Gravitation and Relativity Division
Fachverband Gravitation und Relativitätstheorie (GR)

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Our division's topical focus this year is on "cosmology". This will be reflected by distinguished invited speakers on various aspects of cosmology, classical as well as quantum. Amongst others we have Ruth Durrer (Geneva) as our plenary speaker on Tuesday morning and George Ellis (Cape Town) on Tuesday afternoon as our speaker in the joint symposium on "cosmological model-building", organised together with the division *Theoretical and Mathematical Physics* and the working group on *Philosophy of Physics*. Our posters will be permanently on display throughout the week in a separate room (HS 6) and presented by their authors in a scheduled poster session on Thursday afternoon. After the poster session we will have our general assembly, to which all members of our division *General Relativity and Gravitation* are cordially invited.

Overview of Invited Talks and Sessions

Lecture rooms: HS 4 (Thierschbau, Room 2300) and HS 5 (Thierschbau, Room 2370)
Poster room: HS 6 (Wienandsbau, Neubau Innenhof, Room 0999)

Plenary Talk of GR

PV IV	Di	9:00– 9:45	Plenarsaal	**Testing General Relativity with Cosmological Observations** — •Ruth Durrer

Invited Talks

GR 1.1	Mo	16:00–16:45	HS 4	**Probing the spacetime curvature using geometric optics** — •Mikolaj Korzynski, Julius Serbenta, Michele Grasso
GR 2.1	Mo	17:30–18:15	HS 4	**Physical dimensions/units and universal constants: their invariance in special and general relativity** — •Friedrich W. Hehl, Claus Lämmerzahl
GR 3.1	Di	11:00–11:45	HS 4	**An analytic approach to cosmic structure formation** — •Matthias Bartelmann
GR 6.1	Mi	11:00–11:45	HS 4	**Modeling the strong-field dynamics of binary neutron star merger** — •Sebastiano Bernuzzi
GR 8.1	Mi	14:00–14:45	HS 4	**Loop quantum cosmology, signature change, and the no- boundary proposal** — •Martin Bojowald
GR 10.1	Do	11:00–11:45	HS 4	**Critical Phenomena in Gravitational Collapse** — •Thomas Baumgarte
GR 12.1	Do	14:00–14:45	HS 4	**Gravitational-Wave Astronomy in Action** — •Frank Ohme

Invited talks of the joint symposium SYMD

See SYMD for the full program of the symposium.

SYMD 1.1	Mo	14:00–14:30	Plenarsaal	**Analysis of historical solar Ca II K and sunspot data for irradiance studies** — •Theodosios Chatzistergos, Natalie A Krivova, Sami K Solanki, Ilaria Ermolli, Ilya Usoskin, Gennady Kovaltsov
SYMD 1.2	Mo	14:30–15:00	Plenarsaal	**MUSiC: A Model Unspecific Search for New Physics** — •Deborah Duchardt, Thomas Hebbeker

SYMD 1.3	Mo	15:00–15:30	Plenarsaal	**Search for solar chameleons with an InGrid based X-ray detector at the CAST experiment** — •Christoph Krieger
SYMD 1.4	Mo	15:30–16:00	Plenarsaal	**Positron Annihilation Spectroscopy throughout the Milky Way** — •Thomas Siegert

Invited talks of the joint symposium SYKM

See SYKM for the full program of the symposium.

SYKM 1.1	Di	16:30–17:10	HS 4	**Conceptual problems with cosmological model-building from the point of view of General Relativity** — •George Ellis
SYKM 1.2	Di	17:10–17:50	HS 4	**Inhomogeneities in cosmology and the geometry of spacetime averaging** — •Mauro Carfora
SYKM 1.3	Di	17:50–18:30	HS 4	**Bayes, datasets, and priors in the hunt for dark energy** — •Michela Massimi

Invited talks of the joint symposium SYPS

See SYPS for the full program of the symposium.

SYPS 1.1	Mi	15:00–15:40	HS 5	**Black-hole superradiance: Probing ultralight bosons with compact objects and gravitational waves** — •Paolo Pani
SYPS 1.2	Mi	15:40–16:10	HS 5	**Modelling and analyzing a binary neutron-star merger: Interpreting a multi-messenger picture** — •Tim Dietrich
SYPS 1.3	Mi	16:10–16:40	HS 5	**What can neutron-star mergers reveal about the equation of state of dense matter?** — •Ingo Tews

Sessions

GR 1.1–1.3	Mo	16:00–17:30	HS 4	**Classical GR**
GR 2.1–2.3	Mo	17:30–18:45	HS 4	**General Aspects: Units, History and Quantum**
GR 3.1–3.5	Di	11:00–12:45	HS 4	**Cosmology I**
GR 4.1–4.6	Di	14:00–15:30	HS 4	**Cosmology II**
GR 5.1–5.5	Di	14:00–15:15	HS 5	**Foundational Problems and General Formalism**
GR 6.1–6.6	Mi	11:00–13:00	HS 4	**Numerical Relativity**
GR 7.1–7.7	Mi	11:00–12:45	HS 5	**Modified Gravity and Applications**
GR 8.1–8.7	Mi	14:00–16:15	HS 4	**Quantum Cosmology and Quantum Gravity I**
GR 9.1–9.5	Mi	17:00–19:10	HS 4	**Quantum Gravity (joint session MP/GR)**
GR 10.1–10.6	Do	11:00–13:00	HS 4	**GR and Astrophysics I**
GR 11.1–11.7	Do	11:00–12:45	HS 5	**Quantum Cosmology and Quantum Gravity II**
GR 12.1–12.8	Do	14:00–16:30	HS 4	**Gravitational Waves**
GR 13.1–13.6	Do	15:00–16:30	HS 5	**Alternative Approaches to Quantum Gravity**
GR 14.1–14.22	Do	16:30–18:30	HS 6	**Poster Session (posters are permanently on display)**
GR 15	Do	18:30–19:30	HS 4	**General Assembly of the Gravitation and Relativity Division**
GR 16.1–16.5	Fr	11:30–12:45	HS 4	**GR and Astrophysics II**
GR 17.1–17.5	Fr	11:30–12:45	HS 5	**Alternative Approaches**

General Assembly of the Gravitation and Relativity Division

Thursday 18:30–19:30 HS4

- Report by the chairperson
- Reports on past and future events by members
- Presentation of books authored by members
- Miscellaneous

GR 1: Classical GR

Zeit: Montag 16:00–17:30 Raum: HS 4

Hauptvortrag GR 1.1 Mo 16:00 HS 4

Probing the spacetime curvature using geometric optics — •Mikolaj Korzynski, Julius Serbenta, and Michele Grasso — Center for Theoretical Physics, Polish Academy of Sciences, Warsaw

In general relativity light propagation is affected by gravity, leading to the well-known effects of light bending, Shapiro delays and gravitational redshift. On top of that the results of observation of light by an observer are also affected by the special relativistic phenomena like the aberration or time dilation. All these effects influence the measurements of shape, parallax, redshift and position drift (proper motion) of distant objects. We show that all results of those measurements can be understood as functions of the curvature along the line of sight. This opens up the possibility to probe the spacetime curvature directly using optical observations. Applications of the results include cosmology and numerical relativity.

GR 1.2 Mo 16:45 HS 4

Geodetic Concepts in the Framework of General Relativity — •Dennis Philipp — ZARM, Universität Bremen

The description and determination of the Earth's gravity field is one of the central objectives of geodesy. Fundamental geodetic concepts and notions are usually defined within Newtonian gravity and must be reconsidered in General Relativity (GR) to have a theoretical framework that can keep up with ever increasing experimental accuracy. Moreover, in GR the rate of a clock, as compared to some reference, depends on the clock's state of motion and its position in the gravitational field. This is the starting point of chronometric geodesy, an entirely new field that is based on comparing state of the art (optical) atomic clocks.

In my talk, I will introduce the relativistic description of the Earth's geoid, its so-called normal gravity field, and a relativistic height definition. In the (post-)Newtonian limit, well-known results are recovered. To estimate the magnitude of relativistic "corrections", the differences to the respective Newtonian notions are calculated to first order.

GR 1.3 Mo 17:00 HS 4

The extended gravitational clock compass — •Gerald Neumann[1], Guillermo Rubilar[1], and Dirk Puetzfeld[2] — [1]Departamento de Física, Universidad de Concepción, Casilla 160-C, Concepción, Chile — [2]University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen, Germany

By extending the framework of the gravitational clock compass [1], we show how a suitably prepared set of clocks can be used to extract information about the gravitational field in the context of General Relativity. Conceptual differences between the extended and the standard clock compass are highlighted. Particular attention is paid to the influence of kinematical quantities on the measurement process and the setup of the compass. We also discuss the precision with which quantities as the acceleration and the angular velocity of the frame, as well as the components of the curvature of the spacetime, can be determined.

[1] D. Puetzfeld, Y.N. Obukhov and C. Laemmerzahl, Gravitational clock compass in general relativity, PRD 98 024032 (2018).

15 min. break

GR 2: General Aspects: Units, History and Quantum

Zeit: Montag 17:30–18:45 Raum: HS 4

Hauptvortrag GR 2.1 Mo 17:30 HS 4

Physical dimensions/units and universal constants: their invariance in special and general relativity — •Friedrich W. Hehl[1] and Claus Lämmerzahl[2] — [1]Inst.Theor.Physik, Univ., 50923 Köln, Germany — [2]ZARM, Univ., 28359 Bremen, Germany

The theory of physical dimensions and units in physics is outlined. This includes a discussion of the universal applicability and superiority of quantity equations. The International System of Units (SI) is one example thereof. By analyzing mechanics and electrodynamics, we are naturally led, besides the dimensions of length and time, to the fundamental units of action $\mathfrak{h}$, electric charge q, and magnetic flux ϕ. We have $q \times \phi =$ action and $q/\phi = 1/$resistance. These results of *classical physics* suggests to look into the corresponding quantum aspects of q and ϕ (and also of $\mathfrak{h}$): The electric charge occurs exclusively in elementary charges e, whereas the magnetic flux can have any value; in specific situations, however, in superconductors of type II at very low temperatures, ϕ appears quantized in the form of fluxons (Abrikosov vortices). And $\mathfrak{h}$ leads, of course, to the Planck quantum h. Thus, we are directed to superconductivity and, because of the resistance, to the quantum Hall effect. In this way, the Josephson and the quantum Hall effects come into focus quite naturally. One goal is to determine the behavior of the fundamental constants in special and in general relativity, that is, if gravity is thought to be switched off versus the case in the gravitational field. Relations to the *new* International System of Units (SI) of 2019 are pointed out.

GR 2.2 Mo 18:15 HS 4

Interpreting the Schwarzschild Metric — •Dennis Lehmkuhl — Institut für Philosophie, Universität Bonn, Am Hof 1, 53113 Bonn

It is sometimes said that the Schwarzschild solution to the Einstein field equations was discovered in 1916 but that it took until the 1950s or 1960s before it was understood that the Schwarzschild metric represents a black hole. Such statements are puzzling, for the Schwarzschild metric was successfully used and applied from its very inception. In this talk, I will trace the history of different applications, interpretations and, intimately linked, coordinatizations of the Schwarzschild metric. The focus will be on a.) Einstein's use of an approximation to the Schwarzschild metric in the prediction of Mercury's perihelion in 1915 and his subsequent correspondence with Schwarzschild and others on the corresponding exact solution; b.) discussions of what we would today call the event horizon of the Schwarzschild metric during the 1920s; and c.) the development of a conceptual distinction between singularities and horizons in the late 1950s and early 1960s and the resulting new perspective on the Schwarzschild metric.

GR 2.3 Mo 18:30 HS 4

Gravitation and Quantum Theory - Reflections on some basic questions — •Thomas Görnitz — Karl-Mangold-Str. 13, 81245 München — Fachbereich Physik, Goethe-Uni Frankfurt/M

Einstein's GRTh has proven itself excellently in all empirical investigations, including the universal equality of inertial and heavy mass. Gravity proves to be a space-time geometry that affects everything identically. Nevertheless, there are cloudings of this fascinating image. It has been known since 1933 that there must be "dark matter". Homogeneity and isotropy of the background radiation led to the invention of inflation. The Kruskal metric shows a seamless incidence from the outside into the inside of a black hole, in which all matter disappears in a mathematical point. Most problematic is that the efforts to connect GRTh with quantum theory in a conventional way remained in vain, as did the search for particles to explain inflation or dark matter. Fundamental quantum theoretical reflections reveal the core of this problem and a way out of it. The solutions already achieved are presented.

GR 3: Cosmology I

Zeit: Dienstag 11:00–12:45 Raum: HS 4

Hauptvortrag GR 3.1 Di 11:00 HS 4
An analytic approach to cosmic structure formation — •Matthias Bartelmann — Universität Heidelberg

The non-linear, late-time evolution of cosmic structures is notoriously hard to tackle with analytic methods. While numerical simulations are highly successful and lead to impressive results, there are fundamental as well as pragmatic reasons for an analytic understanding to be sought. Conventional methods based on the hydrodynamic equations are limited mainly by the shell-crossing problem. In this talk, I shall review a novel approach based on kinetic field theory. It structurally resembles a non-equilibrium statistical quantum field theory and avoids the shell-crossing problem by construction. Suitably approximating particle interactions allows the derivation of a closed, non-perturbative, parameter-free expression for the non-linear cosmic-density power spectrum which reproduces numerical results to better than 10% up wave numbers of k ~ 10 h/Mpc at redshift 0. The formalism can straightforwardly be generalised to mixtures of gas and dark matter, axionic dark matter, or modified gravity theories, for which I shall show first examples.

