Doubly Strange Hypernuclei Search in High Baryon Density Matter at STAR

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Abstract

The search for double-Λ hypernuclei and strange dibaryons is crucial for understanding hyperon-hyperon interactions and strange matter in dense environments. Theoretical predictions suggest that weakly attractive Λ-Λ interactions allow for the formation of stable $A = 5$ double-Λ hypernuclei, while $A = 4$ is less likely to be particle-stable. Despite numerous experimental efforts, including those at J-PARC and KEK, conclusive evidence for the stability of double-Λ hypernuclei with $A < 6$ remains elusive. These searches also provide a pathway to exploring the possible existence of the H-dibaryon, a hypothesized six-quark state ($u\bar{u}d\bar{d}s\bar{s}$), whose discovery would offer significant insights into multi-strange interactions. In 2021, high-statistics data from Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 3.0$ GeV were collected by the STAR experiment as part of the Beam Energy Scan II fixed-target program. The low energy collisions provide a high baryon density environment, which favors the formation of such exotic systems.

In this talk, we will present the results on searches for the doubly strange systems using data from Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 3.0$ GeV. We will present new results on searches for the following: ${}^{4}_{\Lambda\Lambda}\mathrm{H}$ (${}^{4}_{\Lambda\Lambda}\mathrm{H} \rightarrow {}^{4}_{\Lambda}\mathrm{He} + \pi^-$, ${}^{4}_{\Lambda\Lambda}\mathrm{H} \rightarrow {}^{3}_{\Lambda}\mathrm{H} + p + \pi^-$), ${}^{4}_{\Lambda\Lambda}\mathrm{n}$ (${}^{4}_{\Lambda\Lambda}\mathrm{n} \rightarrow {}^{4}_{\Lambda}\mathrm{H} + \pi^-$), H-dibaryon (bound state: $\mathrm{H} \rightarrow p + \pi + \Lambda$, resonance: $\mathrm{H} \rightarrow \Lambda + \Lambda$, $\mathrm{H} \rightarrow p + \Xi^-$). In the instances where no signal are found, upper limits for the production yield will be presented and compared with thermal model expectations, and the physics implications will be discussed.