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Future Satellite Gravity Missions enhanced by Cold Atom Interferometry Accelerometers

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Satellite gravity missions, like GRACE and GRACE Follow-On, successfully map the Earth's gravity field and its changes, but the boundaries of spatial and temporal resolution need to be pushed further. The major enhancement from GRACE to GRACE-FO is the laser interferometry instrument which enables a much more accurate inter-satellite ranging. However, the accelerometers used for observing the non-conservative forces have merely been improved and are one major limiting factor for gravity field recovery. Inertial sensors based on cold atom interferometry (CAI) show promising characteristics, especially their long-term stability at frequencies below 10^-3 Hz is very beneficial. The CAI concept has already been successfully demonstrated in ground experiments. In space, an even higher sensitivity is expected due to increased interrogation time of one interferometer measurement cycle.

In this contribution, we investigate potential next-generation gravity missions (NGGM) following the GRACE design, employing an LRI with GRACE-FO characteristics and the utilisation of CAI accelerometry. The combination of CAI technology with a classic electrostatic accelerometer is evaluated as well. The sensor performances are tested via closed-loop simulations for different scenarios and the recovered gravity field results are evaluated. In order to achieve a realistic model of the atomic interferometer, noise levels depending on the architecture of the sensor and its transfer function are included. Here, also the effect of variations of the non-gravitational accelerations during one interferometer cycle is analyzed.

Another crucial aspect for satellite missions is the drag compensation. Its requirement is reduced by two orders of magnitude when using a CAI accelerometer due to its better known scale factor. The feasibility of such requirements is assessed with respect to simulated satellite dynamics for several altitudes and drag compensation parameters.

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