GR 3.2 Di 11:45 HS 4
A semiclassical path to cosmic large-scale structure — •Cora Uhlemann — Centre for Theoretical Cosmology, University of Cambridge, UK — Fitzwilliam College, University of Cambridge, UK

We chart a path towards solving for the nonlinear gravitational dynamics of cold dark matter by relying on a semiclassical description using the propagator. The evolution of the propagator is given by a Schroedinger equation, where the small parameter acts as a softening scale that regulates singularities at shell-crossing, where particle trajectories cross. The leading-order propagator, called free propagator, is the semiclassical equivalent of the Zeldovich approximation, where particles move along straight trajectories. At next-to-leading order, we solve for the propagator perturbatively and obtain the displacement and velocity fields in the classical limit. We show that our perturbative results respect the underlying Hamiltonian structure and complement our analysis with illustrative numerical examples showing that the propagator solutions closely resemble Lagrangian Perturbation Theory. Finally, we demonstrate the generation of vorticity, which is a non-trivial multi-stream phenomenon that arises naturally as a conserved topological charge in our propagator method.

GR 3.3 Di 12:00 HS 4
Structure formation with Kinetic Field Theory in the non-linear regime — •Elena Kozlikin and Matthias Bartelmann — Universität Heidelberg, Zentrum für Astronomie, Institut für Theoretische Astrophysik, Philosophenweg 12, 69120 Heidelberg

Thus far, the non-linear regime of structure formation is only accessible through expensive numerical N-body simulations since the conventional analytic treatment of cosmic density fluctuations via the hydrodynamical equations runs into severe problems even in a mildly non-linear regime. I will give an overview of a novel analytic approach to cosmic large-scale structure formation which provides a density fluctuation power spectrum that agrees well with state of the art N-body simulations up to $k = 10h\,\mathrm{Mpc}^{-1}$. I will point out how our Kinetic Field Theory avoids the difficulties of standard perturbation theory by construction and allows to proceed deeply into the non-linear regime of density fluctuations. My main focus will be on the opportunities this method provides to study the physics behind structure formation. I will show that a delicate balance between damping and the interaction potential is required to produce the large-scale structures we observe and how ignoring this balance in perturbation schemes can give misleading results. I will further discuss how the form of the interaction potential influences the formation of structure and the implication it bears on the density profile of dark matter haloes.

GR 3.4 Di 12:15 HS 4
Influence of baryonic matter on cosmic structure formation with Kinetic Field Theory — •Ivan Kostyuk[1], Robert Lilow[2], and Matthias Bartelmann[1] — [1]Universität Heidelberg, Zentrum für Astronomie, Institut für Theoretische Astrophysik, 69120 Heidelberg — [2]Department of Physics, Technion, Haifa 3200003, Israel

Baryonic matter with its non-gravitational interactions has profound influence on large-scale cosmic structure formation. To gain an understanding of structure growth it is therefore necessary to investigate how a mixture of dark and baryonic matter coevolves through the cosmic history. To describe this evolution Kinetic Field Theory is used whereby individual classical matter particles are evolved using their Hamiltonian dynamics. To average out frequent microscopic interactions between baryonic particles, they are encapsulated in effective mesoscopic particles which follow the hydrodynamic equations of motion. The main effects of baryons on large scale cosmic structures are of two kinds: firstly through baryon acoustic oscillations in the early Universe, and secondly through pressure and cooling effects in the late Universe. In the first case, we are able to reproduce features of baryon-acoustic oscillations in the spectrum. In the later case, taking into account pressure causes a suppression of power at small scales.

GR 3.5 Di 12:30 HS 4
Higher order statistics of cosmic density fluctuations with Kinetic Field Theory — •Sara Konrad and Matthias Bartelmann — Universität Heidelberg, Zentrum für Astronomie, Institut für theoretische Astrophysik

Computing third- and higher-order power spectra of the cosmic density fluctuations is of great interest for our understandig of cosmic structure formation, since polyspectra contain information about the non-gaussianity of the cosmic density field. Furthermore, in order to determine the likelihood of a cosmological model from measured n-point correlation functions, 2n-point correlation functions are necessary. However, up to now, no standard methods exist to compute non-linear polyspectra analytically for arbitrary scales, and obtaining them from simulations is computationally demanding. Our Kinetic Field Theory is a novel approach to describe non-linear structure formation analytically beyond shell crossing. In this talk I present an analytical closed expression for the non-linear free-streaming solution for polyspectra of arbitrary order, emerging from gaussian initial conditions. Furthermore, I show current approaches on how the non-linear evolution due to interactions can be incorporated and present first results for the cosmic bispectrum.

GR 4: Cosmology II

Zeit: Dienstag 14:00–15:30 Raum: HS 4

GR 4.1 Di 14:00 HS 4
Relativistic effects in N-body simulations of cosmic large-scale structure — •Julian Adamek[1], Chris Clarkson[1], Louis Coates[1], Ruth Durrer[2], and Martin Kunz[2] — [1]Queen Mary University of London, UK — [2]Université de Genève, CH

As our advanced telescopes produce ever larger and deeper maps of our Universe we need to consider that observations are taken on our past light cone and on a spacetime geometry that is pervaded by small distortions. A precise understanding of the weak-field regime of General Relativity allows one to model these aspects consistently within N-body simulations of cosmic structure formation. The subtle relativistic effects in cosmic structure can tell us how gravity operates on the largest scales that we observe and may hold the key to unravelling the mystery of dark energy.

GR 4.2 Di 14:15 HS 4
Non-linear cosmic structure formation with Fuzzy Dark Matter using Kinetic Field Theory — •Carsten Littek — Zentrum für Astronomie Heidelberg, Heidelberg, Germany

In recent years, Fuzzy Dark Matter (FDM) such as an Ultra-Light Axion has attracted much interest. The FDM particle is an extremely light scalar boson, and the FDM dynamics is that of a condensate.

The particles are therefore subject not only to gravity but also to a quantum potential which acts repulsively. Kinetic Field Theory (KFT) is a non-equilibrium statistical field theory which describes structures as ensembles of classical Hamiltonian particles in phase-space. I will present how FDM and the quantum potential can be included in the KFT approach to structure formation. In comparison to Cold Dark Matter we find differences in the power-spectrum on scales near the onset of non-linear structure formation.

GR 4.3 Di 14:30 HS 4

Void dynamics as a probe of cosmology and gravity — •Nico Hamaus — Universitäts-Sternwarte München, Fakultät für Physik, Ludwig-Maximilians Universität München, Scheinerstr. 1, 81679 München, Germany

Redshift surveys measure the location of millions of galaxies in the observable Universe, thereby constructing a three-dimensional map of its large-scale structure. This structure is characterized by dense clusters of galaxies, connected by filaments and sheets of lower density. The remaining and dominant volume within this cosmic web is taken up by voids, vast regions of relatively empty space. I will highlight some recent advances in modeling average void density and velocity profiles, as well as their anisotropic shapes in redshift space on the basis of simulations and mock galaxy catalogs. While clusters, filaments and sheets have entered various stages of nonlinearity in the past, voids represent structures whose dynamic evolution can be described remarkably well by linear theory, suggesting them to be among the most pristine objects to consider for future studies on the nature of dark energy, dark matter and gravity. I will present first results in this context, obtained via the analysis of galaxy survey data from the Sloan Digital Sky Survey.

GR 4.4 Di 14:45 HS 4

A halo mass function from the non-linear density field: an analytic approach — •Johannes Schwinn — ZAH, ITA, Universität Heidelberg, Heidelberg, Germany

The halo mass function is a very important probe for testing cosmological models and our theory of structure formation. However, the only analytical deduction of the halo mass function (apart from fitting formulas) is based on the linear evolution of the cosmic density field and spherical collapse. Since both of these assumptions are not ideal, we derived an analytical estimate of the HMF from the non-linearly evolved density field. Our approach is based on excursion set statistics with correlated steps, which we combine with a PDF model of the cosmic density field. The parameters of this PDF model are fixed by the Kinetic Field Theory (KFT) of cosmic structure formation. This yields a closed-form expression of the HMF that only depends on the overdensity threshold. Treating this threshold as a free parameter, we find very good agreement with measurements from numerical simulations over the mass range from 10^{10} to 10^{16} $M_\odot$.

GR 4.5 Di 15:00 HS 4

Kosmische Strukturbildung für doppelbrechende Materietheorien — •Hans-Martin Rieser und Björn Malte Schäfer — Zentrum fuer Astronomie der Universitaet Heidelberg, Astronomisches Rechen-Institut

Die jüngsten Fortschritte in der konstruktiven Gravitation [1] erlauben die Betrachtung von Phänomenen auf kosmologischen Distanzen für materieinduzierte, insbesondere nichtmetrische Gravitationstheorien. Ausgehend von einer potentiell doppelbrechenden Materietheorie, die mit einer generalisierten Elektrodynamik der Form $\mathcal{L} \propto G^{abcd} F_{ab} F_{cd}$ beschrieben werden kann, und der zugehörigen Raumzeitstruktur aus dem Algorithmus der konstruktiven Gravitation lassen sich Wachstumsgleichungen für kosmische Strukturen herleiten.

Die Verwendung der neuen Theorie führt eine zweite Längenskala zusätzlich zu der durch die lokale Schallgeschwindigkeit festgelegten Skala ein. Dies führt zu einer Modifikation des Wachstumsverhaltens, das sich beispielsweise in der Veränderung von Größen wie der Jeans-Länge zeigt.

[1] Düll, M.; Fischer, N; Schäfer, B; Schuller, F (2019): Constructive Cosmology. In Vorbereitung.

GR 4.6 Di 15:15 HS 4

Weltpotentialtheorie (WPT) – Urknall, beschleunigte Expansion und Krummräume: alles nur Trugbilder müden Lichts — •Peter Wolff — Wolff Grundlagenforschung, Balterswil

Den Schwerpunkt des Vortrags werde ich auf die äusserst einfache Erklärung der beschleunigten Expansion und damit der dunklen Energie als Trugbild „müden“ Lichts legen: Sie beruht auf Einsteins originalem Äquivalenzprinzip von 1907 und dem neuen Weltpotential mit zugehöriger universeller, gravitativer Bremsbeschleunigung Hc, die die kosmische Zeitdehnung und Rotverschiebung als Schwere- statt Expansionseffekt erklärt.

Weiter verstärkt die Weltbremsbeschleunigung Hc „genügend“ schwache lokale Schwerefelder und gaukelt so Dunkle Materie vor. Als leicht freier Parameter bleibt nur noch die mittlere Dichte des in der WPT als aktual unendlich angenommenen Weltalls. Trotzdem kann die WPT die Beobachtungen gesamthaft betrachtet besser erklären als die Standardkosmologie.

Für näher Interessierte: www.wolff.ch/astro/WPT-Lesetipp.pdf

GR 5: Foundational Problems and General Formalism

Zeit: Dienstag 14:00–15:15 Raum: HS 5

GR 5.1 Di 14:00 HS 5

Deviation of structured test bodies — •Dirk Puetzfeld — ZARM, Universitaet Bremen

Within the theory of General Relativity, the relative motion of test bodies is described by means of the geodesic deviation (Jacobi) equation. This equation only holds under certain assumptions and can be used only for the description of structureless neutral test bodies. Here we present a generalized deviation equation in a Riemann-Cartan background, also allowing for spacetimes endowed with torsion. This equation describes the dynamics of the connecting vector which links events on two general (adjacent) world lines. Thereby it provides the foundation for a unified description of structured test bodies in a large class of geometries.

GR 5.2 Di 14:15 HS 5

Gravitational closure of weakly birefringent spacetimes to second order — •Florian Wolz — Leibniz Universität, Hannover, Deutschland — Friedrich-Alexander-Universität, Erlangen, Deutschland

Within the constructive gravity program it was shown that any predictive and quantizable matter field theory poses strong conditions on the underlying geometry. This allows to determine the geometry's Lagrangian completely by solving a system of linear homogeneous partial differential equations called the gravitational closure equations.

In most practical situations it suffices to perturbatively solve these equations. In this talk I will present the results for the gravitational closure to second order field equations of the geometry of birefringent electrodynamics. This is necessary to calculate the generation of gravitational waves in a binary system.

GR 5.3 Di 14:30 HS 5

Refined cosmology from refined electrodynamics — •Maximilian Düll — Zentrum für Astronomie der Universität Heidelberg

The Constructive Gravity program provides new insights into the interaction of matter and gravity. Its central statement is that the gravitational action is derived from a matter action as the solution to a set of linear partial differential equations, the gravitational closure equations. Requiring common canonical evolution of initial data for both matter and background geometry, the task of finding viable gravity theories is reduced to solving a set of linear partial differential equations.

Once gravitational field equations have been obtained, one often wishes to solve them under symmetry assumptions. We will show how to include such a symmetry reduction into the Constructive Gravity program. This allows us to solve a simplified version of the closure equations to directly obtain the appropriately symmetry-reduced gravitational field equations.

Using Maxwell electrodynamics as matter input, we showed that such a symmetry-reduction at the level of the gravitational closure equations works. We can directly derive the Friedmann equations without having to know the full Einstein equations. Refining the matter input by implementing general linear electrodynamics, we can follow the same steps towards refined Friedmann equations. When performing this symmetry reduction, we find new techniques how to handle the gravitational closure equations and obtain solutions to them.

GR 5.4 Di 14:45 HS 5

Der Sagnac-Effekt widerspricht Einsteins Relativität — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

Die Verträglichkeit des Sagnac-Effekts mit der Speziellen Relativitätstheorie wurde schon häufig untersucht; üblicherweise mit dem Ergebnis, dass beides verträglich ist. Dabei beschränkten sich die Untersuchungen jedoch stets auf Situationen, bei denen ein Konflikt nicht sichtbar ist.

