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The unexpected shape of the primordial black hole mass function

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In a Universe with nearly-Gaussian initial curvature perturbations, the abundance of primordial black holes can be derived from the curvature power spectrum. When the latter is enhanced within a narrow range around a characteristic scale, the resulting mass function has a single distinct peak, corresponding to Schwarzschild radii set by the horizon entry time of that scale. In contrast, we show (both numerically and by providing an analytic estimation) that a broad enhancement - such as a plateau bounded by infrared and ultraviolet scales - produces a bimodal mass function, with a primary peak close to the infrared scale. We find that the typical initial gravitational potential (compaction function), conditioned on meeting the threshold for critical collapse, is generated by a thin spherical shell with infrared radius and a thickness comparable to the ultraviolet scale. This suggests a higher-than-expected abundance of PBH originating from Type II initial fluctuations. Our results significantly impact overproduction bounds on the amplitude of the power spectrum, and tighten the viable mass range for primordial black holes as dark matter.

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