Cold Atom Interferometers for measuring the Earth's gravity field and possible implementation for Space Science Missions

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In the past decades, it has been shown that atomic quantum sensors are a newly emerging technology that can be used for measuring the Earth's gravity field [1]. Whereas classical accelerometers typically suffer from high noise at low frequencies, cold atom interferometers are highly accurate over the entire frequency range.

In space, there are two ways of using that technology for measuring Earth's gravity field. The first is a gravity gradiometer concept [2] that has a high common mode rejection, which greatly relaxes the drag-free control requirements compared to the GOCE mission. The second is to deploy quantum accelerometers for correcting low frequency errors of electrostatic accelerometers (Fig. 1) that are used in a low-low satellite-to-satellite ranging concept for measuring non-gravitational accelerations.

In both cases, estimation of the Earth gravity field model from the instruments has to be evaluated taking into account different system parameters such as attitude control, altitude of the satellite, time duration of the mission, etc. Miniaturization, lower consumptions and upgrading Technical Readiness Level are the key engineering challenges that have to be faced for these space quantum technologies.

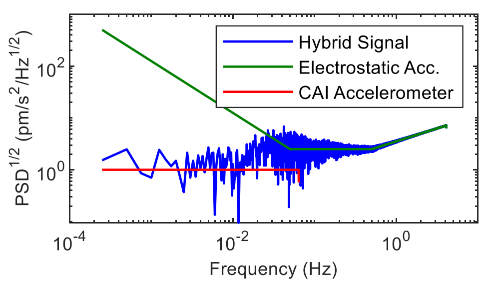

Figure 1: In green: PSD of an electrostatic accelerometer, Red: PSD of a CAI accelerometer, Blue: PSD of the hybrid signal.

We will present for both concepts the expected improvement in measurement accuracy and the possibilities to use this technology for planetary exploration (for instance in the frame of selected ESA-M5 mission concept EnVision for Venus exploration) or exploiting synergies between fundamental physics missions (week equivalent principle, gravitational redshift) and Earth observation missions.

Keywords: GRAVIMETRY, ATOM INTERFEROMETRY, SPACE APPLICATIONS, EQUIVALENCE PRINCIPLE

References

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[2] O. Carraz et al., in Microgravity Sci. Technol. (2014), **139-145** 26.