

Probing Inflationary Origins of Primordial Black Holes with LIGO-Virgo-KAGRA O1-O4a data

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Large primordial curvature perturbations can produce primordial black holes (PBHs) and inevitably generate a scalar-induced stochastic gravitational-wave background upon horizon re-entry. In this talk, based on our recent work arXiv:2609.12867, we will present constraints from the combined LIGO-Virgo-KAGRA O1-O4a data on two representative inflationary mechanisms for producing such perturbations: ultra-slow-roll inflation and an inflationary phase transition. We find no evidence for either signal and derive 95% credible upper limits on the curvature-spectrum amplitude over the frequency range accessible to ground-based interferometers. Because PBH abundance depends exponentially on the perturbation amplitude, even a modest improvement in the amplitude constraint can translate into orders-of-magnitude stronger limits on PBH formation. The resulting bounds probe PBH abundances far below unity and can surpass conventional constraints. Importantly, the gravitational-wave signal preserves information about PBH formation even when the PBHs are too rare for direct searches or have already evaporated. These results demonstrate that stochastic gravitational-wave observations provide a powerful and complementary probe of small-scale inflationary physics, with future interferometers extending the reach to a broader range of inflationary epochs and PBH masses.

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