CONF-880496--1

ALIGNMENTS, SHAPE CHANGES, BAND TERMINATIONS AND TRANSITION RATES IN ^{157}Tm

M. A. Riley
Oak Ridge National Laboratory and Joint Institute for Heavy Ion Research*
Oak Ridge, TN 37831

C. Baktash, Y. A. Ellis-Akovali, M. L. Halbert, D. C. Hensley,
N. R. Johnson, I. Y. Lee, and F. K. McGowan
Oak Ridge National Laboratory, Oak Ridge, TN 37831

V. P. Janzen and L. L. Riedinger
University of Tennessee, Knoxville, TN 37996

CONF-880496--1

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L. Chaturvedi
Vanderbilt University, Nashville, TN 37235

The even-even N = 88 nuclei ^{158}Yb [1], ^{156}Er [2] and ^{154}Dy [3,4] have been well studied at high spin and there is evidence for a shape transition from prolate to oblate shapes (band termination) between spins I ≈ 30 - 42. It is important to study this shape transition in an odd-Z isotone since a particular systematic trend is expected and also because odd-Z nuclei possess special characteristics not found in the even-even cases.

High spin states in ^{157}Tm were populated via the ^{110}Pd(^{51}V,4n) reaction at a beam energy of 220 MeV. Gamma rays were detected in coincidence by using our 19 detector Compton Suppression System. Approximately 165 million events were recorded.

A very preliminary level scheme for the yrast band (based on the [523]7/2 $h_{11/2}$ Nilsson level) is presented in figure 1. Previously only six γ rays had been assigned [5] to this nucleus. (A well-developed side band, most likely of positive parity, is also observed to spin I ≥ 55/2). Spin and parity assignments are based on angular correlation information and the strong systematics that exist in this region.

The yrast band shows large signature splitting at low spins which disappears (and even inverts slightly) after the $i_{13/2}$ neutron alignment at spin I = 31/2. Similar behavior is observed in the N = 90, odd-Z nuclei and has been interpreted as a change in shape from negative to zero or slightly positive values of γ [6]. The interaction strength at the $i_{13/2}$ crossing is very weak with the main intensity flow actually bypassing the 31/2$^-$ yrast level via the 935-keV transition. Such a weak interaction, and also a slightly higher than normal crossing frequency, is expected for nuclei where

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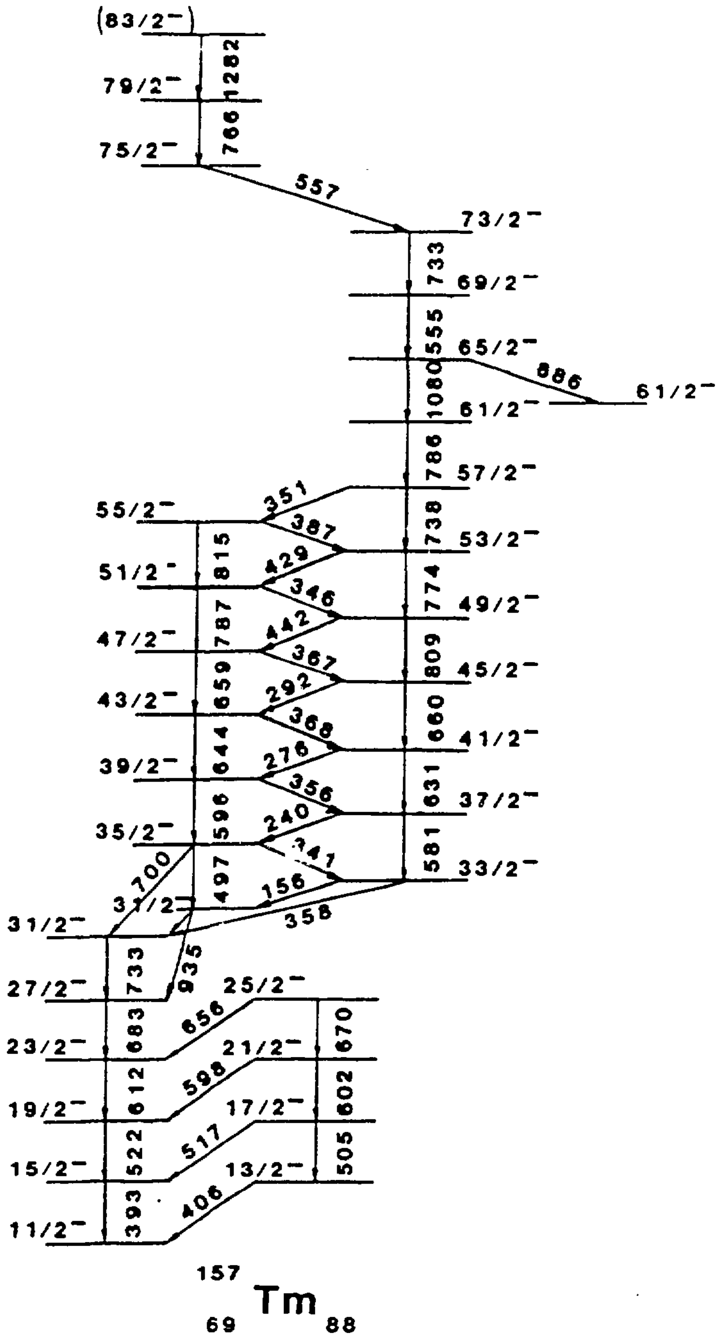

