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 $\rho = 6 \cdot 10^{214} \frac{\text{kg}}{\text{m}^3}$.

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

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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 dila-

tion 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