Gravitation and Relativity Division
Fachverband Gravitation und Relativitätstheorie (GR)

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Welcome to this year's programme of the division *Gravitation and Relativity.* The core of the programme consists of ordinary and invited talks of, respectively, 15 and 45 minutes total duraction each. Special attention is drawn to our joint tutorial-session *Dark Matter* (together with AKjDPG/T/GR) on Sunday 16:00 - 17:45, on our section's (Matter and Cosmos) *Dissertation-Prize Colloquium* on Monday 14:30 - 16:00, our plenary talk on Tuesday 09:00 - 09:45 by Alessandra Bounanno, our poster session on Tuesday 17:00 - 18:30, and to the joint symposium (together with MP and AGPhil) on *Entanglement* on Thursday 11:00 - 13:00. Last, but not least, please note that our annual general meeting takes place on Thursday 18:30 - 20:00, at which we will elect a new chairperson and board members.

Overview of Invited Talks and Sessions

(Lecture halls H-HS IV, V, VII, and IX; Poster Zelt)

Plenary Talks of GR

PV IV	Tue	9:00– 9:45	H-Aula/HS I/HS X	**The Making of High-Precision Gravitational Waves** — •Alessandra Buonanno

Invited Talks

GR 2.1	Mon	11:15–12:00	H-HS IX	**Relativistic geodesy** — •Claus Lämmerzahl, Volker Perlick
GR 5.1	Tue	11:00–11:45	H-HS IX	**Testing GR with gravitational waves: current status and future prospects** — •Collin Capano
GR 7.1	Wed	10:30–11:15	H-HS IX	**The Sagnac effect in General Relativity** — •Jörg Frauendiener
GR 14.1	Thu	16:30–17:15	H-HS IV	**Teaching general relativity with sector models** — •Ute Kraus, Corvin Zahn
GR 14.2	Thu	17:15–18:00	H-HS IV	**How Long Is Now? On the problem of accurate time measurements** — •Thomas Filk

Invited talks of the joint symposium SYMD

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:30–15:00	H-Aula/HS I/HS X	***N*-Particle Scattering and Asymptotic Completeness in Wedge-Local Quantum Field Theories** — •Maximilian Duell
SYMD 1.2	Mon	15:00–15:30	H-Aula/HS I/HS X	**First observation of double electron capture in Xe-124 with the dark matter detector XENON1T** — •Alexander Fieguth
SYMD 1.3	Mon	15:30–16:00	H-Aula/HS I/HS X	**Anisotropic Transport of Galactic Cosmic Rays based on Stochastic Differential Equations** — •Lukas Merten

Invited talks of the joint symposium SYEN

See SYEN for the full program of the symposium.

SYEN 1.1	Thu	11:00–11:40	J-HS D	**Entanglement and Complexity in Quantum Many-Body Systems** — •Tomaz Prosen
SYEN 1.2	Thu	11:40–12:20	J-HS D	**Entanglement and Explanation** — •Chris Timpson
SYEN 1.3	Thu	12:20–13:00	J-HS D	**Production and observation of entanglement in quantum optics** — •Roman Schnabel

Sessions

GR 1.1–1.2	Sun	16:00–17:45	P-HS 1	**Tutorial: Dark Matter (joint session AKjDPG/T/GR)**
GR 2.1–2.4	Mon	11:15–12:45	H-HS IX	**Classical Theory of General Relativity 1**
GR 3.1–3.3	Mon	16:30–17:15	H-HS IX	**Relativistic Astrophysics**
GR 4.1–4.3	Mon	17:15–18:00	H-HS IX	**Other Topics in Gravitational Physics**
GR 5.1–5.5	Tue	11:00–12:45	H-HS IX	**Gravitational Waves**
GR 6.1–6.17	Tue	17:00–18:30	Zelt	**Poster**
GR 7.1–7.2	Wed	10:30–11:30	H-HS IX	**Classical Theory of General Relativity 2**
GR 8.1–8.3	Wed	11:30–12:15	H-HS IX	**Black Holes 1**
GR 9.1–9.7	Wed	14:00–15:45	H-HS IX	**Black Holes 2**
GR 10.1–10.8	Wed	16:30–18:30	H-HS IX	**Quantum Gravity and Quantum Cosmology 1**
GR 11.1–11.5	Thu	14:00–15:15	H-HS V	**Alteranative Classical Theories of Gravitation**
GR 12.1–12.8	Thu	14:00–16:00	H-HS IV	**Cosmology**
GR 13.1–13.3	Thu	15:15–16:00	H-HS V	**Numerical Relativity**
GR 14.1–14.4	Thu	16:30–18:30	H-HS IV	**Didactical Aspects of Relativity**
GR 15	Thu	18:30–20:00	H-HS IV	**Annual General Meeting**
GR 16.1–16.6	Fri	9:00–10:30	H-HS IX	**Alternative Approaches**
GR 17.1–17.3	Fri	9:30–10:30	H-HS VII	**Fundamental Problems and General Formalism**
GR 18.1–18.3	Fri	11:00–11:45	H-HS IX	**Quantum Gravity and Quantum Cosmology 2**

Annual General Meeting of the Gravitation and Relativity Division

Thursday 18:30–20:00 H-HS IX

- Report by the chairperson
- Reports by the members of the board
- Election of new chairperson and board
- Miscellaneous

GR 1: Tutorial: Dark Matter (joint session AKjDPG/T/GR)

Time: Sunday 16:00–17:45 Location: P-HS 1

Tutorial GR 1.1 Sun 16:00 P-HS 1
Tutorial: dark energy, dark matter and dark statistics — •Bjoern Malte Schäfer — Zentrum fuer Astronomie der Universitaet Heidelberg

I will give an overview why cosmology is an interesting branch of theoretical physics and the physics of gravity, the key observations that led to the construction of the cosmological standard model, the fundamental concepts of gravity and of particle physics that are being tested by cosmological observations, and an outlook over the coming decade in new observational techniques.

15 min. break

Tutorial GR 1.2 Sun 17:00 P-HS 1
Search for Dark Matter — •Christian Weinheimer — Institut für Kernphysik, Universität Münster

There is multiple and clear evidence from astrophysics and cosmology that exist more matter than we see in the universe. This dark matter should be mainly exotic, i.e. not made out of particles from the Standard Model of particle physics. There are quite a variety of candidates for dark matter, which reqire different search methods.

In my talk I will present various experimental direct and indirect methods to look for candidates for dark matter at underground laboratories, at collider experiments and by astroparticle physics telescopes. At some characteristic examples I will explain detectors and experimental techniques.

GR 2: Classical Theory of General Relativity 1

Time: Monday 11:15–12:45 Location: H-HS IX

Invited Talk GR 2.1 Mon 11:15 H-HS IX
Relativistic geodesy — •Claus Lämmerzahl and Volker Perlick — ZARM, University of Bremen, Am Fallturm, 28359 Bremen, Germany

Owing to new higly sensitive divices like clocks, freely falling particles, spinning tops, and laser and atom interferometers on ground and in space the relativistic gravitational field of the Earth can now be measured with unprecedented accuracy. This requires a relativistic formulation of geodesy. Here a fully general relativistic scheme for geodesy is presented. Starting from stationarity two geoids can be defined for the Earth, one related to the norm of the underlying Killing vector, the other related to its twist. The first one can be measured with clocks, falling bodies, or atom interferometry, the other can be measured with spinning tops or by measuring a Sagnac effect with laser or atom interferometry. Finally, based on analyses by Hansen, Simon, and Beig a scheme is presented for measuring the full gravitational field of the Earth using laser interferometry employed by GRACE Follow On.

GR 2.2 Mon 12:00 H-HS IX
Relativistic Geodesy - Formalism and Concepts — •Dennis Philipp, Eva Hackmann, Volker Perlick, and Claus Lämmerzahl — ZARM, Universität Bremen

The Earth's geoid is one of the most important fundamental concepts to provide a gravity field-related height reference in geodesy and associated sciences. To keep up with the ever-increasing experimental capabilities and to consistently interpret high-precision measurements without any doubt, a relativistic treatment of geodetic notions within Einstein's theory of General Relativity is inevitable.

Building on the theoretical construction of isochronometric surfaces and the so-called redshift potential for clock comparison, we define a relativistic gravity potential as a generalization of known (post-) Newtonian notions. It is the same as realized by local plumb lines. Thereupon, the relativistic geoid is defined in direct analogy to the Newtonian understanding. Moreover, a generalized version of the so-called normal gravity field is presented. In the respective limits, well-known results are recovered.

A comparison between the Earth's Newtonian geoid and its relativistic generalization is a very subtle problem. However, an isometric embedding into Euclidean three-dimensional space can solve it and allows a genuinely intrinsic comparison of the general relativistic, the post-Newtonian, and the Newtonian concept. We employ this method and determine the leading-order differences, which are at the mm-level.

GR 2.3 Mon 12:15 H-HS IX
Relativistic Effects on Entanglement — •Roy Barzel and Claus Lämmerzahl — University of Bremen, ZARM, 28359 Bremen, Germany

Quantum Entanglement is not only one of the most intriguing and counter-intuitive phenomena in physics, but also plays a key role for future technologies such as Quantum Communication. Recently, in 2017 a new milestone in large scale entanglement distribution was achieved, when the entanglement between photons was verified over a distance more than 1200 kilometers.

In such a macroscopic setup, with increasingly larger distribution distances, general relativistic effects become more and more important. In this talk it is shown that particles undergo a Lorentz-Transformation and thereby a Wigner-Rotation when they travel through space-time. This can be represented as a unitary transformation, which acts on the particles quantum states, for instance electron-spin or photon-polarization. As a consequence Observers, who want to extract EPR-correlations via Bell Measurements from these particles, have to readjust their measurement basis to recover the full violation of Bell's Inequalities, which is the main result of the talk.

GR 2.4 Mon 12:30 H-HS IX
Time velocity - handling time dilation between two points in space-time — •Bjørn Ebbesen — Hamburg, Germany

Combining SRT with static gravitation, as done in the following, could have been a forerunner to the ART.

