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^{132}Te and single-particle density-dependent pairing

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Abstract. ^{132}Te has been studied through β^- decay of ^{132}Sb radioactive beam at HRIBF leading to a significantly revised level scheme. A number of newly identified, likely 2^+ states allows for a test of recent quasiparticle random phase approximation calculations with a density-dependent pairing force. In addition, the removal of a previously proposed 3^- state allows for a simple shell model interpretation of the low-lying negative-parity states.

PACS. 21.10.-k Properties of nuclei; nuclear energy levels – 21.60.Cs Shell model – 27.60.+j $90 \leq A \leq 149$

Access to neutron-rich nuclei in the region around doubly magic ^{132}Sn at the Holifield Radioactive Ion Beam Facility (HRIBF) has revealed very interesting aspects of nuclear structure in this region. Coulomb excitation measurements [1,2,3] have discovered anomalies in the structure of Te isotopes with $N > 82$. These were subsequently explained by Terasaki *et al.* [4] with new microscopic calculations involving a density-dependent pairing force.

The nucleus ^{132}Te was populated in β^- decay using a 396 MeV radioactive beam of ^{132}Sb with an intensity of $\sim 10^7$ particles/s, embedded in a thick target. Gamma-ray coincidence spectroscopy was performed with the CLARION array [5] at the Holifield Radioactive Ion Beam Facility (HRIBF). The new data has led to a significantly revised γ-decay scheme. Partial results were published in ref. [6]. Many new transitions were observed and new levels proposed. A number of previous placements were found to be inconsistent with the new high quality coincidence data and several previously proposed levels were shown not to exist. Some of these changes also appear in the unpublished work of ref. [7].

New coincidence data allowed for the identification of a number of new states below 2500 keV. Four of these new levels, at 1665 keV, 1788 keV, 2249 keV, and 2364 keV, show a similar decay pattern. For example, the level at 1665 keV was identified on the basis of two depopulating and three populating transitions, illustrated in the partial level scheme of fig. 1. A strong decay by a 691 keV transition to the 2_1^+ level and a weak 1665 keV transition to the 0_1^+ were observed. These decays were observed in coincidence with three strong populating transitions of 823 keV, 937 keV and 1098 keV. Coincidence spectra gated on the 823 keV feeding transition showing the depopulating transitions are given in fig. 2. The decay of the 1788 keV, 2249 keV and 2364 keV levels is similar, with each level

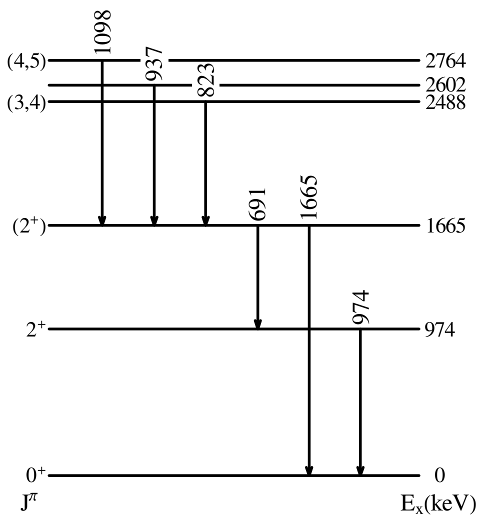

Fig. 1. Partial level scheme for ^{132}Te highlighting those transitions involved in the identification of a new level at 1665 keV.

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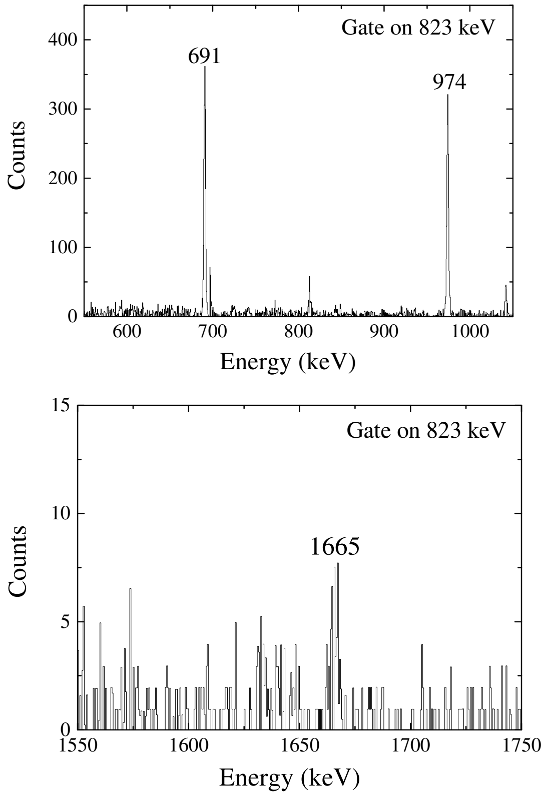

