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RELATIVISTIC GEODESY USING BALLOONS

Abstract

Relativistic geodesy is gaining impetus due to the relentless improvement of atomic clocks. In conjunction to them, stratospheric balloons are very adequate tools. We present a concept under study at CNES, where an optical clock is carried to an altitude of 40 km where its signal is compared to the one of a sister clock on the ground. The experiment is aimed at checking the redshift predicted by General Relativity to an unprecedented accuracy with an improvement factor between 100 and 300 over current knowledge, and 3 to 10 over space missions planned in the meantime. The challenges of the experiment are presented, namely 1) the ability of the balloon platform to accommodate the clock in terms of mass, power requirements, mechanical and thermal constraints, as well as to offer proper flight duration, safety and a positioning in elevation to better than one cm by post-processing, 2) the availability of a device capable of time transfer in the range of 10-18 relative accuracy over the mission duration, 3)the difficulty of relating elevation values with actual gravitational potential, which places a constraint on the location where to operate the flight and 4) the need to use optical clocks with the required reliability (at least 12 h continuous operation), mass constraint (less than one metric ton) and performance (better the 5.10-16 stability at one second). The first flight may take place in 2018/2019 time frame. Beyond this experiment, more possibilities of comparison of the potential in two places a few hundreds kilometers apart is allowed by balloon flights, possibly with lighter, pressurized balloons. For instance tethered balloons flying at lower altitudes (e.g. 4km) would allow a direct comparison of optical clocks resting on the ground, while their signals are transmitted to the balloon by fiber optics and exchanged by a dedicated time transfer tool.