This approach leads to a concept of time velocity, which not only simplifies handling time dilation. Without relying on ART we get strait forward a variety of old and new insights on gravitation, energy, matter and space.

Some suggestions for experimental physics are given.

Finally, time velocity enables a new interpretation of cosmological red-shift.

GR 3: Relativistic Astrophysics

Time: Monday 16:30–17:15 Location: H-HS IX

GR 3.1 Mon 16:30 H-HS IX
Quadrupole distortion of a mass with quadrupole — •Shokoufe Faraji — Bremen

In this paper the space-time of a mass with quadrupole in the presence of an external distribution of matter up to quadrupole is constructed. This space-time explains the exterior of a static and axially symmetric object locally, by its definition. The main goal of this work is to study this space-time and the effects of quadrupole moments via the geodesics motion, especially circular orbits on the equatorial plane. If the effects due to the rotation are negligible, this metric can describe the exterior of any axially symmetric astrophysical model up to quadrupole in a more realistic way in the sense that mostly astrophysical objects, are not isolated.

GR 3.2 Mon 16:45 H-HS IX

Hypermassive hybrid stars within the phase diagram of QCD — •Matthias Hanauske[1,2], Horst Stöcker[1,2], and Luciano Rezzolla[1,2] — [1]Frankfurt Institute for Advanced Studies — [2]Institut für Theoretische Physik, Frankfurt, Germany

Hypermassive hybrid stars (HMHS) are extreme astrophysical objects. In contrast to hypermassive neutron stars (HMNS) these highly differentially rotating objects contain deconfined strange quark matter in their slowly rotating inner region. HMHS and HMNS are formed in a binary neutron star merger event and can survive only a view seconds. During the inspiral, merger and post-merger evolution of the system, gravitational waves (GW) are emitted and the measured GW GW170817 has verified this picture impressively for the late inspiral phase. GWs, emitted from merging neutron star binaries, will be observed frequently within the coming years and it is therefore needful to understand the main characteristics of the underlying merging system in order to predict the expected GW signals. The appearance of a QCD-phase transition in the interior region of the HMHS and its conjunction with the spectral properties of the emitted GW will be addressed during this talk.

GR 3.3 Mon 17:00 H-HS IX

Propagation time delay in Kerr black hole — •Bilel Ben Salem[1,2] and Eva Hackmann[2] — [1]University of Bielefeld — [2]ZARM, University of Bremen

Finding a pulsar closely orbiting the super massive black hole in the galactic center would open the window to a new era of testing General Relativity and other alternative theories of gravity in the strong gravity regime as well as some aspects like the cosmic censorship conjecture and the no-hair theorem. The pulsar timing model which predicts the arrival time of the pulses should include all relativistic effects for a such binary system, in particular the propagation delay of the pulses in the gravitational field of the black hole. In [E. Hackmann, A. Dhan The propagation delay in the timing of a pulsar orbiting a supermassive black hole. General Relativity and Gravitation], an exact analytical formula for the propagation time delay was derived for the Schwarzschild black hole where the pulsar is treated as a test particle due to the extreme mass ratio. We generalize the formula to the Kerr black hole case where we investigate the effect of the frame-dragging on the propagation time delay and compare our result to the post-Newtonian approximation.

GR 4: Other Topics in Gravitational Physics

Time: Monday 17:15–18:00 Location: H-HS IX

GR 4.1 Mon 17:15 H-HS IX

Probabilistic framework for the gravitational clock compass — •Dirk Puetzfeld — ZARM, Uni Bremen

We present a probabilistic description of the gravitational clock compass which allows for a hierarchical determination of the gravitational field as well as a transparent modeling of all errors involved in the measurement process.

GR 4.2 Mon 17:30 H-HS IX

Rogue waves in a selfgravitating BEC — •Sandro Gödtel and Claus Lämmerzahl — ZARM, University of Bremen, Germany

The coupling between gravity and quantum mechanics is still an open question in physics. As an example, we explore self-gravitational effects within a Bose-Einstein condensate. Such a system is described by the Gross-Pitaevskii-Newton equation which was first introduced as a concept of boson stars. The nonlinearity of the particle interaction causes special phenomena like rogue waves. Originally observed in ocean waves these waves are able to increase the density locally. For a mathematical description we use the common model called the Peregrine soliton. In our work, we show that these solutions indeed exist in a BEC and estimate the size of these waves with typical experimental values. Additionally, we determine the gravitational impact on the condensate due to the higher density and we show at which values the gravitational self-interaction becomes significant and observable.

GR 4.3 Mon 17:45 H-HS IX

Accretion processes around boson stars — •Matheus do Carmo Teodoro[1], Jutta Kunz[1], and Lucas Collodel[2] — [1]Oldenburg universität — [2]Tübingen universität

In this work we studied the behavior of ideal gas clouds near boson stars (BS). Being the later described by a complex field scalar theory coupled to general relativity, BS can have a wide set of configuration, ranging from very compact objects to extremely extensive ones, with masses that go from atomic scale to the order of supermassive black-holes. For this reason they are also candidates for Black Hole Mimickers and of particular astrophysical interest. On the other hand, these objects possess no hard surface nor event horizon, meaning that matter could pass through them. Tidal disruption events on these spacetimes would have then a peculiar nature. In order to approach this topic we have performed, using state-of-the-art numerical techniques accomplished by the Black Hole Accretion Code (BHAC), 2D fully relativistic simulations taking as initial condition spherical clouds at rest with a Gaussian distribution of density in hydrodynamic equilibrium with the atmosphere. Aiming to discuss the differences of such events around boson stars and black holes, we shall present the results from our simulations in this talk.

GR 5: Gravitational Waves

Time: Tuesday 11:00–12:45 Location: H-HS IX

Invited Talk GR 5.1 Tue 11:00 H-HS IX

Testing GR with gravitational waves: current status and future prospects — •Collin Capano — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Callinstraße 38, Hannover, Germany

The direct detection of gravitational waves from merging compact objects has opened up several new avenues for testing general relativity. I will discuss current results from these tests, as well as future prospects and challenges. In particular, I will touch on the possibility of testing the no-hair theorem using binary black hole mergers in the coming decade.

GR 5.2 Tue 11:45 H-HS IX

Binary black hole dynamics from scattering — •Jan Steinhoff — Albert Einstein Institute, Potsdam

The ongoing detections of gravitational waves by LIGO and Virgo open a new era for astro- and fundamental physics. With improvements in detector sensitivity, more accurate predictions for gravitational waves are needed, which presents a challenge for numerical relativity and approximation methods. In this talk, recent developments in the area analytic approximations for compact binaries are discussed which are based on scattering processes. This ranges from classical computations of scattering angles for binary black holes to (quantum) probability amplitudes for the gravitational scattering of particles. In the latter regime, modern techniques such as on-shell methods and the Bern-Carrasco-Johansson double copy provide powerful tools to push analytic (approximate) predictions to higher accuracy.

GR 5.3 Tue 12:00 H-HS IX

Is there a mass-ratio gap between numerical relativity and gravitational self-force? — •Harald Pfeiffer and Maarten van de Meent — Max Planck Institut für Gravitationsphysik, Am Mühlenberg 1, 14476 Potsdam

Future gravitational wave observatories —both in space and on the ground — will be sensitive to compact binary coalescences with mass-ratios between 1:10 and 1:1000. Numerical relativity simulations work very well for comparable mass binaries, but become increasingly challenging as the mass-ratio decreases, and are unlikely to cover this entire range. Gravitational self-force methods employ a systematic expansion in the mass-ratio to produce waveform models. Their natural regime of validity is therefore small mass-ratio binaries. We examine how accurate we can expect gravitational self-force models to be in the comparable mass regime. Is 1/4 a small number?

GR 5.4 Tue 12:15 H-HS IX

Combining Greedy Approaches and Gaussian Process Regression in Gravitational-Waveform Modelling — •Florian Wicke — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany — Leibniz Universität Hannover, Hannover, Germany

One of the goals of gravitational wave analysis is to estimate the source parameters of compact binary coalescence signals. This is done by comparing the measured signal to gravitational wave templates generated by a model. The most accurate templates are provided by numerical simulations. However, these are computationally expensive to produce. Varma et al. [Phys. Rev. D99, 2019] use a machine learning method called Gaussian Process Regression (GPR) to build a significantly less expensive surrogate model. GPR is an interpolation method that uses a limited number of numerically generated waveforms as a training set and predicts waveform templates for the surrounding parameter space. The training set is selected in a greedy manner using computationally inexpensive post-Newtonian waveforms. Here we evaluate whether the selection of the training set can be achieved solely by the GPR. To accomplish this, we use that GPR returns an uncertainty at each position in parameter space in addition to a predicted waveform. This uncertainty is then used as an error measure to select the next best training point position. We find that we achieve similar, if not better, convergence behaviour, but at the expense of worse computational efficiency.

GR 5.5 Tue 12:30 H-HS IX

Multi-Messenger Gravitational Wave Signals: Expectations and Results — •Alexander Unzicker — Pestalozzi-Gymnasium München

An overview of the LIGO/VIRGO and possibly KAGRA results on gravitational waves is given, based on the template-free statistical method proposed by Liu et.al. (arXiv:1802.00340, CJAP). Special attention is given to the recent concerns about high-false-alarm rates among trigger events. In particular, the multi-messenger results are discussed and compared with earlier predictions.

GR 6: Poster

Time: Tuesday 17:00–18:30 Location: Zelt

GR 6.1 Tue 17:00 Zelt

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. To achieve interactivity, a four-dimensional KD-tree structure is implemented. We present the features of the simulation including scenes that consist of static and relativistically moving objects. Additionally, the range of application for the teaching of special relativity is shown. The simulation will be available at the presentation.

GR 6.2 Tue 17:00 Zelt

Teaching General Relativity with Sector Models: The Field Equations — •Corvin Zahn and Ute Kraus — Universität Hildesheim, Germany

Einstein's field equations link the distribution of matter to the curvature of spacetime. Due to their complexity it is not feasible to discuss them at a mathematical level in high school or in undergraduate university education.

