Hunting the doubly charmed baryon with strangeness

In the standard model of particle physics, the baryon is formed by three quarks. Unlike the well-known proton and neutron that are composed of three light quarks, the doubly charmed baryon consists of two heavy charm quarks and a light quark. Therefore, it is expected to have different internal structures and properties, and to serve as a unique system for understanding the three-body bound system and testing the mechanism of quantum chromodynamics (QCD).

The doubly charmed baryon Ξ_{cc}^{++} (quark content: ccu) was observed by the LHCb Collaboration via its decay to $\Lambda_c^+ K^- \pi^+ \pi^+$ final states [1], which was then confirmed in another decay mode $\Xi_{cc}^{++} \rightarrow \Xi_c^+ \pi^+$ [2]. The Ξ_{cc}^{++} lifetime was determined to be 256 fs [3]. The Ξ_{cc}^{++} mass was measured to be 3621.6 MeV [4], which is about 4 times of the proton mass. The production rate of the Ξ_{cc}^{++} baryon [5] is about 1000 times smaller than that of the singly charmed baryon Λ_c^+ (quark content: cud). The LHCb Collaboration also performed a search for the doubly charmed baryon Ξ_{cc}^+ (quark content: ccd), which is an isospin partner of the Ξ_{cc}^{++} baryon. A hint (evidence if assuming isospin symmetry) was seen, and the most stringent upper limit on its production rate was set [6].

In this work [7], the LHCb Collaboration reported the results of the first search for the doubly charmed baryon Ω_{cc}^+ (quark content: ccs). As there is a strange quark, the production rate of the Ω_{cc}^+ baryon is about 3 times smaller than that of the Ξ_{cc}^{++} baryon, and the Ω_{cc}^+ mass is predicted to be about 100 MeV higher than the Ξ_{cc}^{++} mass (see references in ref. [7]). The LHCb Collaboration has seen a piece of evidence (hint) with a local (global) significance of 3.2σ (1.8σ) around the mass 3876 MeV/ c^2 , which is much higher than theoretical predictions. Therefore it would provide new insights into the dynamics in the baryon if such hint can be confirmed with more data. In addition, the upper limits on the ratio of the Ω_{cc}^+ production rate relative to that of the Ξ_{cc}^{++} baryon were set. This is an important milestone for the observation of the doubly charmed baryon with strangeness Ω_{cc}^+ .

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