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Gravity as a Portal to Reheating, Leptogenesis and Dark Matter

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We show that a minimal scenario, utilizing only the graviton as an intermediate messenger between the inflaton, the dark sector and the Standard Model (SM), is able to generate simultaneously the observed relic density of dark matter (DM), the baryon asymmetry through leptogenesis, as well as a sufficiently hot thermal bath after inflation. The possibility of reheating via minimal gravitational interactions has been excluded by constraints on dark radiation for excessive gravitational waves produced from inflation. We thus extend the minimal model in several ways: i) we consider non-minimal gravitational couplings; ii) we propose an explanation for the PeV excess observed by IceCube when the DM has a direct but small Yukawa coupling to the SM; and iii) we also propose a novel scenario, where the gravitational production of DM is a two-step process, first through the production of two scalars, which then decay to fermionic DM final states. In this case, the absence of a helicity suppression enhances the production of DM and baryon asymmetry, and allows a great range for the parameters including a dark matter mass below an MeV where dark matter warmness can be observable by cosmic 21-cm lines, even when gravitational interactions are responsible for reheating. We also show that detectable primordial gravitational wave signals provide the opportunity to probe this scenario for $T_{\rm rh} < 5 \times 10^6$ GeV in future experiments, such as BBO, DECIGO, CE and ET.

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no

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