

Primordial regular black holes as all the dark matter

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I present a trilogy of works exploring the possibility that primordial black holes often considered as dark matter candidates, are non-singular objects. The investigations are motivated by the expectation that a complete theory of quantum gravity should ultimately resolve curvature singularities—an endemic feature of the Schwarzschild and Kerr metrics typically used to describe PBHs. In the first two studies, six phenomenological regular space-times were considered—both tr-symmetric and non-tr-symmetric—including well-known cases such as Bardeen and Hayward, as well as more recent metrics inspired by loop quantum gravity, such as the D’Ambrosio-Rovelli and Peltola-Kunstatter constructions. In all cases, the modified evaporation properties of non-singular PBHs were characterized and constraints on their abundance from F^3 -ray observations were derived. Compared to the Schwarzschild case, these metrics generally lead to weakened constraints on the PBH fraction of dark matter, enlarging the asteroid mass window where PBHs can account for all the DM. In the final work, moving beyond effective metrics, PBHs described by the covariant, quantum-corrected space-time proposed by Zhang, Lewandowski, Ma & Yang (ZLMy), were studied. ZLMy PBHs exhibit higher temperatures and no Cauchy horizons, leading to stronger evaporation constraints that partially reverse the previous trend, while relying on a more robust theoretical foundation. Together, this trilogy offers a proof-of-principle that quantum gravity-inspired regular space-times can significantly alter PBH phenomenology and open up—or constrain—new avenues for them to constitute the entirety of DM, highlighting the rich interplay between singularity resolution and cosmological observations.

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