【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Mathematical and physical sciences)

Title of Project : Systematic Study of Double-Hypernuclei with Nuclear Emulsion

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Research Area : Elementary particle physics, Nuclear physics, Cosmic ray, Cosmic physics
Keyword : Nuclear physics (experiment)

【Purpose and Background of the Research】

One of the most important issues on nuclear physics is an understanding of interaction between baryons with strangeness.

Nuclear force under the system with proton and neutron was precisely studied for more than 50 years, thus we have obtained fruitful informations about that. The knowledge of the interaction between hyperon(Y) and nucleon is rapidly proceeding with the technique of gamma ray spectroscopy. Therefore the next challenge is research on Y–Y interaction.

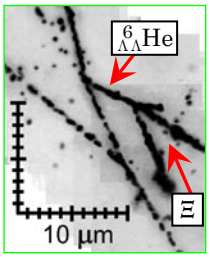
The unique expedient is study of structures of many double–hypernuclei. The most effective method to produce double–hypernuclei is nuclear emulsion experiment which we have developed for long time. With use of the emulsion, we have detected 8 events of double–hypernuclei in these 20 years. Among them, Nagara event was fixed as a new species of nucleus formed by a ^{4}He and two Λ hyperons ($_{\Lambda\Lambda}^{6}$He) and provided an interaction energy between two hyperons, successfully. However, for a firm understanding of Y–Y interaction with less uncertainty by nuclear structure, the masses have to be measured in some more double–hypernuclei other than $_{\Lambda\Lambda}^{6}$He nucleus.

Since the K⁻ beam with good separation from others and high intensity becomes available at J-PARC, we will carry out an experiment (E07) which provides 100 times' double–hypernuclei than before.

【Research Methods】

We will expose K⁻ beam to the emulsion with its volume of 3 times larger than that of the previous experiment (KEK–E373), where the K/beam ratio of J-PARC becomes nearly 4 times better than that of KEK–PS. At the exposure, we use electric detectors, e.g. counters, chambers and so on, which inform us of the production of Ξ⁻ hyperon with two units of strangeness. Especially, Ge detector located in upstream of the emulsion will work for the energy shifts measurement of X–ray from Ξ–atom, where the shifts provide us the information of Ξ–nucleon interaction for the first time. By this hybrid emulsion method, we can expect 10 times more events of double–hypernuclei than before.

In the above hybrid method, we fail to tag 90% Ξ⁻ hyperon production due to the efficiency and acceptance of the electric detectors. We can find three vertices in the decay of double–hypernucleus, as shown in the figure. If the events with such topology can be scanned in overall area of the emulsion, it is expected an additional 10 times more double–hypernuclei than those obtained by the hybrid method.



We are developing systems for whole–area scanning to complete detection for a few years.

The measurement of scattering and energy–loss can be done for decay daughters of double–hypernuclei and the binding energies of two hyperons are provided to study Y–Y interaction.

【Expected Research Achievements and Scientific Significance】

Unified understanding of the baryon–baryon interaction can be obtained in SU(3) symmetry with strangeness. It is expected that new species of double– hypernucleus shall be found and further we will get the know–how for the step of the study on triple–hypernuclei and/or charm–hypernuclei.

【Publications Relevant to the Project】

1.“Observation of a $_{\Lambda\Lambda}^{6}$He Double Hypernucleus”. H.Takahashi *et al.*, Phys. Rev. Lett. Vol.87, 212502 (2001)
2.“Experimental Study of Double-Λ Hypernuclei with Nuclear Emulsion”. K.Nakazawa and H.Takahashi, Prog. Theor. Phys. Suppl. 185, 335-343 (2010)

【Term of Project】 FY2011-2015

【Budget Allocation】 151, 600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.phys.ed.gifu-u.ac.jp/index.htm