Wir werden den Fall des in der Navigation gebräuchlichen Sagnac-Kreisels vorstellen, bei welchem der Beobachter an einer Drehung des Systems teilnimmt. Für diesen Beobachter ist die Lichtgeschwindigkeit im Lichtleiter nicht c, sondern um die Drehgeschwindigkeit des Systems verändert; sonst hätte der Kreisel keine Funktion. Bei einer angenommenen beliebigen Ausdehnung des Kreisels nähert sich nun die gekrümmte Lichtbahn einer Geraden, ohne dass sich die Diskrepanz Sagnac vs. Einstein verringert. Damit erlischt der Einwand der Nichtanwendbarkeit der Speziellen Relativitätstheorie im drehenden System. Folgerung: Die Festlegung Einsteins für ein konstantes c in jedem Bewegungssystem ist tatsächlich nicht haltbar.

Ursache für diesen logischen Konflikt ist eine zu kühne Annahme in Einsteins Arbeit von 1905, welche in einem Zirkelschluss endet. Bei seinem Ansatz der Uhrensync. postulierte Einstein die Konstanz von c im bewegten System, um sie dann wiederum als Ergebnis zu erhalten.

Auch die Diskussion um einen Äther bekommt hierbei neue Nahrung.

Weitere Info unter: www.ag-physics.org/Sagnac

GR 5.5 Di 15:00 HS 5

Parametrodynamics — •Alexander Wierzba — Ludwig-Maximilians-Universität München

Parameters appearing in physical theories are usually considered to be constants whose values have to be determined by experiment. In this talk, however, we present a method to instead predict the values of parameters appearing in a large class of local field theories. In order to do this, we first promote the previously constant parameters to dynamical objects in their own right - analogous to what Einstein did with the previously flat spacetime metric in Maxwell theory in order to obtain his general theory of relativity. In a second step, we then derive a multi-parameter family of actions for these parameters as the unique dynamics that enjoys a consistent co-evolution with the already dynamical matter fields of the initially stipulated matter theory.

We illustrate this mechanism for a refined version of Proca electrodynamics with an anisotropic mass. As crucial technical prerequisite to these studies, we furthermore develop a comprehensive scheme to calculate the principal polynomial for initially non-involutive systems of partial differential equations.

GR 6: Numerical Relativity

Zeit: Mittwoch 11:00–13:00 Raum: HS 4

Hauptvortrag GR 6.1 Mi 11:00 HS 4

Modeling the strong-field dynamics of binary neutron star merger — •Sebastiano Bernuzzi — FSU Jena, Germany

The observation of gravitational and electromagnetic waves from a binary neutron star merger in August 2017 delivered key information on the nature of matter at supranuclear densities, on the origin of short-gamma ray burst, on the production site of of heavy elements via r-process nucleosynthesis, and on cosmography. Thus, multimessenger observations of compact binary mergers hold the promise to unprecedent insights on some of the most fundamental physics questions. A crucial and necessary ingredient to interpret such observations is the precise knowledge of the dynamics of the source. I will talk about recent developments on the modeling of neutron star mergers using numerical simulations in general relativity. I will focus on the numerical exploration of the the merger remnant and mass ejecta and their dependence on the binary parameters. I will discuss detailed models of the gravitational waves and kilonova light curves, highlighting the prospect of using them in joint analysis of multimessenger data.

GR 6.2 Mi 11:45 HS 4

Electromagnetic Counterpart of Neutron Star Mergers — •Vsevolod Nedora and Sebastiano Bernuzzi — Theoretisch-Physikalisches Institut, Jena, Germany

Neutron star merger is a unique cosmic laboratory to investigate general relativity in a strong field regime and fundamental physics, including dense matter and heavy-elements-nucleosynthesis.

Our work focuses on the kilonovae counterpart of the gravitational wave source GW170817. We study the merger dynamics and light curves employing state of the art numerical general relativistic simulations. We provide further insights into the properties of the equation of state of neutron stars and nucleosynthetic yields.

GR 6.3 Mi 12:00 HS 4

Numerical relativity simulations of highly spinning binary neutron star mergers — •reetika dudi[1], tim dietrich[2], wolfgang tichy[3], and alireza Rashti[3] — [1]Theoretical Physics Institute, University of Jena, 07743 Jena, Germany — [2]Nikhef, Amsterdam, The Netherlands — [3]Florida Atlantic University, Boca Raton, USA

Neutron stars in a binary are spinning objects. Therefore, it is very important to include spin in numerical simulations of binary neutron stars(BNS). Our colleagues have developed a formalism to construct BNS initial data with in principle arbitrary masses, spins and eccentricities. Here we present results of evolution of highly spinning BNS (up to dimensionless spin of approx. 0.5) with full (3+1)D numerical relativity simulations using consistent initial conditions. These are among the highest spinning numerical evolutions of BNSs to date. These waveforms with high resolution can be used as a testbed to extract the spin effects in the GW phase evolution and to test other semi-analytical waveform models.

GR 6.4 Mi 12:15 HS 4

Improvements on Initial Data for Spinning Neutron Star Binaries — •Hannes Rüter — Max-Planck-Institut für Gravitationsphysik, Potsdam/Golm

The current formalism to construct numerical relativity initial data for neutron star binaries with spin makes some assumptions that are not compatible with the constraints given by energy-momentum conservation. This talk will discuss issues of the current formalism and propose possible solutions and improvements, which will be important for future high accuracy binary neutron star simulations.

GR 6.5 Mi 12:30 HS 4

Eccentric Binary Neutron Stars in Numerical Relativity — •Swami Vivekanandji Chaurasia[1], Tim Dietrich[2], Nathan K. Johnson-McDaniel[3], Maximiliano Ujevic[4], Wolfgang Tichy[5], and Bernd Bruegmann[1] — [1]Theoretical Physics Institute, FSU-Jena, Germany — [2]Nikhef, Amsterdam, The Netherlands — [3]DAMTP, Centre for Mathematical Sciences, Cambridge, U.K — [4]Centre for Natural Sciences and Humanities, Fedral University of ABC, Brazil — [5]Department of Physics, Florida Atlantic University, U.S.A

This talk summarizes the recent efforts of the BAM collaboration in pursuing the goal of simulating generic binary neutron star mergers. In particular, I will highlight the recent progress from new simulations of eccentric systems in full general relativity which, for the first time, are based on consistent initial data setting new quality-standard for these simulations. We extract from the simulated waveforms the frequency of the *f*-mode oscillations induced during close encounters before the merger of the two stars. We find the extracted frequency to be in good agreement with *f*- mode oscillations of individual stars, which allows an independent measure of the supranuclear equation of state not accessible for binaries on quasi-circular orbits. Furthermore, the energy stored in these *f*-mode oscillations can be as large as 10^{-3} $M_\odot \sim 10^{51}$ erg (energy in a supernova!), even with a soft EOS. While in general (eccentric) neutron star mergers produce bright EM counterparts, we find that for the considered cases the luminosity decreases when the eccentricity becomes too large, due to a decrease in the ejecta.

GR 6.6 Mi 12:45 HS 4

A discontinuous Galerkin elliptic solver with task-based parallelism for the SpECTRE code — •Nils Fischer — Max-Planck-Institut für Gravitationsphysik (AEI) Potsdam, Deutschland

I report on progress on the next-generation pseudo-spectral numerical relativity code SpECTRE, currently in development by the SXS collaboration. It combines nodal discontinuous Galerkin methods and task-based parallelism to achieve more accurate solutions for challenging relativistic astrophysics problems such as core-collapse supernovae and binary neutron star mergers. In particular, I present the numerical scheme to solve elliptic partial differential equations in SpECTRE. Since equations of this type appear in general relativistic initial data problems, they serve as the starting point for time evolutions. I demonstrate the code's ability to scale to the capacity of the Minerva supercomputer at AEI Potsdam.

GR 7: Modified Gravity and Applications

Zeit: Mittwoch 11:00–12:45 Raum: HS 5

GR 7.1 Mi 11:00 HS 5

Wormhole Solutions in Dilatonic Einstein-Gauss-Bonnet Theory — Panagiota Kanti[1], Burkhard Kleihaus[2], and •Jutta Kunz[2] — [1]University of Ioannina, Greece — [2]University of Oldenburg, Germany

Dilatonic Einstein-Gauss-Bonnet theory allows for wormhole solutions without the need for exotic matter. Here the presence of the higher-curvature term coupled to a dilaton, as suggested by string theory, leads to an effective stress-energy tensor, violating the energy conditions. The static wormhole solutions may possess a single throat or a double throat with an equator in between. The global charges of the wormhole solutions are analyzed as well as the properties of their throat(s). Linear stability of the static solutions is considered, and slowly rotating wormhole solutions are obtained perturbatively.

GR 7.2 Mi 11:15 HS 5

Quasinormal modes of neutron stars with scalar hair. — •Jose Luis Blázquez-Salcedo[1], Fech Scen Khoo[2], and Jutta Kunz[1] — [1]University of Oldenburg, Institute of Physics, Oldenburg, Germany — [2]Ruder Bošković Institute, Zagreb, Croatia

In this talk we will discuss the quasinormal modes of neutron stars in modified theories of gravity, where the system possesses a (massive) scalar degree of freedom, in addition to the space-time and fluid degrees of freedom that are present in General Relativity. Hence we will show that the spectrum of resonances of the ringdown phase of the gravitational waves emitted by these objects is richer. We will discuss different properties of this spectrum, such as the dependence with the mass of the scalar field, the equation of state and total mass of the neutron star.

GR 7.3 Mi 11:30 HS 5

The gravitational field of static p-branes in linearized ghost-free gravity — •Jens Boos[1], Valeri P. Frolov[1,2], and Andrei Zelnikov[1] — [1]Theoretical Physics Institute, University of Alberta, Edmonton, Alberta, Canada T6G 2E1 — [2]Yukawa Institute for Theoretical Physics, Kyoto University, 606-8502, Kyoto, Japan

We study the gravitational field of static p-branes in D-dimensional Minkowski space in the framework of linearized ghost-free (GF) gravity. We show that the singular behavior of the gravitational field of p-branes in General Relativity is cured by short-range modifications introduced by the non-locality, and we derive exact expressions of the regularized gravitational fields, whose geometry can be written as a warped metric. For large distances compared to the scale of non-locality our solutions approach those found in linearized General Relativity.

GR 7.4 Mi 11:45 HS 5

Principal Killing strings in higher-dimensional Kerr-NUT-(A)dS spacetimes — •Jens Boos and Valeri P. Frolov — Theoretical Physics Institute, University of Alberta, Edmonton, Alberta, Canada T6G 2E1

We construct special solutions of the Nambu-Goto equations for stationary strings in a general Kerr-NUT-(A)dS spacetime in any number of dimensions. This construction is based on the existence of explicit and hidden symmetries generated by the principal tensor which exists for these metrics. The characteristic property of these string configurations, which we call "principal Killing strings," is that they are stretched out from infinity to the horizon of the Kerr-NUT-(A)dS black hole and remain regular at the latter. We also demonstrate that principal Killing strings extract angular momentum from higher-dimensional rotating black holes and interpret this as the action of an asymptotic torque.

GR 7.5 Mi 12:00 HS 5

Black Hole Superradiance in Modified Gravity (MOG) — •Michael F. Wondrak[1,2], Piero Nicolini[1,2], and John W. Moffat[3] — [1]Frankfurt Institute for Advanced Studies (FIAS), Frankfurt am Main, Germany — [2]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität Frankfurt, Frankfurt am Main, Germany — [3]Perimeter Institute for Theoretical Physics, Waterloo, ON, Canada

When bosonic fields scatter off a black hole, the reflected radiation can gain a larger field amplitude than the incident one. This phenomenon, called superradiance, is typically sourced by the black hole electric charge or its angular momentum.

In this talk, we investigate superradiant scattering by black holes in Moffat's modified gravity (MOG). This theory replaces the need for dark matter in favor of an additional gravitational interaction. By comparison with Einstein's general relativity (GR), we find that the properties of superradiance crucially depend on the MOG parameter space: Even for small deviations from GR, there is a distinct reduction in the critical amplification frequency and in the overall brightness. Astronomical observation of superradiant scattering thus could provide an accurate test of MOG.

GR 7.6 Mi 12:15 HS 5

Axial quasi-normal modes of massive and massless scalarized neutron stars — •Zahra Altaha Motahar, Jose Luis Blázquez-Salcedo, Jutta Kunz, and Burkhard Kleihaus — University of Oldenburg, Institute of Physics, Oldenburg, Germany

The emission of gravitational waves as produced by colliding black holes and neutron stars in the observed events follows a typical sequence of phases, consisting of inspiral, merger and ringdown. The ringdown of the final compact object is dominated by its quasi-normal modes. We studied the axial quasi-normal modes of the massless and massive scalarized neutron stars with self interacting. In particular, we employed various realistic equations of state including nuclear, hyperonic and hybrid matter. Although the effect of spontaneous scalarization of neutron stars can be very large, binary pulsar observations and gravitational wave detections significantly constrain the massless scalar-tensor theories. If we consider a nonzero mass for the scalar field, the parameters of the massive case cannot be restricted by the observations, resulting in the large deviations of massive scalarized solutions from pure general relativity. In addition, we extended the universal relations for quasi-normal modes known in general relativity to the wide range of realistic EOS for massive and massless scalarized neutron stars.

