# Regge Trajectories of Quark Gluon Bags

K. A. Bugaev and G. M. Zinovjev
*Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine*[*]

Using an exactly solvable statistical model we discuss the equation of state of large/heavy and short-living quark gluon plasma (QGP) bags. We argue that the large width of the QGP bags explains not only the observed deficit in the number of hadronic resonances, but also clarifies the reason why the heavy QGP bags cannot be directly observed even as metastable states in a hadronic phase. Also the Regge trajectories of large and heavy QGP bags are established both in a vacuum and in a strongly interacting medium. It is shown that at high temperatures the average mass and width of the QGP bags behave in accordance with the upper bound of the Regge trajectory asymptotics (the linear asymptotics), whereas for temperatures below $T_H/2$ ($T_H$ is the Hagedorn temperature) they obey the lower bound of the Regge trajectory asymptotics (the square root one). Thus, for $T < T_H/2$ the spin of the QGP bags is restricted from above, whereas for $T > T_H/2$ these bags demonstrate the standard Regge behavior consistent with the string models.

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## I. INTRODUCTION

Regge poles have been introduced in particle physics before the QCD era and since the beginning of 60-ies [1] they are widely used to describe the high-energy interactions of hadrons and nuclei. Regge approach establishes an important connection between high energy scattering and spectrum of particles and resonances. It served as a starting point to introduce the dual and string models of hadrons. Up to now a rigorous derivation of Regge poles in QCD remains an unsolved problem since it is related to the nonperturbative effects in QCD and the problem of confinement.

Nowadays the Regge trajectories are widely understood as the linear relation between the resonance mass square and resonance spin or radial quantum number, whereas the Regge trajectory $\alpha(S_r)$ contains information about the resonance mass $M_r$ and width $\Gamma_r$. Indeed, the resonance spin $J$ is defined in the complex energy plane as $J = \alpha\left((M_r - \frac{i}{2}\Gamma_r)^2\right)$. Moreover, the linear trajectories, i.e. $\alpha(S_r) \sim S_r$, which follow from the string models, are often believed to be the only Regge trajectories of hadrons.

However, long ago it was shown that under the plausible assumptions the linear Regge trajectories correspond to the upper bound of the asymptotic behavior, whereas its lower bound is given by the square root trajectory, i. e. $\alpha_l(S_r) \sim [-S_r]^{\frac{1}{2}}$ [2, 3]. Moreover, there were some indications [3] that the square root trajectory should give the asymptotic behavior of excited hadronic resonances. The latter means that for each family of hadronic resonances the Regge poles do not go beyond some vertical line in the complex spin plane, i.e. in asymptotics $S \to +\infty$ the resonances should become infinitely wide.

Since the linear Regge trajectories of hadrons generate the Hagedorn mass spectrum [4], the square root ones should lead to a weaker growth of hadronic mass spectrum. At first glance it seems that the experimental mass spectrum of hadrons [5] does not show an exponential increase at hadron masses above 2.5 GeV and, hence, it evidences against the linear Regge trajectories of heavy hadrons. Moreover, the best description of particle yields observed in a very wide range of collision energies of heavy ions is achieved by the statistical model which incorporates all hadronic resonances not heavier than 2.3 GeV [6]. Again it looks like that heavier hadronic species, except for the long living ones, are simply absent in the experiments [7]. Thus, we are confronted with a serious conceptual problem between a few theoretical expectations and several experimental facts.

Recently this conceptual problem was resolved within the finite width model (FWM) [8]. The FWM introduces the medium dependent finite width of QGP bags into an exactly solvable statistical model. It shows that the large width of the QGP bags explains not only the observed deficit in the number of hadronic resonances, but also clarifies the reason why the heavy QGP bags and strangelets cannot be directly observed even as metastable states in a hadronic phase. Also the FWM allows one to establish [9] the Regge trajectories of large and heavy QGP bags both in a vacuum and in a strongly interacting medium. As will be shown below at high temperatures the average mass and width of the QGP bags behave in accordance with the upper bound of the Regge trajectory asymptotics (the linear asymptotics), whereas at low temperatures they obey the lower bound of the Regge trajectory asymptotics (the square root one). Thus, for low temperatures the spin of the QGP bags is restricted from above, whereas for high temperatures these bags demonstrate the typical Regge behavior consistent with the string models.

The work is organized as follows. Sec. 2 discusses the main ideas and results of FWM. The Regge trajectories of QGP bags are established in Sec. 3, while our conclusions

[*]Electronic address: bugaev@th.physik.uni-frankfurt.de; Gennady.Zinovjev@cern.ch