GR 5: Experimente

Zeit: Dienstag 16:30–18:15 Raum: HS 6

GR 5.1 Di 16:30 HS 6

Optical grating concepts for future gravitational wave detection — •Stefanie Kroker, Thomas Käsebier, Stefan Steiner, Ernst-Bernhard Kley, and Andreas Tünnermann — Friedrich-Schiller-Universität Jena Institut für Angewandte Physik, Abbe Center of Photonics, Max-Wien-Platz 1, 07743 Jena, Germany

Many experiments in the field of optical high-precision metrology are limited in their sensitivity by the thermal noise of optical components, for example, mirrors or beam splitters. Amorphous coating stacks are known to be a major source for these thermal fluctuations. In this contribution we discuss concepts to realize coating free optical components based on subwavelength resonant high contrast gratings (HCGs). The use of crystalline silicon promises a low level of thermal noise. Beside classical cavity mirrors HCGs can also be used to realize reflective cavity couplers acting as beam splitters for the incident light. Therefore, a large angular tolerance of the HCG reflectors has to be ensured. In order to realize HCGs with such angular broadband reflectivity two approaches are presented. The first makes use of stacking HCGs whereas the second benefits from polarization effects in HCGs with two-dimensional periodicity. For reflective beam splitters these angular broadband reflectors can be combined with either additional superposed lateral (grating duty cycle, ridge positions) or transversal (grating thickness) modulations to provide the subwavelength structures with diffraction orders. The diffraction efficiency can therewith be tuned with the strength of the modulation.

GR 5.2 Di 16:45 HS 6

Experiment zur alternative Gravitationstheorien mit LISA Pathfinder — •Natalia Korsakova[1], Martin Hewitson[1], Chris Messenger[2], B.S. Sathyaprakash[2], Gerhard Heinzel[1] und Karsten Danzmann[1] — [1]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) und Institut für Gravitationsphysik der Leibniz Universität Hannover, Hannover, Deutschland — [2]School of Physics and Astronomy, Cardiff University, Cardiff, UK

Die LISA Pathfinder Mission (LPF) wird Technologie für die Laser Interferometer Space Antenna (LISA) am Lagrange-Punkt L1 demonstrieren. Hauptbestandteil der Mission sind zwei freifallende Testmassen, deren relativer Abstand interferometrisch mit Picometer Genauigkeit bestimmt wird. Damit wird LPF eine noch nie dagewesene Sensitivität für differentielle Beschleunigungen bei Frequenzen um 1 mHz erreichen.

In diesem Vortrag soll eine Verlängerung der LISA Pathfinder Mission diskutiert werden. Diese würde sich die Sensitivität von LPF zu Nutze macht um alternative Gravitationstheorien am Sattelpunkt zwischen Erde und Sonne zu testen. Die hierbei notwendige Datenanalyse wird im Detail Vorgestellt.

GR 5.3 Di 17:00 HS 6

Testing the Theory of Relativity Using Ultra-stable Cryogenic Sapphire Oscillators — •Moritz Nagel[1], Stephen Parker[2], Katharina Möhle[1], Klaus Döringshoff[1], Sylvia Schikora[1], Paul Stanwix[2], Eugene Ivanov[2], Evgeny Kovalchuk[1], Mike Tobar[2], and Achim Peters[1] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Optische Metrologie, Newtonstr. 15, 12489 Berlin — [2]School of Physics, The University Of Western Australia, Crawley 6009, Western Australia, Australia

Modern Michelson-Morley-type experiments compare the electromagnetic eigenfrequencies of ultra-stable resonators to scrutinize one of the most fundamental principles of modern physics: Lorentz invariance.

We present details on our currently running Michelson-Morley-type experiment that utilizes two orthogonally aligned cryogenic sapphire microwave oscillators which have a fractional frequency stability in the 10^{-16} regime for integration times from 1 - 100 seconds. The oscillators are being actively rotated on a high-precision air-bearing turntable in the laboratory. This setup will have a sensitivity for signals of Lorentz invariance violations in the 10^{-18} to 10^{-19} regime after one year of continuous operation, representing a 100-fold improvement in such type of experiments.

In a next step we plan to combine these microwave oscillators with a set of ultra-stable cryogenic optical resonators currently being developed to perform an advanced Michelson-Morley-type experiment to investigate simultaneously a multitude of possible Lorentz invariance violations in the 10^{-20} regime.

GR 5.4 Di 17:15 HS 6

Quantum test of the Equivalence Principle: The STE-QUEST mission — •Naceur Gaaloul, Christian Schubert, Ernst Rasel, and the STE-QUEST consortium — Institut für Quantenoptik Leibniz Universität Hannover, Hannover, Germany

STE-QUEST aims for a test of General Relativity through testing the Universality of Free Fall with a dual species atom interferometer on a satellite. This test is based on measuring the differential acceleration of two test bodies assumed to be zero by Einstein's Equivalence Principle (EP). The Eötvös ratio derived from the differential signal will be determined with an accuracy of parts in 10^{15} beyond state-of-the-art precision of 10^{-13} established by lunar laser ranging and torsion balances.

