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QCD phase transition and the confining dynamics at finite density via functional approach

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With the new heavy-ion collision facilities at FAIR (CBM) and HIAF (CEE+) being nearly completed, the experimental researches in the high baryon density region of QCD phase diagram are entering the precision physics era. There is in turn a great demand on the first-principles QCD computations in theory, in order to have a clear understanding on the observational signatures in experiments.

To date, a *direct* QCD computation at high density can only be achieved by the continuum, functional approach, as the first-principles lattice QCD approach is suffering from the sign problem. I would then like to highlight some recent progresses of the functional approach in the study of QCD thermodynamic observables at high density.

In concrete, the talk will cover our recent work on the confinement-deconfinement phase transition and its finite-density signatures in the QCD equation of state (arXiv:2504.05099). Besides, the spinodal decomposition in the chiral dynamics and confining dynamics is discovered recently beyond the QCD critical end point (arXiv:2509.02974), whose indications on the inhomogeneous structure of dense nuclear matter will also be discussed.

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