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Little Red Dots from Small-Scale Primordial Black Hole Clustering

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The James Webb Space Telescope (JWST) observations have identified a class of compact galaxies at high redshifts (4 \lesssim z \lesssim 11), dubbed “little red dots” (LRDs). The supermassive black holes (SMBHs) of 10^{5-8}{\rm\,M}_{\odot} in LRDs favor a heavy-seed origin. We propose a mechanism for their formation: Clusters of primordial black holes, formed through long-short mode coupling on small scales in the early Universe, undergo sequential mergers over extended timescales. This mechanism can evade cosmic microwave background distortions and result in heavy-seed SMBHs via runaway mergers. We employ Monte Carlo simulations to solve the Smoluchowski coagulation equation and determine the runaway merging timescale. The resulting stochastic gravitational wave background offers a distinct signature of this process, and the forming SMBHs can be highly spinning at their formation due to the spin residual of the cluster from tidal fields. This mechanism may explain the rapidly spinning SMBHs in LRDs under the assumption of obscured active galactic nuclei.

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