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Semi-analytical method of calculating the nuclear collision trajectory in the QCD phase diagram

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The finite nuclear thickness affects the energy density $\epsilon(t)$ [1] and conserved-charge densities [2] such as the net-baryon density $n_B(t)$ produced from the primary NN collisions of heavy ion collisions. While the effects are small at high collision energies compared with the standard Bjorken model of the initial state, they are large at low collision energies, where the nuclear passing time is not small compared to the parton formation time. The temperature $T(t)$ and chemical potentials $\mu(t)$ of the dense matter can be extracted from the densities [2]. Therefore, including the nuclear thickness is essential for the determination of the $T-\mu_B$ trajectory in the QCD phase diagram for relativistic nuclear collisions at low to moderate energies such as the RHIC-BES energies.

In this talk, I will discuss our semi-analytical method that includes the nuclear thickness effect and its results on densities $\epsilon(t)$, $n_B(t)$, $n_Q(t)$, and $n_S(t)$. Then, I will show the extracted $T(t)$, $\mu_B(t)$, $\mu_S(t)$, and $\mu_Q(t)$ for a quark-gluon plasma with either quantum statistics or Boltzmann statistics. Next, I will show our results on the $T-\mu_B$ trajectories, highlighting how the trajectories depend on the chosen statistics and the nuclear thickness in relation to the possible location of the critical end point (CEP). Finally, I will show how this semi-analytical model can be useful to researchers who study high density physics and search for the CEP.

References

[1] T. Mendenhall and Z. W. Lin, Phys. Rev. C **103** 024907 (2021).
[2] T. Mendenhall and Z. W. Lin, arXiv:2111:13932 [nucl-th].

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