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Exploring cosmic origins through primordial black hole mass functions

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Primordial black holes (PBHs) are objects formed from early universe density fluctuations, offering insights into the universe's infancy. The PBH mass function characterizes their mass distribution, which is crucial for understanding their role in shaping various structures [1]. Typically, the focus of various studies is on the mass function of supermassive black holes (SMBHs), which originate due to unknown mechanics. However, PBHs can serve as the seeds for SMBHs owing to their extensive mass range and long lifetime. Therefore, the physics of the early universe may have left imprints on the SMBH properties via these massive PBH seeds.

In ref. [2], a novel method investigates PBH mass function to reveal the mysteries of our universe. In this work, PBHs were treated as SMBH seeds of the primordial universe. By employing the Press-Schechter formalism, authors explored the PBH mass function under two cosmic-origin paradigms: standard inflationary ΛCDM and bounce cosmology. In the context of the standard inflationary ΛCDM model, the literature reveals its inability to generate a substantial number of massive PBHs [3]. However, the authors highlighted the potential of nontrivial inflation models with blue-tilted power spectra at small scales and matter bounce cosmology. These alternative frameworks offer viable mechanisms for the formation of heavy PBHs, which could, intriguingly, serve as the seeds for observed SMBHs.

This work takes a remarkable step by fitting SMBH mass functions at high redshift ($z \sim 6$) obtained from the Sloan Digital Sky Survey and Canada-France High-z Quasar Survey quasars. Thus, the authors derive constraints for the PBH density fraction at $z \sim 6$ and characteristic mass ($M_\star$), assuming that all SMBHs originate from PBHs [4]. This innovative approach, relying on high-redshift astronomical measurements from deep-field surveys of SMBHs, presents a promising way to constrain cosmic-origin models. This study explores the formation mechanisms of PBHs and emphasizes the potential impact of understanding the cosmic evolution leading to the existence of SMBHs.

While the primary focus of this paper is on high-redshift constraints, it also briefly discusses the evolution of the mass function from $z \sim 6$ to $z \sim 0$. This analysis broadens the scope of this field, shedding light on the PBH evolution across cosmic epochs. In conclusion, this work introduces a compelling methodology for probing cosmic origins through the analysis of primordial black hole mass functions. The utilization of high-redshift SMBH data offers a unique perspective, opening up avenues for refining our understanding of the universe's early stages.

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