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Fundamental Quantum Limits for Detecting Ultra-high Frequency Gravitational Waves

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The ultrahigh-frequency (above 10 kHz) gravitational waves (GW) window provides a unique opportunity to detect primordial GWs, free from astrophysical foregrounds that dominate lower frequencies. A stochastic GW background in this range is generically predicted from cosmological phase transitions and topological defects associated with grand unification and other ultra-high energy theories. We establish a universal quantum limit framework for various detection schemes, setting a fundamental bound on GW detectability. Our analysis reveals that backgrounds in the kHz –MHz range are in principle observable, whereas higher-frequency signals lie below the quantum limit. These results offer theoretical guidance for future detector designs and open new avenues for probing early universe physics.

Collaboration you are representing

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