Study of $S = -2$ Nuclear System by Emulsion and Scintillating Fiber Hybrid Method (PS-E373)

For the unified description of the baryon-baryon interaction on the $SU(3)_f$ symmetry, it is important to study the singlet 1_s sector of a doubly strange system, which is studied through only $S = -2$ nuclear system. If the interaction between two hyperons is attractive based on the calculation using the MIT bag model, the H dibaryon proposed by R.L.Jaffe [1] may exist. The nuclear system with $S = -2$ is also interesting, because it gives us information about hyperon mixing, *e.g.* $\Lambda\Lambda - \Xi N - \Sigma\Sigma$. Since the H state may appear in the above mixing, it will be expected for various nuclear states. However, experimental information about $\Lambda\Lambda$ interaction energy ($\Delta B_{\Lambda\Lambda}$) was quite limited and the $\Delta B_{\Lambda\Lambda}$ value has not been decided, yet. The main reason was that the expected number of Ξ^- hyperon stopping events in the past experiments was too small to fix $\Delta B_{\Lambda\Lambda}$.

Therefore, the hybrid emulsion experiment E373 at KEK has been carried out to obtain Ξ^- hyperon stopping events with ten times more statistics than that of the previous E176, where the number of the events becomes 10^3. By the 10% data analysis of all, one twin single-Λ hypernuclei event and two events of double-Λ hypernucleus have been successfully detected. The twin single-Λ event was uniquely interpreted as $\Xi^- + {}^{14}\mathrm{N} \rightarrow {}^{5}_{\Lambda}\mathrm{He} + {}^{5}_{\Lambda}\mathrm{He} + {}^{4}\mathrm{He} + n$ for the first time [2]. In the first double-Λ hypernucleus event, "*Demachi-Yanagi*, it was interpreted as $\Xi^- + {}^{12}\mathrm{C} \rightarrow {}^{10}_{\Lambda\Lambda}\mathrm{Be}$(or ${}^{10}_{\Lambda\Lambda}\mathrm{Be}^*$)$+t$, if two-body reaction was occurred at a Ξ^--${}^{12}\mathrm{C}$ system [3].

The second double-Λ hypernucleus event, "*NAGARA*", has been detected with a clearly recognized topology, as shown in Figure. The nuclide and its decay mode have been uniquely identified as; $\Xi^- + {}^{12}\mathrm{C} \rightarrow {}^{6}_{\Lambda\Lambda}\mathrm{He} + {}^{4}\mathrm{He} + t$, ${}^{6}_{\Lambda\Lambda}\mathrm{He} \rightarrow {}^{5}_{\Lambda}\mathrm{He} + \pi^- + p$, ${}^{5}_{\Lambda}\mathrm{He} \rightarrow p + d + 2n$ *etc*. H. Bando and his collaborators have indicated the importance of ${}^{6}_{\Lambda\Lambda}\mathrm{He}$ as a multi-hypernuclear cluster system, and proposed the name "*Lambpha*" for it by analogy of the α particle [4]. By the preliminary result of ${}^{6}_{\Lambda\Lambda}\mathrm{He}$ analyses, the attractive $\Lambda\Lambda$ interaction has been established with $\Delta B_{\Lambda\Lambda} \sim 1$ MeV, where its error is less than 0.5 MeV. This value is considerably smaller than that previously estimated experimentally. The violent disagreement between our result for $\Delta B_{\Lambda\Lambda}$ and that reported by D. J. Prowse [5] confirms the doubts on the authenticity of the previous event. In addition, the lower mass limit of the H dibaryon has been obtained as $\sim$2224 MeV at a 90% confidence level using our value of $\Delta B_{\Lambda\Lambda}$.

References

[1] R. L. Jaffe, Phys. Rev. Lett. **38** (1977) 195.

[2] A. Ichikawa *et al*., Phys. Lett. **B500** (2001) 37.

[3] A. Ichikawa, Ph.D thesis, Kyoto University (2001), (unpublished); J. K. Ahn *et al*., in: *Proceedings of Hadron and Nuclei, in Seoul 2001, AIP Press,* to be published.

[4] H. Bando, K. Ikeda and T. Motoba, Prog. Theor. Phys. **66** (1981) 1344; *ibid*. **67** (1982) 508.

[5] D. J. Prowse, Phys. Rev. Lett. **17** (1966) 782.

