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Laser Interferometer for a spaceborne mapping of the Earth's gravity field

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The Gravity Recovery and Climate Experiment (GRACE) is one of the present missions to map the Earth's gravity field. The aim of a GRACE follow-on mission is to map the gravitational field of the Earth with higher resolution over at least 6 years. This should lead to a deeper insight into geophysical processes of the Earth's system.
One suggested detector for this purpose consists of two identical spacecraft carrying drag-free test masses in a low Earth orbit at an altitude of the order of 300 km, following each other with a distance of about 10 to 100 km. Changes in the Earth's gravity field will induce distance fluctuations between two test masses on separate spacecraft. These variations are to be monitored by a laser interferometer with nanometer precision in the frequency range between 1 mHz and 100 mHz. The relative velocity between the spacecraft induces a Doppler shift in the interferometer beatnote. This effect together with the large variations in the inter-spacecraft separation make heterodyne interferometry ideally suitable as the pathlength readout scheme. The round-trip Doppler shift introduces variations in the interferometer beatnote up to a few 100 kHz. A suitable heterodyne frequency is therefore between several hundred kHz and a few MHz, with the lower limit given by the maximal Doppler shift and the required control bandwidth of the offset phase lock. The upper limit is given by technical considerations concerning the photodiodes and the phasemeter.
We benefit a lot from the current developments for the joint ESA-NASA space-based gravitational-wave detector "Laser Interferometer Space Antenna" (LISA) and its precursor mission LISA Pathfinder, such as a precise drag-free technology and the interferometric readout.
We present preliminary results of an interferometric readout using a heterodyne configuration with polarising optics, demonstrating the required phase sensitivity.