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Identifying multi-quark hadrons from heavy ion collisions

We propose a new approach of using relativistic heavy ion collisions to identify and study multi-quark hadrons. We focus on the expected production yields of these hadrons and show that their production yields are strongly affected by their internal structure [1], e.g. multi-quark configurations or hadronic molecules.

We mainly use the coalescence model, which was successful in explaining the enhanced production of baryons at midrapidity in the intermediate transverse momentum region [2, 3] and the quark number scaling of the elliptic flow of identified hadrons [4]. Based on the coalescence model, we are able to take into account the effects of the internal structure of hadrons, such as the angular momentum and the multiplicity of quarks [5. 6], on their production yields. We also rely on the statistical model [7], which has been known to describe the relative yields of normal hadrons very well, to extract important parameters for the coalescence model and normalize the expected yields.

We find that the ratio of the production yields of normal hadrons calculated in the coalescence model to those from the statistical model, N^{coal}/N^{stat}, is in the range $0.2<N^{coal}/N^{stat}<2$. This ratio is, however, typically an order of magnitude smaller if a hadron is a compact multi-quark state. On the other hand, for a hadron which is a loosely bound hadronic molecule, it would be more abundantly formed than the expected production yield by a factor of two and more. We further find that the yields of multi-quark hadrons in relativistic heavy ion collisions are large enough for detection in experiments. For example, the $D_{sJ}(2317)$ yield per unit rapidity is predicted to be more than $2*10^{-3}$ in central heavy ion collisions at RHIC. Therefore, relativistic heavy ion collision experiments provide a promising opportunity for studying multi-quark hadrons. By measuring their production yields in these experiments, we expect to achieve both new discovery of exotic hadrons and the understanding of their internal structures at the same time.

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