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

Title of Project : Effects of tensor forces in nuclear structure and search for hidden interactions in nuclei

Isao Tanihata
(Osaka University, Research Center for Nuclear Physics, Professor)

Research Area : Nuclear Physics
Keyword : theoretical nuclear physics, experimental nuclear physics, tensor forces

【Purpose and Background of the Research】

Present proposal aim for studying effects of the strong tensor forces caused by pion exchange interactions in stable and unstable nuclei through observations of characteristic changes of nuclear orbitals and high-momentum components in nucleon motion in nuclei. Since the invention of radioactive nuclear beams (RIB), new structures and phenomena have been discovered and that become a driving force of science with RIB in the world. Such discoveries and new suggestions include, neutron halo, neutron skin, soft mode of excitation, new magic numbers.

An appearance of the new magic number (N=16) among other data in neutron rich nuclei triggered a new view to the nuclear interactions that affect orbitals in nuclei. In particular the importance of the tensor forces, that have not played an important roles in shell models, has been pointed out recently. The tensor forces, that are originated from the pion exchange nucleon-nucleon interactions, has been known to play important roles for binding a deuteron and an alpha.

Theoretically, an effect of the tensor force on the internal momentum distribution of nucleon have been published by several authors. All papers show an enhancement of high-momentum component at around 2 fm-1 due to the tensor correlations between two nucleons. It is also clear that this high-momentum component appears only in p-n pair coupled to S=1. No such correlation exist in between n-n, for example, pair with S=0. Therefore the comparison of the high-momentum component between S=1 and S=0 pairs is a sensitive method to see the tensor correlations.

【Research Methods】

To study the effects of tensor interactions on nuclear structure, we plan to studies,
1. to establish the high-momentum components in the nucleon wave function in nuclei though high energy transfer reactions, (experimental)
2. to reveal tensor and other unknown interaction in nuclei though the systematic studies of nuclear structure by precise spectroscopies, (experimental)
3. to establish nuclear structure theory that include tensor forces explicitly and compare the prediction with experimental observations. Then also form a view of nuclei including pions. (theoretical)

【Expected Research Achievements and Scientific Significance】

We would like to confirm the importance of the high-momentum nucleon on the structure of nuclei. Then we build a new theory of nuclei that explicitly include the effect of tensor forces, thus pion interactions.

The theory will be a powerful tool to predict the structure and properties of nuclei far from the stability line that would not be obtained experimentally by the present days technology and thus useful for understanding the nucleo-synthesis path such as R-process.

【Publications Relevant to the Project】

1. “Searching for effects of tensor forces in nuclei”, Modern Physics Letters A 25 (2010) 1886.
2. “Extended relativistic chiral mean field model for finite nuclei”, Y. Ogawa, H. Toki, S. Tamenaga, and A. Haga, Progr. Theor. Phys. 122 (2009) 477.

【Term of Project】 FY2011-2015

【Budget Allocation】 161,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.rcnp.osaka-u.ac.jp/Divisions/cnp/