Figure 1

Preliminary level scheme for ^{157}Tm.

the Fermi surface λ lies below the $\Omega = 1/2$ intruder level [7].

A special feature of the odd-proton nuclei is that it is possible to obtain electromagnetic B(M1)/B(E2) transition rates by measuring the $\Delta I = 1$ to $\Delta I = 2$ branching ratios in the two strongly coupled $h_{11/2}$ yrast sequences. The preliminary ratios obtained for ^{157}Tm are plotted in figure 2. (A mixing ratio $\delta = 0$ has been assumed). These results show similar characteristics to other odd-proton nuclei in this region, displaying a sharp rise at the $i_{13/2}$ neutron alignment. An extensive discussion of these odd-Z nuclei is given by Hamamoto elsewhere in these proceedings. A feature which is not understood and which also occurs to a similar degree in ^{157}Ho is the drop in values between spins $I \approx 15$ to 25. Above spin $I = 25$, the ratio rises which is also true for the 1½ N = 90, odd-Z nuclei. Whether the underlying explanation for this increase is the same for all these nuclei is not clear at present (though possible), but in the case of ^{157}Tm we would suggest it is caused by the influence on the yrast sequence by band termination structures which cross the yrast line just below spin $I = 30$, leading to a reduction in the B(E2) values.

The even-even $N = 88$ nuclei, particularly ^{154}Dy [3,4] and ^{156}Er [2], display convincing evidence for the occurrence of band termination. In the

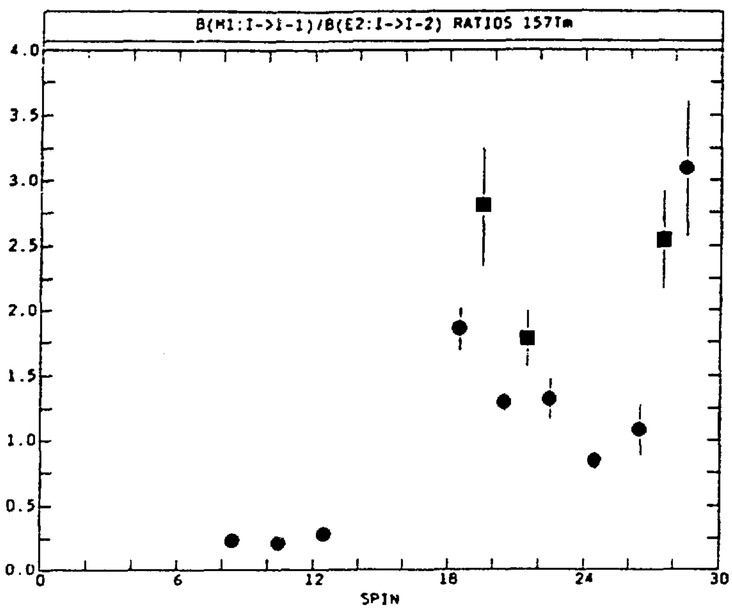

Figure 2

$B(M1:\Delta I = 1)/B(E2:\Delta I = 2)$ ratios in units of μ_N^2/e^2b^2 as a function of spin I for ^{157}Tm. Circles: $\alpha = +1/2$, squares: $\alpha = -1/2$.

case of ^{158}Yb there has been some disagreement on the experimental spectrum at high spin and this has led to the presentation of two possible interpretations, one using the band termination framework [1,8,9] and one rejecting this in favor of a standard cranked shell model interpretation [10]. We were interested in this question and think we can shed some light on it since very definite systematic behavior is expected with both these models.