Fig. 2. Spectra gated on the 823 keV feeding transition illustrating coincidences with 691 keV (top) and 1665 keV (bottom) transitions, providing evidence for a new level at 1665 keV.

observed to decay only to the 2_1^+ and 0_1^+ states. Assuming $E1$, $M1$, or $E2$ de-excitation transitions, the decay properties restrict the spin assignment of these levels to $1^{\pm}$, 2^+. Since all available configurations place the $1^{\pm}$ states quite high in energy [6], all 4 states are given a tentative spin assignment of 2^+.

These results allow a test of very recent quasiparticle random phase approximation calculations [4] with a density-dependent pairing force that accounts for the anomalous violation of the Grodzins rule below and above $N = 82$ in the Te isotopes and provides an important new approach to shell model calculations in both stable and exotic nuclei. These calculations take account of the differing density of neutron single-particle levels below and above $N = 82$. However, this interpretation was developed to explain a previously known anomalous behavior. The newly identified 2^+ energies provide an independent test of these calculations. In fig. 3, a comparison of the energies of the 2^+ states with those predicted in the calculations of ref. [4] is presented. Overall, the agreement is very good: The correct number of low-lying 2^+ levels is predicted and at approximately the observed energies.

Another important result is the removal of a previously reported [8] 3^- state at 2281 keV. The previous placement was based on three depopulating transitions from this level at 2281 keV to the 4_1^+, 2_1^+ and 0_1^+ states. The new coincidence data show that all three γ-rays have the reported

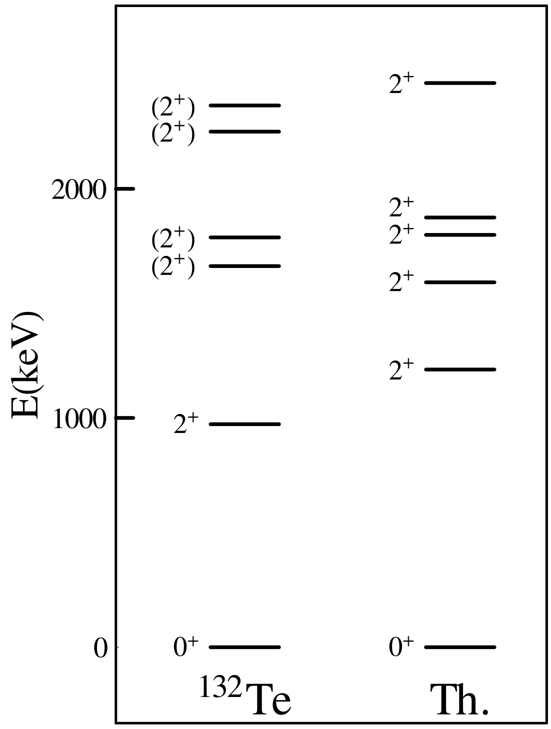

Fig. 3. Comparison of the low-lying 2^+ states in ^{132}Te with the theoretical calculation of ref. [4].

intensities but, in fact, have different placements within the level scheme of ^{132}Te. (The lowest candidate for a 3^- state is identified at 2488 keV.) A simple shell model analysis [6] leads to a simple interpretation of the structure of the negative-parity states. The 7_1^- and 5_1^- states are based on two-neutron configurations [8,9] and the 3^- state could be the lowest member of the $(1h_{11/2}, 2d_{5/2})$ two-proton multiplet.

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