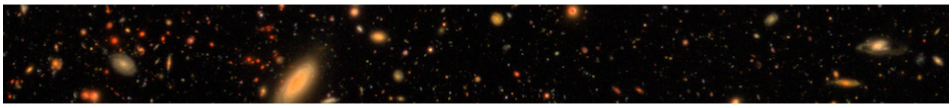

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Complementarity Probes of light dark sector via Gravitational Waves and Laboratories

The non-thermal production of dark matter (DM) usually requires very tiny couplings of the dark sector with the visible sector and therefore is notoriously challenging to hunt in laboratory experiments. Here we propose a novel pathway to test such a production in the context of a non-standard cosmological history, using both gravitational wave (GW) and laboratory searches. We investigate the formation of DM from the decay of a scalar field that we dub as the reheaton, as it also reheats the Universe when it decays. We consider the possibility that the Universe undergoes a phase %of kination with \textit{kination-like} stiff equation-of-state (wkin>1/3) before the reheaton dominates the energy density of the Universe and eventually decays into Standard Model and DM particles. We then study how first-order tensor perturbations generated during inflation, the amplitude of which may get amplified during the kination era and lead to detectable GW signals. Demanding that the reheaton produces the observed DM relic density, we show that the reheaton's lifetime and branching fractions are dictated by the cosmological scenario. In particular, we show that it is long-lived and can be searched by various experiments such as DUNE, FASER, FASER-II, MATHUSLA, SHiP, etc. We also identify the parameter space which leads to complementary observables for GW detectors such as LISA and u-DECIGO. In particular we find that a kination-like period with an equation-of-state parameter wkin≈0.5 and a reheaton mass O(0.5–5) GeV and a DM mass of O(10–100) keV may lead to sizeable imprints in both kinds of searches. Based on: Journal of High Energy Physics volume 2022, Article number: 105 (2022)

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