

Constraining the Primordial Black Hole Abundance with Space-Based Detectors

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Primordial black holes, hypothesized to form from the collapse of large density fluctuations in the early universe, remain a compelling candidate for dark matter and a powerful probe of primordial cosmological physics. In this work, we explore the capabilities of future space-based gravitational wave detectors, including LISA, Taiji, and TianQin, to constrain the PBH abundance. We focus on the stochastic background of scalar-induced gravitational waves associated with PBH formation, and derive upper bounds on the PBH abundance across a wide mass range. We systematically account for the width of the primordial curvature power spectrum and determine the mass windows in which PBHs can be excluded as the dominant component of dark matter under null detection scenarios. Notably, we find that the exclusion window is narrowest for a power spectrum width of $\Delta \sim 0.28$, yet PBHs with masses in the range 10^{-17} – $10^{-9} M_{\odot}$ can still be robustly ruled out. This implies that if PBHs constitute the majority of dark matter, the associated SIGW signal must be detectable by upcoming space-based interferometers.

Primary authors: HONG, Wencong (ITP-CAS); KUROYANAGI, Sachiko; PI, Shi; WANG, Ao; ZHANG, Zhenyu

Presenter: HONG, Wencong (ITP-CAS)

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