Critical Point in Nuclear Physics

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An extension of the ideal hadron resonance gas (HRG) model is constructed which includes the attractive and repulsive van der Waals (vdW) interactions between baryons and between antibaryons [1]. This quantum vdW-HRG model yields the first order liquid-gas phase transition at low temperatures and high baryon densities. The phase transition ends at the nuclear critical point at the temperature $T_c \cong 20$ MeV. A beam energy dependence of the net baryon number susceptibilities is studied in relativistic nucleus-nucleus collisions. The obtained results are compared with the experimental net proton number fluctuations measured by the STAR collaboration at the RHIC BNL. We find that a behavior of the skewness $S\sigma$ and kurtosis $\kappa\sigma^2$ deviate significantly from the Poisson baseline and demonstrate the existence of rich structures at moderate collision energies [2]. This behavior results from the critical end point of the nuclear matter. In particular, $\kappa\sigma^2$ shows a non-monotonic energy dependence. The model is further extended to the two conserved charges – the net baryon number and the net electric charge – with the noncongruent first order phase transition [3]. A behavior of the electric charge fluctuations is predicted.

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