Net-charge probability distributions in heavy ion collisions at chemical freeze-out*

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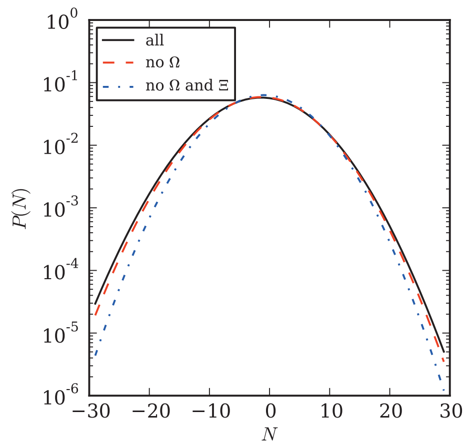
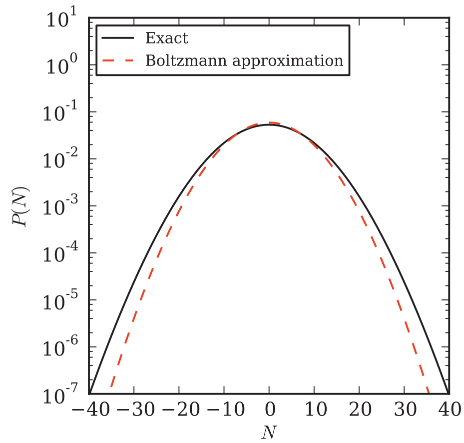
The distributions for strangeness, electric charge and baryon number are explored in heavy ion collisions within the hadron resonance gas model. The proximity of the freeze-out curve to the phase boundary indicates that the QCD phase transition and its related critical properties should be observable in heavy ion collisions. However, an experimental verification of a phase change in a medium created in such collisions requires sensitive probes. In this context, a particular role is attributed to fluctuations of conserved charges [1].

Recently, it was argued that, at high energies, the history of the system, in particular the path through the QCD crossover transition from the deconfined and chirally symmetric phase to the hadronic one, may be reflected in fluctuations of conserved charges, specifically in their higher cumulants [2]. The characteristic signature, which is a consequence of the critical O(4) dynamics at the chiral phase transition, may thus be manifested in a deviation of higher cumulants of the charge distributions from the HRG results, if the freeze-out happens near or at the QCD phase boundary. At vanishing chemical potential, the sixth and higher order cumulants can be negative, also in the hadronic phase, in contrast to the HRG model, which yields only positive values. It is therefore useful to consider the HRG model results on moments of charge fluctuations as a theoretical baseline; any deviation from this could be an indication for critical phenomena at the time of hadronization [2].

In this work we explore the influence of multi-charged particles and of quantum statistics on fluctuations [3]. In the HRG model, the product of kurtosis and variance of the net baryon number, $\kappa\sigma^2$, which receives contributions from singly charged particles only, is always equal to unity. This result does not depend on the hadron mass spectrum nor on the thermal parameters. However, for fluctuations of the electric charge, the contribution of particles with charge two, Δ^{++} and $\bar{\Delta}^{--}$, leads to a non-trivial T and μ dependence of this quantity [1]. Furthermore, a straightforward calculation shows that in an ideal pion gas, $\kappa\sigma^2$ is temperature dependent and differs from unity, due to quantum statistics effects.





In the top figure, the probability distribution for net strangeness is shown. It is clear that the multi-strange states broadens the distribution. Similarly, as illustrated in the lower figure, the quantum corrections to the Bose-Einstein distribution of the pions lead to a broader probability distribution for net electric charge.

References

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