Spectroscopy of ^{99}Cd and ^{101}In from β decays of ^{99}In and ^{101}Sn[†]

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Experimental knowledge in the doubly magic ^{100}Sn region, relevant for tests of nuclear shell models (SM), proton-neutron interactions in $N \approx Z \approx 50$ nuclei and the end of the rapid proton-capture process (*rp*-process) in nuclear astrophysics, has been expanded through a β-decay spectroscopy campaign at RIBF.[1)] The literature on β decays of ^{99}In and ^{101}Sn has been either nonexistent or contentious due to low statistics, but subsequent analyses of the β-delayed γ-ray spectroscopy data from the RIBF9 experiment revealed new states in ^{99}Cd and addressed the ambiguity concerning the level scheme of ^{101}In.

Using WAS3ABi[2)] and EURICA[3)] detectors which were deployed at the end of the ZeroDegree spectrometer, decay events following ^{99}In and ^{101}Sn ion implantations were correlated. 30 new γ rays belonging to ^{99}Cd were observed, and a subset of γ rays previously assigned to ^{101}In has been confirmed in this measurement. Two new high-energy γ rays were assigned to ^{101}In in this work. The available γ-γ coincidence data was analyzed to build on the level scheme of ^{99}Cd, as shown in Fig. 1. Alternatively, the experimental energies and intensities of the γ rays were compared with the SM calculations based on the SR88MHJM[4)] interaction, in a model space of $\pi(2p_{1/2}, 1g_{9/2})$ and $\nu(1g_{7/2}, 2d_{5/2}, 2d_{3/2}, 3s_{1/2}, 1h_{11/2})$ orbitals above the ^{88}Sr core. The effect of varying effective charges and theoretical transition energies on the branching ratios of γ rays was assessed. Tentative assignments of new excited states were made for both ^{99}Cd and ^{101}In, where a good agreement was found within theoretical uncertainties. No significant inconsistencies in the intensities of γ rays were found between the experiment and theory in a γ-ray energy range of 0–2500 keV.

β-delayed proton emission events from the decay of ^{101}Sn were recorded and incorporated in the γ-ray intensity analysis. The competition between branching ratios of protons versus γ rays from high-energy states in ^{101}In was evaluated using a semi-empirical theory on proton emission.[5)] The two competing hypotheses concerning the ground-state spin of ^{101}Sn, being either the $5/2^+$ based on the $2d_{5/2}$ single-neutron configuration or the $7/2^+$ based on the $1g_{7/2}$ configuration, were examined by comparing the experimental γ-ray intensities and the integrated β-delayed proton emission branching ratio to theoretical values. Due to the imprecise knowledge of the proton separation energy of ^{101}In and low experimental γ-ray statistics, there was insufficient circumstantial evidence for an unambiguous spin assignment of the ground state of ^{101}Sn. Determining the single-particle energies of the $N = 51$ isotones, ^{99}Cd and ^{101}Sn, would result in an enhanced systematic review of the $N = 50$ shell evolution in the proton-rich nuclei close to ^{100}Sn.

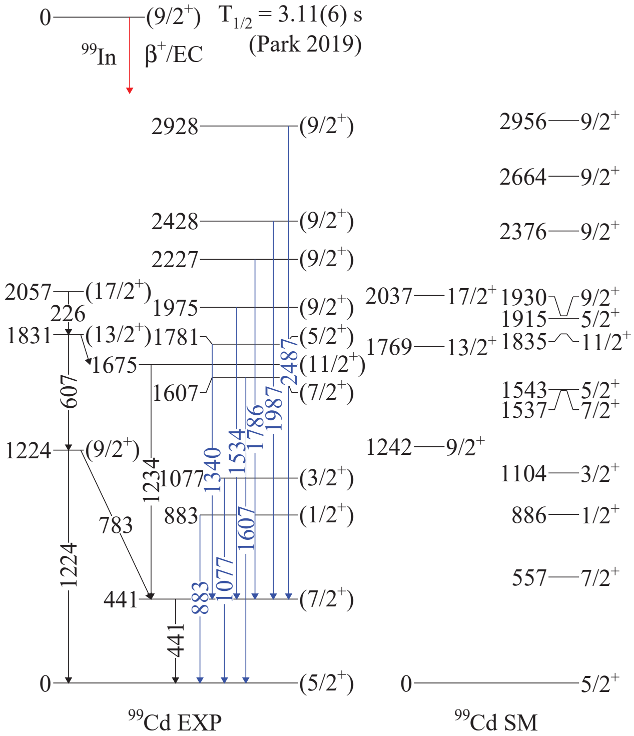

Fig. 1. Experimental level scheme of ^{99}Cd, compared to SM calculations. Only the states revealed by the β decay of ^{99}In are shown. The blue arrows indicate new γ rays observed in this work.

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