Single-particle states and collective modes: magnetic moment of ^{75m}Cu

Y. Ichikawa,[*1] H. Nishibata,[*1,*2] Y. Tsunoda,[*3] A. Takamine,[*1] K. Imamura,[*1,*4] T. Fujita,[*1,*2] T. Sato,[*1,*5] S. Momiyama,[*6] Y. Shimizu,[*1] D. S. Ahn,[*1] K. Asahi,[*1,*5] H. Baba,[*1] D. L. Balabanski,[*1,*7] F. Boulay,[*1,*8,*9] J. M. Daugas,[*1,*9] T. Egami,[*10] N. Fukuda,[*1] C. Funayama,[*5] T. Furukawa,[*11] G. Georgiev,[*12] A. Gladkov,[*1,*13] N. Inabe,[*1] Y. Ishibashi,[*1,*14] T. Kawaguchi,[*10] T. Kawamura,[*2] Y. Kobayashi,[*1,*15] S. Kojima,[*5] A. Kusoglu,[*7,*12,*16] I. Mukul,[*17] M. Niikura,[*6] T. Nishizaka,[*10] A. Odahara,[*2] Y. Ohtomo,[*1,*5] T. Otsuka,[*1,*3,*6,*18] D. Ralet,[*12] G. S. Simpson,[*19] T. Sumikama,[*1] H. Suzuki,[*1] H. Takeda,[*1] L. C. Tao,[*1,*20] Y. Togano,[*1,*5] D. Tominaga,[*10] H. Ueno,[*1] H. Yamazaki,[*1] and X. F. Yang[*18]

Atomic nuclei show dual features, the single-particle shell nature and collective modes, which compete with each other to express the actual nuclear structure. For an attempt to describe the structural variety of unstable nuclei by using unified and general models, it is necessary to understand how the shell evolves in unstable-nuclei regions, and how the shell competes with the collectivity. In the present study, we demonstrate the precision analysis of this competition by focusing on the magnetic moment of an isomeric state of a neutron-rich nucleus ^{75}Cu,[1,2)] where an intriguing shell evolution along the Cu isotopic chain has been reported.[3–5)]

The experimental magnetic moment measurement was conducted at the BigRIPS at RIBF, taking advantage of a spin-aligned RI beam obtained in a scheme of two-step projectile fragmentation with a technique of momentum-dispersion matching.[6)] The ^{75}Cu beam with a spin alignment of 30(5)% was produced by one proton removal from ^{76}Zn, which was a fission product of ^{238}U. The magnetic moment was determined with the time-differential perturbed angular distribution (TDPAD) method. Owing to the high spin alignment realized with the two-step scheme, the oscillation in the TDPAD spectrum was observed with a significance larger than 5σ. The magnetic moment of the 66.2-keV isomer with spin parity $3/2^-$ was determined for the first time to be $\mu = 1.40(6)\mu_N$.

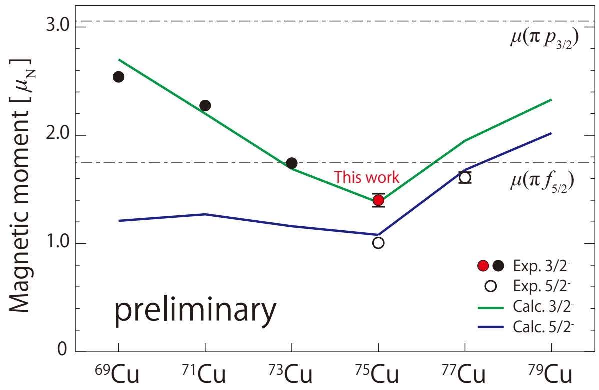

Fig. 1. Systematics of the magnetic moments for odd-A Cu isotopes. Filled and open circles represent experimental data for the $3/2^-$ states and the $5/2^-$ states, respectively. The filled red circle represents the result obtained in this work. The solid green and blue lines represent the MCSM calculations for the $3/2^-$ states and the $5/2^-$ states, respectively, with the $20 \leq (N, Z) \leq 56$ model space.[7)] $\mu(\pi p_{3/2})$ and $\mu(\pi f_{5/2})$ denote the proton Schmidt values for $p_{3/2}$ and $f_{5/2}$, respectively.

The magnetic moment, thus obtained, shows a considerable deviation from the Schmidt value, $\mu = 3.05\mu_N$, for the $p_{3/2}$ orbital. Figure 1 shows the systematics of magnetic moments of the $3/2^-$ and $5/2^-$ states, where deviation from the Schmidt values appears to be maximal at ^{75}Cu. The analysis of the magnetic moment with the help of state-of-the-art shell-model calculations[7)] reveals that the trend of the deviation corresponds to the effect of the core excitation. Furthermore, it was found that the low-lying states in ^{75}Cu are, to a large extent, of single-particle nature on top of a correlated ^{74}Ni core.

*1 RIKEN Nishina Center
*2 Department of Physics, Osaka University
*3 Center for Nuclear Study, University of Tokyo
*4 Department of Physics, Meiji University
*5 Department of Physics, Tokyo Institute of Technology
*6 Department of Physics, University of Tokyo
*7 ELI-NP, IFIN-HH
*8 GANIL, CEA/DSM-CNRS/IN2P3
*9 CEA, DAM, DIF
*10 Department of Advanced Sciences, Hosei University
*11 Department of Physics, Tokyo Metropolitan University
*12 CSNSM, CNRS/IN2P3, Université Pris-Sud
*13 Department of Physics, Kyungpook National University
*14 Department of Physics, University of Tsukuba
*15 Department of Informatics and Engineering, University of Electro-Communications
*16 Department of Physics, Istanbul University
*17 Department of Particle Physics, Weizmann Institute
*18 Intsituut voor Kern-en Srralingsfysica, K. U. Leuven
*19 LPSC, Université Grenoble Alpes, CNRS/IN2P3
*20 School of Physics, Peking University

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