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Gravitational Wave Constraints on Clustered Primordial Black Hole Dark Matter

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Primordial black holes (PBHs) are a well-motivated candidate for dark matter that regained research interest after the first detections of gravitational waves by LIGO. PBHs can form binaries in the early universe. Due to the production process of PBHs, e.g. by large and rare density perturbations, clustering of PBHs can become important. This is used in the literature to avoid current exclusion limits. However, we point out that once the clustering is high enough such that the merger time for typical PBH binaries is sufficiently less than the age of the universe, multiple successive mergers, i.e. merging of binaries consisting of previously merged PBHs, can occur and gain importance. This has been neglected up to now. We present a simple cascading model taking into account this effect and show that it enhances existing constraints due to the observed binary black hole merger rate, the stochastic gravitational wave background, the effective number of additional neutrino species, and the conversion of PBHs as dark matter to gravitational waves as dark radiation.

Primary authors: SCHMIDT-HOBERG, Kai (DESY); Mr DEPTA, Paul Frederik (DESY); BRINGMANN, Torsten (Oslo University); Ms DOMCKE, Valerie (DESY)

Presenter: Mr DEPTA, Paul Frederik (DESY)

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