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Space-based optical lattice clocks as gravitational wave detectors

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We investigate the sensitivity and performance of space-based Optical Lattice Clocks (OLCs) in detecting gravitational waves, in particular the Stochastic Gravitational Wave Background (SGWB) at low frequencies $(10^{-4}, 1)$Hz, which are inaccessible to ground-based detectors. We first analyze the response characteristics of a single OLC detector for SGWB detection and compare its sensitivity with that of Laser Interferometer Space Antenna (LISA). Due to longer arm lengths, space-based OLC detectors can exhibit unique frequency responses and enhance the capability to detect SGWB in the low-frequency range, but the sensitivity of a single OLC detector remains insufficient overall compared to LISA. Then, as a preliminary plan, we propose a novel method for space-based OLC detectors that can significantly improve the signal-to-noise ratio (SNR) by utilizing the cross-correlation between two of them. This method leverages the uncorrelated origins but statistically similar properties of noise in two detectors while the SGWB signal is correlated between them, thus achieving effective noise suppression and sensitivity enhancement. Our results indicate that the cross-correlation technique can improve the sensitivity by approximately an order of magnitude compared to a single OLC detector configuration, and even would surpass current detection systems such as LISA in the full-band detection capability of SGWB.

Collaboration you are representing

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