With sector models (Zahn and Kraus 2014) we are developing an accessible approach to general relativity relying only on elementary mathematics and geometric insight. A sector model represents a 2D or 3D subspace of a 4D curved spacetime, the model being true to scale. It is created according to the description of curved spacetimes in the Regge calculus, where the spacetime is subdivided into small, uncurved sectors (Regge 1961).

We show sector models of 3D and 2+1D slices of the curved spacetime of a neutron star and a black hole as computer graphics and as haptic models.

The curvature of the space or spacetime can be measured using ruler and protractor. From this the numerical value of the local matter density and the other components of the stress-energy tensor can be easily computed from the sum of three measured curvature values.

References:
C Zahn and U Kraus 2014 Eur. J. Phys. 35 055020
Regge T 1961 General relativity without coordinates Il Nuovo Cimento 19 558-71

GR 6.3 Tue 17:00 Zelt

First and second order hyperbolic formulations of the Einstein equations: a review. — •Daniela Cors and Bernd Brügmann — Theoretisch-Physikalisches Institut, Fröbelstieg 1, 07743 Jena

The BSSN and Z4 formulations of the Einstein equations have been very successful for numerical simulations of black holes and neutron stars. However, these are of first order in time but second order in space. A fully first order formulation in time and space offers additional advantages. For instance, higher order methods such as spectral methods do benefit from first order formulations. Here we present a review of these different hyperbolic reformulations of the Einstein equations in vaccum. We compare their adequacy for different numerical simulations and assess the possibility of first order reductions. An example of such reductions is the recently introduced FOCCZ4 system, which is a first order reformulation of the conformal and covariant formulation of the Z4 system, the so called CCZ4. We propose to pursue a similar strategy in order to reduce the conformal Z4c formulation to first order in time and space.

GR 6.4 Tue 17:00 Zelt

Best Test of the Weak Equivalence Principle with the Space Mission MICROSCOPE — Meike List[1], Benny Rievers[2], and •Claus Lämmerzahl[2] — [1]DLR Institute for Satellite Geodesy and Inertial Sensing, Bremen, Germany — [2]ZARM, University of Bremen, Bremen, Germany

The Weak Equivalence Principle (or Universality of Free Fall) is the basis of General Relativity and determines our understanding of space and time. Even for this reason alone, this principle must be tested as precisely as possible. In addition, a theory of quantum gravity is being sought, which is necessary because of an apparent incompatibility between General Relativity and quantum mechanics. Although there is still no fully worked out quantum gravity theory, all the approaches predict a tiny violation of the equivalence principle. Tests of the Weak Equivalence Principle are therefore key tests in the search for quantum gravity, but they are also of importance for practical purposes like geodesy. Recently, the satellite experiment MICROSCOPE carried out the best test so far.

GR 6.5 Tue 17:00 Zelt

Best Test of the Gravitational Redshift with the Satellites Galileo 5 and 6 — Sven Herrmann[1], Felix Finke[1], Meike List[2], Benny Rievers[1], and •Claus Lämmerzashl[1,2] — [1]ZARM, University of Bremen, Bremen, Germany — [2]DLR Institute for Satellite Geodesy and Inertial Sensing, Bremen, Germany

The gravitational redshift, i.e. the decrease in the frequency of light with altitude or the increase in the ticking rate of clocks with altitude, is one of the prominent predictions of Einstein's General Relativity. It is a particular important aspect of our understanding of space and time. This redshift has practical applications in positioning and geodesy. With increasingly accurate clocks (the most accurate clocks today would only go wrong by about 1 second after 30 billion years) it is important to know whether the influence of gravity on clocks is really as Einstein predicted. The best test so far was determined with a hydrogen maser in a rocket in a single parabolic flight. Since in 2014 the Galileo satellites 5 and 6 were put into a wrong, eccentric orbit due to a malfunction of the Fregat upper stage of the Soyuz rocket, the possibility arose to measure the periodic change in the rate of the atomic clocks on the Galileo satellites. A laborious data analysis showed an improvement of this test by a factor 5.

GR 6.6 Tue 17:00 Zelt

Virtuelle Sektormodelle: Interaktive Betrachtung der gekrümmten Raumzeit in der Nähe eines Neutronensterns — •Sven Weissenborn, Ute Kraus und Corvin Zahn — Universität Hildesheim

In der Allgemeinen Relativitätstheorie werden die Bahnen von Licht und frei fallenden Teilchen als Geodäten in der gekrümmten Raumzeit beschrieben. Virtuelle Sektormodelle ermöglichen die Konstruktion dieser Geodäten, ohne dabei auf den üblichen mathematischen Apparat zurückgreifen zu müssen. Durch eine webbasierte Applikation wird ein mobiler Zugang bereitgestellt, der das Ergründen physikalischer Phänomene in einer gegebenen Raumzeit ermöglicht. Beispiele sind Lichtablenkung und Rotverschiebung in der Nähe eines Neutronensterns.

Während der Poster-Sitzung kann die Applikation getestet werden.

GR 6.7 Tue 17:00 Zelt

A journey into a Kerr black hole – First person visualization of general relativity — •Thomas Reiber — Universität Hildesheim

What would an observer falling into a rotating black hole see? The view of an observer moving in Kerr spacetime on a geodesic or accelerated path is calculated using general relativistic ray tracing. Covering the whole maximal analytic extension of Kerr spacetime requires a multitude of coordinate patches. On the poster we show some representative pictures from the created movies, the complete movies can be seen during the poster session.

GR 6.8 Tue 17:00 Zelt

Influence of magnetic field and charge black hole on equilibrium of thick accretion disk — •Audrey Trova — Zarm, University of Bremen, Germany

We are presenting an analytical model of a thick accretion disk modeled by a charged fluid encircling a charged black hole and endowed in an asymptotically magnetic field. Both electric and magnetic fields are known to influence the accretion flow. Our study is based on the Polish doughnut model and provides an extension of this well-known model. Here our interest is to know how each of the interactions involved in the equilibrium process as the gravity, the electric force, and the magnetic force, are influencing the shape and the density distribution of the fluid. We are focusing on orbiting structures in the equatorial plane, as single or double tori, and structures above the equatorial plane as levitating torus which can be relevant for coronal plasma.

GR 6.9 Tue 17:00 Zelt

The rotating mass shell in general theory of relativity — •Florian Atteneder[1,3], Tobias Benjamin Russ[2], Helios Sanchis-Alepuz[3], and Reinhard Alkofer[3] — [1]Theoretical Physics Institute, University of Jena, 07743 Jena, Germany — [2]Theoretical Physics, Ludwig Maxmillians University, 80333 Munich, Germany — [3]Institute of Physics, NAWI Graz, University of Graz, 8010 Graz, Austria

The model of a rotating mass shell (RMS) was initially introduced to judge if rotation has only relative meaning. It comprises a description of a spacetime with an energy-matter content that is assembled in a statically rotating quasi-spherical shell with zero radial extension. Latest perturbation theory (PT) calculations have shown that relativity of rotation is indeed realized in such a spacetime. However, because this conclusion was based on PT, its validity is limited to slowly RMSs. This work pursues a numerical treatment of the problem, where the mathematical formulation involves a splitting of the spacetime into a region that is flat and one that is asymptotically flat. The latter is used as a reference to define relative rotation. The RMS forms at the common boundary of these two regions. On the basis of previous work, we formulate Einstein's equations as a free-boundary value problem and solve them numerically using a pseudo-spectral method. As a result we obtain a three-parameter solution that is characterized by the shell's polar radius, its gravitational mass and angular momentum. The existence of the solution is enough to positively answer the question if Mach's idea of relativity of rotation can be extended for rapidly RMSs.

GR 6.10 Tue 17:00 Zelt

Astrophysically relevant chaos in Extreme Mass Ratio Inspirals from spinning particles — •Ondřej Zelenka, Georgios Lukes-Gerakopoulos, and Vojtěch Witzany — Astronomical Institute of the Czech Academy of Sciences, Fričova 298, 251 65 Ondřejov, Czech Republic

An Extreme Mass Ratio Inspiral is the merger of a compact binary system with a very large ratio of masses, such as a supermassive black hole and a stellar mass compact object (black hole or neutron star). A model for such an event is the motion of a test spinning particle in a fixed spacetime background. We study the case of non-spinning supermassive black hole and spinning stellar mass compact object, which is described by the Mathisson-Papapetrou-Dixon equations in the Schwarzschild background. We investigate low values of the spin, show that chaotic behavior is present for astrophysically relevant scenarios and study the growth of prolonged resonances when deviating from the spinless case. We also demonstrate that chaos is encoded in the gravitational waveforms from such events.

GR 6.11 Tue 17:00 Zelt

Quasinormal modes of dilatonic Reissner-Nordström black holes — Jose Luis Blázquez-Salcedo, •Sarah Kahlen, and Jutta Kunz — Carl von Ossietzky Universität, Oldenburg, Germany

Quasinormal modes of static spherically symmetric dilatonic Reissner-Nordström black holes for general values of the electric charge and of the dilaton coupling constant are shown. The spectrum of quasinormal modes is composed of five families of modes: polar and axial gravitational-led modes, polar and axial electromagnetic-led modes, and polar scalar-led modes. The spectrum strongly depends on the electric charge and on the dilaton coupling constant. For large electric charge and large dilaton coupling, strong deviations from the Reissner-Nordström modes arise. In particular, isospectrality is strongly broken, both for the electromagnetic-led and the gravitational-led modes, for large values of the charge.

GR 6.12 Tue 17:00 Zelt

Explanation of the Rapid Enlargement of Distances in the Early Universe and Comparison with 'Inflaton Models' — •Hans-Otto Carmesin — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

First, we summarize the nature of an explanation. Secondly, we achieve a cognitive conflict resulting in the insight, that there has been a special enlargement of distances in the early universe. Thirdly, we apply model experiments in order to resolve the cognitive conflict. Fourthly, we use a simple calculation in order to compare with observations. Fifthly, we show that the proposed 'inflaton model' does not achieve the criteria of an explanation introduced above. Sixthly, we summarize experiences with teaching (Carmesin, H.-O. (2019): Die Grundschwingungen des Universums - The Cosmic Unification - With 8 Fundamental Solutions based on G, c and h - With Answers to 42 Frequently Asked Questions. Berlin: Verlag Dr. Köster.).

