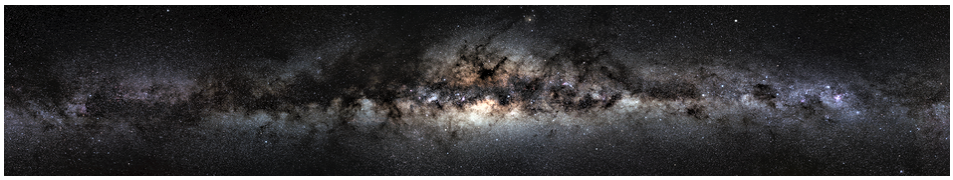

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Connecting the Extremes: A Story of Supermassive Black Holes and Ultralight Dark Matter

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The formation of ultra rare supermassive black holes (SMBHs), with masses of $ord10^9 M_{odot}$, in the first billion years of the Universe remains an open question in astrophysics. At the same time, ultralight dark matter (DM) with mass in the vicinity of $ord10^{-20}$ eV has been motivated by small scale DM distributions. Though this type of DM is constrained by various astrophysical considerations, certain observations could be pointing to modest evidence for it. We present a model with a confining first order phase transition at $\sim$ 10 keV temperatures, facilitating production of $ord10^9 msol$ primordial SMBHs. Such a phase transition can also naturally lead to the implied mass for a motivated ultralight axion DM candidate, suggesting that SMBHs and ultralight DM may be two sides of the same cosmic coin. We consider constraints and avenues to discovery from superradiance and a modification to $N_{\rm eff}$. On general grounds, we also expect primordial gravitational waves – from the assumed first order phase transition – characterized by frequencies of $ord10^{-12} - 10^{-9}$ Hz. This frequency regime is largely uncharted, but could be accessible to pulsar timing arrays if the primordial gravitational waves are at the higher end of this frequency range, as could be the case in our assumed confining phase transition.

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