Realization of the control systems of a small scale suspended interferometer for quantum noise reduction in gravitational wave detectors

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Content

In 2015, the first direct observation of a gravitational wave (GW) event has been possible by the second generation of ground-based GW detectors: Advanced Virgo and Advanced LIGO. In the following years, many other events have been detected by Virgo and LIGO. The sensitivity improvement which allowed these detections, is leading these instruments to face the limit imposed by the quantum nature of light: the Standard Quantum Limit (SQL). Hence, any further upgrade should imply quantum noise (QN) reduction techniques. Virgo and LIGO already adopt frequency independent squeezers, which reduce QN in the high frequency range where shot noise is dominant (above 200Hz). In the very near future, GW detectors will be also limited by QN in the low frequency range (below 100Hz), where radiation pressure noise (RPN) is dominant. Therefore, it is crucial to develop table-top experiments aiming at testing broadband quantum noise reduction (10Hz-1kHz): frequency dependent squeezers (FDS). We are developing a small-scale interferometer with monolithic suspensions of the main optics, named SIPS, that will be sensitive to RPN in the audio frequency band of GW detectors. Since SIPS will be RNP-limited by design, it constitutes a suitable test bench for a FDS setup based on the Einstein Podolsky Rosen (EPR) principle, which needs to be preliminary tested in a RPN-limited cavity before any possible integration in Virgo. Hence, it is fundamental to finalize SIPS experiment with the study and realization of the local and global control system to keep the interferometer in its working point. This is quite challenging because the Fabry-Pérot cavities of SIPS have an extremely high finesse (23000), implying very narrow bands for the realization of the global control. This research activity is mainly devoted to the realization of LabView-based feedback loops designed to damp and control the position of suspended elements, by means of optical lever read-out system and coil-magnet actuators. This initial control is meant to drive the optical degrees of freedom of the interferometer within the accuracy range required to lock the operation setpoint. In this talk I will present the status of SIPS and its integration with EPR experiment, focusing on our preliminary work on local controls using optical levers.

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