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Complementary Probe of Beyond the Standard Model Physics with Gravitational Waves from Electroweak Phase Transition

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Studying cosmic phase transitions is a key focus in modern cosmology and particle physics. Both new and existing physics at any scale can be responsible for catalyzing either a first, second, or cross-over phase transition, which could be thermal or non-thermal with an observable imprint, such as stochastic gravitational waves (GW). Understanding the sources of such primordial waves can serve as complementary to the collider searches of new physics beyond the Standard Model (BSM). Strong first-order phase transitions (SFOPT), a necessary ingredient for Electroweak Baryogenesis (EWBG) to incorporate the observed baryon asymmetry, can also give rise to GWs. We explored two BSM frameworks: one supersymmetric (SUSY) and one non-SUSY model as promising candidates for Electroweak Baryogenesis (EWBG) that can produce detectable gravitational waves (GWs) at space-based detectors. For a SUSY extended model scenario, the $\mathcal{Z}_3$ -invariant Next-to-Minimal Supersymmetric Standard Model is (NMSSM) extended with a right-handed neutrino (RHN) superfield, and we found that strong first-order phase transitions (FOPTs) may occur in regions favoring a light right-handed sneutrino-like state below 125 GeV, with predicted GWs detectable within the sensitivity range of DECIGO-corr, U-DECIGO, U-DECIGO-corr [[1]]. Additionally, we propose a multi-component dark matter (DM) scenario involving the neutral part of a $Y = 0$ scalar triplet and a Majorana fermion. Our investigation explores the parameter space for strong phase transitions, correct relic density, and direct detection compatibility, offering an alternative probe to the collider experiments.

1 P. Borah, P. Ghosh, S. Roy and A. K. Saha, Electroweak Phase Transition in a Right-Handed Neutrino Superfield Extended NMSSM JHEP 08 (2023) 029, [2301.05061][hep-ph]

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IIT Delhi

Author: Mr BORAH, Pankaj (Indian Institute of Technology Delhi)

Presenter: Mr BORAH, Pankaj (Indian Institute of Technology Delhi)

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