Testing general relativity in space with atomic clocks: ACES mission

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Cold atom interferometers - clocks and inertial sensors - reach record accuracies, are sensitive to gravitational effects, and technologically mature enough for being systems for outside laboratory measurements and applications. They now open a new window for fundamental physics tests, including theories of gravitation, crucial to benchmark progress of theoretical physics beyond general relativity [1].

The first cold atom clock will be sent in space in 2016 within the ESA mission ACES (Atomic Clock Ensemble in Space). On board International Space Station, a laser cooled Cesium clock (PHARAO), a hydrogen maser, and a precise time and frequency transfer system will enable ground-to-satellite and ground-to-ground remote clock comparisons, allowing to test fundamental physics at an unprecedented level [2].

The measurement of Einstein's gravitational frequency shift will be improved by a factor of 70 compared to previous measurements, reaching a precision of 2.10^{-6}. PHARAO will also enable first intercontinental ground-to-ground clocks comparison, allowing to take full advantage of the recent progress of optical clocks, which today reach accuracy levels in the 10^{-18} range. By comparing clocks based on different transitions and different atomic species, time variations of fundamental constants [3] will be estimated better than the 10^{-17} / year level, with a precision improved by one to two orders of magnitude compared to present measurements.

We will present an overview of the instruments and methods used for this mission, and insight into the fundamental physics tests planned.

References:
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