Exotic hadrons and/or molecules from relativistic heavy ion collisions

ExHIC Collaboration

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Exotic hadrons are one of the most interesting topics in the hadron physics. Their properties are still not understood well from QCD and are investigated by many researchers. We discuss the production of exotic hadrons from relativistic heavy ion collisions. We estimate their yields by applying the statistical model and the coalescence model. In both approaches, the yields of normal hadrons are not so different, but the yields of exotic hadrons are quite different. We find that ***the yields of exotic hadrons are sensitive to the assumed quark structures, namely compact multiquarks or extended hadronic molecules***. Therefore, the experimental measurements of the yields of exotic hadrons in relativistic heavy ion collisions provide us a useful tool to investigate their internal structures.

[1] S. Cho, T. Furumoto, T. Hyodo, D. Jido, C.-M. Ko, S. H. Lee, M. Nielsen, A. Ohnishi, T. Sekihara, S. Yasui, K. Yazaki, Phys. Rev. Lett. 106, 212001 (2011)
[2] S. Cho, T. Furumoto, T. Hyodo, D. Jido, C.-M. Ko, S. H. Lee, M. Nielsen, A. Ohnishi, T. Sekihara, S. Yasui, K. Yazaki, Phys. Rev. C84, 0694910 (2011)

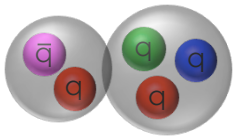
1. Introduction

What are exotic hadrons?

(a) **Compact multiquark**

?

(b) **Extended hadronic molecule**



?

2. Models for hadron production

2.1 Statistical model*

$$N_h^{\rm stat} = V_H \frac{g_h}{2\pi^2}\int_0^\infty \frac{p^2 dp}{\gamma_h^{-1} e^{E_h/T_H} \pm 1}$$

$$\approx \frac{\gamma_h g_h V_H}{2\pi^2} m_h^2 T_H K_2(m_h/T_H)$$

$$\approx \gamma_h g_h V_H \left(\frac{m_h T_H}{2\pi}\right)^{3/2} e^{-m_i/T_H}$$

* A. Andronic, P. Braun-Munzinger, and J. Stachel, Nucl. Phys. A **772**, 167 (2006).

2.2 Coalescence model**

$$N_h^{\rm coal} = g_h \int \left[\prod_{i=1}^{n} \frac{1}{g_i} \frac{p_i \cdot d\sigma_i}{(2\pi)^3} \frac{{\rm d}^3\mathbf{p}_i}{E_i} f(x_i, p_i)\right] \times f^W(x_1, \ldots, x_n : p_1, \ldots, p_n).$$

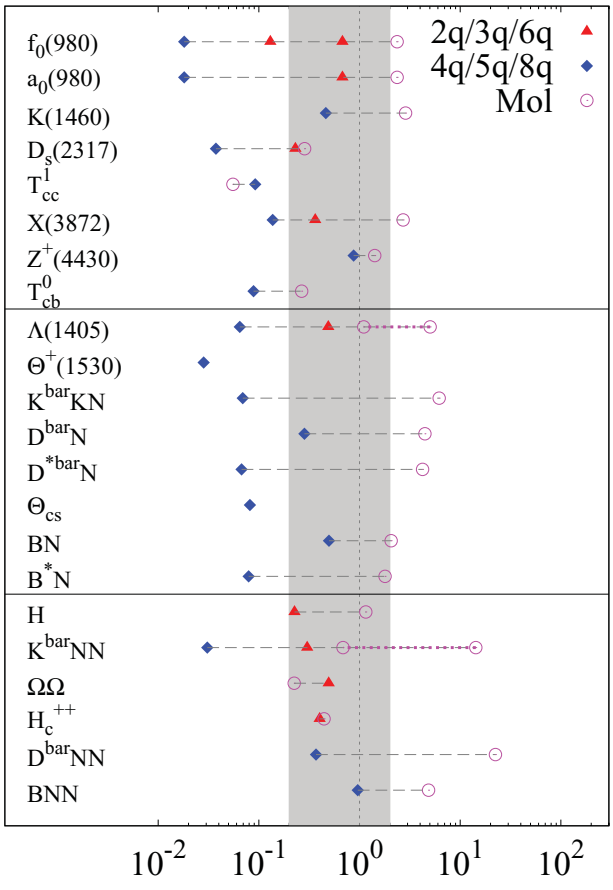
Constituent particle
(a) Quark (compact multiquark; nq)
(b) Hadron (extended molecule; Mol)

** V. Greco, C. M. Ko, and P. Levai, Phys. Rev. Lett. **90**, 202302 (2003); Phys. Rev. C **68**, 034904 (2003).

3. Results for yields of exotic hadrons

"Normal Band" for non-exotic hadrons

Coalescence / Statistical model ratio at RHIC



Coalescence / Statistical model ratio at LHC