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Enhanced noise suppression for LISA by combining cavity and arm locking control systems

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The Laser Interferometer Space Antenna (LISA) mission is a space-based gravitational wave detector, that consists of three spacecrafts in a triangular formation with 2.5-million-kilometer sides. The displacement sensitivity goal is approximately 10 pm/√Hz for each arm-link to detect gravitational waves in the frequency band, 100 μHz to 1 Hz.
The proposed research introduces a novel method for enhanced laser stabilisation in the mission by locking the master laser to two references –the on-board optical cavity and the arms of the inter-spacecraft interferometer. The changes could be implemented via digital controllers to ensure no hardware changes to the LISA baseline are required.
The main technical issue with this dual sensor approach is the undesirable slow laser frequency pulling which couples into the control system with the imperfect knowledge of the Doppler shift of the light in the LISA arm. In order to maintain the cavity well within resonance, requirements on the Doppler shift knowledge are outlined, with techniques to partially realise these requirements using laser frequency measurements.
The results show the technique lowers the residual laser frequency noise in the LISA science band over by 3 orders of magnitude: from 30 Hz√Hz to as low as 4 mHz√Hz, potentially allowing the requirements on Time-Delay-Interferometry (TDI) to be relaxed - possibly to the point where first generation TDI may be sufficient to realise the sensitivity of LISA.

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