GR 6: Experimente zur Gravitation 2

Zeit: Dienstag 14:00–16:00 Raum: JUR K

GR 6.1 Di 14:00 JUR K

STAR - Space Time Asymmetry Research — •Claus Braxmaier[1], Thilo Schuldt[1], Mohammed Allab[1], Tim van Zoest[2], Stephan Theil[2], Ivanka Pelivan[2], Sven Herrmann[3], Claus Lämmerzahl[3], Achim Peters[4], Katharina Möhle[4], Andreas Wicht[4], Moritz Nagel[4], Evgeny Kovalchuk[4], Klaus Döringshoff[4], and Hansjörg Dittus[2] — [1]Hochschule Konstanz (HTWG) — [2]DLR, Institut für Raumfahrtsysteme, Bremen — [3]ZARM Universität Bremen — [4]Institut für Physik, Humboldt-Universität zu Berlin

STAR is a proposed satellite mission that aims for significantly improved tests of fundamental space-time symmetry and the foundations of special and general relativity. In total STAR comprises a series of five subsequent missions. The STAR1 mission will measure the constancy of the speed of light to one part in 10^{19} and derive the Kennedy Thorndike (KT) coefficient of the Mansouri-Sexl test theory to $7 \cdot 10^{-10}$. The KT experiment will be performed by comparison of an iodine standard with a highly stable cavity made from ultra low expansion (ULE) ceramics. With an orbital velocity of 7 km/s the sensitivity to a boost dependent violation of Lorentz invariance as modeled by the KT term in the Mansouri Sexl test theory or a Lorentz violating extension of the standard model (SME) will be significantly enhanced as compared to Earth based experiments. The low noise space environment will additionally enhance the measurement precision such that an overall improvement by a factor of 400 over current Earth based experiments is expected.

GR 6.2 Di 14:20 JUR K

Mobile accelerometers and gravity gradiometers based on atom interferometry — •Malte Schmidt[1], Guglielmo Tino[2], Philippe Bouyer[3], Ernst M. Rasel[4], Wolfgang Ertmer[4], Klaus Sengstock[5], Arnaud Landragin[6], Massimo Inguscio[7], Wolfgang Schleich[8], Reinhold Walser[8], Claus Lämmerzahl[9], Kai Bongs[10], and Achim Peters[1] — [1]Humboldt-Universität zu Berlin — [2]Università di Firenze — [3]Institut d'Optique, Orsay — [4]Institut für Quantenoptik, Hannover — [5]Universität Hamburg — [6]SYRTE, Paris — [7]LENS, Firenze — [8]Universität Ulm — [9]ZARM, Bremen — [10]University of Birmingham

Since 1992, matter wave interferometry has been used in many laboratories for a variety of fundamental physics experiments, e.g. measurement of the fine-structure and gravity constants. However, due to the complexity of these experiments, they were confined to laboratory environments. In recent years, however, efforts have been undertaken to develop mobile atom interferometers. These new sensors open up the possibility to perform on-site high-precision measurements of rotations, gravity gradients as well as absolute accelerations.

After briefly reviewing the basic principles underlying atom interferometers, we report on the status of different projects that are currently investigating and testing possible applications of mobile interferometers. These possibilities include earthbound mobile gravimeters as well as future employment of this technology in satellite missions (ESA Space Atom Interferometer project SAI). For both of these aspects, efforts are currently underway to construct prototype sensors. We give an overview of these sensors' designs and elaborate on their potential usefulness for earth observation missions. We acknowledge funding by ESA under contracts 20578/07/NL/VJ (SAI) and 21583/08/NL/HE (APPIA).

GR 6.3 Di 14:40 JUR K

Applications of Bose-Einstein-Condensates in microgravity — •Hauke Müntinga[1], Claus Lämmerzahl[1], Sven Herrmann[1] und das QUANTUS Team[1,2,3,4,5,6] — [1]ZARM, Universität Bremen — [2]Institut für Quantenoptik, LU Hannover — [3]Institut für Physik, HU Berlin — [4]Institut für Laserphysik, Universität Hamburg — [5]Institut für Quantenphysik, Universität Ulm — [6]MPQ, München

We report on the current status of the QUANTUS free fall BEC experiment at the ZARM drop tower in Bremen.

After the first realization of a BEC in microgravity in 2007, we were able to observe condensates after 1 s of free evolution. The extremely shallow traps possible in microgravity and resulting ultralow temperatures of a few nK allow for further studies ranging from coherence properties of condensates to inertial sensors based on matter waves.

In our talk we will focus on the implementation of a matter wave interferometer into our apparatus, which aims to extend measurement times to unprecedented durations and sensitivities. This leads the way to high precision measurements of gravitational forces and eventually a quantum test of Einstein's weak equivalence principle. Phenomena like quantum reflection and Anderson localization can also be examined with our apparatus. These goals are worked on in close cooperation with QUEST and the project PRIMUS.

The QUANTUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number DLR 50WM0836.

GR 6.4 Di 15:00 JUR K

High-Precision Atom Interferometry — •Naceur Gaaloul[1], Ernst M. Rasel[1], and das QUANTUS Team[1,2,3,4,5,6,7,8,9] — [1]Institut für Quantenoptik, LU Hannover — [2]ZARM, Uni Bremen — [3]Institut für Physik, HU Berlin — [4]Institut für Laserphysik, Uni Hamburg — [5]Institut für Quantenphysik, Uni Ulm — [6]MPQ, München — [7]Institut für angewandte Physik, TU Darmstadt — [8]Midlands Ultracold Atom Research Centre, University of Birmingham, UK — [9]FBH, Berlin

The recent developments in quantum optics transformed atom interferometry from pure fundamental research to a powerful technique giving birth to a multitude of tools for metrology, gravimetry and fundamental physics. Besides the measurement of fundamental constants (Fine structure constant, gravitational constants) or the tests of fundamental laws (Equivalence principle), the application of atom interferometers for gravimetry or generally for the measurement of inertial forces (Earth rotation, acceleration) became a central focus of research. Indeed, atom interferometers show not only a high sensitivity compared to other techniques but also an intrinsically high accuracy comparable to atomic clocks. Our efforts to advance the field of atom interferometry by carrying out challenging experiments, building networks and identifying the physical limitations as well as the potential applications will be reported in this contribution.

The QUANTUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number DLR 50WM0835-0839.

GR 6.5 Di 15:20 JUR K

GAP on Odyssey — •Tim van Zoest[1], Hansjörg Dittus[1], Claus Lämmerzahl[2], Hanns Selig[2], Bruno Christophe[3], and the Odyssey Science Team[3] — [1]DLR, Inst. f. Raumfahrtsysteme, Bremen — [2]ZARM, Universität Bremen — [3]ONERA, France

The objective of Odyssey is a set of gravitational tests in the solar system. Specifically, this mission is going to achieve four major scientific objectives, the test of the deep space gravity, the investigation of flybys, tests of the general relativity at solar conjunctions and planetary observations at Neptune and Triton. The tests will be performed by the "Gravity Advanced Package" (GAP). Since the instrument is only sensitive to non-gravitational forces, it tells whether or not the spacecraft follows a pure geodesic trajectory. This allows to obtain a much more precise orbit determination trajectory. As a consequence, the dependence of the gravitational force versus the distance to the sun is measured with a largely improved accuracy, opening new perspectives for the test of hypothetical deviations from the $1/r^2$ law predicted by higher dimensional models with large extra dimensions. During its trip from 1 up to 50 AU, the mission would search for dynamical anomalies in the motion of the spacecraft with an accuracy at the level of $4\text{x}10^{-11}$ m/s^2. The GAP instrument consists of an electrostatic accelerometer (ONERA design) and a bias rejection subsystem, where the rejection is obtained by modulating, at a frequency between 1 and 10 mHz, the non-gravitational acceleration delivered by the accelerometer. The total mass of the instrument is less than 3 kg, with a power consumption less than 3 W and a volume of less than 3 liters.

GR 6.6 Di 15:40 JUR K

Modelling and evaluation of Pioneer 10/11 thermal recoil: Work status and first results — •Benny Rievers and Claus Lämmerzahl — Zentrum für angewandte Raumfahrttechnologie und Mikrogravitation (ZARM), Universität Bremen, Am Fallturm, 28359 Bremen

The origin of the anomalous constant deceleration of the Pioneer 10/11 spacecrafts, first identified by Anderson et al in 1998, has been subject of several scientific investigations and speculations. Many systematic effects have been ruled out as the cause, however, the anisotropic radiation emitted by the crafts is supposed to explain at least a non-negligible part of the observed anomaly. In order to evaluate the exact magnitude and the dynamics of thermal recoils a method based on ray tracing and finite element (FE) modeling has been developed at the Center of Applied Space Technology and Microgravity (ZARM). Preliminary results show that a significant amount of the observed effect can be credited to thermal effects. A complete FE model of Pioneer 10 including detailed outer shape, internal payloads and temperature measurements of the radioisotopic thermal generators is developed at ZARM and will enable the exact evaluation of thermal disturbance accelerations. An overview of the current work status and a detailed insight in the used method will be given. Besides the evaluation of thermal effects with respect to Pioneer anomaly investigations the elaborated method can also benefit the upcoming high-precision missions (LISA, LISA pathfinder, MICROSCOPE ...) where the high scientific requirements demand precise modeling of thermal perturbations.