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Excursion-set approach for Primordial Black Holes: small-scale clustering and merger rates

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By extending the so-called excursion-set formalism - often used in the context of Dark Matter halos formation - to two-point statistics, we revisit the initial spatial clustering of Primordial Black Holes (PBHs) originating from the Hubble reentry of large Gaussian density fluctuations in the early Universe. Our work propose a way to correlate the formation of pairs of PBHs, revealing features that the ubiquitously used Poisson model of clustering was unable to capture: the new model effectively includes short-range exclusion effects and proves that PBHs are anticorrelated at short distances. It shows that going beyond point-like treatments for PBHs and taking into account their spatial extension lead to non-trivial volume-exclusion effects.
As a next step, by embedding our formalism within the Tidal Torque Theory (TTT), we show how keeping tracks of correlations impact both the resulting mass and spin distributions of PBHs binaries. From these results, we suggest a novel approach to estimate merger rates from PBHs two-body channel in the early universe, which could apply for models of PBHs formation with broad mass spectrum and spatial clustering, two features that the current analytical treatments of merger rates fail to capture.

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