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Exploring Ultra-Slow-Roll Inflation in Composite Pseudo-Nambu–Goldstone Boson Models: Implications for Primordial Black Holes and Gravitational Waves

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We study inflation driven by a scalar potential arising from composite-sector dynamics, inspired by generalized composite Higgs models. The introduction of a non-minimal coupling, possessing the same functional form as the potential, induces a flattening at large field values that enables successful inflation. We analyze the conditions for ultra-slow-roll inflation, which leads to enhanced curvature perturbations, by combining analytical criteria near the inflection point with comprehensive numerical scans of the parameter space. The region consistent with Cosmic Microwave Background constraints and yielding approximately $N_e \approx 55$–60 e-folds also predicts primordial black holes with masses in the range 10^3–10^5 g. Although such ultra-light primordial black holes are typically expected to have evaporated, recent proposals invoking evaporation suppression via memory-burden effects could allow their survival as viable dark matter candidates. Under this assumption, the predicted gravitational wave signal lies in a frequency range currently inaccessible to any existing or proposed detectors. Although no experimental proposals presently reach this frequency band, our results provide strong motivation to push the frontiers of gravitational wave detection towards these unexplored high-frequency regimes.

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