Competition between shape and shell in ^{75}Cu clarified by the novel magnetic moment measurement

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The structure of a nucleus is a result of competition between the shell evolution and the shape effects, such as surface vibration and deformation. In this study, we demonstrate the precision analysis of the competition by focusing on an isomeric state of a neutron-rich ^{75}Cu nucleus[1,2], where an intriguing shell evolution along the Cu isotopic chain has been reported[3–6], through its nuclear magnetic moment.

The experiment of the 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, recently established[7]. The ^{75}Cu beam with spin alignment reaching 30% was produced from a primary beam of ^{238}U via an intermediate product ^{76}Zn. For the measurement of the magnetic moment, a method of time-differential perturbed angular distribution (TDPAD) was employed. Owing to the high spin alignment realized with the two-step scheme, the oscillation in the $R(t)$ ratio which represents the change of anisotropy of γ-ray emission synchronized with the Larmor precession was observed for 66.2-keV γ rays with significance larger than 5σ, as shown in Fig. 1. The spin-parity of the 66.2-keV level was firmly fixed to be $3/2^-$. The magnetic moment of the 66.2-keV isomer was determined for the first time to be $\mu = 1.40(6)\mu_{\rm N}$.

The magnetic moment thus obtained shows a considerable deviation from the Schmidt value, $\mu = 3.05\mu_{\rm N}$, for the $p_{3/2}$ orbital. The analysis of the magnetic moment with a help of state-of-the-art shell-model calculations[8] reveals that this state contains a considerable fraction of the mixed $f_{5/2}$ configuration in addition to the primary $p_{3/2}$ configuration. The same holds true for the $5/2^-$ ground state, except that the roles played by the two orbitals are interchanged. Through the decomposition of the total angular momentum into the spins and the orbital angular momenta of the proton and the neutron, the admixing configuration is found to be brought to this state by a neutron quadrupole excitation in the $g_{9/2}$ orbital which may also play an essential role in the emergence of exotic phenomena in this extremely neutron-rich region.

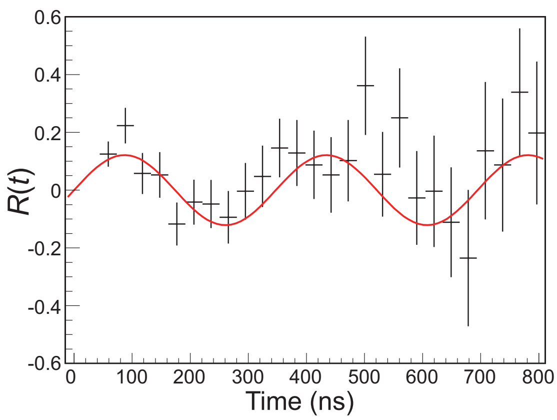

Fig. 1. $R(t)$ ratio for the 66.2-keV γ ray observed in the TDPAD measurement. The solid line represents the theoretical $R(t)$ after fitting to the experimental $R(t)$.

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