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

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The region around ^{132}Sn has attracted much experimental and theoretical interest recently due to its doubly—magic character. A microsecond isomeric state has been observed experimentally in ^{130}Sn[1–3] ($t_{1/2} = 1.6$ μs). Its tentative spin-parity assignment of 10^+ suggests a neutron $h^2_{11/2}$ configuration, which, due to its high spin, is expected to have a very pure wave-function configuration. A magnetic moment study on this isomeric state should be able to shed light on the robustness of the double shell closure ($Z = 50$ and $N = 82$) at ^{132}Sn.

The NP1712-RIBF143R1 experiment was performed in December 2018 at the BigRIPS separator at RIBF. A two-step fragmentation scheme[4] was employed to produce a spin-aligned ^{130}Sn beam. A secondary beam of ^{132}Sn was produced following the fission of a 345 MeV/nucleon ^{238}U beam on a 6 mm ^{9}Be target at F0. A wedge-shaped aluminium degrader (having a mean thickness of 6 mm), positioned at the F1 dispersive focal plane, was used for the secondary-beam purification. The momentum acceptance was restricted to ±1.4% using the F1 momentum slits. A tertiary beam of ^{130}Sn was produced with a wedge-shaped (2 mm) aluminium secondary target placed at the F5 momentum-dispersive focal plane. A two-neutron (2n) removal reaction mechanism was used to populate the 10^+ isomeric state of interest. Special care was taken to match the momentum dispersion between F5 and F7 to that between F3 and F5. The momentum slits at F7 were set to ±9 mm, which corresponds to ±0.26% momentum selection. A beam intensity of 30 pps, with a purity of ∼20%, was obtained for ^{130}Sn.

The isomeric states of interest were implanted in a 3 mm Cu host positioned between the poles of an electro-magnet in the center of the time-differential perturbed angular distribution (TDPAD) apparatus at the F12 focal plane.

Four Ge and two $LaBr_3$ detectors, positioned 7 cm from the host in a horizontal plane around the magnet, were used to monitor the γ-rays from the decay of the isomeric state. The dipole magnet provided a static magnetic field of $B = 0.150$ T in the vertical direction. A 0.1 mm plastic scintillator, placed upstream of the stopper, provided the $t = 0$ signal for isomeric-decay measurement. The TDPAD technique entails observing the modulation of the angular distribution of the isomeric γ-rays due to the rotation of the nuclear spin ensemble in the magnetic field with the Larmor frequency $\omega_L = g\mu_N B/h$. This is realized by constructing a ratio function ($R(t)$), which combines detectors positioned at 90° with respect to each other. Provided that the magnetic field at the nuclear site is well known, one can readily determine the g factor of the state of interest from the oscillation pattern in the $R(t)$ function.

Two γ-rays (97 keV and 391 keV) were observed from the decay of the isomeric state, as expected from the previously known decay scheme. Their lifetimes, determined from the time spectra, were in agreement with the previously observed lifetime of the isomeric state. An oscillation pattern with a statistical significance of 2.7σ was observed during the analysis of the ratio function. It indicates a gyromagnetic factor very close to the free-nucleon Schmidt limit, in contrast with the g factors of other $h_{11/2}$ states in the region, for which a reduction of about 30% of the free-nucleon g factors ($g_s^{\rm eff} = 0.7 \times g_s^{\rm free}$) is observed. This very small reduction of the g factor compared to the Schmidt-limit indicates a very robust double—shell closure at ^{132}Sn. Following this observation, a new proposal has been submitted to the RIKEN NP PAC in December 2019. It aims at confirming this very intriguing indication with a higher statistical significance.

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