

SPECTROSCOPY OF  $^{179}\text{Re}$ ,  $^{173}\text{Ta}$ ,  $^{167}\text{Lu}$  and  $^{163}\text{Tm}$  NUCLEI WITH THE  $(\alpha, 6n)$  REACTION

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The spectroscopy of  $^{179}\text{Re}$ ,  $^{173}\text{Ta}$ ,  $^{167}\text{Lu}$  and  $^{163}\text{Tm}$  has been investigated<sup>1)</sup> with the  $(\alpha, 6n\gamma)$  reactions using Ta, Lu, Tm and Ho targets, respectively. For each of the four targets the following measurements were made. (1)  $\gamma$ -ray spectra were recorded with a Ge(Li) detector at  $90^\circ$  to the beam direction at 64 to 80 MeV  $\alpha$  bombarding energy in about 3-MeV steps, (2) The time distribution of the gamma rays with respect to the beam burst at 70 MeV  $\alpha$  energy where the cross section for the  $(\alpha, 6n\gamma)$  reaction was found to peak, (3) Four parameter coincidence data ( $E_{\gamma_1}$ ,  $E_{\gamma_2}$ ,  $\gamma$ - $\gamma_2$  TAC,  $\gamma_1$ -RF TAC) were acquired at 70 MeV alpha energy using two Ge(Li) detectors. (4) The angular distributions of the  $\gamma$  rays in  $90^\circ$ - $150^\circ$  angular interval. The first three measurements were made using the cyclotron facility at the Naval Research Laboratory, Washington, D.C., and the angular distributions were measured at the Kernfysisch Versneller Instituut (KVI) Cyclotron Facility in Groningen, the Netherlands. These measurements have been used to determine the level scheme, the  $\gamma$ -decay modes, and the lifetimes of nuclear states of the above nuclei. The salient results are summarized below for each case.

As shown in Fig. 1, three rotational bands of configuration  $5/2^+[402]$ ,  $1/2^-[541]$  and  $9/2^-[514]$  were established for  $^{179}\text{Re}$  with

$5/2^+[402]$  bandhead as its ground state. An isomeric state located at about 1114.4 keV and having a half-life ( $T_{1/2}$ ) of  $\approx 21$  ns was also located.

For  $^{173}\text{Ta}$  (Fig. 2) four rotational bands of  $1/2^-[541]$ ,  $7/2^+[404]$ ,  $9/2^-[514]$  and  $5/2^+[402]$  configuration were established. The  $5/2^-$  member of the  $1/2^-[541]$  band appears to be the lowest-energy state and is tentatively assumed to be the ground state of  $^{173}\text{Ta}$ . The relative locations of  $7/2^+[404]$  and  $5/2^+[402]$  bandheads with respect to the ground state could not be determined. The  $9/2^-[514]$  bandhead was found to have  $T_{1/2} \approx 196$  ns. An isometric state with a  $T_{1/2}$  of 51 ns was located at 1470 keV above the  $9/2^-[514]$  bandhead.

Fig. 3 shows the level scheme for  $^{167}\text{Lu}$ . Four bands of configuration  $7/2^+[404]$ ,  $1/2^+[411]$ ,  $1/2^-[541]$  and  $9/2^-[514]$  were established with  $7/2^+[404]$  bandhead as its ground state. The  $9/2^-[514]$  and  $1/2^-[541]$  bandheads were both found to have  $T_{1/2}$  of about 23 ns. The moment of inertia for the  $7/2^+[404]$  band was found to show the back-bending phenomenon past a level of spin  $I = 25/2$ .

The level scheme for  $^{163}\text{Tm}$  is shown in Fig. 4. Four bands of  $1/2^+[411]$ ,  $7/2^+[404]$ ,  $1/2^-[541]$  and  $7/2^-[523]$  configuration were established. The  $1/2^-[411]$  bandhead is considered to be its ground state in terms of the overall accumulated evidence.





The  $7/2^-$ [525] bandhead is found to have  $T_{1/2}$  of  $\sim 24$  ns and an isomeric state with  $T_{1/2}$  of  $\sim 9$  ns was located at an energy of 1093 keV above the  $7/2^-$ [523] bandhead.

The collective and intrinsic properties of the bands identified for these nuclei are compared with those obtained from the literature for other isotopes and these were found to be correlated with the variation in the deformation with the nuclear mass in this region. A detailed report on this work is in preparation for publication.

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- 1) Ph.D. thesis, L.G. Robinson, Indiana University, Dec. 1976.