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van der Waals Interactions in Hadron Resonance Gas: From Nuclear Matter to Lattice QCD

Monday 7 August 2017 16:30 (30 minutes)

We construct an extension of the ideal hadron resonance gas (HRG) model which includes attractive and repulsive van der Waals (VDW) interactions between hadrons, and analyze different observables with this model [1]. 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 baryonic interactions leads to a qualitatively different behavior of the fluctuations of conserved charges in the crossover region.
In many cases it resembles the lattice data. For instance, the VDW-HRG model predicts the drop of the \chi_4/\chi_2 cumulant ratio for the net baryon number fluctuations in the crossover region, which is also seen on the lattice.

Calculations are also performed at finite chemical potentials.
The VDW-HRG model predicts a non-monotonic behavior of the net baryon \chi_4/\chi_2 ratio with respect to the collision energy, in stark contrast to the ideal HRG.
This implies that non-trivial fluctuations of net-baryon number
in heavy-ion collisions
manifest traces of the nuclear liquid-gas phase transition.

We also analyze the preliminary lattice data at imaginary chemical potential [2] with the VDW-HRG model.
The lattice behavior of the Fourier coefficients in the Fourier expansion of baryon density at imaginary baryochemical potential is shown to be consistent with presence of eigenvolume-type repulsive baryonic interactions.
The same conclusion is obtained by analyzing the phase shifts of nucleon-nucleon scattering.

[1] V. Vovchenko, M.I. Gorenstein, H. Stoecker, Phys. Rev. Lett. 118, 182301 (2017)

[2] S. Borsanyi et al. [Wuppertal-Budapest Collaboration], Talk at Quark Matter 2017 conference (5-11 February 2017, Chicago, USA)

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