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Corrigendum

Corrigendum to “The kinematics of cosmic reheating” [Nucl. Phys. B 875 (2) (2013) 315–350]

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Abstract

After publication we found a few errors in our article *The kinematics of cosmic reheating* [1], which we correct below for clarity. The resulting changes in our main result, the temperature dependent damping rate Γ, are not significant.

1. Highest temperature in the early universe

In the published version of the article we incorrectly state after Eq. (1) that T_R defined in that equation poses a strict upper bound on the temperature in the early universe if the temperature dependence of the damping rate Γ is negligible. This statement was based on the incorrect assumption that instantaneous conversion of the inflaton energy must be the most efficient way of reheating, given that Hubble expansion cools the radiation during the reheating process if the dissipation occurs at a finite rate Γ. It is incorrect because dissipation already starts before the moment when Γ equals the Hubble rate H. Even though the fraction by which the energy of

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the inflaton ϕ is reduced per Hubble time is very small prior to $\Gamma = H$, the absolute amount of energy released into radiation is larger than at $\Gamma = H$ and later times due to the larger amplitude of the ϕ-oscillations.

The correct statement is that T_R defined in (1) provides an estimate for the reheating temperature (defined as the temperature at the onset of the radiation dominated era) if 1) reheating is achieved by perturbative processes and 2) finite density effects are negligible. Even in this simple scenario the maximal temperature in the early universe in general exceeds T_R. This fact has previously been pointed out in Ref. [2]. The authors of that paper also give an estimate for the maximal temperature under the assumption that conditions 1) and 2) are fulfilled. We could confirm their results analytically and numerically in Ref. [3], where we also give generalised estimates for the reheating temperature and maximal temperature that include thermal corrections, i.e. remain valid if assumption 2) is dropped.

2. Self-energy

In the self-energy given in Eq. (34) in the published article an additional term, a power of the coupling constant, and the symmetry factor 1/2 of the Feynman diagrams in Fig. 9 are missing. The correct expression reads [4]

$$\Pi^-_{i,\mathbf{p}} = \frac{\mathfrak{g}_i^2}{16 i\pi|\mathbf{p}|}\left[-\theta\left(-p^2\right)\left(p_0 + T\log\left[\frac{f_B(p_0-\omega^+)f_B(-\omega^-)}{f_B(-\omega^+)f_B(p_0-\omega^-)}\right]\right)\right.$$
$$\left. + \theta\left(p^2-(2m_\xi)^2\right)T\log\left[\frac{f_B(p_0-\omega^+)f_B(-\omega^-)}{f_B(-\omega^+)f_B(p_0-\omega^-)}\right]\right]$$

with the Bose–Einstein distribution $f_B(p_0) \equiv (e^{p_0/T}-1)^{-1}$ and

$$\omega^\pm = \frac{p_0}{2} \pm \mathrm{sign}\left(p^2\right)\frac{|\mathbf{p}|}{2}\sqrt{1-\frac{(2m_\xi)^2}{p^2}}.$$

This leads to a change in Fig. 10. The corrected figure is shown in Fig. 1 here. However, the effects of this change on the rate Γ shown in Fig. 11 and all other results are negligible.

3. Typos

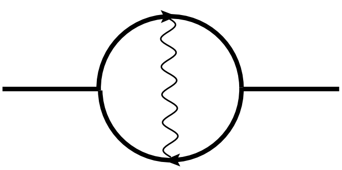
The sum rule (37) should read

$$\int \frac{dp_0}{2\pi} p_0 \rho_i(p_0) = 1.$$

The energy ω in Eq. (43) should be set to M, i.e. the expression should read

$$\Gamma_{\mathrm{decay}} = \frac{g^2}{16\pi M}\left[1-\left(\frac{2M_\chi}{M}\right)^2\right]^{1/2}\left(1+2f_B(M/2)\right)\theta(M-2M_\chi).$$

The diagram in Fig. 16 should be replaced by



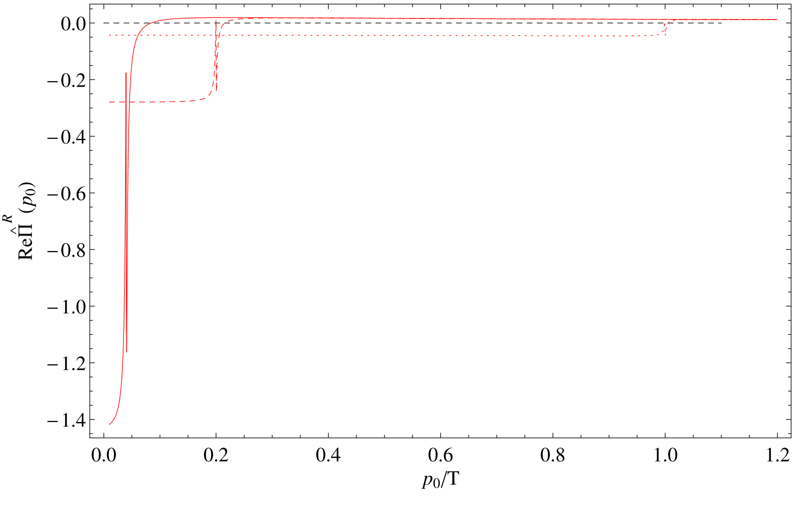


Fig. 1. The corrected dispersive part of the χ_i-self-energy $\mathrm{Re}\,\hat{\Pi}_i^R(p_0) = \mathrm{Re}\,\Pi_i^R(p_0)/\mathfrak{g}_i^2$ for $m_\xi/m_i = 10^{-2}$ at $T = 5m_i$ for $|\mathbf{p}| = m_i/5$ (solid line) and $|\mathbf{p}| = m_i$ (dashed line) and $|\mathbf{p}| = T = 5m_i$ (dotted line) as a function of energy.

Acknowledgements

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