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Towards solving the puzzle of high temperature light (anti)-nuclei production in ultra-relativistic heavy ion collisions

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The creation of loosely bound objects in heavy ion collisions, e.g.˜light clusters, near the phase transition temperature ($T_{\mathrm{ch}} \approx 155 MeV$) has been a puzzling observation that seems to be at odds with Big Bang nucleosynthesis suggesting that deuterons and other clusters are formed only below a temperature $T \approx 0.1 - 1 MeV$. We solve this puzzle by showing that the light cluster abundancies in heavy ion reactions stay approximately constant from chemical freeze-out to kinetic freeze-out. To this aim we develop an extensive network of coupled reaction rate equations including stable hadrons and hadronic resonances to describe the temporal evolution
of the abundancies of light (anti-)(hyper-)nuclei in the late hadronic
environment of an ultrarelativistic heavy ion collision.
It is demonstrated that the chemical equilibration of the light
nuclei occurs on a very short timescale as a consequence of the strong
production and dissociation processes.
However, because of the partial chemical equilibrium of the stable hadrons, including the nucleon feeding from Δ resonances, the abundancies of the light nuclei stay nearly constant during the evolution and cooling of the hadronic phase. This solves the longstanding contradiction between the thermal fits and the late stage coalescence (and the Big Bang nucleosynthesis) and explains why the observed light cluster yields are compatible with both a high chemical production temperature and a late state emission as modelled by coalescence.
We also note in passing that the abundancies of the light clusters in the present approach are in excellent agreement with those measured by ALICE at LHC.

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