GR 7.7 Mi 12:30 HS 5

The Ringdown of Wormholes — •Xiao Yan Chew, Jose Luis Blazquez-Salcedo, and Jutta Kunz — Carl von Ossietzky Universität Oldenburg Fakultät V - Mathematik und Naturwissenschaften Carl-von-Ossietzky-Str. 9-11 26129 Oldenburg

We calculate the quasinormal modes by WKB method and numerical direct integration for scalar, axial and radial perturbations of wormholes supported by a phantom scalar field. The spectrum of the quasinormal modes is compared with the spectrum of Schwarzschild black holes. For fixed multipole number l and large mass M the wormhole modes approach their black hole counterparts as 1/M.

GR 8: Quantum Cosmology and Quantum Gravity I

Zeit: Mittwoch 14:00–16:15 Raum: HS 4

Hauptvortrag GR 8.1 Mi 14:00 HS 4

Loop quantum cosmology, signature change, and the no-boundary proposal — •Martin Bojowald — The Pennsylvania State University, University Park, PA, USA

Loop quantum gravity suggests a discrete structure of space which should be relevant for physics at large energy scales, in particular near the big bang. Several unexpected consequences have been derived in loop quantum cosmology. The possibility of signature change at high density is one example, which not only reveals a heuristic kinship with the no-boundary proposal of Hartle and Hawking but also helps to solve stability problems recently found by Feldbrugge, Lehners and Turok in an application of Lorentzian path integrals.

GR 8.2 Mi 14:45 HS 4

Singularity Avoidance of the Quantum LTB Model for Gravitational Collapse — •Tim Schmitz and Claus Kiefer — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany

We quantize the marginally bound Lemaître–Tolman–Bondi model for spherically symmetric dust collapse by considering each dust shell in it individually, taking the outermost shell as a stand-in for every other one. Because the dust naturally provides a preferred notion of time, one can construct a quantum theory for this shell analogously to ordinary quantum mechanics, and impose unitary evolution. It then generically avoids the classical singularity, provided the quantization ambiguities fulfill some (weak) conditions. We demonstrate that the collapse to a singularity is replaced by a bounce. Finally we construct a quantum corrected spacetime describing bouncing dust collapse and discuss some of its properties, for example the black hole lifetime.

GR 8.3 Mi 15:00 HS 4

Gauge Fixing and the Semiclassical Interpretation of Quantum Cosmology — •Leonardo Chataignier — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Cologne, Germany

We make a critical review of the semiclassical interpretation of quantum cosmology and emphasise that it is not necessary to consider that time emerges only when the gravitational field is (semi)classical. We show that the usual results of the semiclassical interpretation can be obtained by a gauge fixing, both at the classical and quantum levels. By 'gauge fixing' we mean a particular choice of the time coordinate. In the quantum theory, we adopt a tentative definition of the (Klein-Gordon) inner product, which is positive definite for solutions of the quantum constraint equation found via an iterative procedure that corresponds to a weak coupling expansion in powers of the inverse Planck mass. We conclude that the wave function should be interpreted as a state vector for both gravitational and matter degrees of freedom, the dynamics of which is unitary with respect to the chosen inner product and time variable.

GR 8.4 Mi 15:15 HS 4

Dynamical Properties of the Mukhanov-Sasaki Hamiltonian — •Michael Kobler, Kristina Giesel, and Max Joseph Fahn — Institut für Quantengravitation, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Deutschland

In the context of linearized cosmological perturbation theory, the Mukhanov-Sasaki equation plays a pivotal role. Each mode of this equation resembles a time-dependent harmonic oscillator. We consider the single-mode Mukhanov-Sasaki Hamiltonian as a toy model in mechanics and use the known Lewis-Riesenfeld invariant and the extended phase space formalism introduced in previous works in order to analyze this system. These techniques allow to classically construct an extended canonical transformation that maps an explicitly time-dependent Hamiltonian into a time-independent one, as well as to implement the corresponding unitary map in the quantum theory. Our further analysis leads us to a closed form of the time-evolution operator for the single-mode Mukhanov-Sasaki Hamiltonian, that is to the associated Dyson series. Finally, we discuss an extension of these techniques to the bosonic Fock space, together with some applications for a quasi-de Sitter background.

GR 8.5 Mi 15:30 HS 4

Dynamics of Dirac observables in canonical cosmological perturbation theory — •David Winnekens and Kristina Giesel — University of Erlangen-Nürnberg, Institute for Quantum Gravity, Institute for Quantum Gravity, Staudtstr. 7, 91058 Erlangen

Canonical cosmological perturbation theory describes a Hamiltonian framework for cosmology. Ultimately, a link to the standard Lagrangian treatment is of interest. Proceeding into this direction, Pons et al [1] chose the extended ADM phase space as natural footing that allows for a complete treatment of cosmological gauges that also rely on perturbations of lapse and shift, as it treats them not only as Lagrange multipliers but as dynamical variables. A recent approach [2] generalized their formalism by using geometrical clocks as reference fields and constructing gauge invariant Dirac observables for all conjugate pairs of metric and matter perturbations. Choosing specific clocks corresponds to different Gauge fixings and thereby lead naturally to the respective gauge invariant variables. These are the Bardeen potential for the longitudinal gauge and the Mukhanov-Sasaki variable for the spatially flat gauge. We also present an efficient method to obtain the second order evolution equations of these variables and find accordance with the literature at linear order.

[1] J. M. Pons, D. C. Salisbury and K. A. Sundermeyer. Phys. Rev. D, 80:084015, 2009 & J. Phys.: Conf. Ser., 222, 2010 [2] K. Giesel, A. Herzog. Int. J. Mod. Phys., D27(08):1830005, 2018; K. Giesel, A. Herzog and P. Singh. Class. Quant. Grav., 35(15):155012, 2018 & K. Giesel, P. Singh and D. Winnekens. https://arxiv.org/abs/1811.07972

GR 8.6 Mi 15:45 HS 4

Ramsey Gravity Resonance Spectrosopy with Ultracold Neutrons as a Tool to Probe the Dark Sector — •René Sedmik[1], Joachim Bosina[1,2], Peter Geltenbort[2], Andrei Ivanov[1], Tobias Jenke[2], Jakob Micko[1,2], Mario Pitschmann[1], Tobias Rechberger[1], Martin Thalhammer[1], and Hartmut Abele[1] — [1]Technische Universität Wien, Atominstitut, 1020 Vienna, Austria — [2]Institut Laue-Langevin, 38042 Grenoble, France

While being very successful, general relativity and the standard model of particle physics – presently forming the basis of our physical understanding – seem incomplete due to their incapability to adequately describe dark energy and dark matter. Slowly being accepted, this fact has fuelled a surge in developments of possible modifications of these two theories. Accordingly, numerous experimental attempts testing such modifications have been reported. In this respect, neutrons have proven to be ideal test bodies. With their vanishing electric charge and negligible polarizability, they evade many of the technical difficulties typically plaguing high precision measurements with atoms, molecules, or macroscopic test bodies. The qBounce collaboration has repeatedly used ultracold neutrons to set tight limits on several candidate models aiming to explain the observed dark sector effects. In this talk, we present the next step in the development of qBounce: Ramsey-type gravity resonance spectroscopy. We discuss the implementation, prospects, and challenges of this new method, and show first results yielding an unambiguous proof of principle.

GR 8.7 Mi 16:00 HS 4

Post-Newtonian corrections to Schrödinger equations in gravitational fields — •Philip Schwartz and Domenico Giulini — Institute for Theoretical Physics, Leibniz University Hannover, Appelstraße 2, 30167 Hannover, Germany

With the aim of comparing different methods for the post-Newtonian description of single quantum particles in gravity, we develop a WKB-like systematic 'non-relativistic' expansion scheme for the classical minimally coupled Klein–Gordon equation to arbitrary order in $1/c$. Comparing the results to canonical quantisation of free particles, as widely employed in the literature, we find differences which could in principle become relevant for precision tests of General Relativity using quantum systems.

GR 9: Quantum Gravity (joint session MP/GR)

Zeit: Mittwoch 17:00–19:10 Raum: HS 4

Hauptvortrag GR 9.1 Mi 17:00 HS 4

Geodesic Incomplete but Quantum Complete Spacetimes — •Stefan Hofmann — Arnold Sommerfeld Center for Theoretical Physics at LMU Munich, Germany

Important spacetimes such as black holes and Friedmann cosmologies border on space-like singularities. In the vicinity of these geodesic borders, the evolution of quantum fields is described by semigroups. Semigroups allow for a complete quantum evolution if the probabilistic measure for quantum fields to populate the geodesic border becomes zero, and if the norm of quantum states is monotonously decreasing towards the geodesic border.

It is shown that black holes are quantum complete albeit geodesic incomplete. The relation to Hawking's hidden surface is discussed. Furthermore, a quantum complete prelude to inflation is presented. The apparent clash of completeness cultures is discussed and resolved.

GR 9.2 Mi 17:40 HS 4

Towards Gaussian states for the holonomy-flux Weyl algebra — •Robert Seeger — Institut für Quantengravitation, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

An important challenge in loop quantum gravity is to find semiclassical states. This is difficult because states in the Hilbert space are excitations over a vacuum in which geometry is highly degenerate. Additionally, fluctuations are distributed very unevenly between configuration and momentum variables in this state. Coherent states that have been proposed to balance the uncertainties more evenly can, up to now, only do this for finitely many degrees of freedom. Our work is motivated by the desire to obtain Gaussian states that encompass all degrees of freedom. To implement this idea mathematically we reformulate the U(1) holonomy-flux algebra in any dimension as a Weyl algebra, and discuss generalisations to SU(2). We then define and investigate a new class of states on these algebras which behave like quasifree states on momentum variables.

10 Minuten Pause

GR 9.3 Mi 18:10 HS 4

Quantum Gravity Phenomenology: Modified dispersion relations on curved spacetimes - circular orbits and time delays — •Christian Pfeifer — University of Tartu, Tartu, Estonia

The Hamiltonian formulation of modified dispersion relations allows for their implementation on generic curved spacetimes, and thus enables us to derive effective quantum gravity corrections to the behaviour of probe particles.

In this talk I will consider general first order perturbation of the general relativistic dispersion relation on Schwarzschild and Friedmann-Lemaitre-Robertson-Walker spacetime. For the Schwarzschild case I present the correction to the innermost circular photon orbits; for the FLRW case general I discuss corrections to the cosmological redshift, and the emerging time delay in the time of arrival of simultaneously emitted photons. These results extend existing analyses which consider particularly chosen modified dispersion relations and usually neglect curved spacetime effects. Compared to the predictions of general relativity, the dependence of the observables on the four momentum of the particle is increased. This signature is in principle detectable in observations with instruments of sufficient sensitivity, for example in the shadows of black holes and the time of arrival measurements of high energetic photons from gamma ray bursts.

GR 9.4 Mi 18:30 HS 4

Canonical cosmological perturbation theory with geometrical clocks — •Kristina Giesel[1], Adrian Herzog[1], and Parampreet Singh[2] — [1]FAU Erlangen-Nuernberg, Institut fuer Theoretische Physik III, 91058 Erlangen — [2]Louisiana State University, Baton Rouge, Louisiana, USA

We apply the extended ADM-phase space formulation originally introduced by Pons et al to canonical cosmological perturbation theory and analyze the relationship between various gauge choices made in this framework and the choice of geometrical clocks in the relational formalism. We show that various gauge invariant variables obtained in the conventional analysis of cosmological perturbation theory correspond to Dirac observables tied to a specific choice of geometrical clocks. As examples, we show that the Bardeen potentials and the Mukhanov-Sasaki variable emerge naturally in our analysis as observables when gauge fixing conditions are determined via clocks in the Hamiltonian framework. Furthermore, we will show that the extended ADM phase space provides a framework in which the relation between conventional and canonical cosmological perturbation theory can be naturally analyzed and how existing results in the canonical approach can be generalized.

GR 9.5 Mi 18:50 HS 4

Hamiltonian Renormalization — •Thorsten Lang, Klaus Liegener, and Thomas Thiemann — FAU Erlangen-Nürnberg

We propose a renormalization procedure in the Hamiltonian formalism with applications in canonical quantum gravity. The procedure is motivated from path integral renormalization by applying the Osterwalder-Schrader reconstruction.

GR 10: GR and Astrophysics I

Zeit: Donnerstag 11:00–13:00 Raum: HS 4

Hauptvortrag GR 10.1 Do 11:00 HS 4

Critical Phenomena in Gravitational Collapse — •Thomas Baumgarte — Bowdoin College, Brunswick, Maine, USA

Critical Phenomena, including the appearance of universal scaling laws and critical exponents in the vicinity of phase transitions, appear in different fields of physics and beyond. Critical phenomena in gravitational collapse to black holes were first observed by Matt Choptuik about 25 years ago - a seminal discovery that launched an entire new field of research. Until recently, however, most numerical work in this field was restricted to spherical symmetry and - with some notable exceptions - could not account for effects that break this symmetry. In this talk I will review the appearance of scaling laws and self-similarity close to the onset of black hole formation. I will then present new numerical relativity simulations of gravitational collapse to black holes in the absence of spherical symmetry, and will discuss the effects of rotation and aspherical deformations.

GR 10.2 Do 11:45 HS 4

Accretion disks in axially symmetric space-times — •Claus Lämmerzahl — ZARM, University of Bremen, Germany

For axially symmetric space-times we present the general analytic theory of thick accretion disks (Polish doughnts) based on an ideal fluid which also can be charged. Based on that, accretion disks can be constructed and can be characterized in terms of the effective gravitational potential, shape, mass density and pressure. First steps in order to extend this approach to viscous fluids are presented.