Plotted in figure 3 is the excitation energy minus a rigid rotor reference for the yrast band of ^{157}Tm. Also plotted (shifted in energy) are some very recent band termination predictions by Ragnarsson and Bengtsson [11]. These calculations omit pairing and, therefore, some care should be taken when interpreting the theory values for low spins, $I < 30$. The similarity between experiment and theory is striking! However, it must be pointed out that some transition ordering changes are possible when the analysis is completed. The strong down sloping, ending in a particular favored oblate state (encircled), is a characteristic feature of terminating bands. The predicted low states, at spins $I = 61/2$ and $73/2$ indeed coincide with low experimental states. We suggest the terminating structures cross the more collective yrast sequences above spin $I = 57/2$. The intense very high energy γ ray (1080 keV) and the observation of a dipole transition (557 keV) at spin $I = 75/2$ are also phenomena which may be explained in these band termination calculations. The high spin experimental spectrum, $I \gtrsim 57/2$, however, is not readily understood within a CSM framework.

Another interesting point is that the low states at spins $I = 45/2$ and $47/2$ coincide exactly with anomalies observed in the experimental γ-ray spacing (see figure 1). These calculations are without pairing, the inclusion of which would tend to lower the collective structures at these spins. Thus, while we are not suggesting that the observed 45/2 and 47/2 yrast levels are oblate, which is actually not reflected in the B(M1)/B(E2) ratios of figure 2, it is possible that the calculated favored oblate states are sufficiently close to yrast to disturb the regular γ-ray energy pattern. There is some evidence for this perturbation at $I = 45/2$ in figure 2. Similar anomaly correlations at higher spins have been observed in the $N = 90$ isotones [12].

In conclusion, the high spin data presented here for ^{157}Tm are compatible with the expectations of shape changes and band termination above spin 30 in

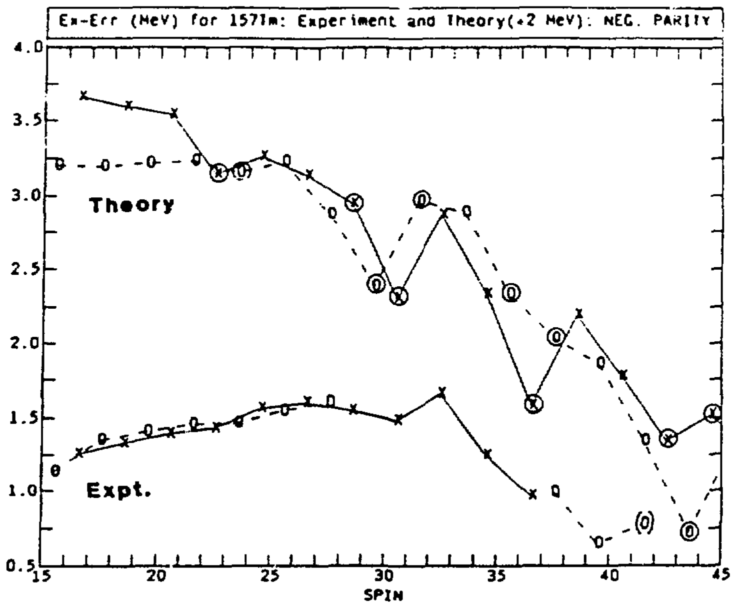

Figure 3

Excitation energy minus a rigid rotor reference for negative parity levels, experimental and calculated [11] (shifted up 2 MeV), in ^{157}Tm.

this nucleus. These observations are consistent with similar effects seen in the lighter N = 88 nuclei and support the interpretation [1,8,9] for band terminating behavior in the heavier ^{158}Yb nucleus.

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*Operated by Martin Marietta Energy Systems, Inc. under contract DE-AC05-84OR21400 with the U.S. Department of Energy.

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