

Probing Memory-Burdened Primordial Black Holes with Multi-Messenger Observations

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The memory burden (MB) effect can dramatically slow black hole evaporation once half of the initial mass is radiated, allowing very light primordial black holes (PBHs) to persist today as dark matter (DM). We probe this scenario across three complementary messengers.

Using LHAASO ultra-high-energy gamma-ray spectra of four Galactic sources, we constrain PBHs with masses 10^9 g. From 10 years of IceCube muon-track data and 14 dwarf spheroidal galaxies with D-factor uncertainties treated via a profile likelihood, we derive neutrino limits on the PBH abundance. The cosmic-ray signal from memory-burdened PBHs is also considered but yields weaker constraints.

In all channels no significant excess over background is found. The gamma-ray and neutrino probes provide independent and complementary limits on the MB scenario; the neutrino results improve substantially on previous work in the $k=1$ case, while the $k=2$ case and the cosmic-ray channel remain less constraining due to limited instrumental sensitivity in the relevant energy ranges. Our combined analysis thus significantly narrows the allowed parameter space for PBH dark matter under the MB effect.

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