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Data Investigations for the GRACE Follow-On Laser Ranging Interferometer (LRI)

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Earth's gravity field is a major topic to investigate in order to understand mass variations on Earth, for example, associated with climate change. After the Gravity Recovery And Climate Experiment (GRACE) mission was an enormous success, the GRACE Follow-On (GFO) mission was developed and launched in May 2018. Its main objective is the continuation of gravity field measurements, however, a secondary objective is to demonstrate inter-satellite ranging by means of laser interferometry for the very first time.

The novel Laser Ranging Interferometer (LRI) was designed to measure changes in the inter-spacecraft distance of $\approx$220$\pm$50km with a noise less than 80nm/rtHz at high Fourier frequencies, which is a significant improvement compared to the microwave ranging (MWI) with a noise level of about 2μm/rtHz. The actual in-flight performance of the LRI is even well below 1nm/rtHz at high frequencies. The instrument is measuring since June 2018, only interrupted due to operational activities not connected to the LRI.

In this poster, we cover three aspects of instrument characterization.

1. The Carrier to Noise ratio (CNR) is a good indicator to assess the signal strength of the interferometer. This ratio needs to be $>$70dB-Hz to ensure a precise range measurement. The CNR is mainly affected by the interferometric contrast, by the received and transmitted beam power and by the noise level of the photoreceiver. We propose a method to derive a reliable low noise CNR value from the satellites telemetry.

2. Some properties of the transmitted beam are difficult to measure on ground, for example, the intensity or the phasefront profile in 220km distance. During the commissioning phase, the pointing of the transmit beam was modulated. From the phase data during this scan, we can infer some information on the phasefront.

3. Spectral analysis is a well-established technique, for example, to assess the nominal behaviour of the instrument and to determine the noise level of the ranging data. By plotting the spectral power for short arcs and for particular frequency bands as a function of the geographical location, we aim to identify eventual artefacts related to the orbital position in the measurements.

These investigations help us to understand the LRI behaviour. The learned lessons are valuable for future missions utilizing laser interferometry, such as next generation geodesy missions or even the space-based gravitational wave observatory LISA.