GR 6.13 Tue 17:00 Zelt

The Actual Controversy of the Hubble - Constant: Comparison of Observations with Theory — •Ole Rademacker[1] and Hans-Otto Carmesin[1,2,3] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Bahnhofstraße — [3]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

First, we evaluate observations in order to show that the Hubble-constant is a function of the redshift. Secondly, we discuss the significance of that finding for the standard model of cosmology. Thirdly, we compare our results with a fundamental theory of quantum gravity (Carmesin, H.-O. (2019): Die Grundschwingungen des Universums - The Cosmic Unification - With 8 Fundamental Solutions based on G, c and h - With Answers to 42 Frequently Asked Questions. Berlin: Verlag Dr. Köster.).

GR 6.14 Tue 17:00 Zelt

Density Problem in the Early Universe and Solution by Quantum Gravity — •Philipp Schöneberg[1] and Hans-Otto Carmesin[1,2,3] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Bahnhofstraße — [3]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

No density can be larger than the Planck density $\rho_P = 5,155 \cdot 10^{96}\,\frac{\text{kg}}{\text{m}^3}$. The time evolution of the actual light horizon should be traced back until the Planck length $L_P = 1.616 \cdot 10^{-35}$m is reached. However there arises a problem, as the framework of general relativity theory, GRT, that length L_P is only reached at the density $\rho = 6 \cdot 10^{214} \frac{kg}{m^3}$.

We present a solution of that model. We illustrate that solution with several model experiments. Additionally we derive the correct solution by using EXCEL in a graphic manner (Carmesin, H.-O. (2019): Die Grundschwingungen des Universums - The Cosmic Unification - With 8 Fundamental Solutions based on G, c and h - With Answers to 42 Frequently Asked Questions. Berlin: Verlag Dr. Köster.).

GR 6.15 Tue 17:00 Zelt

Density Limit of the Evolution of Space According to General Relativity — Laurie Heeren[1], Hans-Otto Carmesin[1,2,3], and •Paul Sawitzki[1] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Bahnhofstraße — [3]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

No density can be larger than the Planck density $\rho_P = 5,155 \cdot 10^{96} \frac{kg}{m^3}$. The time evolution of the actual light horizon should be traced back until the Planck length $L_P = 1.616 \cdot 10^{-35}$m is reached. However there arises a problem, as in the framework of general relativity theory, GRT, that length L_P is only reached at the density $\rho = 6 \cdot 10^{214} \frac{kg}{m^3}$.

We investigate the Planck scale, the evolution of space according to the Friedmann Lemaitre equation and the resulting density limit. Additionally we derive a corresponding time limit. We outline a possible solution of the problem (Carmesin, H.-O. (2019): Die Grundschwingungen des Universums - The Cosmic Unification - With 8 Fundamental Solutions based on G, c and h - With Answers to 42 Frequently Asked Questions. Berlin: Verlag Dr. Köster.).

GR 6.16 Tue 17:00 Zelt

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

Theories of quantum gravity are attempting without success the quantization of spacetime. The present proposal puts forward the fact that the current concept of spacetime is only a mathematical tool which has been developed for the description of the principles of general relativity, and it is based on assumptions which are neither deriving from general relativity nor compatible with quantum mechanics. The following three corrections of the current spacetime concept are opening the way for quantum gravity:

1. Spacetime is no continuous manifold - general relativity defines worldlines but no vacuum points between worldlines.

2. For the solution of fundamental physical problems about time, we must refer to the proper time parameter of worldlines instead of the coordinate time of spacetime.

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

The result: General relativity and quantum mechanics are perfectly harmonizing, and gravity acts within quantum mechanics in the form of gravitational time dilation.

GR 6.17 Tue 17:00 Zelt

Three observations questioning classical GRT - EHT image M87*, spin, ALMA image Sgr A* — •Jürgen Brandes — Karlsbad, Germany

The EHT image of M87* is an impressing proof of classical GRT but it proves LI of GRT [1] as well since it is a face on image of the equatorial plane of M87*. Three astronomical observations prefer LI of GRT:

1.) Some details of the intensity distribution of the EHT image of M 87*, 2.) conflicting high and low spin measurements of M87* and Sgr A* and 3.) the ALMA image of Sgr A* since it is an edge on image of the equatorial plane of Sgr A*. The poster and the homepage [2] present the details.

[1] Brandes, J.; Czerniawski, J. (2010): Spezielle und Allgemeine Relativitätstheorie für Physiker und Philosophen - Einstein- und Lorentz-Interpretation, Paradoxien, Raum und Zeit, Experimente, Karlsbad: VRI, 4. erweiterte Auflage

[2] Three observations questioning classical GRT - EHT image M87*, spin, ALMA image Sgr A*, www.grt-li.de

GR 7: Classical Theory of General Relativity 2

Time: Wednesday 10:30–11:30 Location: H-HS IX

Invited Talk GR 7.1 Wed 10:30 H-HS IX

The Sagnac effect in General Relativity — •Jörg Frauendiener — Department of Mathematics and Statistics, University of Otago, Dunedin, New Zealand

The Sagnac effect can be described as the difference in travel time between two photons traveling along the same path in opposite directions. In this talk we explore the consequences of this characterisation in the context of General Relativity. We derive a general expression for this time difference in an arbitrary space-time for arbitrary paths. In general, this formula is not very useful since it involves solving a differential equation along the path. However, we also present special cases where a closed form expression for the time difference can be given. We discuss the effect in a small neighbourhood of an arbitrarily moving observer in their arbitrarily rotating reference frame. We also discuss the special case of stationary space-times and point out the relationship between the Sagnac effect and Fizeau's 'aether-drag' experiment.

GR 7.2 Wed 11:15 H-HS IX

The Ether (Äther) Discussion in Relativity — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

The ether question was once decided in favor of Einstein's position, following the 'Zeitgeist' of that epoch. Was it a good decision?

Lorentz debated this question with Einstein, and he presented Einstein counterarguments (1917), which Einstein did not refute. - We will present the arguments of this discussion and in addition aspects of nowadays physics about it. Furtheron we will briefly explain the impacts of Lorentz's alternative view on the understanding of physics in general and on relativity (SRT and GRT) in particular.

Und wir hoffen auf eine lebhafte Diskussion zu diesem Thema.

Literatur: Ludwik Kostro, Einstein and the Ether, Apeiron 2000

GR 8: Black Holes 1

Time: Wednesday 11:30–12:15 Location: H-HS IX

GR 8.1 Wed 11:30 H-HS IX

A global view on Kerr spacetime – visualizing the maximal analytic extension — •Thomas Reiber — Universität Hildesheim

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. We calculate videos of what such an observer would see by using general relativistic ray tracing in the maximal analytic extension of Kerr spacetime. For that purpose we use a covering af Kerr spacetime by a atlas consisting of Kerr-Schild and Kruskal-like coordinate patches.

GR 8.2 Wed 11:45 H-HS IX

Aschenbach effect for particles with spin — •Volker Perlick[1], Jafar Khodagholizadeh[2], and Ali Vahedi[3] — [1]ZARM, University of Bremen, 28359 Bremen, Germany — [2]Farhangian University, P.O. Box 11876-13311, Tehran, Iran — [3]Faculty of Physics, Kharazmi university, P. O. Box 15614, Tehran, Iran

In the Schwarzschild spacetime the orbital velocity of a freely falling particle in circular motion is a monotonically decreasing function of the radius, as we are used to from Newtonian physics. Therefore, it came as a surprise when in 2004 Bernd Aschenbach realised that in a Kerr spacetime with spin parameter $a^2 > a_c^2$, $a_c \approx 0.9953M$, there is a radius interval close to but outside of the innermost stable circular orbit for which the orbital velocity of co-rotating particles is increasing with the radius coordinate. He showed that this non-monotonic behaviour is related to the presence of a certain resonance that would link the effect to possible observations. Here we investigate how the non-monotonic behaviour of the orbital velocity is modified if particles with spin are considered. To that end we use the Mathisson-Papapetrou-Dixon equation with the Tulczyjew-Dixon and the Frenkel-Mathisson-Pirani supplementary conditions.

GR 8.3 Wed 12:00 H-HS IX

Gravitational lensing in Newman-Unti-Tamburino spacetime — •Mourad Halla and Volker Perlick — ZARM Universität Bremen, 28359 Bremen

Gibbons and Werner have shown that in the Schwarzschild and in the Kerr spacetime the deflection angle of light in the equatorial plane is related to the Gauss curvature by the Gauss-Bonnet theorem. Here we generalise this result to the NUT-metric, where the motion of light is not in a plane but in a cone.

GR 9: Black Holes 2

Time: Wednesday 14:00–15:45 Location: H-HS IX

GR 9.1 Wed 14:00 H-HS IX

Gravitational Lensing by an Accelerating Black Hole — Torben Frost and •Volker Perlick — ZARM, University of Bremen, Bremen, Germany

The C-metric is an exact solution of Einstein's vacuum field equations. It generalises the Schwarzschild metric by introducing an acceleration parameter and describes the spacetime of an accelerating black hole. Although it is plagued by unphysical singularities, a conical singularity on the axis of acceleration and another one hidden behind the acceleration horizon, it can be used as a first attempt to describe linearly accelerating black holes. In our work we investigate the effect of the acceleration on classical lensing observables, e.g., redshift, lens map and travel time. We discuss the differences in comparison to the Schwarzschild metric and if and how the effects of the acceleration parameter can be investigated using astrophysical observations.

GR 9.2 Wed 14:15 H-HS IX

The ISCO of charged particles — •Saskia Grunau[1] and Kris Schroven[2] — [1]Institute of Physics, Carl-von-Ossietzky University, Oldenburg, Germany — [2]Astronomical Institute, Czech Academy of Sciences, Prague, Czech Republic

The innermost stable circular orbit (ISCO) is defined by the smallest radius at which a test particle can move on a circular trajectory around a black hole. In accretion disk theory the ISCO is an important property of black holes, since it marks the inner edge of the accretion disk. In the Schwarzschild spacetime the ISCO is located at 6M, while in the Kerr spacetime the ISCO depends on the angular momentum of the black hole as well as on the direction of the angular momentum of the test particle. Here we will study the influence of the charge of a test particle on the ISCO in charged black hole spacetimes.

