Evaluation of Ξ^- absorption using the diamond target data of the J-PARC E07 Experiment

M. Fujita[1]*, H. Tamura[2,3], K. Tanida[3], M. Ukai[4,2], T.O. Yamamoto,[3]
on behalf of J-PARC E07 collaboration

[1] *Department of Physics, The University of Tokyo, Hongo, Tokyo 113-0033, Japan,*
[2] *Department of Physics, Tohoku University, Sendai, Miyagi 980-8578, Japan,*
[3] *ASRC, JAEA, Tokai, Ibaraki 319-1195, Japan,*
[4] *Institute of Particle and Nuclear Studies, KEK, Tsukuba, Ibaraki 305-0801, Japan*

Content

Understanding the baryon-baryon interaction with strangeness −2 is crucial for studying hypernuclear systems and high-density objects such as neutron stars. At the J-PARC K1.8 beamline, spectroscopy of Ξ hypernuclei and double-Λ hypernuclei is conducted via the (K^-,K^+) reaction.

In these experiments, Ξ^- hyperons can be captured into atomic orbits, forming Ξ^- atoms. Since the ΞN interaction affects the energy levels and widths of Ξ^- atomic states, measuring the X-rays emitted from these atoms is a powerful tool for probing this interaction. The energy shifts and widths of several Ξ^- atoms were theoretically estimated by C. J. Batty *et al.* [1]. T. Koike calculated the absorption probability of Ξ^- in nitrogen atoms using several models. The total *s*- and *p*-state absorption probabilities were estimated to be less than 4% per stopped Ξ^-, suggesting that most Ξ^-s are absorbed before reaching the 3D atomic state.

However, in the J-PARC E07 experiment, deeply bound Ξ systems were observed in nuclear emulsion. The IBUKI event was interpreted as a Ξ^- captured by a nitrogen atom, which reached the 2*P* state and subsequently decayed into a twin-Λ hypernucleus. The IRRAWADDY event was interpreted as a case in which the Ξ^- was bound in the 1*s* state before decaying. These observations imply that the imaginary part of the ΞN potential may be smaller than previously assumed.

To quantitatively assess the strength of Ξ^- absorption, measuring the intensities of X-ray transitions is essential. Motivated by the implications of the IBUKI event, I analyzed the diamond target data from the E07 experiment to search for the 154 keV X-ray from the 3*D* → 2*P* transition. I developed a new analysis technique referred to as the "kinematical method" and obtained the corresponding X-ray spectrum. Although no significant peak structure was observed, we evaluated the upper limit of the branching ratio for the absorption and compared it with theoretical calculations using a Woods-Saxon-type potential. As a result, due to limited experimental sensitivity, the imaginary potential, *W*, could not be constrained. In response, we are considering future experiments with improved sensitivity to detect X-rays from C–Ξ atoms. We are developing measurement methods incorporating CdTe detectors and will report on our ongoing efforts in detector development.

Reference

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