Identification of a millisecond isomeric state ^{129}Cd via the detection of internal conversion and Compton electrons†

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Isomeric states near nuclear shell closures are a sensitive probe to study the position of single-particle orbitals and their evolution. In the present work we have studied for the first time excited states in ^{129}Cd which decay via the emission of γ rays. The neutron-rich ^{129}Cd ions were produced at the Radioactive Isotope Beam Factory (RIBF), identified and separated in BigRIPS and then implanted in the active stopper WAS3ABi, consisting of eight closely packed DSSSD, which is surrounded by the germanium array EURICA.

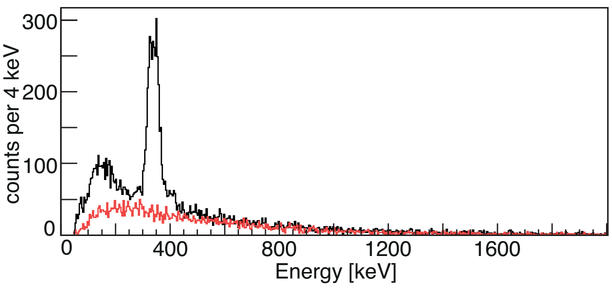

Fig. 1. Energy spectrum of the Si detector in which the ^{129}Cd ions were implanted for all decays observed in the first 10 ms (black) and from 30 to 40 ms (red) after the implantation.

Two types of events were recorded by the data acquisition system, the implantation of the ions into the active stopper WAS3ABi and their subsequent decays. In the decay of ^{129}Cd a very short-lived component in the range of a few milliseconds was observed, much shorter than the previously reported half-lives of the two β-decaying states in ^{129}Cd[1)]. The inspection of the energy spectrum of the Si detector in which the ^{129}Cd ions were implanted for all decays observed in the first 10 ms after the implantation (see black curve in Fig. 1) revealed a peak structure at about 340 keV and an excess of counts below 250 keV. Those structures are not visible for decays occurring in the time interval of 30 to 40 ms after the implantation for which the smooth energy distribution expected for β decays is observed (red curve) in Fig. 1. A comparison to Monte-Carlo simulations indicated that conversion electrons and Compton electrons from transitions following the decay of a ms isomeric state in ^{129}Cd lead to the registration of decay events in the active stopper. The energies of subsequent X-rays are summed with a certain chance to the energy of the Compton electron which shifts the peak to about 340 keV. Four transitions with energies of 353, 406, 1181 and 1587 keV were observed in delayed coincidence with the implanted ^{129}Cd ions and the half-life of the new isomeric state was determined to $T_{1/2}$=3.6(2) ms from the summed time difference distributions between the observed decay events and the observation of either the 406- or 1181-keV γ rays. Furthermore, the measured intensities of both γ rays and conversion electrons were used to tentatively assign an E3 multipolarity to the primary isomeric transition with an energy of 353 keV.

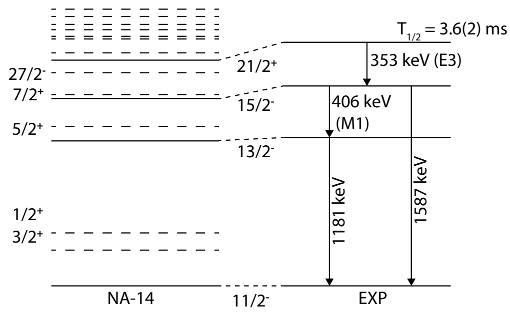

Fig. 2. Proposed decay scheme and comparison to the shell model calculations NA-14.

The deduced decay scheme is compared to shell-model calculations employing state-of-the-art realistic interactions (NA-14, same as in Ref.[2)]) in Fig. 2. The dashed lines represent the predicted positions of low-lying positive parity states as well as states with positive and negative parity in the spin range $17/2-23/2$. None of these states is predicted to be isomeric. Based on this comparison the new state was assigned to have spin and parity $(21/2^{+})$. The experimentally determined reduced transition strength of B(E3) = 0.50(3) W.u. for the $(21/2^{+}) \rightarrow (15/2^{-})$ E3 transition is in perfect agreement with the value predicted by the SM calculations, B(E3) = 0.48 W.u..

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