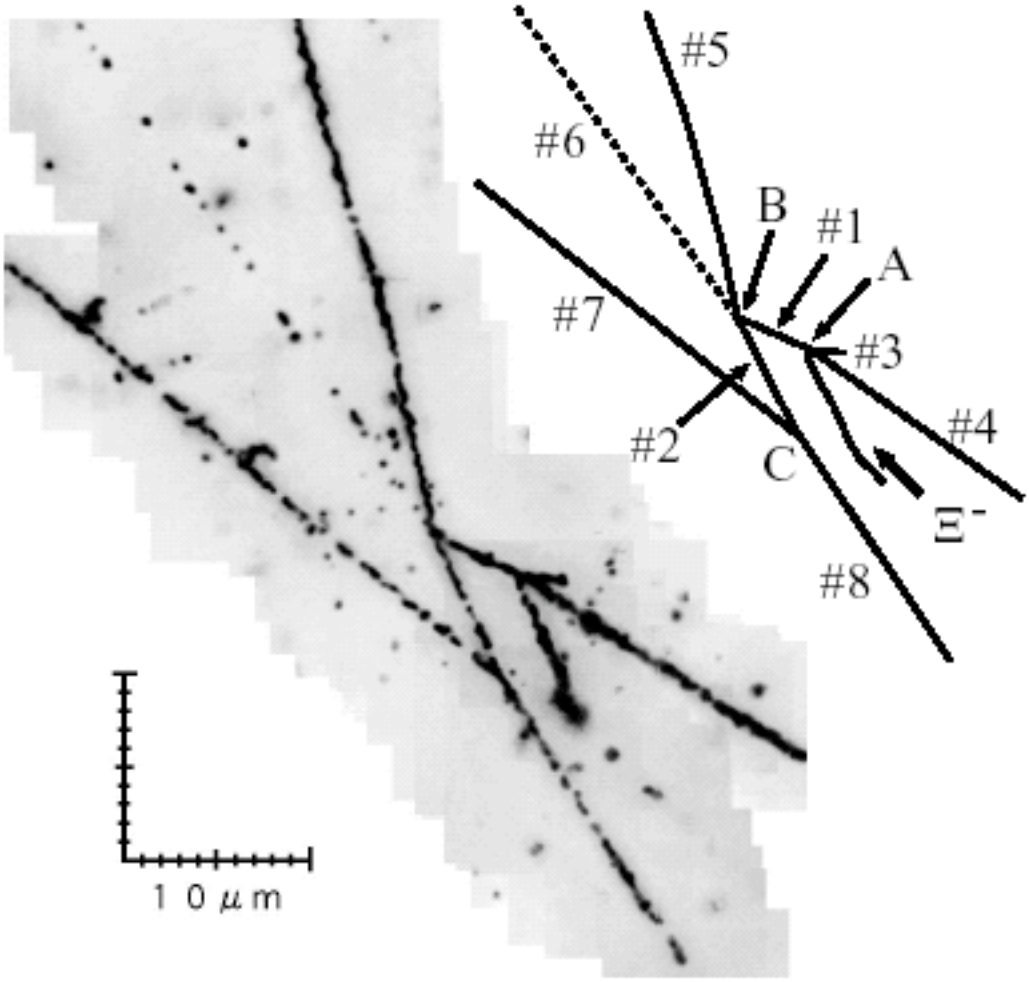

Figure. An emulsion image of *Lambpha* (${}^{6}_{\Lambda\Lambda}$He double-Λ hypernucleus) event by E373. A Ξ^-hyperon was captured by ^{12}C in the emulsion at point A. The particle of track#1 produced with stable nuclei of #3 and #4 decayed at point B into track#2, #5 and #6. Track#2 decayed into #7, #8 and neutral particle(s). The end points of particles except for track#5 and #7 were clearly recognized in the emulsion. The particle of #6 was identified as π^- by the topology at its end point in the emulsion. Although track#7 was escaping from the emulsion, its stopping point was detected in Scintillating fiber block located downstream the emulsion, and then we could measure its energy. The ranges of the double-Λ (track#1) and the single-Λ (track#2) hypernucleus are 8.3 and 9.2 μm, respectively. Since the event was found by Y. S. Iwata (graduate student of Gifu univ.), it was named ”*NAGARA*”, which is a river originating in Gifu.