UNIVERSITÉ DU LUXEMBOURG

Physics seminar

Monday, 2nd November at 16h00

Campus Limpertsberg, room BS 1.04

Christian Rothleitner, Post-doc / intermediate academic staff at LPG will speak about

" Development of free-fall absolute gravimeters"

Absolute gravimeters are devices used to measure the absolute acceleration due to gravity. On the Earth surface this value is approximately 9.81 m s^{-2}. This value, however, is not constant. It is a function of time, as well as of space. Tides, e.g. give rise to gravity changes on the order of 300 mGal (1 mGal = 10 nm s^{-2}). With high-resolution gravimeters tiny changes in local and temporal gravity can be detected.

In this presentation, I will describe two apparatuses for an absolute measurement of gravity, which within the framework of my thesis were designed, constructed, and tested for the purpose of detecting long-term variations of gravity, determining the absolute gravity value for metrological applications, and for research in fundamental physics. The work includes a stationary gravimeter, which functions as a highly accurate reference system and a portable gravimeter, which is aimed at field observations.

The principle these gravimeters use to determine the gravity value is based on the relation between the falling distance, the falling time, and the acceleration due to gravity. A Michelson interferometer measures the distance change between a falling object mirror and an inertial reference mirror with a Helium-Neon laser (633 nm). The whole fringe signal is digitized by a high-speed ADC, which is disciplined by a rubidium frequency standard. This fringe recording is novel compared to common gravimeters, which use an analogue zero-crossing determination.

Our portable gravimeter's mechanics also deviate from the standard field type instruments. Springs, preloaded by a small motor accelerate the carriage supporting the falling object. This reduces the shock vibrations on the system.

Furthermore, a novel method was developed to reduce the uncertainty due to the falling body's rotation. The position of the optical centre is determined in order to subsequently superpose it with the falling object's centre of mass by means of a common balancing method. Resolutions of distance of less than 16 µm were reached in three dimensions, which reduce the uncertainty contribution to less than 0.7 µGal (7 nm s^{-2}).

A complete uncertainty budget is given for both gravimeters. The combined standard uncertainty for the portable gravimeter is estimated to give 38.4 µGal, and that for the stationary 16.6 µGal, whereas for the portable gravimeter a standard error of 1.6 µGal (statistical uncertainty for 24 hours of measurement), and for the stationary gravimeter 0.6 µGal (1 month of measurement) was reached. This is comparable to the resolution of the world's best absolute gravimeters.

The portable gravimeter was brought to the European Comparison of Absolute Gravimeters (ECAG) 2007 in Luxembourg, and to another comparison with the German Federal Agency of Cartography and Geodesy (Bundesamtes für Kartographie und Geodäsie - BKG), where it showed an agreement of the measured values obtained with other gravimeters within the instrument's uncertainty.