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Massive particle pair production and oscillation in Friedman Universe: its effect on inflation

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We study the classical Friedman equations for the time-varying cosmological term $\tilde{\Lambda}$
and Hubble function H, together with quantised field equations for the production of massive $M \gg H$ particles, namely, the $\tilde{\Lambda}$CDM scenario of dark energy and matter interactions. Classical slow components $\mathcal{O}(H^{-1})$ are separated from quantum fast components $\mathcal{O}(M^{-1})$. The former obeys the Friedman equations, and the latter obeys a set of nonlinear differential equations. Numerically solving equations
for quantum fast components, we find the production and oscillation of massive
particle-antiparticle pairs in microscopic time scale $\mathcal{O}(M^{-1})$. Their density and pressure averages over microscopic time do not vanish.
It implies the formation of a massive pair plasma state in macroscopic time scale $\mathcal{O}(H^{-1})$, whose effective density and pressure contribute to the Friedman equations. Considering the inflation driven by the time-varying cosmological term and slowed down by the massive pair plasma state, we obtain the relation of spectral index and tensor-to-scalar ratio in agreement with recent observations. We discuss the singularity-free
pre-inflation, the CMB large-scale anomaly, and dark-matter density perturbations imprinting on power spectra.

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