GR 9.3 Wed 14:30 H-HS IX

Overcharging and discharging processes in black hole physics — •Emanuele Di Maio[1,2], Piero Nicolini[2], and Mariafelicia De Laurentis[1] — [1]Università degli studi di Napoli federico II, Napoli, Italia — [2]Goethe-Universität, Frankfurt Am Main, Germany

Upon specific conditions for charge and mass parameters, it has been conjectured that black holes might overcharge in contrast to the tenets of the cosmic censorship. The net result of overcharging is the destruction of the event horizon and the formation of a naked singularity. In this talk we will scrutinize the overcharging against quantum processes, such as the Schwinger effect and the Hawking radiation.

GR 9.4 Wed 14:45 H-HS IX

Barriola Vilenkin gravitational monopole: an exact solution. — •Piero Nicolini[1], Marco Knipfer[2], Sven Köppel[1], and Jonas Mureika[3] — [1]Goethe Universität, Frankfurt — [2]University of Alabama, Tuscaloosa — [3]Loyola Marymount University, Los Angeles

After briefly recalling the properties of the Barriola-Vilenkin metric, we will present a new exact monopole solution in five dimensional nonlocal gravity. This object turns out to be the end point of the black hole evaporation. Interestingly for smaller masses, the spacetime admits a "naked monopole" rather than a generic naked singularity. The solution is discussed against current proposals for dark matter component candidates.

GR 9.5 Wed 15:00 H-HS IX

Rotating and excited black holes in Einstein-scalar-Gauss-Bonnet theory — Lucas Collodel[1], Burkhard Kleihaus[2], •Jutta Kunz[2], and Emanuele Berti[3] — [1]University of Tübingen — [2]University of Oldenburg — [3]Johns Hopkins University

We present rotating fundamental and radially excited black holes in Einstein-scalar-Gauss-Bonnet theory with a quadratic coupling function. We determine their domains of existence and show that there are also angularly excited rotating black holes. We determine the bifurcation points of the radially and angularly excited solutions from the Schwarzschild black hole and show that these follow a regular pattern.

GR 9.6 Wed 15:15 H-HS IX

Quasinormal modes of black holes with scalar hair — •Jose Luis Blazquez-Salcedo — Carl von Ossietzky University of Oldenburg, Oldenburg, Germany

We study quasinormal modes of black holes in several alternative theories of gravity. In particular, we focus on theories that include an additional scalar field coupled non-trivially with gravity. Several models exist that allow to obtain black holes with non-trivial scalar hair. In this talk we will discuss some results concerning linear perturbations of these configurations, their ringdown spectrum and their stability.

GR 9.7 Wed 15:30 H-HS IX

Quasinormal modes of dilatonic Reissner-Nordström black holes — Jose Luis Blázquez-Salcedo, •Sarah Kahlen, and Jutta Kunz — Carl von Ossietzky Universität, Oldenburg, Germany

Some numerically obtained quasinormal modes of static spherically symmetric dilatonic Reissner-Nordström black holes for general values of the electric charge and of the dilaton coupling constant are presented. The spectrum of quasinormal modes is composed of five families of modes: polar and axial gravitational-led modes, polar and axial electromagnetic-led modes, and polar scalar-led modes. A quantitative analysis of the spectrum reveals its dependence on the electric charge and on the dilaton coupling constant. For large electric charge and large dilaton coupling, strong deviations from the Reissner-Nordström modes arise. In particular, isospectrality is strongly broken for large values of the charge, both for the electromagnetic-led and the gravitational-led modes.

GR 10: Quantum Gravity and Quantum Cosmology 1

Time: Wednesday 16:30–18:30 Location: H-HS IX

GR 10.1 Wed 16:30 H-HS IX

On the construction of diffeomorphism-invariant observables — •Leonardo Chataignier — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Cologne, Germany

We describe a method of construction of diffeomorphism-invariant operators (Dirac observables or "evolving constants of motion") from the knowledge of the eigenstates of the gauge generator in time-reparametrisation invariant mechanical systems. These invariant operators evolve unitarily with respect to an arbitrarily chosen time variable. We emphasise that the dynamics is relational, both in the classical and quantum theories. We conclude with some remarks about possible phenomenological applications of this framework, such as singularity avoidance in quantum cosmology.

Ref.: L.C., "On the Construction of Quantum Dirac Observables and the Emergence of WKB Time", arXiv:1910.02998 [gr-qc].

GR 10.2 Wed 16:45 H-HS IX

Cosmological Decoherence from Thermal Gravitons — Ning Bao[1,2], •Aidan Chatwin-Davies[3], Jason Pollack[4], and Grant Remmen[1] — [1]University of California, Berkeley, USA — [2]Brookhaven National Lab, NY, USA — [3]KU Leuven, Belgium — [4]University of British Columbia, Canada

Coupling a coherent superposition of stress-energy to a bath of gravitons of course causes the superposition to decohere. While the decoherence rate may be very small in everyday configurations, such gravitational interactions can nevertheless have an appreciable effect over the course of cosmic history in the presence of a positive cosmological constant, which sources a thermal bath of gravitons. I will discuss some recent work which studies the effects of gravitationally-driven decoherence on tunneling processes associated with false vacuum decays, commenting on the consequences of these effects, as well as on further applications and observability.

GR 10.3 Wed 17:00 H-HS IX

Quantum cosmology of Starobinsky inflation revisited — Mariam Bouhmadi-López[1,2] and •Manuel Krämer[3] — [1]Department of Theoretical Physics, University of the Basque Country UPV/EHU, Bilbao, Spain — [2]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain — [3]Institute for Theoretical Physics, KU Leuven, Belgium

We study the canonical quantization of a cosmological model of Starobinsky inflation. We solve the resulting Wheeler–DeWitt equation in the Einstein frame formulation using a Born–Oppenheimer approximation and compare our findings to the quantization in the Jordan frame. We then discuss the implications for the question of whether Jordan and Einstein frame are equivalent at the quantum level.

GR 10.4 Wed 17:15 H-HS IX

Towards a quantum Oppenheimer-Snyder model — •Tim Schmitz — Institut für Theoretische Physik, Universität zu Köln, Germany

We present a consistent canonical formulation of the flat Oppenheimer-Snyder model, including the Schwarzschild exterior. The switching between comoving and stationary observer is realized by promoting the coordinate transformation between dust proper time and Schwarzschild-Killing time to a canonical one. This leads to two different forms of the Hamiltonian constraint, both (almost) deparameterizable with regard to one of these times. A preliminary quantization of these constraints reveals a consistent picture for both observers: the singularity is avoided by a bounce.

GR 10.5 Wed 17:30 H-HS IX

Towards a classical correspondence of wave packets in quantum cosmology — Chen Lan[1], •Yi-Fan Wang[2], and Yan-Gang Miao[1] — [1]School of Physics, Nankai University, Tianjin 300071, China — [2]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, D-50937 Köln, Germany

In Wheeler–DeWitt quantum cosmology, a classical universe can emerge from a realistic wave function at a suitable scale. It has been argued that such wave functions are strongly peaked around classical solutions; in other words, the ridgeline of a physical wave packet corresponds to a classical solution.

We give quantitative descriptions of the ridge-line of a wave packet. With explicit examples of wave packets, it is shown that ridgelines can deviate from classical trajectories at classical scales. Possible interpretations are discussed.

GR 10.6 Wed 17:45 H-HS IX

Quantum Corrected Black Holes from String T-Duality — •Piero Nicolini[1,2], Euro Spallucci[3], and Michael Wondrak[1,2] — [1]Goethe Universität, Frankfurt — [2]Frankfurt Institute for Advanced Studies — [3]University of Trieste

After recalling the relation between the T-duality and the path integral duality, we present an exact static, neutral black hole solution emerging from the stringy modifications of Newton's potential. The spacetime is singularity free and formally equivalent to the Bardeen metric, apart from the presence of a string dependent ultraviolet regulator. Some considerations about the thermodynamics will be offered as a conclusion.

GR 10.7 Wed 18:00 H-HS IX

Primordial black holes in a dimensionally reduced universe — •Athanasios Tzikas[1], Piero Nicolini[2], Jonas Mureika[3], and Bernard Carr[4] — [1]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [2]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [3]Loyola Marymount University, Los Angeles, USA — [4]Queen Mary University of London, London, UK

We investigate the spontaneous creation of primordial black holes in a lower-dimensional expanding early universe. We use the no-boundary proposal to construct instanton solutions for both the background and a black hole nucleated inside this background. The resulting creation rate could lead to a significant population of primordial black holes during the lower dimensional phase. We also consider the subsequent evaporation of these dimensionally reduced black holes and find that their temperature increases with mass, whereas it decreases with mass for 4-dimensional black holes. This means that they could leave stable sub-Planckian relics, which might in principle provide the dark matter.

GR 10.8 Wed 18:15 H-HS IX

Dirac's Way to Quantum Gravity — •Alexander Unzicker — Pestalozzi-Gymnasium München

It is shown that Dirac's Large Number Hypotheses are equivalent to a numerical coincidence regarding Planck's constant, the speed of light and the mass and radius of the proton. Though this observation goes back to Finkelnburg (1947), the proton radius puzzle (Pohl, 2010) has augmented its possible relevance. As it happened with many other fundamental problems, a numerical coincidence may be the key to the quantum gravity conundrum.

GR 11: Alteranative Classical Theories of Gravitation

Time: Thursday 14:00–15:15 Location: H-HS V

GR 11.1 Thu 14:00 H-HS V

Particle-like solutions in Einstein-scalar-Gauss-Bonnet theories — •Burkhard Kleihaus[1], Jutta Kunz[1], and Panagiota Kanti[2] — [1]University of Oldenburg — [2]University of Ioannina

Einstein-scalar-Gauss-Bonnet (EsGB) theories are motivated from a quantum gravity perspective and include higher-curvature contributions in the form of the quadratic Gauss-Bonnet term coupled to a scalar field. Black holes and wormholes in EsGB theories have been extensively studied in the past. Here a new type of particle-like solutions is discussed. It represents globally regular spacetime manifolds and its effective stress-energy tensor is free from pathologies. We determine the domain of existence and compare with wormhole solutions, black holes and Janis-Newman-Winicourt-Wyman solutions. We show that the particle-like solutions are ultracompact objects possessing a lightring and featuring echoes in the gravitational-wave spectrum.

