Magnetic-moment measurement of the isomeric state of ^{130}Sn in the vicinity of doubly-magic nucleus ^{132}Sn

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The ^{130}Sn nucleus is located in the vicinity of the doubly-magic nucleus ^{132}Sn and known to have an isomeric state at an energy level of 2435 keV with a half-life of 1.61 μs.[1–3] Its spin parity has been tentatively assigned to be 10^+ where a configuration of two neutron holes coupled in parallel in the $h_{11/2}$ orbital is expected to be predominated. The purity of the configuration can be a good indicator of the magicity near ^{132}Sn. Therefore, we measured the magnetic moment of the isomeric state of ^{130}Sn.

The experiment was conducted at the BigRIPS at the RIBF. The two-step fragmentation scheme[4] was employed to produce spin-aligned ^{130}Sn beam. In the reaction at F0, ^{132}Sn was produced by a fission reaction of a 345-MeV/nucleon ^{238}U beam on a ^{9}Be target with a thickness of 6 mm. A wedge-shaped aluminium degrader with a mean thickness of 6 mm was placed at the first momentum-dispersive focal plane F1, where the momentum acceptance at F1 was $\pm 1.4\%$. The secondary ^{132}Sn beam was introduced to a second target of wedge-shaped aluminum with a mean thickness of 2 mm, placed at the momentum-dispersive focal plane F5. The ^{130}Sn nuclei including those in the isomeric state $^{130\mathrm{m}}$Sn, were produced by removing two neutrons from ^{132}Sn. The ^{130}Sn beam was subsequently transported to F7 under the condition that the momentum dispersion between F5 and F7 was matched to that between F3 and F5. The slit width at F7 was set to ± 9 mm. The intensity and purity of ^{130}Sn in the tertiary beam were 30 cps and 30%, respectively.

The ^{130}Sn beam was introduced to the experimental apparatus for time-differential perturbed angular distribution (TDPAD) measurement, which was placed at the focal plane F12. The TDPAD apparatus consisted of a dipole magnet, a Cu crystal stopper, Ge detectors, and a plastic scintillator. The Cu stopper was 3.0 mm in thickness and 30×30 mm^2 in area. The dipole magnet provided a static magnetic field of $B_0 = 0.150$ T. $^{130\mathrm{m}}$Sn was implanted into the Cu stopper and γ rays were detected with four Ge detectors located in a plane perpendicular to B_0 at a distance of 7.0 cm from the stopper and at every 90 degrees. Two LaBr$_3$ detectors were also placed at 90 degrees with respect to each other so as not to interfere with the Ge detectors. The plastic scintillator with a thickness of 0.1 mm was placed upstream of the stopper. Its signal provided the time-zero trigger. The TDPAD apparatus enabled us to determine the g-factor of $^{130\mathrm{m}}$Sn by observing the changes in anisotropy of the de-excitation γ rays emitted from spin-aligned $^{130\mathrm{m}}$Sn in synchronization with the spin precession in the presence of an external field.

In this experiment, we observed two cascade γ rays from ^{130}Sn with energies of 97 keV and 391 keV. The $R(t)$ ratio representing the change in the anisotropy of γ rays was obtained according to

$$R(t) = \frac{N_{13}(t) - \epsilon N_{24}(t)}{N_{13}(t) + \epsilon N_{24}(t)}, \tag{1}$$

where $N_{13}(t)$ and $N_{24}(t)$ are the aggregates of the photo-peak count rates in the two pairs of Ge detectors placed diagonally to each other, and ϵ denotes a correction factor for the difference in detection efficiency. The same applies to the LaBr$_3$ detectors. Theoretically, $R(t)$ is expressed as a function of t as,

$$R(t) = \frac{3A_{22}}{4 + A_{22}} \cos 2(\omega_\mathrm{L} t + \alpha), \tag{2}$$

in terms of the rank-two anisotropy parameter $A_{22} = AB_2F_2$, where A denotes the degree of spin alignment, B_2 is the statistical tensor for complete alignment, and F_2 is the radiation parameter. The Larmor frequency ω_L is given by $\omega_\mathrm{L} = g\mu_\mathrm{N} B_0/\hbar$, where g is the g-factor of $^{130\mathrm{m}}$Sn in the unit of nuclear magneton μ_N. α is the initial phase of the precession depending on the detector arrangement. The detailed analysis and deduction of the g-factor are in progress.

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