Dark Matter Production in Quadratic Gravity!
Can We Extend Radiation Era to the Big Bang?

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Can the radiation era extend back to the Big Bang? Rethinking dark matter production and graviton thermalization in quadratic gravity

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Naive estimates based on Einstein gravity with Lagrangian $\frac{1}{2}M_{pl}^2(R-2\Lambda)$ suggest that, if the radiation era extended back to the Big Bang (*i.e.* as far back as the classical spacetime background makes sense), this would result in an over-production of dark matter and a relic cosmic background of thermal gravitons. Here we revisit these conclusions in quadratic gravity, the minimal renormalizable completion of Einstein gravity, whose Lagrangian also includes the terms $\frac{1}{6}f_0^{-2}R^2-\frac{1}{2}f_2^{-2}C^2$. Assuming the radiation era *does* extend back to the bang, we find a novel constraint relating the coefficient f_2 and the dark matter mass m_{dm}, needed to obtain the correct dark matter abundance. This is an elegant gravitational production mechanism for dark matter (*e.g.* stable right-handed neutrinos). Moreover, the presence or absence of the relic graviton background (detectable by forthcoming CMB experiments via its small imprint on $N_{\rm eff}$) will place new constraints on f_0, f_2.

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