GR 11.2 Thu 14:15 H-HS V

Gauge-invariant approach to the parametrized post-Newtonian formalism — •Manuel Hohmann — University of Tartu, Tartu, Estonia

We present an approach to the parametrized post-Newtonian (PPN) formalism which is based on gauge-invariant higher order perturbation theory. This approach divides the components of the metric perturbations into gauge-invariant quantities, which carry information about the physical system under consideration, and pure gauge quantities, which describe the choice of the coordinate system. This separation generally leads to a simplification of the PPN procedure, since only the gauge-invariant quantities appear in the field equations and must be determined by solving them. Another simplification arises from the fact that the gauge-invariant approach supersedes the necessity to first choose a gauge for solving the gravitational field equations and later transforming the obtained solution into the standard PPN gauge. Both the metric and tetrad versions of the formalism are presented and applied to an example theory.

GR 11.3 Thu 14:30 H-HS V

Post-Newtonian limit of general scalar-torsion theories of gravity — •Kai Flathmann[1] and Manuel Hohmann[2] — [1]Institute for Physics, University of Oldenburg, 26129 Oldenburg, Germany — [2]Laboratory of Theoretical Physics, Institute of Physics, University of Tartu, 50411 Tartu, Estonia

In this talk we derive the post-Newtonian limit of a general class of teleparallel theories of gravity, where the action is a free function of the Torsion scalar and several quantities derived from a dynamical scalar field. In order to use the parameterized post-Newtonian (PPN) formalism without modifications, such as introducing an effective gravitational constant, we restrict the analysis to a massless scalar field. This class of theories is fully conservative, with only two non-vanishing PPN parameters. For a particular choice of the free function, the theory is even indistinguishable from General Relativity in its post-Newtonian approximation.

GR 11.4 Thu 14:45 H-HS V

Tsallis holographic dark energy in the Brans-Dicke theory with logarithmic scalar field — •Pradyumn Sahoo — Birla Institute of Technology and Science-Pilani, Hyderabda Campus, Hyderabad, India

In this paper, we investigate the dark energy phenomenon by studying the Tsallis holographic dark energy within the framework of Brans-Dicke (BD) scalar-tensor theory of gravity [Phys. Rev. **124**, 925 (1961)]. In this context, we choose the BD scalar field ϕ as a logarithmic function of the average scale factor $a(t)$ and Hubble horizon as the IR cutoff ($L = H^{-1}$). We reconstruct two cases of non-interacting and interacting fluid (dark sectors of cosmos) scenario. The physical behavior of the models are discussed with the help of graphical representation to explore the accelerated expansion of the universe. Moreover, the stability of the models are checked through squared sound speed v_s^2. The well-known cosmological plane i.e., $\omega_{de} - \omega'_{de}$ is constructed for our models. We also include comparison of our findings of these dynamical parameters with observational constraints. It is also quite interesting to mention here that the results of deceleration, equation of state parameters and $\omega_{de} - \omega'_{de}$ plane coincide with the modern observational data.

GR 11.5 Thu 15:00 H-HS V

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

General Relativity (GR) is the theory of gravitation of the SM. It is a mathematical approach from 1915, based on the representation of subatomic particles as isolated entities in space, arriving to the wondrous concept of space-time curvature. GR resists all intents of integration into a unified field theory and is not compatible with quantum mechanics. An approach is presented for a gravitation theory that is based on the representation of a subatomic particle (SP) as a focal point of rays of Fundamental Particles (FPs) that go from infinite to infinite, FPs where the energy of the subatomic particle is stored as rotations defining angular momenta. With this representation all SPs interact permanently through the angular momenta of their FPs, according to the Mach principle that postulates that physical laws are determined by the large-scale structure of the universe. The approach explains gravitation as the result of the physical reintegration of migrated electrons and positrons to their nuclei. Gravitation is so composed of a Newton and an Ampere component, with the Newton component dominant at sub galactic distances and the Ampere component at galactic distances. A positive Ampere component explains the dark matter and a negative Ampere component the dark energy. More at: www.odomann.com

GR 12: Cosmology

Time: Thursday 14:00–16:00 Location: H-HS IV

GR 12.1 Thu 14:00 H-HS IV

Weighing neutrinos on cosmological scales with counts-in-cells — •Cora Uhlemann — DAMTP Cambridge, UK — Newcastle University, UK

Counts-in-cells statistics capture essential non-Gaussian properties of the cosmic large-scale structure, including peculiar regions of high and low density. I will show that those statistics not only provide information complementary to common two-point statistics, but also allow for accurate theoretical predictions. I will explain how matter counts-in-cells statistics and their dependence on cosmological parameters can be predicted from first principles. With a Fisher forecast for constraints on LCDM parameters and the total neutrino mass, I demonstrate the constraining power of the matter PDF and its complementarity to the matter power spectrum at mildly nonlinear scales. Finally, I will discuss how predictions for the matter PDF can be related to biased tracers and weak lensing observables.

GR 12.2 Thu 14:15 H-HS IV

Cosmological structure formation beyond the perfect fluid approximation — •Alaric Erschfeld — Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, D-69120 Heidelberg, Germany

Late time cosmological structure formation is often studied in a perfect pressureless fluid approximation in which dark matter is described in terms of its mass density and velocity. Deviations from a homogeneous and isotropic background cosmology are treated perturbatively, leading to good agreement with observations and simulations on large scales. On smaller scales on the other hand the perfect pressureless fluid approximation breaks down due to the phenomenon of shell-crossing. Further, standard cosmological perturbation theory is not applicable anymore since the deviations from the background cosmology become highly non-linear.

In order to overcome the limitations of the perfect pressureless fluid approximation, we extend the description of dark matter in a kinetic theory approach, taking the velocity dispersion tensor into account. To tackle the regime where the deviations are non-linear, we employ the Martin-Siggia-Rose/Janssen-De Dominicis formalism describing dark matter in terms of a statistical field theory. This allows to use resummation techniques such as the one-particle irreducible scheme as well as study the functional renormalisation group for cosmological structure formation.

GR 12.3 Thu 14:30 H-HS IV

Dark matter halo mass densities from a statistical viewpoint — •Jenny Wagner — Universität Heidelberg, Zentrum für Astronomie, Astron. Rechen-Institut, Mönchhofstr. 12–14, 69120 Heidelberg, Germany

During the past decades, large-scale N-body simulations have successfully reconstructed cosmic structure formation with increasing resolution and complexity, as observations corroborate. Complementary efforts have arrived at a hydrodynamical theory that explains cosmic structure evolution up to the non-linear regime. A very recent approach based on a kinetic field theory can derive an analytic, parameter-free equation for the non-linear cosmic power spectrum. While the statistical properties of mass density perturbations for the observable universe as a whole is currently being understood from first principles, it is still unknown why our heuristic approaches for the characterisation of individual, locally collapsed mass agglomerations work so well.

Using a minimum set of prerequisites and approximations, I would like to put forward a new idea to explain the shape of the most common parametric dark matter halo mass density models in the framework of probability theory. It allows for an interpretation of the scaling radii and scaling densities which gives the limiting behaviour in the halo centre and in the outskirts a physical reason. Joining forces with simulation groups, surprising insights into the bulge-halo conspiracy and the cusp-core problem could be gained.

GR 12.4 Thu 14:45 H-HS IV

Causal Diamonds in Cosmology — Mauro Carfora[2], Francesca Familiari[2], and •Dennis Stock[1] — [1]University of Bremen, Center of Applied Space Technology and Microgravity (ZARM) — [2]University of Pavia, Department of Physics

We discuss causal diamonds in a cosmological set-up. In particular, making use of the relations between the area associated with the diamond and the spacetime curvature, we discuss the impact of cosmological inhomogeneities. Using the Einstein field equations and given a reference cosmological model, deviations from the reference model due to inhomogeneities can be understood as additional matter terms within the model. These deviations are linked to (ideal) observations.

GR 12.5 Thu 15:00 H-HS IV

Intensity Mapping observables of cosmology — •Caroline Heneka — Scuola Normale Superiore, Piazza dei Cavalieri 7, 56126 Pisa, Italy

Intensity Mapping (IM) techniques target the Universe from present time up to redshifts beyond ten when the first galaxies formed, from small to largest scales. Similar to CMB measurements, power spectra of emission line fluctuations tell about structure growth and underlying cosmology; but imagine the information encoded in thousands of intensity maps at varying redshifts and for multiple emission lines.

In this talk I will review IM as a test for cosmology and fundamental physics during the dark ages and the epoch of reionization, with power and cross-power spectra (suitable for multi-messenger methods) and global temperature signals probing cosmological structure formation, properties of dark matter and of astrophysical sources. As examples cosmological volumes of line fluctuations and their global temperature signal in general modified gravity scenarios are highlighted to measure deviations from the gravitational constant G and a possible dark matter – dark energy coupling. The ability of upcoming surveys like the SKA to constrain these modifications is demonstrated.

GR 12.6 Thu 15:15 H-HS IV

Systematic Bias in the Zwicky Transient Facility Photometric Calibration and Effects on Hubble Constant Measurement — •Simeon Reusch — DESY Zeuthen, Platanenallee 6, 15738 Zeuthen

I am investigating the photometric accuracy of the Zwicky Transient Facility (ZTF; an all-sky survey) to identify possible sources of systematic errors.

By analyzing data from June to September 2018 I was able to identify a systematic bias in the ZTF photometry which is correlated to the amount of scattered moonlight adding to the background. At full moon, 20.5 mag calibrator stars are estimated up to 400 mmag too bright and at new moon, up to 35 mmag too faint. As simulation shows, such a bias can affect supernova population studies in a systematic way. Studies like this are necessary starting points for the the precise and accurate measurement of the supernovae's distance moduli, which are needed to map the expansion history of the universe. A systematic bias thus directly affects precision measurements of the local Hubble constant. The method developed here could be employed to test the time stability of other optical instruments as well.

