GR 5: Experimental Gravitation II

Time: Monday 14:45–16:05 Location: SPA SR220

GR 5.1 Mon 14:45 SPA SR220

Towards a test of the Universality of Free Fall of atoms in microgravity — •Christian Vogt, Sascha Kulas, Andreas Resch, and Sven Herrmann — ZARM, Universität Bremen, Am Fallturm, 28259 Bremen

Today matter wave interferometry is an established tool to perform precision measurements in fundamental physics. One of the main limiting factors in such experiments is the finite free evolution time available for matter waves in a laboratory setup. Thus, the extended free fall time which can be achieved in a space mission is expected to be of great benefit to future matter wave precision measurements. First promising results towards this have been achieved by the QUANTUS collaboration in experiments at the Bremen drop tower. Within the PRIMUS project we aim to further explore this potential in a dedicated drop tower experiment. This experiment will consist of a dual species interferomer to compare the free fall of 87Rb and 39K. Ultimately it shall provide the opportunity to study the potential sensitivity and systematic effects of a future space mission to test the Einstein Equivalence Principle with ultra-cold atoms at enhanced precision. Here, we present the current status of our experiment and discuss the perspectives and attainable sensitivity of such a free fall test in the Bremen drop tower. The PRIMUS 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 50 WM 1142.

GR 5.2 Mon 15:05 SPA SR220

Quantum Weak Equivalence Principle — •Magdalena Zych[1,2] and Caslav Brukner[1,2] — [1]Faculty of Physics, University of Vienna, Vienna, Austria — [2]Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Vienna, Austria.

Equivalence between the gravitational and the inertial mass of a body, the Weak Equivalence Principle (WEP), lies at the heart of both Newton's and Einstein's theories of gravity and is a prerequisite for its understanding as a curvature of space-time. Beginning with Galileo's experiments WEP continues to be probed with ever increasing precision reaching nowadays the scale where quantum mechanics becomes relevant. Here we show that the classical formulation of the WEP does not apply in such a regime. The total mass of a test body includes contributions from the internal energy, which in quantum mechanics is given by a Hamiltonian operator describing the dynamics of internal degrees of freedom. We therefore introduce a quantum formulation of the WEP - equivalence between the inertial and gravitational internal energy operators. We show that the validity of the classical WEP does not imply the validity of the quantum WEP which thus requires independent experimental verification. We discuss how this goal can be achieved in quantum interference experiments with massive particles with internal structure.

GR 5.3 Mon 15:25 SPA SR220

A method to test Newton's law of gravity at micro- and submicrometre distances with parallel plates — •Helena Schmidt and Vladimir Nesterov — Physikalisch-Technische Bundesanstalt, 5.1 Oberflächenmesstechnik/Surface Metrology, Bundesallee 100, 38116 Braunschweig, Germany

We propose an experiment to test Newton's Law of Gravity at micro- and submicrometre length scale. Usually the correction to Newtonian gravity is parameterized through an additional Yukawa-type potential term: $V(r) = -G\frac{m_1 m_2}{r} \cdot \left[1 + \alpha \cdot e^{-r/\lambda}\right]$, α and λ are the parameters of the Yukawa-potential. The main idea is to measure the force variation between two parallel plates with periodically varying distances. The force variation is derived from the yukawa-part of the pontential. To minimize electrostatic parasitic forces a goldmembrane is placed between the plates. The membrane will be produced as a grid and included in one of the two plates. Therefore that plate is called Yukawa-Attraktor. The other plate is called detector, which is connected to the force sensor. The force sensor is the nanonewton force facility at the PTB (Physikalisch Technische Bundesanstalt). With this facility it is possible to measure up to a resolution of 10^{-14} N at a measuring time of $2 \cdot 10^5$ s. That resolution ables us to measure differences from Newton's Law of gravity up to 10^3 times better than current experiments.

GR 5.4 Mon 15:45 SPA SR220

Is it possible to measure the gravitomagnetic clock effect? — Eva Hackmann[1], •Claus Lämmerzahl[1], and Fritz Merkle[2] — [1]ZARM, University of Bremen, Germany — [2]OHB-Systems, Bremen, Germany

On the level of orbits of satellites the gravitomagnetic field of a rotating gravitating body like the Earth manifests itself in the precession of the orbital plane, which is known as the Lense-Thirring effect, or in the precession of the spin of a spinning top, known as the Schiff effect. Here we discuss the question whether and how this gravitomagnetic field can also be detected using clocks on orbiting satellites. Two clocks on counter rotating equatorial circular orbits around the Earth show a difference of about 10^{-7} s per revolution. However, the detectability of this effect depends on the accuracy and stability of the used clocks as well as on the precise knowledge of the satellites orbits. We show that with present technology it is possible in principle to measure this gravitomagnetic clock effect with satellites on arbitrary orbits. In particular, we analyze whether this gravitomagnetic clock effect has an impact on the clocks on the Galileo satellites. Such a measurement would constitute another important Solar System test of Einstein's General Relativity.