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Chemical freeze-out curve in heavy-ion collisions and the QCD critical point

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The chemical freeze-out curve in heavy-ion collisions is investigated in the context of QCD critical point (CP) search at finite baryon densities. Taking the hadron resonance gas picture at face value, chemical freeze-out points at a given baryochemical potential provide a lower bound on the possible temperature of the QCD CP. We first verify that the freeze-out data in heavy-ion collisions are well described by a constant energy per particle curve, $E/N = \text{const}$, under strangeness neutrality conditions ($\mu_S \neq 0$, $\mu_Q \neq 0$). We then evaluate the hypothetical freeze-out curve based on this criterion in the absence of strangeness neutrality ($\mu_S = 0$, $\mu_Q = 0$) and confront it with recent predictions on the CP location. We find that recent estimates based on Yang-Lee edge singularities from lattice QCD data on coarse lattices place the CP significantly below the freeze-out curve and are thus disfavored by the heavy-ion data. On the other hand, predictions based on functional methods and holography place the CP slightly above the freeze-out curve, indicating that the QCD CP may be located very close to the chemical freeze-out in A+A collisions at $\sqrt{s_{NN}} = 3.5 \div 5$ GeV.

The report is based on a recently published article: https://arxiv.org/abs/2408.06473

Primary author: LYSENKO, Artemiy (Bogolyubov Institute of Theoretical Physics)

Presenter: LYSENKO, Artemiy (Bogolyubov Institute of Theoretical Physics)

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