GR 10.3 Do 12:00 HS 4

Black hole shadow in an expanding universe with a cosmological constant — •Volker Perlick[1], Oleg Tsupko[2], and Gennady Bisnovatyi-Kogan[2] — [1]ZARM, University of Bremen, 28359 Bremen, Germany — [2]Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, Moscow 117997, Russia

We analytically investigate the influence of a cosmic expansion on the shadow of the Schwarzschild black hole. We suppose that the expansion is driven by a cosmological constant only and use the Kottler (or Schwarzschild-eSitter) spacetime as a model for a Schwarzschild black hole embedded in a deSitter universe. We calculate the angular radius of the shadow for an observer who is comoving with the cosmic expansion. It is found that the angular radius of the shadow shrinks to a non-zero finite value if the comoving observer approaches infinity. –

The talk presents results that have been published in Phys. Rev. D 97, 104062 (2018).

GR 10.4 Do 12:15 HS 4

Accretion disk in distorted BH — •Shokoufeh Faraji and Eva Hackmann — Zarm, Bremen

The space-time in the vicinity of the horizon in the presents of a static distribution of matter localized outside the black hole horizon in the form of accretion disks,remain vacuum; however, this presence of matter distort the metric. This solution is called distorted black hole. The metric near horizon of a general statistic black hole was studied by V.P. Frolov and N. Sanchez in 1986. In general, if the distribution of matter outside the black hole is axisymmetric, the metric of the distorted black hole allows a details description that discussed by R. Geroch and J.B. hartle in 1982. In this work, we describe the construction of a thin accretion disk outside a distorted black hole horizon, when only low order multipols are present. The physical characteristics of the resulting thin disk are discussed. "

GR 10.5 Do 12:30 HS 4

The influence of electromagnetic fields on the ISCO in Schwarzschild spacetime — Jan Hackstein and •Eva Hackmann — ZARM, University of Bremen

Astrophysical black holes are often surrounded by a geometrically thin accretion disk, whose inner edge is approximately given by the innermost stable circular orbit (ISCO) of test particles. Moreover, they are usually embedded in magnetic fields, for instance of interstellar origin. The rotation of a black hole then enables selective accretion of charged particles, leading to a small net electric charge. Here we discuss the influence of electromagnetic test fields, which do not influence the spacetime geometry, on the radius of the ISCO of charged particles in the equatorial plane of a (non-rotating) Schwarzschild black hole.

GR 10.6 Do 12:45 HS 4

A toy model of viscous relativistic geometrically thick disk in Schwarzschild geometry — •Sayantani Lahiri and Claus Laemmerzahl — ZARM, Universität Bremen, Am Fallturm 2, 28359 Bremen, Germany

In this work we study relativistic geometrically thick accretion disks, commonly known as Polish doughnuts in Schwarzschild spacetime, in the presence of dissipative effects generated as a consequence of differential rotation of the fluid within the disk around a given black hole. We therefore aim to study quasi-stationary solutions of the disk using causal Navier-Stokes equation proposed in Israel-Stewart formalism and later reformulated by Romatschke et al. In this work, we focus only on shear viscous effects and the bulk viscosity is not taken into consideration. The viscosity is introduced as perturbation to the ideal fluid configuration of the disk and we categorically investigate effects of both shear viscosity and curvature of the Schwarzschild black hole on the shape of the geometrically thick disk. As a simplifying assumption, the heat flow which may arise as a result of viscosity within the fluid, is assumed to be small and consequently the heat flux is neglected in our study.

GR 11: Quantum Cosmology and Quantum Gravity II

Zeit: Donnerstag 11:00–12:45 Raum: HS 5

GR 11.1 Do 11:00 HS 5

Quantum Cosmological Perturbations with Back Reactions — •Susanne Schander and Thomas Thiemann — Institute for Quantum Gravity, Friedrich-Alexander-Universität Erlangen-Nürnberg

We investigate linear quantum cosmological perturbation theory in scenarios of the very early Universe while including back reactions from a homogeneous background.

GR 11.2 Do 11:15 HS 5

Hamiltonian diagonalization in hybrid quantum cosmology — •Beatriz Elizaga Navascués[1], Guillermo A. Mena Marugán[2], and Thomas Thiemann[1] — [1]Institute for Quantum Gravity, Friedrich-Alexander University Erlangen-Nürnberg, Staudstraße 7, 91058 Erlangen, Germany — [2]Instituto de Estructura de la Materia, IEM-CSIC, Serrano 121, 28006 Madrid, Spain

In this work, we explore the possibility of selecting a natural vacuum state for scalar and tensor gauge-invariant cosmological perturbations in the context of hybrid quantum cosmology. For that, we make use of a canonical formulation of the entire cosmological system (background geometry and perturbations) in which the gauge-invariant degrees of freedom are identified as canonical variables. Introducing background-dependent linear canonical transformations that respect the spatial symmetries of the background on the gauge-invariant perturbations, and completing these transformations in the entire system, we are able to characterize a generic collection of annihilation and creation-like variables that obey the dynamics dictated by a respective collection of Hamiltonians. We then impose that such Hamiltonians display no self-interaction terms, and thus in a Fock representation with normal ordering they act diagonally on the basis of n-particle states. This leads to a very precise characterization of the allowed annihilation and creationlike variables, which we argue can be further restricted to a unique choice under some physical considerations. Finally, we discuss the relation of our selected vacuum and the standard adiabatic vacua in the context of quantum field theory in curved spacetimes.

GR 11.3 Do 11:30 HS 5

Massive vector bosons in Hamiltonian formulation — •Maria Schlungbaum, Thoralf Chrobok, and Horst-Heino von Borzeszkowski — Institut für Theoretische Physik, Technische Universität Berlin

In the Standard Model of particle physics the vector bosons assume the function of "force carrier particles", i.e. they convey the interaction between massive particles. Their dynamics can be described either by the Proca or Stückelberg Lagrangian density, which both take the form of a singular system. Therefore constraints arise when passing to Hamiltonian formulation. This talk takes a closer look on these constraints and the differences, which may occur due to the gauge invariance of the Stückelberg theory.

GR 11.4 Do 11:45 HS 5

Non-Locality in the Cosmic Microwave Background — •Dipanshu Gupta — Goethe Universität, Frankfurt am Main

We want to explore signatures of Quantum Gravity in cosmology in the UV spectrum. We do so by studying the non-local effects one expects in a fundamental theory of gravity and derive its consequences. We study Non-Commutative Geometry (NCG) and Generalised Uncertainty Principle (GUP) in this context. In principle, we would like to put a bound on the non-commutative parameter in both these theories using Cosmic Microwave Background (CMB) data from the Planck satellite.

GR 11.5 Do 12:00 HS 5

Localized gravitons as essence of dark energy: Implications for accelerated cosmic expansion — •Deiana Drakova[1] and Gerold Doyen[2] — [1]Sofia University, Sofia, Bulgaria — [2]LMU Munich, Germany

A theory of Emerging Quantum Mechanics (EQM) has been developed [1] contributing to the understanding of the measurement problem by assigning a quantum dynamical process to collapse within Schrödinger's theory.

EQM treats cosmological problems in a quantum field theory in high dimensional spacetime (11D) including matter and the gravitational field. Gravity is quantized in the weak interaction limit. The EQM Lagrangian contains terms up to fourth order in the gravitational field. Second and fourth order terms are associated with repulsive dark energy and third order terms with attractive dark matter effects. Gravonon-gravonon repulsion, i.e. dark energy in EQM, modifies the structure of the gravitational field and leads to accelerated expansion of the universe.

Quantum diffusion of the matter particles in three dimensional space is suggested as the mechanism of the expansion of the universe. The rate of expansion is given by the frequency of the soft gravitational modes. The deceleration parameter for the expansion of the universe suggested in EQM is in the range between -0.6 and -0.8, an observed

value of -0.54 has been reported.
[1] G. Doyen and D. Drakova, Foundations of Physics **45**, 959 (2015).

GR 11.6 Do 12:15 HS 5

Reconciling reality, space and time: A graviton driven quantum mechanism of cosmic expansion and CMB radiation — •Gerold Doyen[1] and Deiana Drakova[2] — [1]LMU Munich, Germany — [2]Sofia University, Sofia, Bulgaria

The theory of emerging quantum mechanics (EQM) is a quantum field theory in flat 11 dimensional spacetime, quantizing gravity in the weak interaction limit. In EQM the quantum fields materialize (i.e., they become real) if they entangle with the gravonons, i.e. localized gravitons, thereby forming beables. If not entangled with gravonons, the quantum field is in a limbo state as e.g. exemplified by the state inbetween source and screen in the double slit experiment. Quantum diffusion proceeds via repeated limbo - beable transitions. This leads to the impression that particles having been measured at a certain separation in space suddenly disappear and reappear at a different separation, For any cosmological experiment this is consistent with the interpretation that space has expanded. The rate of cosmic expansion is then equal to the rate of beable - limbo transitions. This rate is calculated from first principles and equals the experimentally determined Hubble parameter. Explicit calculations on the generation of the cosmic microwave radiation (CMB) require to consider the beabling process of the electromagnetic quantum field. The beabling condition is fulfilled for light-atom-lattices. Temperature emerges in EQM by escape of the particle out of the warp resonance (beable). Without fitting any free model parameter the CMB radiation temperature as 2.2 K which is to be compared to the experimental value of 2.7 K.

GR 11.7 Do 12:30 HS 5

Riding on a Dark Bubble : Emergent de Sitter cosmology from decaying AdS — •Souvik Banerjee, Ulf Danielsson, Giuseppe Dibitetto, Suvendu Giri, and Marjorie Schillo — Uppsala University, Uppsala, Sweden

Recent developments in string compactications demonstrate obstructions to the simplest constructions of low energy cosmologies with positive vacuum energy. The existence of obstacles to creating scale-separated de Sitter solutions indicates a UV/IR puzzle for embedding cosmological vacua in a unitary theory of quantum gravity. Motivated by this puzzle, we propose an embedding of positive energy Friedmann-Lemaitre-Robertson-Walker (FLRW) cosmology within string theory. Our proposal involves confining four dimensional gravity on a brane which mediates the decay from a non-supersymmetric five dimensional Anti deSitter false vacuum to a true vacuum. In this way, it is natural for a four dimensional observer to experience an effective positive cosmological constant coupled to matter and radiation, avoiding the need for scale separation or a fundamental de Sitter vacuum.

GR 12: Gravitational Waves

Zeit: Donnerstag 14:00–16:30 Raum: HS 4

Hauptvortrag GR 12.1 Do 14:00 HS 4

Gravitational-Wave Astronomy in Action — •Frank Ohme — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany — Leibniz Universität Hannover, Germany

The Advanced LIGO gravitational-wave detectors and Virgo have concluded their first two observing runs and are about to start the longest observing run yet, O3. In total, the gravitational-wave signals of ten black-hole binary mergers and one binary neutron-star system have been observed and released in the first Gravitational-Wave Transient Catalog (GWTC-1). In my talk, I will summarize these observations, the methods that were used to identify them, and I will give a glimpse of what we can expect to come in the near future.

GR 12.2 Do 14:45 HS 4

Gravitational-wave luminosity of binary neutron stars mergers — •Francesco Zappa and Sebastiano Bernuzzi — Friedrich-Schiller-Universität Jena Theoretisch-Physikalisches Institut, Fröbelstieg 1, D-07743 Jena

We give Numerical Relativity estimate of the luminosity peak of Gravitational Waves emitted during the coalescence of Binary Neutron Stars. Our model is constructed from the CoRe-collaboration database and depends only on the main binary's parameters, allowing to make predictions of the luminosity of such events. Highest luminosity peaks are produced when the merger ends in a Black Hole that promptly forms after the collision of the two stars, while the largest amount of GW energy is emitted when a massive, rapidly rotating neutron star forms. This allows to make estimates on the outcome of BNS mergers based on the fundamental parameters of the binary of the binary system only. In addition we provide the upper limit for the maximum GW energy emitted in the process as predicted by NR and eventually we discuss a simple empirical relation between the total GW energy and the angular momentum of the remnant, with its implications.

GR 12.3 Do 15:00 HS 4

Deep learning in gravitational wave data analysis — •Marlin Schäfer — Albert Einstein Institut, Hannover, Deutschland

We discuss the application of machine learning through deep convolution neural networks to the search for gravitational waves from compact binary mergers. We further consider the usefulness of such techniques in low and high latency searches, and discuss the prospects for the future.

GR 12.4 Do 15:15 HS 4

Laser Amplification and Coherent Beam Combination for Gravitational Wave Detectors — •Nina Bode[1,2] and Benno Willke[1,2] — [1]Max-Planck-Institut für Gravitationsphysik, Hannover, Deutschland — [2]Albert-Einstein Institut der Leibniz Universität Hannover, Deutschland

The sensitivity of gravitational wave detectors scales with the laser power. To reduce shot noise it is nescessary to have a high power, scalable and stable laser system.

Here we present two options for such systems. Both are based on solid state high power amplifiers seeded with NPRO lasers at a wavelength of 1064nm.

In the first system the laser power from two separetly seeded amplifiers is coherently combined on a variable beam splitter. The second one comprises two amplifiers in sequence. Compared to actual laser systems these techniques achieve a better noise behaviour and a higher reliability with similar output power.

We show the promising results of the characterization of both systems.

