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Probing Miracle-less WIMP Dark Matter via Gravitational Waves Spectral Shapes

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We propose a novel probe of weakly interacting massive particle (WIMP) dark matter (DM) candidates of a wide mass range which fall short of the required annihilation rates to satisfy correct thermal relic abundance, dubbed as "Miracle-less WIMP". If the DM interactions are mediated by an Abelian gauge boson like B-L, its annihilation rates typically remain smaller than the WIMP ballpark for very high scale B-L symmetry breaking, leading to overproduction. The thermally overproduced relic is brought within observed limits via late entropy dilution from one of the three right handed neutrinos (RHN) present for keeping the model anomaly free and generating light neutrino masses. Such late entropy injection leads to peculiar spectral shapes of gravitational waves (GW) generated by cosmic strings, formed as a result of B-L symmetry breaking. We find interesting correlation between DM mass and turning frequency of the GW spectrum with the latter being within reach of future experiments. The two other RHNs play major role in generating light neutrino masses and baryon asymmetry of the universe via leptogenesis. Successful leptogenesis with Miracle-less WIMP together restrict the turning frequencies to lie within the sensitivity limits of near future GW experiments.

Primary authors: KUMAR SAHA, Abhijit (Indian Association for the Cultivation of Science); Dr BORAH, Debasish (Indian Institute of Technology Guwahati); SAMANTA, Rome (University of Southampton); JYOTI DAS, Suruj (Indian Institute of Technology Guwahati)

Presenter: Dr BORAH, Debasish (Indian Institute of Technology Guwahati)

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