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Van der Waals interactions and Hadron Resonance Gas

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Extension of the ideal hadron resonance gas (HRG) model is constructed which includes attractive and repulsive van der Waals (VDW) interactions between hadrons [1]. The model employs a novel multi-component quantum statistical VDW approach which incorporates the Fermi-Dirac and Bose-Einstein effects in the system of interacting particles.
The VDW parameters a and b are fixed by the ground state properties of nuclear matter, and this VDW-HRG model yields the nuclear liquid-gas transition at low temperatures and high baryonic densities.

The predictions of the model are confronted with the lattice QCD calculations at zero chemical potential.
The inclusion of VDW interactions between baryons leads to a qualitatively different behavior of cumulants of fluctuations of conserved charges, for many observables closely resembling the lattice QCD results.
We also explore the effect of VDW interactions on the thermal fits to heavy-ion hadron yield data and find that existing agreement of ideal HRG is not spoiled in the VDW-HRG model.
The VDW interactions are found to have a substantial influence on the higher orders of fluctuations of conserved charges at finite chemical potential, in the regions where chemical freeze-out in heavy-ion collisions is expected to occur. Thus, the nuclear liquid-gas transition manifests itself into non-trivial net-baryon fluctuations in heavy-ion collisions.

Finally, we explore the lattice QCD observables at imaginary chemical potential and also phase shifts of nucleon-nucleon scattering. Both are found to be consistent with a presence of significant repulsive interactions between baryons.

[1] V. Vovchenko, M.I. Gorenstein, H. Stoecker, arXiv:1609.03975, Phys. Rev. Lett., in print

List of tracks

Freeze-out, hadronisation and statistical models

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