GR 12.5 Do 15:30 HS 4

IMR consistency tests with higher modes on gravitational signals from the second observing run of LIGO and Virgo — •Matteo Breschi — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Jena, Germany

Current tests of General Relativity are performed using approximations which neglet a key feature of complete solution: higher-order modes. Our analysis will reasses these tests including the higher modes effects. We have chosen to perform inspiral-merger-ringdown consistency tests on the gravitational transients detected by LIGO and Virgo during the observing run O2. We use an approximant which include all higher modes with $\ell \leq 4$, labelled NRSur7dq2. For the most interesting cases, we repeat the tests involving fits on Numerical Relativity simulations from the RIT catalog. We do not find any inconsistency of the data with the predictions of General Relativity.

GR 12.6 Do 15:45 HS 4

Binary Hybrid Star Mergers and the Phase Diagram of Quantum Chromodynamics — •Matthias Hanauske[1,2], Luciano Rezzolla[1,2], and Horst Stöcker[1,2,3] — [1]Institute for Theoretical Physics, Goethe University Frankfurt, Germany — [2]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The astrophysical consequences of a hadron-quark phase transition (HQPT) in the interior of a neutron star merger product will be focused within this presentation. The results of numerical simulations of binary neutron star mergers will be presented, where a strong HQPT has been implemented in the equation of state of the underlying elementary matter of the compact star binary. The evolution of the density and temperature distributions inside the produced hypermassive hybrid star will be analysed and visualised in a QCD phase diagram manner. The results show that the appearance of the HQPT in the interior region of the produced hypermassive hybrid star will change the spectral properties of the emitted gravitational wave, if the phase transition is strong enough.

GR 12.7 Do 16:00 HS 4

Gravitational waves and neutrino signals from magneto-rotational stellar core collapse — •Martin Obergaulinger[1,2], Miguel Ángel Aloy[2], Pablo Cerdá-Durán[2], José Antonio Font[2], and Alejandro Torres-Forné[2,3] — [1]Institut für Kernphysik, TU Darmstadt, Germany — [2]Departament d'Astronomía i Astrofisica, Universitat de València, Spain — [3]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Potsdam, Germany

The collapse of the cores of massive stars to a proto-neutron star (PNS) can power supernova explosions or long gamma-ray bursts and leaves behind either a neutron star or a black hole. The evolution is shaped by the interplay of many complex processes such as relativistic gravity,(magneto-)hydrodynamics, nuclear physics, and neutrino radiation and depends strongly on the pre-collapse state of the core. Direct observational evidence of the inner engine, otherwise obscured by the outer layers of the star, could be provided by gravitational waves (GWs) and neutrinos. Present instruments would be detect signals of galactic events. Their interpretation relies on numerical models. We analysed detailed simulations to connect the GW signal to oscillation modes of the core. Our rapidly rotation stars produce strong, highly variable GW amplitudes. To facilitate the analysis, we performed a detailed analysis of the eigenmodes of the PNS that could be used to extract properties of the PNS from the signal. Furthermore, the models are the sources of intense neutrino emission, which is characterised by a strong asymmetry between emission along the rotational axis and in the equatorial plane.

GR 12.8 Do 16:15 HS 4

Reanalysis of Gravitational Wave Data with Mathematica — •Alexander Unzicker[1] and Jan Preuss[2] — [1]Pestalozzi-Gymnasium München — [2]Universität Lübeck

Thanks to the open data policy of LIGO/VIRGO, gravitational waves events are independently analyzed with the Mathematica software. We follow the template-free statistical method proposed by Liu et.al. (arXiv:1802.00340, CJAP) which is based on cross-correlations. Results show the peculiar properties of GW150914.

GR 13: Alternative Approaches to Quantum Gravity

Zeit: Donnerstag 15:00–16:30 Raum: HS 5

GR 13.1 Do 15:00 HS 5

The tacit assumption of continuity of spacetime in quantum gravity — •René Friedrich — Strasbourg

Theories of quantum gravity are attempting without success the quantization of spacetime. They are founded on the tacit assumption of a continuous, differentiable manifold of Lorentzian spacetime. It will be shown, based on 5 different approaches, that general relativity unexpectedly does not admit any manifold character for spacetimes with Lorentzian metric.

GR 13.2 Do 15:15 HS 5

Equivalence Principle of Quantum Gravity — •Hans-Otto Carmesin — Universität Bremen, Fachb. 1, Pf. 330440, 28334 Bremen — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstraße 5, 21682 Stade

An equivalence principle is elaborated and founded. With it a third development of H.-O. Carmesins theory of quantum gravity is presented. The theory combines quantum physics with general relativity and is based on three numerical inputs only: the constants G, c and h (Carmesin, H.-O. (2017): Vom Big Bang bis heute mit Gravitation, Model for the Dynamics of Space. Berlin: Verlag Dr. Köster. Carmesin, H.-O. (May 2018): Entstehung dunkler Materie durch Gravitation, Model for the Dynamics of Space and the Emergence of Dark Matter. Berlin: Verlag Dr. Köster. Carmesin, H.-O. (November 2018): Entstehung der Raumzeit durch Quantengravitation, Theory for the Emergence of Space, Dark Matter, Dark Energy and Space-Time. Berlin: Verlag Dr. Köster.). With that theory cosmic inflation is explained. Hereby energy is conserved, no reheating occurs, the flatness problem and horizon problem are solved and the deviation from observations is only 3 %. Additionally with that theory dark matter is explained by a novel elementary particle, hereby the deviation from observations is only 0.23 %. Moreover with that theory dark energy is explained by zero-point oscillations, hereby the deviation from observations is only 0.073 % and differences of measured Hubble constants are explained by a polychromatic vacuum, hereby the deviation from observations is only 1 %.

GR 13.3 Do 15:30 HS 5

Anisotropic Solutions in Quantum Gravity — •Ben Joshua Helmcke[1] and Hans-Otto Carmesin[1,2,3] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Universität Bremen, Fachb. 1, Pf. 330440, 28334 Bremen — [3]Studienseminar Stade, Bahnhofstraße 5, 21682 Stade

A novel equivalence principle has been developed and utilized in a research club. From that principle Hans-Otto Carmesins theory of quantum gravity has been derived. With it various fundamental problems of physics have been solved and an accurate accordance with observations has been achieved. Thereby all results have been obtained by utilizing only three numerical inputs: the fundamental natural constants G, c and h. In addition a novel minimization principle has been developed. It establishes a tool for the analysis of emerging structures at the ground state. In particular the emergence of dark matter has been explained and excellent quantitative accordance with observations of the CMB has been achieved, whereby the deviation is below 0.23 %. Hereby the elementary particle of dark matter has been derived (see for instance Carmesin, H.-O.: Entstehung dunkler Materie durch Gravitation, Model for the Dynamics of Space and the Emergence of Dark Matter. Berlin: Verlag Dr. Köster, May 2018). The obtained elementary particle of dark matter is an isotropic solution of quantum gravity. Here we present a numerical study of anisotropic solutions of quantum gravity.

GR 13.4 Do 15:45 HS 5

Investigation of the Emerging Potential and corresponding Wave Function in Quantum Gravity — •Linnea Willeke[1] and Hans-Otto Carmesin[1,2,3] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Universität Bremen, Fachb. 1, Pf. 330440, 28334 Bremen — [3]Studienseminar Stade, Bahnhofstraße 5, 21682 Stade

An equivalence principle has been developed and used in a research club. From that principle H.-O. Carmesins theory of quantum gravity has been derived. With it fundamental problems of physics have been solved and an accurate accordance with observations has been achieved based on the natural constants G, c and h. In particular the era of cosmic inflation has been explained and excellent quantitative accordance with observations of the CMB is achieved, whereby the deviation is below 3 %. Thereby the flatness problem, the horizon problem and the problem of energy conservation have been solved (see for instance Carmesin, H.-O. (2018): A Model for the Dynamics of Space - Expedition to the Early Universe. PhyDid B, p. 1-9. Carmesin, H.-O. (November 2018): Entstehung der Raumzeit durch Quantengravitation, Theory for the Emergence of Space, Dark Matter, Dark Energy and Space-Time. Berlin: Verlag Dr. Köster.). The theory utilizes wave functions and corresponding gravitational potentials. Thereby a slight approximation has been used. Here we generate these wave functions and the corresponding gravitational potentials simultaneously with help of a fixed point method. Thereby the convergence is established numerically.

GR 13.5 Do 16:00 HS 5

Surrounding — •Frederic Lassiaille — Nice, France

SMT (Surrounding Matter Theory), an alternative theory to dark matter, is presented. It is based on a modification of Newton's law. This modification is done by multiplying a Newtonian potential by a given factor, which is varying with local distribution of matter, at the location where the gravitational force is exerted. With this new equation the model emphasizes that a gravitational force is roughly inversely proportional to mass density at the location where this force is applied. After presentation of the model, its dynamic is quickly applied to cosmology and galaxy structure. Some possible caveats of the model are identified. But the simple mechanism described above suggests the idea of a straightforward solution to the following issues: virial theorem mystery, the value of cosmological critical density, the fine tuning issue, and expansion acceleration. A de Sitter Universe is predicted. The predicted time since last scattering is 68 h-1 Gyr. With this value the heterogeneities of large scale structures and galaxy formation might be better explained. Simulations of the stars in a galaxy have been executed with SMT. They show interesting speed profiles, and the fact that ring galaxies seems to be generated by SMT dynamic itself, without the help of any particular external event. Those studies give motivation for scientific comparisons with experimental data.

GR 13.6 Do 16:15 HS 5

Künstliche Intelligenz KI in der Gravitationsphysik und der Kosmologie. — •Norbert Sadler — Sadler Norbert; Wasserburger Str. 25a 85540 Haar

Durch Anwendung der KI auf Quantensysteme, wie Energie- und Materie-Zustände, können diese Zustände mittels der Matrizenmechanik auf die Eigenvektoren bzw. die Eigenwerte linear abgebildet werden.

So kann gezeigt werden, dass der lineare Planckenergiedichte Zustand E(Pl.)/l(Pl) auf den Eigenvektor der Gravitation mit 4/9 Protonen Energieäquivalenten auf 1m Ortsraum abgebildet werden kann.

Die linearen Materie Zustände von (1kg Mol)/1m Protonen Zuständen N(A)/1m werden mit dem dunklen Anteil von 23.8% einer Protonenmasse über den Radius des Universums linear abgebildet.

Die Größe der dunklen Materie ist somit abhängig von der Krümmung des Universums. Die dunkle Materie resultiert aus der Geometrie des Raumes und kann nicht über ein spezifisches Elementarteilchen verifiziert werden.

Informationen: www.artificial-intelligence-in-science.com

GR 14: Poster Session (posters are permanently on display)

Zeit: Donnerstag 16:30–18:30 Raum: HS 6

GR 14.1 Do 16:30 HS 6

Relativistic Interactive Flight Simulation — •Stephan Preiss — Universität Hildesheim, Hildesheim, Germany

First-person visualizations can be used as virtual laboratories where relativistic scenes are explored and relativistic phenomena like length contraction, time dilation and aberration of light are directly observable. We developed an interactive relativistic flight simulation with a drastically reduced speed of light to show these effects. The images are calculated using ray tracing methods. The observer can move through scenes that consist of static and relativistically moving objects. With this tool, we are able to address common difficulties in the understanding of the special theory of relativity that arise in the treatment of e.g. the twin and ladder paradoxa.

GR 14.2 Do 16:30 HS 6

Flying around and through a rotating black hole – Visualizations — •Thomas Reiber — Universität Hildesheim, Universitätsplatz 1, 31141 Hildeheim

Kerr spacetime describes the axisymmetric gravitational field of a rotating black hole. The maximal analytic extension of slow Kerr spacetime contains an infinity of asymptotically flat "exterior" regions connected by a strongly curved region. An observer may stay in one of the exterior regions or – crossing event horizons – pass through the strongly curved region to reach one of the other asymptotically flat regions. What would one observe on such a journey? Tracing the light rays back to a background scene in the exterior part, we calculate videos of the observers view.

GR 14.3 Do 16:30 HS 6

Simulation of the general-relativistic light deflection with a plastic lens — •Volker Perlick and Claus Lämmerzahl — ZARM, University of Bremen, Germany

One of the most important predictions of the general theory of relativity is the light deflection by gravitating masses. This effect was verified for the first time in 1919 with light rays passing close by our Sun. It is now one of the most important tools for discovering dark matter. Here we explain how the general-relativistic light deflection can be simulated with an appropriately shaped plastic lens and we demonstrate this with a lens made from plexiglass. In this way an important aspect of general relativity can be visualised in a way that makes it accessible to high school students.

GR 14.4 Do 16:30 HS 6

Geodesic equations for the Reissner-Nordström (anti-)de Sitter black hole surrounded by different kinds of regular and exotic matter fields — Anik Rudra[1], •Kai Flathmann[2], Arindam Chatterjee[3], and Hemwati Nandan[4] — [1]H. N. B. Garhwal University, Uttarakhand-249199, India — [2]University of Oldenburg, D-26111 Oldenburg, Germany — [3]West Bengal State University, Barasat, Kolkata-700126, India — [4]Gurukul Kangri Vishwavidyalaya, Haridwar 249407, India

We study the geodesic motion of test particles and light for the Reissner-Nordström (anti-)de Sitter black hole surrounded by different kinds of regular and exotic matter fields. We use effective potentials and parametric diagrams to analyze the possible orbit types for each matter field separately. The solution of the geodesic equations can be formulated in terms of hyperelleptic functions. Furthermore we present a list of all possible orbit types.

