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β-decay scheme of ^{140}Te to ^{140}I: Suppression of Gamow-Teller transitions between the neutron $h_{9/2}$ and proton $h_{11/2}$ doublet orbitals

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In astrophysical environments, the beta(β)-decay of unstable nuclei plays a crucial role in generating the final isotopic abundances along with rapid neutron-capture reactions (r-processes). The β-decay strengths are largely influenced by the so-called Gamow-Teller (G-T) interaction that is closely related to the spin-isospin interaction. This spin-isospin excitation is one of important ingredient for modeling the nuclear shell structure. Consequently, the role played by the G-T transition provides plenty of information on nuclear structure and nucleosynthesis. The G-T strength has been mainly constrained by the transformation between a proton and a neutron in the high-angular momentum orbital-spin partners such as; $\pi f_{7/2}$-$\nu f_{7/2}$, $\pi g_{9/2}$-$\nu g_{9/2}$, and $\pi h_{11/2}$-$\nu h_{11/2}$. However, in extreme neutron-rich environments, it can be controlled by the interplay between a neutron in the upper orbital and a proton in the lower orbital among a spin-orbital doublets, for instance, $\pi h_{11/2}$-$\nu h_{9/2}$.

Investigating of the neutron-rich nuclei beyond ^{132}Sn has attracted much attention because they are expected to reveal changes of size, diffuseness, and shell closures and, on the other side, to give information on nucleosynthesis along the r-process paths. However, it is a challenging task to determine decay rates and life times for the nuclei in this region. Here we present for the first time the β-decay of ^{140}Te ($Z = 52$) to odd-odd ^{140}I ($Z = 53$). The parent nuclide ^{140}Te was produced through the in-flight fission of ^{238}U beam with the energy of 345 MeV per nucleon on a ^{9}Be target at the Radioactive Ion Beam Factory (RIBF), RIKEN. By using a β-delayed γ-ray spectroscopy, a decay scheme of ^{140}I has been established. Three levels fed strongly from the ground 0^+ state of the mother nucleus ^{140}Te have been assigned as a 1^+ state based on the $\log ft$ values. These 1^+ states can be interpreted as being associated with the $\pi h_{11/2}\nu h_{9/2}$ configuration formed by the G-T transition between a neutron in the $h_{9/2}$ orbital and a proton in the $h_{11/2}$ orbital. Systematic features of level structures and G-T transitions are discussed within the framework of the spherical shell model and deformed shell model descriptions.

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