GR 12.7 Thu 15:30 H-HS IV

New theory considers cosmological red-shift to be originated in time dilation interacting with universes gravitation — •Bjørn Ebbesen — Hamburg, Germany

Thus far, in cosmology the imagination of an expanding universe is widely accepted. But still some physical laws claimed are not approved by local experiments.

The competing theory here considers cosmological red-shift as effect of universes time velocity changing in time. (Different time velocities at two points in space-time results in time dilation.) It is stated that a cosmological process takes place where universes time velocity evolves from and interacts with universes gravitation.

Examine observations so far in the context of this theory leads to the perspective of a shrinking universe with a decreasing Hubble factor.

GR 12.8 Thu 15:45 H-HS IV

New explanation for the accelerated expansion and flat galactic rotation curves — •Ahmad Sheykhi — Max Planck Institute (AEI)-Potsdam, Golm

Employing the non-additive Tsallis entropy, for the large-scale gravitational systems, we disclose that in the cosmological scales both Friedmann equation and the equation of motion for the Newtonian cosmology get modified, accordingly. We then derive the modified Newton's law of gravitation which is valid on the large scales. We show that on the relativistic regime, the modified Friedmann equation admits an accelerated expansion, for a universe filled with ordinary matter, without invoking any kind of dark energy, provided the non-extensive parameter is chosen $\beta < 1/2$. On the non-relativistic regime, however, the modified Newton's law of gravitation can explain the flat galactic rotation curves without invoking particle dark matter.

GR 13: Numerical Relativity

Time: Thursday 15:15–16:00 Location: H-HS V

GR 13.1 Thu 15:15 H-HS V

Hyperbolic-like Encounters of Binary Black Holes — •Hannes Rüter — Albert-Einstein-Institut, Potsdam

Using fully general-reativistic simulations, we are investigating the encounter of two black holes that are initially on a hyperbolic-like orbit. Due to emission of gravitational waves the black holes can eventually become bound and merge. We are particularly interested in the physics near the region between this capture and escape to inifinity.

GR 13.2 Thu 15:30 H-HS V

Application of numerical relativity to the prediction of thermal noise in interferometric gravitational wave detectors — •Tom Wlodarczyk, Nils Fischer, and Harald Pfeiffer — Albert-Einstein-Institut Potsdam

One factor limiting the sensitivity of interferometric ground-based gravitational wave (GW) detectors such as Advanced LIGO and Virgo is thermal noise originating in the coatings of the mirrors which form the interferometer. An improved understanding of the properties of this thermal noise may lead to a reduction of this noise-source, with an attendant improvement in the GW detector's sensitivity. The fluctuation-dissipation theorem relates thermal noise properties to elastic deformations of the mirrors when certain external forces are applied. The resulting partial differential equations are similar to those that arise in solutions of the Einstein constraint equations for merging black holes, and therefore opens the possibility to utilise modern numerical relativity codes to improve the design of future GW detectors. This talk reports on the status of this project. Our goal is to make statements about thermal noise with regard to the geometry and structure of the mirror coatings and potential beam shapes.

GR 13.3 Thu 15:45 H-HS V

Initial data for neutron-star binaries with the new SpECTRE code — •Nils L. Fischer — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) 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 first results solving for initial data for neutron-star binaries using our new numerical technology and I demonstrate the code's ability to scale to the capacity of the Minerva supercomputer at AEI Potsdam.

GR 14: Didactical Aspects of Relativity

Time: Thursday 16:30–18:30 Location: H-HS IV

Invited Talk GR 14.1 Thu 16:30 H-HS IV
Teaching general relativity with sector models — •Ute Kraus and Corvin Zahn — Universität Hildesheim

In teaching general relativity, the use of models can help to build geometric insight. Geodesics and the curvature tensor are of particular interest. Sector models visualize the geometry of specific curved spacetimes; these models are based on the Regge calculus and represent two- or three-dimensional subspaces true-to-scale. Geodesics and curvature tensor components can be inferred from them. This talk presents several examples of sector models, including models for a Schwarzschild black hole, a neutron star, and a wormhole, and discusses the potential of this approach.

Invited Talk GR 14.2 Thu 17:15 H-HS IV
How Long Is Now? On the problem of accurate time measurements — •Thomas Filk — Institute of Physics, University of Freiburg, 79104 Freiburg, Germany

The eigentime in relativity depends on the world line of an object. If an object is extended or consists of several subunits (composite systems or bound states), one has to define a reference point (e.g. the center of mass) in order to assign a definite eigentime to the object. However, the eigentimes of the constituents may differ from this reference time, making an unambiguous assignment of an eigentime to the object as a whole questionable. If the object is a clock, which part defines the reading?

Even worse is the situation, when one has to assign a precise eigentime to a quantum object. Quantum objects do not follow well defined trajectories and, therefore, the assignment of an accurate eigentime is problematic. In addition, further quantum effects - superposition states of systems which serve as clocks, or the entanglement of such systems - make these assignments even more difficult.

The presentation will address and discuss some of these issues and their consequences also in the context of teaching relativity.

GR 14.3 Thu 18:00 H-HS IV
Experiment for time comparison in moving and resting clocks — •Jordan Petrow — University of Rostock, Faculty of Mathematics and Natural Scienses, Wismarschestrasse 45, 18057 Rostock, Germany

With the mission "Gravity Probe B" in 2011 was found that the Earth rotates space around itself. The rotation of space around the Earth means that space is also rotated around our Sun and basically around every matter rotating in space. This principle is effective even in the smallest dimensions.Therefore atomic clocks may not be moved during a time measurement.There is the danger that its atomic clock generator becomes spatially deformed so that the atomic clock would show false times. If atomic clocks would be unsuitable for time measurement in moving systems, experiments are required that allow a direct time comparison between moving and stationary systems: On the outer edge of a rotating disk a circular hollow light guide is attached. Inside this light guide, light pulses are sent along the path and their propagation time is evaluated for various boundary conditions at rest and when the disk rotates. In this way it will be possible to directly compare the propagation times of the light pulses in the rotating part with their projection on the resting plane outside the rotating disk. Present activities aim at constructing the experimentally device.

GR 14.4 Thu 18:15 H-HS IV
Circular Sagnac experiment confirms equivalence principle — •Jordan Petrow — University of Rostock, Faculty of Mathematics and Natural Scienses, Wismarsche Strasse 45, 18057 Rostock, Germany

In Albert Einstein's idea, the principle of relativity was derived from a moving train*paradigm. This hypothetical train is only a thought experiment,*while*practical measurements e.g.*on*light behaviour in this train are difficult. The*problems connected*with Einstein*s moving train can be*avoided by folding a rotationally symmetrical construction from this hypothetical train. The straight ahead movement of the train is replaced by a rotation. In this way, the novelty*we propose*is a circular Sagnac experiment as a device that is accessible for practical measurements. The*classical*Sagnac experiment was invented in 1913 and is currently used in many high technologies. The circular Sagnac experiment thus*may well rise*to a position to be honoured as the key experiment in physics. With it, many of the basic statements of modern physics can be verified. In particular, it demonstrates a fundamental relationship between space and matter. Previously more or less intuitive assumptions can be anchored in an experimentally determined set of formulas with the circular Sagnac device. Present activities aim at constructing the device to also experimentally confirm the equivalence principle.

GR 15: Annual General Meeting

Time: Thursday 18:30–20:00 Location: H-HS IV

Duration: 90 min.

GR 16: Alternative Approaches

Time: Friday 9:00–10:30 Location: H-HS IX

GR 16.1 Fri 9:00 H-HS IX
Gravitation auf der Basis der lorentzianischen Relativität — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

Als die Relativitätstheorie um das Jahr 1900 eingeführt wurde, da standen zwei fundamental verschiedene Ansätze zur Diskussion. Der frühere wurde vorgetragen von Lorentz / Poincare auf der Basis physikalischer Prozesse: Kontraktion abgeleitet aus der bekannten Kontraktion von Feldern bei Bewegung, Dilatation von einer angenommenen Oszillation mit c innerhalb von Elementarteilchen. - Dieser Ansatz wurde jedoch als spekulativ angesehen, weil das damalige Verständnis von Physik diesen Ansatz nicht stützte. Die von Einstein postulierten Prinzipien erschienen gradliniger.

Mittlerweile jedoch entsprechen diese Annahmen vollständig dem physikalischen Verständnis. Diesem folgend, können nicht nur die Vorgänge der Speziellen Relativitätstheorie auf bekannten physikalischen Tatbeständen aufgebaut werden, sondern ebenso die Allgemeine Relativität, also die Gravitation. Wenn wir die bekannten Tatsachen der Reduktion von c im Gravitationsfeld und die innere Oszillation von Teilchen verwenden, lassen sich alle Ergebnisse der relativistischen Gravitation daraus deduzieren. Und das unter Verwendung von euklidischer Geometrie und klassischer Physik anstelle von eigens definierten Prinzipien.

Die so aufgebaute Relativitätstheorie ist dramatisch einfacher als die Einsteins, liefert aber alle bekannten Ergebnisse ebenso wie Einstein und löst daneben unverstandene Probleme wie u.a. die Dunkle Energie.

Weitere Information: www.ag-physics.org/gravity

GR 16.2 Fri 9:15 H-HS IX

Relativity expressed as a speed problem instead of a space-time problem as done by special relativity. — •Osvaldo Domann — Stephanstr. 42, 85077 Manching, Germany

Variables of one physical event expressed in two relative moving inertial reference systems are defined by the constant relative speed. As the variables of special relativity are built on space and time instead of speed to get the constant light speed in both reference systems, unphysical relative variables of time and space and contractions (twin paradox) result. The present paper is a work where relativity is treated as a speed problem to get the constant light speed in both reference systems. The result is that time and space are absolute variables without contradictions. Relativity is given as Galilei relativity multiplied with the relativistic gamma factor. The approach also concludes that light is emitted with light speed in the reference system of its source and that it arrives to the second inertial reference system with the speed c+-v, contrary to Einsteins postulate, that light moves always with light speed independent of its source. More at www.odomann.com

GR 16.3 Fri 9:30 H-HS IX

A solution of the interpretation problem of Lorentz transforms — •Grit Kalies — HTW University of Applied Sciences Dresden

By connecting the energy concepts of thermodynamics and special theory of relativity (SR) it can be shown that Einstein's interpretation of the well-known equation E = mc^2 as complete mass-energy equivalence results as a special case for moving point masses and contradicts the first and second laws of thermodynamics. Thermodynamics suggests matter-energy equivalence with an energetic distinction between matter and mass [1, 2].

