A new micro-second isomer in neutron-rich ^{136}Sb

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By studying the properties and decay patterns of isomeric states resulting from the coupling of valence particles in high-j orbitals at the $Z = 50$ and $N = 126$ shell closures, valuable information on nuclear structure and nucleon-nucleon interaction in very neutron-rich systems can be obtained. In December 1999, we therefore performed an experiment at GSI to search for new, relatively long-lived (100ns - 100μs) isomeric states in the region around the neutron-rich doubly magic nucleus ^{132}Sn. The nuclei of interest were produced by projectile fission of ^{238}U at 750 MeV/u in a 1.0 g/cm^2 ^{9}Be target, separated using the Fragment Separator (FRS) and implanted in a catcher at the final focus surrounded by Ge detectors. More details about the experiment are given in [1, 2].

The well-known decay of the $I^\pi = 19/2^-$ isomer in ^{135}Te [3] was used to verify the particle identification and lifetime determination procedures. Figure 1 shows the γ-spectra recorded in delayed coincidence with ions of ^{135}Te and ^{136}Sb implanted in the catcher. A previously unknown delayed γ-transition at 173 keV is clearly seen in the ^{136}Sb-gated spectrum.

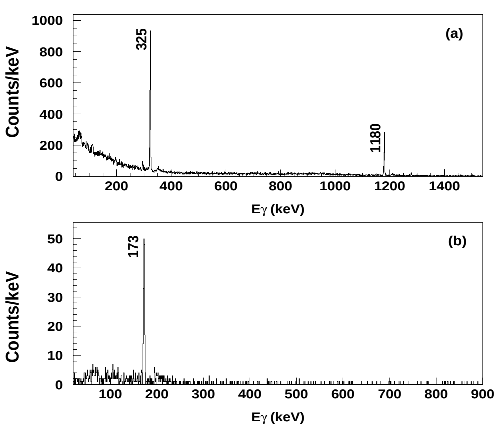

Figure 1: Delayed γ-ray spectra measured in coincidence with implanted ^{135}Te (a), and ^{136}Sb (b) ions. The time-delay is 250 ns, and 500 ns, respectively. The energy labels are in keV.

The decay curves of ^{135}Te and ^{136}Sb are presented in figure 2. The distributions were fitted to obtain the corresponding half-lives of the isomeric decays, and the results are summarized in Table 1. The half-life of the proposed new isomeric state in ^{136}Sb is $T_{1/2}$=566±46 ns [2].

The β-decay of the ^{136}Sb ground state was studied by Hoff et al. [4], who suggest it is the $I^\pi = 1^-$ member of the $\pi g_{7/2}\nu f^3_{7/2}$ multiplet. Previous to our experiment, however, no excited states were known. The energy (173 keV) and half-life (566 ns) of the single delayed γ-ray we observe make it an unlikely candidate for the transition deexciting the isomeric state. More likely, the primary isomeric transition has low energy (<50 keV) and escapes detection in our setup due to internal conversion or absorption.

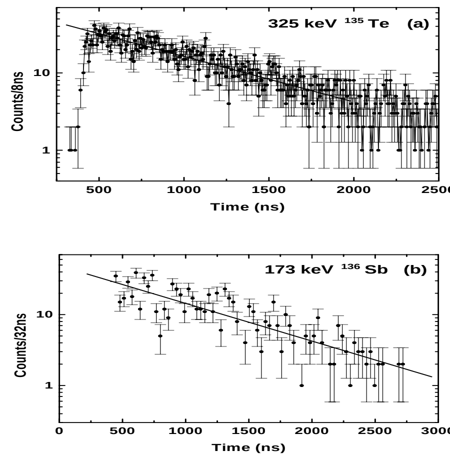

Figure 2: Time distribution curves of a) the 325 keV line from the decay of the $I^\pi = 19/2^-$ isomer in ^{135}Te and b) the 173 keV line identified in ^{136}Sb.

Table 1: Determined isomer half-lives

Isotope	I^π	$T_{1/2}$ (ns) (this work)	$T_{1/2}$ (ns) (previous)
^{135}Te	$19/2^-$	512±22	510±20 [3]
^{136}Sb	-	566±46	-

To help in interpreting the experimental observations we have performed spherical shell model calculations, using two different sets of interactions, to calculate the excitation energies for the $\pi g_{7/2}\nu f^3_{7/2}$ multiplet members. The calculations indicate that the isomer may have $I^\pi = 6^-$, and the observed 173 keV γ-ray could be the $4^- \rightarrow 2^-$ transition. However, although ^{136}Sb has only one proton and three neutrons outside the doubly magic ^{132}Sn core, the gradual onset of collectivity as more valence particles are added could influence the level ordering and spacing. More experimental studies of ^{136}Sb are clearly needed.

References

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