Quantum degenerated ensembles of Rb87 and Rb85 will act as test bodies in the dual species interferometer and would show the first quantum test of the EP. Due to the weightlessness conditions in space these test masses will be simultaneously prepared and interrogated with a free evolution time of 10 s. Within a single cycle of 20 s a shot noise limited sensitivity to accelerations of 3e-12 m/s^2 is anticipated. The simultaneous interferometry is carried out in a double diffraction Mach-Zehnder geometry.

Challenges in this mission lie both in suppressing noise and bias terms as well as in the accommodation to the limited resources of a satellite. In the talk the measurement principle will presented, an overview of the preliminary payload design will be given, and the estimated error budget will be discussed. The STE-QUEST is a proposal for an M3 mission in the frame of the Cosmic Vision program of ESA.

GR 5.5 Di 17:30 HS 6

Vorbereitung der Datenanalyse für die Satellitenmission Microscope — •Stefanie Bremer, Meike List, Benny Rievers, Hanns Selig und Claus Lämmerzahl — ZARM - Universität Bremen, Am Fallturm, 28359 Bremen

Die französische Satellitenmission Microscope hat als Zielsetzung den Test des schwachen Äquivalenzprinzips und die Bestimmung des Eötvös Parameters mit einer Genauigkeit von 1e-15. Der Test wird mithilfe von zwei hoch-genauen kapazitiven Differentialaccelerometern, die jeweils zwei zylindrische Testmassen beinhalten, durchgeführt. Die Bewegung dieser Testmassen im Schwerefeld der Erde wird sehr genau vermessen und das Ergebnis in Zusammenhang mit einer Vielzahl weiterer Faktoren, die das Experiment beeinflussen, interpretiert. Um diese Datenanalyse durchführen zu können, ist die genau Kenntnis des Instruments, der Testmassendynamik und der Wechselwirkungen, die über den Satellitenbus entstehen, Voraussetzung. Zur Vorbereitung der Datenanalyse werden daher Simulationen eingesetzt, die im Vorfeld der Mission bereits die Möglichkeit bieten unterschiedliche Störeffekte künstlich zu erzeugen und deren Auswirkung auf das Messergebnis zu testen. Das ZARM ist Bestandteil des Teams, das die Datenauswertung von Microscope als Erste vornehmen wird. Zu diesem Zweck wird an einem Simulationstool gearbeitet, das den komplexen dynamischen Prozessen sowie allen äußeren Störeinflüssen Rechnung trägt. Der Entwicklungsstand dieses Microscope Simulators wird präsentiert.

GR 5.6 Di 17:45 HS 6

The impact of high precision modeling of non-gravitational forces on the accuracy of gravitational measurements in space — •Benny Rievers, Meike List, Stefanie Bremer, and Claus Lämmerzahl — ZARM, Universität Bremen

The requirements on the knowledge of the perturbations acting on measurement systems in space are increasing constantly. Motivated by this, the Center of Applied Space Technology and Microgravity (ZARM) is developing improved modeling methods for the evaluation and prediction of these effects. For current missions like GRACE, these high precision perturbation models can be used to improve measured data by a better understanding of the sources of the perturbed measurements. For future mission concepts like LISA or GRACE-FO, the same models can be used for an optimization of mission and spacecraft design (with respect to the perturbations) as well as for the generation of mock data, which is needed to qualify the data evaluation techniques used during the respective mission. The importance of the implementation of accurate non-gravitational forces modeling has been demonstrated by ZARM with the interpretation of the Pioneer anomaly as a thermal drag as well as the explanation of anomalous drag effects for the Rosetta mission. In this talk the involved methods will be discussed in detail. Furthermore first results of the evaluation of the dominant non-gravitational forces acting on LISA and the NASA Messenger mission will be shown.

GR 5.7 Di 18:00 HS 6

A covariant approach to the description of a violation of the Weak Equivalence Principle — •Claus Lämmerzahl[1,2], Eva Hackmann[1], and Meike List[1] — [1]ZARM, University Bremen, Germany — [2]IfP, University Oldenburg, Germany

Violations of the Weak Equivalence Principle (WEP) are usually described within the Newtonian framework where masses of different composition couple differently to the gravitational field. Here we develop a covariant formalism and show that violations of the WEP are then described within a kind of bi-metric theory. We describe the consequences of such an ansatz and possible tests of the WEP. Particular features may appear in the strong gravity regime.