that impact mentioned features. The modifications are due to implementing the Quantum Gravity inspired Generalized Uncertainty Principle (GUP) in the Theory. An extension to Large Extra Dimensions (LXDs) needs a modified GUP as I will show.

GR 16.4 Fr 9:30 SFG 0140

Wave propagation on discrete quantum geometries and the spectral dimension — •Johannes Thürigen — Laboratoire de Physique Théorique, Bâtiment 210, Université Paris-Sud XI, F-91405 Orsay Cedex

In various approaches to a quantum theory of gravity, quantum states of space and histories of spacetime are based on discrete geometries. Wave propagation on such quantum geometries is governed by modified dispersion relations and a nontrivial spectral dimension of spacetime. Here I present a systematic analysis of the essential properties of quantum geometries which lead to characteristic modifications of wave propagation and the spectral dimension, in particular those leading to a flow of spacetime dimension to a value smaller than four.

GR 16.5 Fr 9:50 SFG 0140

Inter-universal entanglement in a cyclic multiverse model — Salvador Robles-Pérez[1,2], Adam Balcerzak[3,4], Mariusz P. Dabrowski[3,5,4], and •Manuel Krämer[3] — [1]Instituto de Física Fundamental, CSIC, Madrid, Spain — [2]Estación Ecológica de Biocosmología, Medellín, Spain — [3]Instytut Fizyki, Uniwersytet Szczeciński, Szczecin, Poland — [4]Copernicus Center for Interdisciplinary Studies, Kraków, Poland — [5]National Centre for Nuclear Research, Otwock, Poland

We study the model of a multiverse consisting of parallel cyclic universes that are classically disconnected, but quantum-mechanically entangled. This model is based on a quantum field theoretical formulation of the Wheeler–DeWitt equation, the so-called third quantization. We calculate the entropy of entanglement and find that it is large at the big-bang and big-crunch singularities as well as at the maxima of the expansion of the parallel universes. The latter hints towards a relation to earlier findings that quantum effects are strong at the turning point of the evolution of a universe.

GR 16.6 Fr 10:10 SFG 0140

Holographic Entanglement Entropy of Local Quenches in AdS_4/CFT_3: A Finite-Element Approach — •Alexander Jahn[1] and Tadashi Takayanagi[2] — [1]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Germany — [2]Yukawa Institute for Theoretical Physics (YITP), Kyoto University, Japan

Understanding entanglement in three-dimensional conformal field theory (CFT_3) is a challenging task, as direct analytical calculations are often impossible to perform. Using the holographic entanglement entropy formula, the calculation of entanglement entropy turns into a problem of finding extremal 2-surfaces in 4-dimensional curved spacetime, which we tackle with a numerical finite-element approach. In particular, we compute the entanglement entropy between two half-spaces resulting from a local quench, triggered by a local operator insertion in the CFT_3. We find that when the conformal dimension of the local operator is small, the growth of entanglement entropy shortly after the quench corresponds to predictions from the first law of entanglement entropy. At large times the behavior of the system resembles the logarithmic time dependence familiar from the CFT_2 case. We hope that our work will motivate further analytical research on entanglement entropy in higher dimensions.

GR 17: Kosmologie

Zeit: Freitag 11:00–12:00 Raum: SFG 0140

GR 17.1 Fr 11:00 SFG 0140

Towards counts-in-cells statistics for galaxy surveys — •Cora Uhlemann — Institute for Theoretical Physics, Utrecht University

Recently, we developed an analytical formalism to predict the one-point probability distribution of the dark matter density in spheres from the Gaussian initial conditions using the spherical collapse model. Here, we present how this theory can be extended to biased tracers such as dark matter halos and galaxies and hence used to predict counts-in-cells statistics for galaxy surveys.

GR 17.2 Fr 11:15 SFG 0140

New estimates of the Cosmic Radio Dipole — •Thilo Siewert — Universität Bielefeld

Continuum surveys of the radio sky provide a rich resource of information. Besides the analysis of individual galaxies and other astrophysical sources, they also allow us to probe cosmological models. We analyze the data provided by several surveys across radio frequencies to estimate the Cosmic Radio Dipole in the radio source counts. This dipole is a deviation from the statistically isotropic Universe caused by the proper motion of the Solar system and the large scale structure. The kinetic effect is also hold responsible for the temperature dipole of the Cosmic Microwave Background. In this presentation the results of recent dipole analysis based on the TGSS ADR1 at 150 MHz is presented and compared with results at other frequencies.

GR 17.3 Fr 11:30 SFG 0140

Identification and state of the universe. — •Norbert Sadler — Wasserburger Str. 25a ; 85540 Haar

The identification and the physical state of the universe is made over the four essential order parameters of the universe. The four essential order parameters relate to:

The Reynold number (Re), the Hubble paramerter (Ho), the entropy (S(Univ.) and the algebra of the Exzeptional E8-Group (E8). From these four parameters the physical state of the universe can be derived and determined. The four essential parameter build a fortex-basic form of a cosmolical T.O.E. The determination of the state is made over the technically measureable and reproducable Reynold number.

The cosmolical state of the universe:
Re(Univ.)=(Ho x Ho)x(E8 x E8)/(S(Univ.) x (S(Univ.))=861.

With: Ho=69.4 km/Mpcs; E8=8.61x10**17; S(Univ.)=0.066. The technical analogon to the Reynold number would be a moscito with a relativ speed of 1 meter per second.

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

GR 17.4 Fr 11:45 SFG 0140

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

Dirac's Large Number Hypothesis reflects one of the most tantalizing cosmological observations. It involves not only the ratio of electric and gravitational force and the size of the universe, but also the number of particles contained in it, making it an a-priori very unlikely coincidence. Yet Dirac's suggestion is often dismissed as 'numerology', presumably because it is totally incompatible with any of the existing cosmological models. Thus it is certainly surprising that the Large Number Hypothesis is a direct consequence of Einstein-Dicke cosmology, a variable speed of light model that was first considered by Albert Einstein in 1911 and substantially improved by Robert Dicke in 1957. Further implications for the early universe are discussed.

GR 18: Numerische Relativitätstheorie

Zeit: Freitag 12:00–12:30 Raum: SFG 0140

GR 18.1 Fr 12:00 SFG 0140

Solving Elliptic Equations by Hyperbolic Relaxation — •Hannes Rüter and Bernd Brügmann — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Deutschland

It will be demonstrated how hyperbolic evolution codes can be used to solve elliptic equations by the hyperbolic relaxation method. We present applications to typical numerical relativity initial data problems, i.e. scalar fields and binary neutron star systems. For the hyperbolic evolution we employ the pseudo-spectral numerical relativity code bamps.

GR 18.2 Fr 12:15 SFG 0140

Discontinuous Galerkin methods in general relativistic neutron star simulations — •Marcus Bugner, David Hilditch, Hannes Rüter, and Bernd Brügmann — Theoretical Physics Institute, University of Jena, 07743 Jena, Germany

After the successful combination of Discontinuous Galerkin (DG) and pseudo-spectral methods for matter plus spacetime simulations, we present further extensions of our method. Targeting a reliable high-order algorithm, we put special focus on our shock capturing method and show the latest convergence results for fully general relativistic systems. Furthermore, we investigate the scalability of our numerical implementation.