GR 14.5 Do 16:30 HS 6

Quantum mechanics in non-inertial frames — •André Grossardt — Queen's University Belfast, United Kingdom — Friedrich-Schiller-Universität Jena

Separability of the centre of mass and internal motion serves as a helpful tool when studying the dynamics of non-relativistic complex quantum systems. When special or general relativistic corrections to the dynamics are taken into account, separability is lost and the very definition of a centre of mass becomes ambiguous. We present a framework in which relativistic corrections can be treated in a well-defined and systematic way. Consequences with regard to different effects, decoherence effects in particular, are discussed, as well as open problems.

GR 14.6 Do 16:30 HS 6

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

The most general theory of electrodynamics with linear field equations introduces a new geometry, the area metric, that regulates the propagation of light rays and massive particles instead of the usual Lorentzian metric. In the majority of the experimental situations, the area metric is expected to be a small perturbation around a metric background. In this perturbative case, two interesting results can be achieved. First, the dynamics of the area metric can be found explicitly. Second, the relative quantum theory of electrodynamics can be shown to be renormalisable at every loop order in a gauge-invariant way and can be used to compute various fundamental processes.

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

GR 14.7 Do 16:30 HS 6

Quantum-improved Schwarzschild-(A)dS and Kerr-(A)dS Spacetimes — •Dennis Stock[1,2] and Jan M. Pawlowski[2] — [1]University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen, Germany — [2]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120

Heidelberg, Germany

We study the effects of quantum gravity on black hole geometries within the set-up of asymptotically safe quantum gravity. Under the assumption that leading order quantum effects are taken into account by promoting Newton's and the cosmological constant to scale-dependent functions, we arrive at a quantum-improved metric for Schwarzschild-(A)dS and Kerr-(A)dS. Because scale identifications based on a radial path or the eigentime of an infalling observer in the quantum improved geometry lead to problems, we base our scale identification on the upgraded classical Kretschmann scalar. The arising spacetimes are discussed by studying the Penrose diagrams, the motion of test particles, the effect on the central curvature singularity and the implication for the endpoint of the black hole evaporation process.

GR 14.8 Do 16:30 HS 6

Off-equatorial orbits as a violation of No-hair theorem — •Leonardo A. Pachon, Andres F. Gutierrez, and Juan L. Restrepo — Universidad de Antioquia, Medellin, Colombia

The problem of describing the motion of a highly-diluted electrically-charged medium when both gravitational and electromagnetic fields are present is widely studied and is of great interest for describing magnetospheres, accretion disks and when investigating chaos in general relativity. Nevertheless, this problem is commonly addressed treating the electromagnetic filed as a perturbation instead of solving the exact Einstein-Maxwell field equations. In this paper, it is considered the coupling between both fields and used a closed solution of the Einstein-Maxwell field equations for a neutron star in order to obtain the dynamics of charged particles orbiting it. This exact description is particularly important in the vicinity of the star where both fields are both strong and alter the geometry of the space time. It is shown here that even for a qualitative description this closed solution has to be used because its closest approximation gives regular dynamics where there is actually a chaotic one. Off-equatorial lobes are found and cases when they are separated, mixed and when they begin to mix are studied. Chaos is found when separated and when mixed in contrast whit the closest approximate solution that only shows chaos when they are mixed. For studying chaos 3-D Poincare surfaces are plotted, in contrast with the 2-D common ones, for a conceptual advantage: in the 3-D surfaces the chaotic an regular regions do not cross each other.

GR 14.9 Do 16:30 HS 6

Frame Dragging Suppresses Astrophysical Chaos around Compact Objects — •Leonardo A. Pachon and Andres F. Gutierrez — Universidad de ANtioquia, Medellin, Colombia

Dragging of inertial frames is one of the most surprising and quintessential effects of General Relativity. In its simplest version, a particle which is directed radially towards a rotating source acquires non-radial components of motion as it falls freely in the gravitational field. Here, by considering analytical exact solutions to the Einstein-Maxwell field equation, it is shown that this purely general relativistic effect is capable of reconstructing KAM tori from initial highly chaotic configurations around static gravitational sources. Since signatures of chaotic dynamics in gravitational waves have been suggested to test the validity of General Relativity in the strong field regime, chaos suppression by inertial frame dragging may undermine present proposals to verifying the no-hair theorem and validity of General Relativity.

GR 14.10 Do 16:30 HS 6

The AEI 10 m prototype interferometer — •Philip Koch — Albert Einstein Institut Hannover, Deutschland

Precision interferometry is the leading method for extremely accurate measurements in gravitational wave astronomy. The current generation of gravitational wave detectors is designed to be limited by quantum processes, whereas future gravitational wave detectors will use techniques to surpass the quantum noise. The AEI 10 m prototype interferometer will be a test bed for these techniques. It will be limited by quantum radiation pressure noise at frequencies between 20 and 200 Hz and by shot noise above 200 Hz. To reach these fundamental noise sources, all classical noise sources such as seismic, thermal and technical noise have to be suppressed. We present techniques of active and passive seismic isolation, frequency stabilization of our laser to a suspended reference cavity and an overview of the AEI 10 m prototype interferometer.

GR 14.11 Do 16:30 HS 6

Investigation towards fibre-based squeezed light injection into gravitational wave detectors — •Joscha Heinze — Max-Planck-Institute for Gravitational Physics, Hanover, Germany

It has been investigated whether a commercially available optical fibre can transport (squeezed) light at an efficiency which is sufficient for gravitational wave detectors. An incoupling efficiency of up to 99.1%, a power transmission of up to 97.9% and a visibility between two fibre output beams of 99.0% has been achieved. This corresponds to a maximum loss in the squeezing level of 4dB for initial 15dB.

The incoupling stage was found to be highly stable and the usage of non-angled fibre end faces as well as relatively large residual Fresnel reflections limited the results. This is, however, easy to improve on.

The performance may also be improved by using fibres with a larger core and lens-shaped end caps directly attached to the fibre end faces. Such a monolithic connection provides an even higher mechanical stability. Possible effects of the attachment procedure on the fibre output have been examined by comparing an untreated fibre to one that had a substrate (two plane faces) attached. The substrate-fibre showed a power transmission which was remarkably higher by 0.7% without any deterioration in the beam profile or polarisation extinction ratio.

GR 14.12 Do 16:30 HS 6

Coating Thermal Noise Interferometer for the AEI 10m Prototype — •Janis Wöhler — MPI für Gravitationsphysik Hannover, Deutschland

Thermal noise in the coatings of highly reflective mirrors is becoming a limiting noise source in interferometers used for the detection of gravitational waves. It is caused by mechanical losses of the thin films used in the coatings. A way to reduce the noise is to use crystalline coatings due to their inherently lower mechanical losses. Crystalline AlGaAs-coatings are a promising candidate and their noise properties will be measured before using them in a quantum limited Michelson interferometer. For the measurement, all other noise sources, especially seismic noise and acoustic disturbances, have to be reduced below the thermal noise level. The AEI 10 m Prototype facility is probably the best suited environment for this kind of experiment.

On this poster the setup of the Thermal Noise Interferometer will be presented, which will be able to measure thermal noise in a frequency band from 10Hz to 50kHz, limited from below by seismic noise and from above by photon shot noise. Current progress in commissioning and aquiring lock in a test environment is shown. Furthermore prospects of using crystalline coatings in large scale gravitational wave detectors will be discussed.

GR 14.13 Do 16:30 HS 6

Active seismic isolation for the AEI 10 m prototype interferometer — •Robin Kirchhoff — Albert-Einstein-Institute for gravitational physics Hannover, Germany

High precision measurements in various scientific fields suffer from seismic motion. Active seismic isolation is used to decouple the experiments from this disturbance. It is based on feedback control loops. The motion is measured by sensors and sent to actuators applying a counter force to reduce the motion. The poster explains the active seismic isolation of the AEI 10 m prototype interferometer. This is a testbed for large scale gravitational wave detectors. Different techniques to improve the isolation are introduced and the overall isolation performance is depicted.

GR 14.14 Do 16:30 HS 6

Mirror suspensions to reduce seismic noise of the AEI 10m prototype interferometer — •Johannes Lehmann — Albert Einstein Institute for Gravitational Physics, Hannover

The coupling of unwanted ground motion to interferometer test masses is reduced by suspending them. In order to control the suspended mirrors without feeding back ground motion in the process, special actuators are needed.

A new design for an electrostatic drive has been tested on the triple cascaded-pendulum suspensions used as part of the AEI 10m prototype interferometer. This interferometer is planned to reach and surpass the standard quantum limit, which limits the sensitivity of gravitational wave interferometers employing classical laser light.

This poster will present a preliminary experiment where one interferometer arm was set up to act as a testbed for suspensions, control schemes and actuators, and to measure the performance of the pre-isolation system and laser stabilisation.

GR 14.15 Do 16:30 HS 6

Interferometer to measure temperature-dependent angular tilts and mode matching of fiber couplers — •Juliane von Wrangel — Max-Planck-Institut für Gravitationsphysik Hannover (Albert-Einstein-Institut)

Space-based laser interferometers as the Laser Interferometer Space Antenna (LISA) bear the challenge of developing qualified optical components that have to meet several requirements. One of the most important aspects to be considered is thermal stability: Thermally induced tilts of the components can easily couple to changes in the optical pathlength.

This poster explains an interferometer that was constructed to measure temperature-dependent angular tilts and mode matching of fiber couplers. Differential Wavefront Sensing as well as Differential Power Sensing will be used to investigate the thermal stability of commercial fiber couplers.

GR 14.16 Do 16:30 HS 6

Pre-Stabilized Laser System for Ground Based Gravitational Wave Detectors — •Fabian Thies and Benno Willke — Max Planck Institute for Gravitational Physics, Hannover, Germany

Current gravitational wave detectors (GWDs) are Fabry-Pérot dual-recycling laser interferometers, which sense space-time strain caused by gravitational waves. Besides many other subsystems, they require a low noise, high power pre-stabilized laser system to reach their design sensitivity. In such a laser system power stability and frequency stability is achieved by feedback control, so that noise does not couple significantly to the readout of the interferometer.

Here we present improvements of the solid state laser systems at 1064nm wavelength for current GWDs (aLIGO [1], Virgo[2]). These laser systems show a reduced noise and operate at 100W of laser power.

In addition we started to setup a pre-stabilized laser system at 1550nm wavelength for future GWDs (ET[3]). This laser system operates at a wavelength usable with cryogenically cooled silicon test masses. We characterized the free running noise of the laser and started to implement active stabilizations.

[1] J. Aasi et al. (LIGO Scientific Collaboration), Class. Quantum Gravity 32, 074001 (2015).

[2] F. Acernese et al. (Virgo Collaboration), Class. Quantum Gravity 32, 024001 (2014).

[3]ET Science Team, ET conceptual design document ET-0106C-10, http://www.et-gw.eu/index.php/etdsdocument

GR 14.17 Do 16:30 HS 6

Relevance of tidal effects and post-merger dynamics for binary neutron star parameter estimation — •reetika dudi[1], francesco pannarale[2], tim dietrich[3], mark hannam[2], sebastiano bernuzzi[1], frank ohme[4], and bernd bruegmann[1] — [1]Theoretical Physics Institute, University of Jena, Jena, Germany — [2]School of Physics and Astronomy, Cardiff University, Cardiff — [3]Nikhef, Amsterdam, The Netherlands — [4]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany

Measurements of the properties of binary neutron star systems from gravitational-wave observations require accurate theoretical models for such signals. However, current models are incomplete, as they do not take into account all of the physics of these systems. In this work, we have explored the importance of two physical ingredients: tidal interactions during the inspiral and the imprint of the post-merger stage. We use complete inspiral–merger–post-merger waveforms constructed from a tidal effective-one-body approach and numerical-relativity simulations as signals against which we performe parameter estimates with waveform models of standard LIGO-Virgo analyses. We show that neglecting tidal effects does not lead to appreciable measurement biases in masses and spin for typical observations (small tidal deformability and signal-to-noise ratio approx. 25). However, with increasing signal-to-noise ratio or tidal deformability there are biases in the estimates of the binary parameters. The post-merger regime, instead, has no impact on gravitational-wave measurements with current detectors for the signal-to-noise ratios we consider.

GR 14.18 Do 16:30 HS 6

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

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

However, if we follow Hubble's view of the universe, then there is a very unspectacular explanation for the measurement. There are indications that the speed of light 'c' was higher at early times. This inserted into the Doppler equation to determine the star's speed from red-shifts yields higher speeds for early stars. So there is no acceleration.

This is, however, objected by main stream physics by the argument that according to Einstein's relativity 'c' was always constant. But this was not clearly stated by Einstein. And there is anyway the non-understood problem of cosmologic inflation.

To explain the horizon problem, i.e. the apparent logical connection of parts of the universe far apart from each other, the cosmological inflation was introduced. It is the assumption that after the big bang 'space' was extremely small compared to now. Then it expanded first rapidly, these days still slowly. - But there is no understanding why this expansion should have happened. The assumption of a higher 'c' at earlier times can be backed by a comparatively simple model.

Further info: www.ag-physics.org/darkenergy

GR 14.19 Do 16:30 HS 6

What is Dark Matter? — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

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

There are fundamentally two solutions possible: (1) there may exist a type of presently undetected particles which provides the missing contribution to the gravitational field; (2) the theory of gravity of Newton and of Einstein which related gravitation to mass and energy may be erroneous.

For the second alternative there is a working ansatz. If one extends the Lorentzian interpretation of relativity to the area of general relativity, so to gravitation, there follows a different causality for gravity. Gravity is no longer caused by mass or energy but it is a side effect of other forces. So every elementary particle contributes to the field independently of its mass. And in this case photons and neutrinos are playing a particular role.

