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Evaluation of optical accelerometry for next generation gravimetry missions

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Twenty years of gravity observations from the satellite missions GRACE, GOCE, GRACE-FO have provided unique data about mass redistribution processes in the Earth system, such as melting of Greenland's ice shields, sea level changes, underground water depletion, droughts, floods, etc. Ongoing climate change underlines the urgent need to continue this kind of observations utilizing Next Generation Gravimetry Missions (NGGM) with enhanced instruments. Here, we focus on accelerometers (ACC).

Drifts of the electrostatic accelerometers (EA) are one of the limiting factors in the current space gravimetry missions dominating the error contribution at low frequencies (<10^{-3} Hz). The focus of this study is on the modelling of enhanced EAs with laser-interferometric readout, so called 'optical accelerometers' and evaluating their performance at Low Earth Orbits (LEO). Contrary to GRACE(-FO) or GOCE capacitive accelerometers, optical ones sense the motion of the test mass (TM) in one or more axes by applying laser interferometry. Combination of sensing in multiple directions and of several test masses would lead to enhanced gradiometry which would improve the determination of the static gravity field to a higher spatial resolution and may even enable to observe time-variable gravity changes.

Our research is based on very promising results of the mission LISA-Pathfinder which has demonstrated the benefit of using a drag-free system in combination with optical accelerometry and UV TM discharge which allowed sensing of non-gravitational accelerations several orders of magnitude more accurate than it is realized in current gravity missions like GRACE-FO. This research project is carried out in close collaboration with the IGP and the DLR-SI, to provide - on the long run - a roadmap for improved angular and linear accelerometry for NGGM.

In this presentation, we now introduce a framework for modeling enhanced EA with laser-interferometric readout mainly developed by IGP including major noise sources, like actuation noise, capacitive sensing, stiffness and thermal bias. Also, parametrization of the developed ACC model will be discussed including different TM weights and TM-electrode housing gaps. Finally, improved results of the recovered gravity field will be shown based on various mission scenarios

applying optical accelerometry and gradiometry.

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