GR 16: Experimental Tests

Time: Friday 11:00–12:40 Location: HSZ/0401

GR 16.1 Fri 11:00 HSZ/0401

New search for differences in active and passive gravitational masses using Lunar Laser Ranging — •Claus Lämmerzahl[1], Vishwa V. Singh[2], Liliane Biskupek[2], Jürgen Müller[2], and Eva Hackmann[1] — [1]ZARM, University of Bremen — [2]IfE, Leibniz Universität Hannover

Each body possesses three masses: inertial mass, passive gravitational mass (weight), and active gravitating mass. With MICROSCOPE the equality of inertial and passive gravitational mass has been confirmed at the order 10^{-15}. Laboratory test confirmed the equality of active and passive mass at the order 10^{-5}. Using Lunar Laser Ranging (LLR) data from 1970 to 2022, we obtained a new limit of 3.9×10^{-14} that improves the previous LLR-based result by two orders of magnitude. We also propose a new laboratory experiment for the search of a difference between active and passive masses, and present a new orbital analysis for stellar binary systems made of different masses. Finally, we add some remarks on active and passive charges.

GR 16.2 Fri 11:20 HSZ/0401

A concept for testing the gravitomagnetic clock effect with GNSS satellites — •Jan Scheumann[1,2], Dennis Philipp[1,2], Eva Hackmann[1,2], Sven Herrmann[1,2], Benny Rievers[1,2], and Claus Lämmerzahl[1,2] — [1]ZARM, University of Bremen, 28359 Bremen, Germany — [2]Gauss-Olbers Space Technology Transfer Center, Bremen, Germany

General Relativity (GR) predicts that the rotation of a central body influences the trajectory of an orbiting mass in a non-Newtonian way. One of the predicted effects was first described by Cohen and Mashhoon, concerning the proper time difference of two counter-revolving clocks in an orbit around a rotating mass, which is yet to be verified experimentally. After the accuracy of the tests of the gravitational redshift could be improved using two Galileo satellites on eccentric orbits, other possibilities to use GNSS satellites for tests of GR are under investigation. This work presents a concept to test the gravitomagnetic clock effect (GMCE) with GNSS satellites and looks into the technical requirements for such a test.

The introduced theoretical framework yields an incrementally defined observable, that is accesible e.g. via orbit and clock products. Some usage of the framework is presented, taking advantage of state-of-the-art orbit simulations as an a-priori data source.

A comparison of a dedicated mission's technical requirements with the state-of-the-art in SLR and modelling of gravitational and non-gravitational perturbations yields that a measurement is highly demanding, but might just be within reach of current technology.

GR 16.3 Fri 11:40 HSZ/0401

Taking gravity tests with the Double Pulsar to higher orders — •Huanchen Hu[1], Michael Kramer[1,2], Norbert Wex[1], and David J. Champion[1] — [1]Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany — [2]Jodrell Bank Centre for Astrophysics, The University of Manchester, Oxford Road, Manchester M13 9PL, UK

Relativistic binary pulsars are excellent testbeds for probing strong-field aspects of gravity. In particular, the Double Pulsar system PSR J0737-3039A/B offers a wealth of relativistic effects that can be studied in depth. Pulsar timing observations with MeerKAT and the future Square Kilometre Array (SKA) can bring the accuracy of these gravity tests to an unprecedented level, as well as enable precision tests of next-to-leading order (NLO) effects in the orbital motion and signal propagation. In this talk, I will present the timing results of PSR J0737-3039A based on 3-yr MeerKAT observations with a focus on the NLO signal propagation effects. These include the retardation effect due to the movement of pulsar B and the deflection of the signal of A by the gravitational field of B. Moreover, future observations with MeerKAT and the SKA are expected to provide one of the first measurements of the moment of inertia of a neutron star, hence an important complementary constraint on the equation of state at ultra-nuclear density. Finally, other prospects from future observations will be also demonstrated.

GR 16.4 Fri 12:00 HSZ/0401

Measurement of Gravitational Coupling of Planck Mass-sized Object — •Hans Hepach[1], Mathias Dragosits[2], and Jeremias Pfaff[2] — [1]IQOQI Vienna, OeAW, Austria — [2]University of Vienna, Austria

Gravity is the weakest of all known fundamental forces and continues to pose some of the most outstanding open problems to modern physics: it remains resistant to unification within the standard model of physics and its underlying concepts appear to be fundamentally disconnected from quantum theory. Testing gravity on all scales is therefore an important experimental endeavour. Thus far, these tests involve mainly macroscopic masses on the kg-scale and beyond. Here we show gravitational coupling between a gold sphere of 1mm radius and a Planck mass sized object. Periodic modulation of the source mass position allows us to perform a spatial mapping of the gravitational force. The current measurement improves upon our previous result by a reduction of the source mass by three orders of magnitude and opens the way to a yet unexplored frontier of microscopic source masses. This enables new searches of fundamental interactions and provides a natural path towards exploring the quantum nature of gravity.

GR 16.5 Fri 12:20 HSZ/0401

Measuring the gravitational field using quantum imaging — •Marian Cepok — ZARM, University of Bremen, 28359 Bremen, Germany

Quantum Imaging is a method which can be used to image an object using photons which have not interacted with the object. This scheme uses an entangled pair of photons, one of the photons interacts with the object while it is only the other photon which is being measured. Here a setup similar to quantum imaging is proposed which images the gravitational field instead of an object.