Nuclear Magnetic Moment of ^{57}Cu Ground State

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The nuclear magnetic moment of the ground state of ^{57}Cu(I^π = 3/2$^-$, $T_{1/2}$ = 196.3 ms) was measured for the first time. Together with a known magnetic moment of the mirror partner, ^{57}Ni, the spin expectation value, which is a contribution of nucleon spins to the magnetic moment, was extracted from the isoscaler part of magnetic moments, taking advantage of their charge symmetry. In the sd shell, all of the ground state magnetic moments of isospin T = 1/2 mirror nuclei have been measured and a systematic trend of the spin expectation value depending on the shell structure has been observed. On the other hand, in the fp shell, only few mirror magnetic moments are known (^{41}Ca-^{41}Sc and ^{43}Sc-^{43}Ti pairs) and therefore it is essential to measure more magnetic moments in order to explore the evolution of shell structure. Because ^{57}Cu consists of the closed-shell ^{56}Ni core plus one proton, the single-particle contribution is expected to be strong and any deviation from the shell model is a direct proof of shell breaking at ^{56}Ni, which has been suggested [1] based on a systematic deviation between magnetic moments of odd-mass Cu isotopes and theoretical shell-model predictions.

The experiment was performed at the National Superconducting Cyclotron Laboratory at Michigan State University. The ^{57}Cu ions were produced from a primary beam of ^{58}Ni (140 MeV/nucleon) impinging on a ^{9}Be target. A charge pick-up reaction was employed for the production and nuclear polarization of ^{57}Cu. The ^{57}Cu ions were separated from other reaction products by the A1900 fragment separator, delivered to the β-NMR apparatus and implanted into a single-crystal NaCl under a strong external magnetic field.

From the resonance frequency, the magnetic moment was derived as $|\mu(^{57}\mathrm{Cu})| = (2.00 \pm 0.05)\mu_\mathrm{N}$ [2]. Together with the known magnetic moment of ^{57}Ni, the spin expectation value was extracted as $\langle \Sigma\sigma_z \rangle = -0.78 \pm 0.13$, which is shown in Figure 1. The small $\mu(^{57}$Cu) results in a large deviation and opposite sign from the shell-model calculations. Considering the systematic behavior of the spin expectation value of T = 1/2 nuclei in the sd shell, where the spin expectation values are restored close to the single-particle values around the shell closures, the present result indicates a significant shell breaking at ^{56}Ni with the neutron number N = 28.

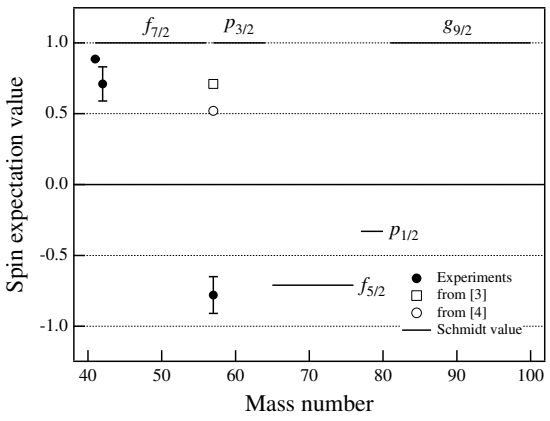

Figure 1: *Spin expectation values in the fpg shell.*

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