If the thoroughly investigated rotating galaxy NGC 3198 is taken as an example for this approach, it can be shown that the result for the amount of the field as well as its spatial distribution fits quite precisely to the measurement. And the recently detected galaxy NGC 1052-DF2, which emits dim light and has only a small amount of Dark Matter, is a good confirmation of this view.

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

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

GR 14.20 Do 16:30 HS 6

Time dilation and length contraction — •Osvaldo Domann — Stephanstr. 42, D- 85077 Manching

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

GR 14.21 Do 16:30 HS 6

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

LI of GRT [1] is a rational variation of classical GRT. Nobel Prize winner Kip S. Thorne calls it ” the flat spacetime paradigm ” of GRT [2]. There is no difference in the predictions of relativistic experiments of both interpretations except, within LI of GRT black holes have no event horizon. It contradicts: ” A black hole is a region of spacetime exhibiting such strong gravitational effects that nothing - not even particles and electromagnetic radiation such as light - can escape from inside it. ” *But claiming the same for gravitational waves LI of GRT is proven:* In the case of GW170608 the total mass of the binary system was 19 M_{sun} with components of 12 and 7 M_{sun}. The final black hole mass was 18 M_{sun}. This means a loss of mass as large as 1 M_{sun} and contradicts the features of a black hole. At least it is an argument for even better measurements of the GW spectra and looking for an effect happened to GW170817 where a black hole became a neutron star of 2.75 M_{sun}. Further proof: Using the Tolman Oppenheimer Volkoff (TOV) equation [2] LI of GRT gets supermassive objects larger than its Schwarzschild radius - possibly realized in the galactic centers. The poster discusses newest results of LIGO, GRAVITY and EHT.

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

GR 14.22 Do 16:30 HS 6

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

The apparent incompatibility of the current spacetime concept with quantum mechanics seems to be the main obstacle of quantum gravity. But as it will be shown here, our spacetime concept is based on assumptions which are not only contradicting quantum mechanics, but also the two postulates of special relativity and the Schwarzschild metric.

The following three corrections of the current spacetime concept are necessary to avoid these contradictions:

1. Spacetime is not continuous, in particular not in spacelike direction, and thus it cannot be quantized.

2. For the solution of fundamental problems of physics about time, we must consider the notion of proper time instead of the coordinate time of spacetime.

3. Gravitation may be represented by Schwarzschild metric not only as the curved spacetime, but alternatively also as gravitational time dilation in absolute, uncurved space.

From these three insights are following the characteristics of quantum gravity. The result: Gravity appears within quantum mechanics in the form of gravitational time dilation.

GR 15: General Assembly of the Gravitation and Relativity Division

Zeit: Donnerstag 18:30–19:30 Raum: HS 4

Mitgliederversammlung

GR 16: GR and Astrophysics II

Zeit: Freitag 11:30–12:45 Raum: HS 4

GR 16.1 Fr 11:30 HS 4

The Role of Electric Charge in Relativistic Accretion onto Compact Objects — •Kris Schroven — Universität Bremen, Bremen, Germany

The role of electric charge in relativistic accretion onto compact objects is discussed by means of analytic models. Many high-luminosity phenomena in the observed universe can be traced back to accretion processes, in which electromagnetic fields play an important role. These fields are either produced within the accreted matter or they enter the stage as external fields like interstellar magnetic fields or fields, produced by the accreting object.

Two analytic models are applied to examine the effects of a realistically small electric BH charge and the effects of a charge distribution in the accreted matter onto the accretion process and accretion disc structure.

GR 16.2 Fr 11:45 HS 4

Charged fluids around black hole — •Trova Audrey — ZARM, University of Bremen

Studies of equilibrium of toroidal structures of a perfect fluid are important to understand the physics of accretion disks in active galactic nuclei (AGN). Our interest is about equilibrium of electrically charged-perfect fluid surrounding a rotating or non rotating compact object, embedded in magnetic field. The structure of the torus is influenced by the balance between the gravitational, the rotational and the magnetic force. Previous study of rotating charged test fluid around a non rotating black hole showed that according to the spin of the black hole the existence of such structures change. We focus on orbiting structures in the equatorial plane, as single or double tori, and structures above as levitating tori. Our interest is about their existence, shape and how the various forces (electromagnetic, centrifugal and gravitational) influence their physics.

GR 16.3 Fr 12:00 HS 4

Bardeen black hole chemistry — •Athanasios Tzikas — Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany

We connect the Bardeen black hole with the concept of the recently proposed black hole chemistry. We study thermodynamic properties of the regular black hole with an anti-deSitter background. The negative cosmological constant plays the role of the positive thermodynamic pressure of the system. After studying the thermodynamic variables, we derive the corresponding equation of state and we show that a neutral Bardeen-anti-deSitter black hole has similar phenomenology to the chemical Van der Waals fluid. This is equivalent to saying that the system exhibits criticality and a first order small/large black hole phase transition reminiscent of the liquid/gas coexistence.

GR 16.4 Fr 12:15 HS 4

r-process nucleosynthesis from matter ejected in binary neutron star mergers — Luke Bovard[2], Dirk Martin[1,3], •Federico Guercilena[1], Almudena Arcones[1,3], Luciano Rezzolla[2,4], and Oleg Korobkin[5] — [1]IKP, TU Darmstadt — [2]ITP, Uni Frankfurt — [3]GSI, Darmstadt — [4]FIAS, Frankfurt — [5]LANL, Los Alamos

We perform full GR simulations of binary neutron-star mergers employing three different nuclear-physics EOS, considering both equal- and unequal-mass configurations, and adopting a leakage scheme to account for neutrino radiative losses. Using a combination of techniques, we carry out an extensive and systematic study of the hydrodynamical, thermodynamical, and geometrical properties of the matter ejected dynamically, employing a nuclear-reaction network to recover the relative abundances of heavy elements produced by each configurations. Three results are particularly important. First we find that within the sample considered here, both the properties of the dynamical ejecta and the nucleosynthesis yields are robust against variations of the EOS and masses. Second, using a conservative but robust criterion for unbound matter, we find that the amount of ejected mass is less than 1e-3 solar masses, hence at least one order of magnitude smaller than the standard assumptions in modelling kilonova signals. Finally, using a simplified and gray-opacity model we assess the observability of the kilonova emission, finding that for all binaries the luminosity peaks around ~1/2 day in the H-band, reaching a maximum magnitude of -13, and decreasing rapidly after. Supported by European Research Council Grant No. 677912 EUROPIUM

GR 16.5 Fr 12:30 HS 4

An integral spectral representation of the massive Dirac propagator in the Kerr geometry in Eddington–Finkelstein-type coordinates — •Christian Röken — University of Granada, Faculty of Sciences, Department of Geometry and Topology, 18071 Granada, Spain

An integral spectral representation of the massive Dirac propagator in the non-extreme Kerr geometry in horizon-penetrating coordinates, which describes the dynamics of Dirac particles outside and across the event horizon, up to the Cauchy horizon, is presented. To this end, the Kerr geometry is described in the Newman–Penrose formalism by a regular Carter tetrad in advanced Eddington–Finkelstein-type coordinates and the massive Dirac equation is given in a chiral Newman–

Penrose dyad representation in Hamiltonian form. The essential self-adjointness of the Hamiltonian is shown employing a new method of proof for non-uniformly elliptic mixed initial-boundary value problems on a specific class of Lorentzian manifolds that combines results from the theory of symmetric hyperbolic systems with near-boundary elliptic methods. The resolvent of this operator is computed via the projector onto a finite-dimensional, invariant spectral eigenspace of the angular operator and the radial Green's matrix stemming from Chandrasekhar's separation of variables. By applying Stone's formula to the spectral measure of the Hamiltonian in the spectral decomposition of the Dirac propagator, that is, by expressing the spectral measure in terms of this resolvent, one obtains an explicit integral representation of the propagator.

GR 17: Alternative Approaches

Zeit: Freitag 11:30–12:45 Raum: HS 5

GR 17.1 Fr 11:30 HS 5

Geometrie der Weltformel E = S — •Barbara Schramm — FORUM DIVIDUUM, Schwanitzstr. 7, 98693 Ilmenau

Es geht um den Beweis meiner These. Sie lautet: Einsteins Formel E = mc hoch zwei beschreibt zwar den relativistischen Zusammenhang von Masse und Energie, aber nicht ihre Äquivalenz. Ein kosmologischer Schnitt durch die Erde im Himmel offenbart die kausale Geometrie der Makro-Struktur der Masse-Energie-Einheit als Dreiheit (Trinity) von Licht, Erde und Schatten. Seine Aussage: Befindet sich eine Masse (m) im 3D-Lichtfeld (c x c = c hoch zwei) entsteht ein Antifeld des Lichtes, ein 3D-Schattenfeld. Ein Modus-Vivendi der Formel E = mc hoch zwei lautet: mc hoch zwei = S. Damit ist E = S. Der Schatten(S)als ein räumliches Anti-Energie-Feld ist das kausale Ergebnis (E = S) der Bindung der Erde als Masse (m) an ein mit ihr wechselwirkendes Licht-Feld(c x c). Die Licht-Schatten-Polarität des Himmels als dividuum (lat. das Zweigeteilte)bestimmt die Machtverhältnisse des Himmels. Tag und Nacht bilden ihre Besitzverhältnisse. Nur aus dem kosmologischen Schnitt durch die Erde in der Ekliptik-Ebene ist der Zusammenhang aller drei Elemente von Licht, Erde und Schatten als Geometry of Trinity erkennbar. Die Anfangsbuchstaben von Licht, Erde und Schatten führten zum Namen ihrer Einheit: L-ES-Struktur. Das kosmologische L-ES-Modell bietet auch der String-Theorie einen plausiblen Beweis ihres Atom-Modells und ist damit der Schlüssel zur Weltformel. Aus dem dynamischen Schnitt durch die Himmel-Erde-Einheit ergibt sich auch die paarweise symmetrisch-verschränkte Geometrie der Gravitation. Sie ist keine vierte Naturkraft.

GR 17.2 Fr 11:45 HS 5

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

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

GR 17.3 Fr 12:00 HS 5

Derivation of the Sommerfeld Fine-Structure-Constant (α) — •Manfred Geilhnaupt — University of Applied Sciences MG

Sommerfeld introduced the Fine-Structure-Constant (α) in 1916 by definition while combining fundamental constants (h, c, e) to come up with that number. But here is the way how to derive the FSC from Theory. Use Einstein*s Field Equation from General Relativity and you can first derive the restmass of the electron by solving the corresponding *1.Equation of Motion* and a 2.Equation of Motion yield the charge of the electron. For that step assume an electron*s (virtual and local) center of mass (point) to be at rest while applying the common Principles of Physics (1. and 2. Law of Thermodynamics) to find a solution r(t). The solution r(t), unit meter, reveals an internal action of motion of (non-local but dynamic) space-structure while only the virtual center of *mass* is assumed at rest. So we can interpret r(t) to be a *Mass-Generating-Function* - solving the Differential Equation. The complete solution is a combination of two independent ones. One solution leads to the effective value RG: we call it *Point-Like-Radius* (to be introduced into the following Newton-Schwarzschild-Einstein-Equation: c^2=G*me/(2alpha*RG)). The other solution gives the effective value rG: we call it *Wave-Like-Radius* (to be introduced into the Planck-Compton-Einstein-Equation: h=2pi*2rG*me*c). And now to the focus of this presentation: How to derive the FSC from GR+TD the combination of two Principle Theories. Both derivations of restmass and charge reveal a dependence on the Fine Structure Constant (α). (Experiment Webb. et al. 2011 meets GR+TD!)

GR 17.4 Fr 12:15 HS 5

Biquadric Fields on a Finite Geometry as a Quantum World — •Judith Höfer, Alexander Laska, and Klaus Mecke — Institut für Theoretische Physik 1, FAU Erlangen-Nürnberg, Germany

A unification of quantum field theory and general relativity might be based on finite projective geometry [1]. To this end the standard approach of using real (or complex) numbers as number field for coordinates (or wavefunctions) is replaced by a Galois field. The idea is to model spacetime similar to general relativity but based on a finite field such that quantization is not additionally imposed but emerges intrinsically from the finite geometry. Then, singularities and divergences cannot exist neither in a curved spacetime nor in a quantum world modeled over finite fields. However, the quite unusual properties of finite fields require additional care in defining physical quantities. Central to this approach is a 'biquadric' that defines, similar to a metric, distances and neighbourhoods. The long-time goal is to derive the properties of the standard model in a continuum limit for very large finite fields. In the presented work a local domain is defined as the subspace where an Euclidean-like ordering of the points is possible, and the coordinate transformations between different local domains are investigated. Furthermore, the finite field and the neighbouring relations defined by a homogeneous field of biquadrics are interpreted as a graph and its diameter is explored in order to elucidate non-local features in finite geometries.

[1] Klaus Mecke, Biquadrics configure Finite Projective Geometry into a Quantum Spacetime, EPL 120(1), 10007 (2017).

GR 17.5 Fr 12:30 HS 5

Newton's Error - the Concepts of Space and Time — •Alexander Unzicker — Pestalozzi-Gymnasium München

The fantastic success of classical mechanics was based on Isaac Newton's postulate of the existence of space and time. Much later, relativistic effects and quantum phenomenology modified significantly our picture of reality, while leaving the very notion of space and time intact.

In contrast to the current paradigm of theoretical physics, it is argued that both the speed of light c and Planck's constant h are free parameters in a Kuhnian sense. In that case, relativity and quantum theory would be ingenious workarounds rather than solutions of the real problems. c and h may indeed be anomalies that falsify the very concept of space and time, a rather unpleasant perspective for modern physics.