# Nuclear structure studies around $^{132}$Sn through nuclear moment measurements of isomeric states

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The region around $^{132}$Sn has recently attracted huge attention both experimentally and theoretically. Considered as one of the pillars of the nuclear shell model, its stability is often compared with that of the $^{208}$Pb region, raising the question of how fundamentally different they are. Experimentally, the studies of those two regions are slightly imbalanced as low-spin states in the vicinity of $^{132}$Sn are better studied with radioactive ion beams, whereas the higher-spin isomeric states around $^{208}$Pb make the low-energy states more challenging to investigate. A number of microsecond isomeric states have been observed recently around $^{132}$Sn[1–3], including an isomeric state at $^{130}$Sn ($E_x = 2435$ keV, $t_{1/2} = 1.61(15)$ $\mu$s), which is the subject of the present study. Its tentative spin-parity assignment of $10^+$ suggests a neutron $h_{11/2}$ configuration, which, because of its high spin, is expected to have a very pure configuration. A magnetic moment study on this isomer is expected to shed light on the robustness of the double shell closure ($Z = 50$ and $N = 82$) at $^{132}$Sn.

The first part of the NP1712-RIBF143 experiment was performed in December 2018 at BigRIPS separator at RIBF. After a careful analysis of the collected data[4], an R(t) function with a statistical significance of slightly less than the $3\sigma$ limit was observed, indicating a $g$ factor considerably closer to the *free-nucleon Schmidt limit* than the standard $g_s^{eff} = 0.7 g_s^{free}$. To verify the observation, a new proposal was submitted to the RIKEN NP PAC in December 2019.

The NP1712-RIBF143R2 experiment has been performed in December 2024, following some improvements in the setup. A two-step reaction scheme, previously developed at RIBF[5] was applied to produce a spin-aligned $^{130}$Sn beam. A secondary beam of $^{132}$Sn was produced following the fission of 345 MeV/u $^{238}$U beam on a 6 mm $^{9}$Be target, using a secondary, wedge-shaped (3 mm), aluminium target at F5, following a two-neutron removal reaction. Special attention was paid to the dispersion matching condition. The tertiary beam was further purified using a wedge degrader at F7 and sent to the Time Dependent Perturbed Angular Distribution (TDPAD) setup at F12.

The setup consisted of 4 Ge Planar detectors, positioned in a horizontal plane around a dipole magnet, providing a static field of $B = 0.15$ mT in the vertical direction. The transport of the beam, from the production target up to the implantation point, was performed entirely in a vacuum, to avoid any possible spin de-orientation. The TDPAD technique is based on the observation of the angular-distribution modulation of the isomeric $\gamma$ rays, due to the rotation of the nuclear spins in the magnetic field with Larmor frequency $\omega_L$. The $R(t)$ function is constructed using detectors positioned at $90^o$ with respect to each other.

Online analysis showed that the isomeric population in the two-neutron removal reaction is extremely low ($\sim 0.2\%$). However, the oscillation patterns hinted in the two $\gamma$-ray transitions of the de-exciting isomeric states, namely 97 keV(*E2*) and the 391 keV(*E1*), have opposite signs of the amplitude of the $R(t)$ functions, as expected from multipolarity one and multipolarity two transitions. This allows a consistent $g$-factor to be extracted through careful analysis.

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