Due to the observer dependence of quantities in SR, the changes in time, length, mass etc. with velocity should be apparent on the one hand, but on the other hand they are measured and partly described as real, which is called the "interpretation problem" [3] of Lorentz transforms that exists within SR since more than a hundred years. In this paper is shown that the interpretation problem can be solved by means of matter-energy equivalence, in full agreement with the experimental evidence and newer findings of quantum physics [2].

[1] G. Kalies: Matter-Energy Equivalence, Zeitschrift für Physikalische Chemie, 2019, DOI: 10.1515/zpch-2019-1487. [2] G. Kalies: Vom Energieinhalt ruhender Körper: Ein thermodynamisches Konzept von Materie und Zeit, De Gruyter, Berlin, 2019. [3] P. Lorenzen: Theorie der technischen und politischen Vernunft, Reclam, Stuttgart, 1978.

GR 16.4 Fri 9:45 H-HS IX

Unique Root Approach A Working Alternative to String/M-Theory — •Jürgen Kässer — Diekholzen Deutschland

The Unique Root (UR) approach takes a new way to unification. It is based on the demand of local isomorphism between internal and external symmetry groups. It results that SO(6) and SU(4)are the basic symmetries of the universe. These symmetries allow formulating physics in a timeless six dimensional space and a Lagrangian describing interaction between four entities.

Assuming this physics to hold also in our universe - a subspace of the complex expansion of the six dimensional one - four dimensional physics is deducted. Link is the action integral.

The conflict between background dependent and independent theories can be resolved. So as well the Standard model of particle physics as a quantum theory of gravitation, giving inter alia the results of General Relativity, an explanation of Dark Matter and a solution for the fundamental problem of separability and individuation are found.

GR 16.5 Fri 10:00 H-HS IX

Matter-energy equivalence and the origin of mass — •Grit Kalies — HTW University of Applied Sciences Dresden

By connecting the energy concepts of thermodynamics and special theory of relativity it can be shown that Einstein's interpretation of the well-known equation E = mc^2 as complete mass-energy equivalence results as a special case for moving point masses, but contradicts the first and second laws of thermodynamics. Thermodynamics suggests matter-energy equivalence with an energetic distinction between matter and mass [1, 2].

Today, the concepts of the origin of mass are fragmented into many ideas, including the suggestion of the Higgs mechanism. By means of matter-energy equivalence, the origin of mass can be deduced from only one principle, which corresponds to the basic rule of economy and elimination of unnecessary assumptions. The empirically very precisely confirmed equivalence of inert and heavy mass can, for the first time, not only be described, but explained [2]. The far-reaching consequences for fundamental concepts of theoretical physics (because special relativity and the associated idea of spacetime form a basis for the standard models of particle physics and cosmology) will be outlined.

[1] G. Kalies: Matter-Energy Equivalence, Zeitschrift für Physikalische Chemie, 2019, DOI: 10.1515/zpch-2019-1487. [2] G. Kalies: Vom Energieinhalt ruhender Körper: Ein thermodynamisches Konzept von Materie und Zeit, De Gruyter, Berlin, 2019.

GR 16.6 Fri 10:15 H-HS IX

Alpha, to be invariant or not to be? — •Manfred Geilhaupt — 41844 Dalheim, Hessenfeld 10

Within QED the elementary charge (e) and the Planck-Constant (h) are fundamental constants. Within GR the velocity of light (c) is a fundamental constant. So for that in such classical physics those constants are assumed to be independent of space and time. The Sommerfeld fine structure constant (FSC), definition from 1916 (alpha: e^2/hc), depends on charge, velocity of light, and Planck constant. So the fine structure number must be independent of space and time as well. However, in 2011 Webb et al. showed by experiment that the FSC depends on the metric of space when comparing many of different white dwarf spectra all over the universe directions and distances. So the FSC is not space invariant from the experimental point of view. So here we have a basic problem in classical Physics revealed by experiment. So the only chance to explain this experimental result from a logical and physical point of view is to focus on Einsteins General Theory of Relativity. We will demonstrate and show: The FSC depends on Einsteins g44-metric-number of space if we combine the GR Field Equation of Motion with the principles of Thermodynamics (TD). Conclusion: The FSC must be different in value if the atomic-interferometry experiment is executed on earth (137,035999046), Parker et al., already done 2018 or on the moon (137,035999239), to be done.

GR 17: Fundamental Problems and General Formalism

Time: Friday 9:30–10:30 Location: H-HS VII

GR 17.1 Fri 9:30 H-HS VII

The gravitating kinetic gas - Lifting the Einstein Vlasov system to the tangent bundle — •Christian Pfeifer[1], Manuel Hohmann[1], and Nicoleta Voicu[2] — [1]University of Tartu, Tartu, Estonia — [2]Transilvania University, Brasov, Romania

In this talk I will present a new model for the description of a gravitating kinetic gas, by coupling the 1-particle distribution function (1PDF) of the gas directly to the gravitational field, lifted to the tangent bundle of spacetime. This procedure takes the influence of the velocity distribution of the kinetic gas particles on their gravitational field fully into account, instead of only on average, as it is the case for the Einstein-Vlasov system.

By using Finsler spacetime geometry I construct an action for the kinetic gas on the tangent bundle, which is added as matter action to a canonical Finslerian generalisation of the Einstein-Hilbert action. The invariance of the kinetic gas action under coordinate changes gives rise to a new notion of energy-momentum conservation of a kinetic gas in terms of an energy-momentum distribution tensor. The variation of the total action with respect to the spacetime geometry defining Finsler function yields a gravitational field equation on the tangent bundle, which determines the geometry of spacetime directly from the full non-averaged 1PDF. This equation can be regarded as generalisation of the Einstein-Vlasov system, which takes all features of the kinetic gas into account.

GR 17.2 Fri 9:50 H-HS VII

The Hawking Energy in Cosmology — •Dennis Stock — University of Bremen, Center of Applied Space Technology and Microgravity (ZARM)

The definition of gravitational energy is a complex issue in general relativity. Amongst other candidates, Hawking's quasi-local energy satisfies many natural limits, however, fails in general to be positive and monotonous. In this talk, I will discuss how one could use the Hawking energy on a past light cone in cosmology and under which circumstances it can be shown to be positive and monotonously increasing.

GR 17.3 Fri 10:10 H-HS VII

Hamiltonian treatment of asymptotic symmetries in gauge theories — •Roberto Tanzi — University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen

Asymptotic symmetries are an important feature of gravity (where they give rise to the BMS group), of electromagnetism, and of other gauge theories. The interest in this topic has increased in the last few years, in particular after it has been conjectured by Hawking, Perry, and Strominger that it could be related to the solution of the long-standing information loss paradox.

I will discuss the Hamiltonian approach to asymptotic symmetries in gauge theories (first pursued by Henneaux and Troessaert), with a particular focus on non-abelian gauge theories.

GR 18: Quantum Gravity and Quantum Cosmology 2

Time: Friday 11:00–11:45 Location: H-HS IX

GR 18.1 Fri 11:00 H-HS IX

The Density Parameter Ω_Λ of the Dark Energy is a Function of G, c and h, and it Evolves with Time — •Hans-Otto Carmesin — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

The nature of the dark energy is modeled: First, a very general and fundamental density problem of the early universe is pointed our and resolved by dimensional phase transitions. With it, the concept of the dimensional horizon is introduced. As a consequence, there occur zero-point oscillations of the quantized gravitational field. Therefrom, $\Omega_\Lambda(G, c, h)$ is derived as a function of the universal constants G, c and h. The result is obtained from a completely fundamental theory without any fit parameters. In addition, the actual controversy of the Hubble - constant is resolved (Carmesin, H.-O. (2019): Die Grundschwingungen des Universums - The Cosmic Unification - With 8 Fundamental Solutions based on G, c and h - With Answers to 42 Frequently Asked Questions. Berlin: Verlag Dr. Köster.).

GR 18.2 Fri 11:15 H-HS IX

Quantum Mechanic Analysis of Masses in their Own Gravitational Field — Hans-Otto Carmesin[1,2,3] and •Maximilian Carmesin[4] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — [3]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen — [4]Arndt Gymnasium, Lindenstraße 52, 47798 Krefeld

The position of masses can be measured and is based on laws describing fundamental interactions among matter. For objects at a very high density, the gravitational force is the most important for describing their interactions. As a result from the Heisenberg uncertainty principle, measurements of complementary properties cannot be exact, examples are position and momentum. Accordingly, such objects have to be investigated in terms of a mass distribution. This is an essential difference to classical mechanics, viewing objects as masses concentrated at a single point. Such a model is not exact, but sufficient in many fields of physics, except quantum physics. This project numerically simulates the gravitational potential of a particle in a 3-dimensional space. Thereby, a mass distribution instead of a concentrated mass is modeled. For this purpose, a computer simulation has been developed. As a result, properties of the gravitational potential and of the wave function of a particle have been examined.

GR 18.3 Fri 11:30 H-HS IX

The equivalence of gravity and gravitational time dilation in general relativity and in quantum mechanics — •René Friedrich — Strasbourg

The curved spacetime of the Schwarzschild metric seems to be incompatible with quantum mechanics. But gravity may not only be represented by curved spacetime, it is also entirely described by gravitational time dilation in flat, uncurved space.

This talk is the third part of the concept of quantum gravity without need for any additional theory: Gravity modulates in the form of gravitational time dilation the proper time parameter of the worldlines of quantum systems.