GR 7: Experimental tests

Time: Thursday 11:00–12:00 Location: H9

GR 7.1 Thu 11:00 H9

Perspectives of measuring gravitational effects of laser light and particle beams — Felix Spengler[1], •Dennis Rätzel[2], and Daniel Braun[1] — [1]Eberhard-Karls-Universität Tübingen, Institut für Theoretische Physik, 72076 Tübingen, Germany — [2]Humboldt Universität zu Berlin, Institut für Physik, Newtonstraße 15, 12489 Berlin, Germany

We can expect the gravitational field of light to be extremely weak. However, studying the gravitational field of light could give new fundamental insights to our understanding of space and time as well as classical and quantum gravity and it is worthwhile to investigate if gravitational effects of light may be experimentally accessible in the near future. Similarly, the gravitational properties of relativistic particle beams have not been experimentally tested. Their total relativistic mass is dominated by their kinetic energy and the same dominance for the gravitational field is predicted by general relativity. Therefore, the gravitational field of particle beams shows strong similarities to that of laser beams. In addition, both can be brought into non-trivial quantum states. We present a short overview of the gravitational properties of light and relativistic particle beams and the prospects to measure them in experiments by means of sensors based on resonant mechanical oscillators. With an optimized pendulum or torsion balance combined with the planned high-luminosity upgrade of the LHC as a source, a signal-to-noise ratio substantially larger than 1 should be achievable in principle.

GR 7.2 Thu 11:15 H9

Constraining modified gravity with quantum optomechanics — •Sofia Qvarfort[1,2], Dennis Rätzel[3], and Stephen Stopyra[2] — [1]QOLS, Blackett Laboratory, Imperial College London, SW7 2AZ London, United Kingdom — [2]Department of Physics and Astronomy, University College London, Gower Street, WC1E 6BT London, United Kingdom — [3]Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin, Germany

In this talk, I will present some recent results on estimating the performance of quantum optomechanical sensors for searches of modified gravity. Specifically, I will show how we derive the best possible bounds that can be placed on Yukawa– and chameleon–like modifications to the Newtonian gravitational potential with a cavity optomechanical quantum sensor. We do so by modelling the effects from an oscillating spherical source on the optomechanical system from first-principles. To then estimate the sensitivity to chameleon-like modifications, we take into account the size of the optomechanical probe and quantify the resulting screening effect for the case when both the source and probe are spherical. Our results show that an optomechanical system in high vacuum could, in principle, further constrain the parameters of chameleon-like modifications to Newtonian gravity.

GR 7.3 Thu 11:30 H9

BECs with Yukawa-type gravitational selfinteraction — •Sandro Gödtel and Claus Lämmerzahl — ZARM, University of Bremen, Germany

The theories of Newtonian and Einsteinian gravity are extremely powerful in describing the macroscopic world. On the other side, however, we still do not have a widely accepted description of short-range gravity. Nowadays many theories going beyond the standard model predict deviations from Newtonian gravity, commonly in the form of a Yukawa-like potential. Different experiments so far have found upper boundaries for the strength and the range of this deviation. However, most of the experiments are focused on a test body in an external gravitational field.

In this talk we present a model for a Bose-Einstein condensate which particles interact via a Newton and a Yukawa potential. In a selfconsistent manner, we determine the influence of such gravitational potentials onto the condensate. We derive the changes in the width of the cloud and the frequencies of the collective oscillations. With this, we are able to set boundaries for the parameters of the Yukawa potential and compare them to the results of current experiments.

GR 7.4 Thu 11:45 H9

The secret of planets perihelion between Newton and Einstein — •Christian Corda — Istituto Livi, via Marini 9, 59100 Prato, Italy

It is shown show that,contrary to a longstanding conviction older than 160 years, the advance of Mercury perihelion can be achieved in Newtonian gravity with a very high precision by correctly analyzing the situation without neglecting Mercury mass. General relativity remains more precise than Newtonian physics, but Newtonian framework is more powerful than researchers and astronomers were thinking till now, at least for the case of Mercury. The Newtonian formula of the advance of planets perihelion breaks down for the other planets. The predicted Newtonian result is indeed too large for Venus and Earth. Therefore, it is also shown that corrections due to gravitational and rotational time dilation, in an intermediate framework which analyzes gravity between Newton and Einstein, solve the problem. By adding such corrections, a result consistent with the one of general relativity is indeed obtained. Thus, the most important results of this Lecture are two: (i) It is not correct that Newtonian theory cannot predict the anomalous rate of precession of the perihelion of planets orbit. The real problem is instead that a pure Newtonian prediction is too large. (ii) Perihelion precession can be achieved with the same precision of general relativity by extending Newtonian gravity through the inclusion of gravitational and rotational time dilation effects.