
A SHORT SURVEY OF MATTER-ANTIMATTER EVOLUTION IN THE PRIMORDIAL UNIVERSE

A PREPRINT

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1 Composition of the Universe

The composition of the Universe, in terms of energy density fractions of various particle species, gives valuable insight into the history of the Universe. We begin on the right at the end of the QGP era. The first dotted vertical line shows the QGP phase transition and hadronization, near $T = 150$ MeV. The hadron era proceeds with the disappearance of muons, pions, and heavier hadrons. This constitutes a reheating period, with energy and entropy from these particles being transferred to the remaining e^\pm , photon, neutrino plasma. The black circle near $T = 115$ MeV denotes our change from 2 + 1-flavor lattice QCD data for the hadron energy density, taken from Borsanyi et al., to an ideal gas model at lower temperature. We note that the hadron ideal gas energy density matches the lattice results to less than a percent at 115 MeV. [1]

References

- [1] R. Ruffini, G. Vereshchagin, and S.-S. Xue, “Electron-positron pairs in physics and astrophysics: from heavy nuclei to black holes,” *Phys. Rept.*, vol. 487, pp. 1–140, 2010.