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Monte-Carlo simulations of multi-specie relativistic thermalization and Analysis of Boltzmann Equation for Big bang nucleosynthesis[1]

ATUL KEDIA, GRANT MATHEWS, NISHANTH SASANKAN, University of Notre Dame, MOTOHIKO KUSAKABE, Beihang University — A fundamental assumption in BBN is that the nuclear velocity distributions obey Maxwell-Boltzmann (MB) statistics as they do in stars. Specifically, the BBN epoch is characterized by a dilute baryon plasma for which the velocity distribution of nuclei is mainly determined by the dominant Coulomb elastic scattering with mildly relativistic electrons. One must therefore deduce the momentum distribution for reacting nuclei from the multi-component relativistic Boltzmann equation. However, the full multi-component relativistic Boltzmann equation has only recently been analyzed and its solution has only been worked out in special cases. Moreover, a variety of schemes have been proposed that introduce non-thermal components into the BBN environment which can alter the thermal distribution of reacting nuclei. Here, we construct the relativistic Boltzmann equation in the context of BBN. We also perform relativistic Monte-Carlo simulations which clarify the baryon distribution during BBN and can be used to analyze any relaxation from a non-thermal injection. We will discuss the development and application of this simulation to explore the thermalization process in a relativistic multi-component environment. As an illustration we simulate the fully relativistic three-dimensional Brownian-motion-like solution to the thermalization of a high mass particle in a bath of relativistic low-mass particles. We follow the thermalization and ultimate equilibrium distribution of the Brownian-like particle as can happen in the cosmic plasma during Big bang nucleosynthesis. We show by these analyses that the thermalization process leads to a nuclear distribution function that remains very close to MB statistics even during the most relativistic environment relevant to BBN.

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