The mixing of Nilsson configurations in ^{159}Tb

1974 J. Phys. A: Math. Nucl. Gen. 7 L125

(http://iopscience.iop.org/0301-0015/7/10/002)

J. Phys. A: Math., Nucl. Gen., Vol. 7, No. 10, 1974. Printed in Great Britain. © 1974

LETTER TO THE EDITOR

The mixing of Nilsson configurations in ^{159}Tb

G Winter, L Funke, P Kemnitz, H Sodan and E Will

Akademie der Wissenschaften der DDR, Zentralinstitut für Kernforschung Rossendorf, DDR-8051 Dresden

Received 13 May 1974

Abstract. The excited states of ^{159}Tb have been studied in the reaction ^{160}Gd(p, 2nγ)^{159}Tb using in-beam gamma ray spectroscopy. New levels of two strongly mixed negative-parity bands and of the known $K^\pi = \frac{1}{2}^+$ band have been identified. From an analysis of the E1 transitions de-exciting the $\frac{7}{2}^+$[404] level to the coupled $\frac{7}{2}^-$ states, the mixing between them was evaluated to be 17%. In order to explain the experimental value of the decoupling parameter for the $\frac{1}{2}^+$ band, an influence of the $\frac{1}{2}^+$[660] configuration is suggested.

The low-lying levels of the nucleus ^{159}Tb have been investigated through various means, as detailed in the review paper of Bunker and Reich (1971). In addition, proton transfer reaction data obtained by Boyno and Huizenga (1972) as well as by Tippett and Burke (1972) enabled these authors to provide a more complete description of this nucleus (for a compilation of data see Tuli 1973). However, the information on the Coriolis coupling between members of the rotational bands $\frac{5}{2}^-$[532] and $\frac{7}{2}^-$[523] was still not sufficient for a quantitative analysis. The purpose of the present work was to investigate this effect and, in this way, to extend the results already obtained for the nuclei ^{155}Tb and ^{157}Tb (Winter *et al* 1971) to the nucleus ^{159}Tb.

The levels of ^{159}Tb were populated by the ^{160}Gd(p, 2nγ)^{159}Tb reaction using the 10 MeV proton beam of the Rossendorf tandem accelerator. In these experiments, the gamma radiation emitted during the irradiation of a $^{160}Gd_2O_3$ target was studied in singles and coincidence measurements (for details of the experimental arrangement see Funke *et al* 1972). Background radiations arising from the (p, n) reaction were identified by a measurement at a proton energy of 8 MeV.

A part of the ^{159}Tb level scheme deduced by combining the results of our measurements with previously known data is shown in figure 1. Members of the strongly coupled rotational bands $\frac{5}{2}^-$[532] and $\frac{7}{2}^-$ [523] have been found up to an angular momentum of $I = \frac{11}{2}$. The $\frac{7}{2}^-$ band head and the $\frac{9}{2}^-$ rotational level based on this state were not reported previously. Furthermore, both strongly mixed $\frac{7}{2}^-$ states are found to be populated by E1 transitions de-exciting the $\frac{7}{2}^+$[404] state established at an energy of 778·0 keV (see figure 1). Since a transition between the $\frac{7}{2}^+$[404] state and the $\frac{5}{2}^-$ band head was not observed, it is reasonable to assume that the relative E1 transition intensities to the $\frac{7}{2}^-$ states correspond to the relative amounts of admixtures arising from the $\frac{7}{2}^-$[523] configuration in both $\frac{7}{2}^-$ states. An E1 transition to the $\frac{5}{2}^-$[532] component would be a particle–hole transition and, therefore, hindered by the pairing effect (for a discussion see Winter *et al* 1973). On the other hand, between the configurations $\frac{7}{2}^+$[404] and $\frac{7}{2}^-$[523] fast E1 transitions have been found (Funke *et al* 1972) in the neighbouring nuclei ^{161}Ho and ^{163}Ho. Under these conditions, the mixing ratio of the final

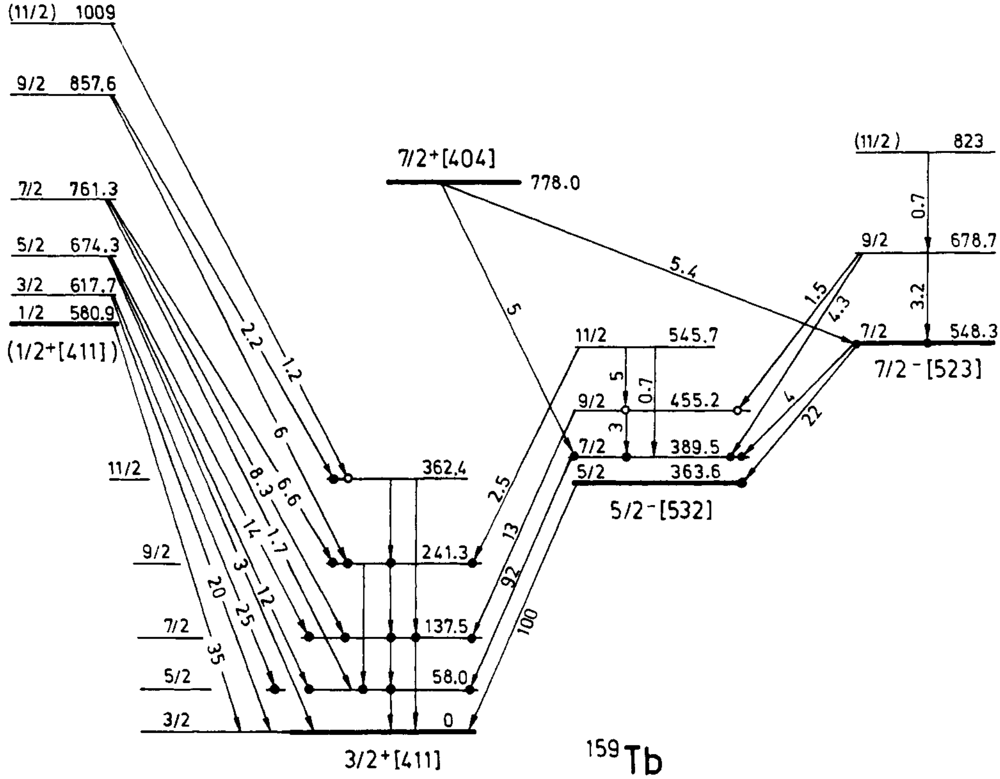

Figure 1. Partial level scheme of ^{159}Tb. The numbers at the arrows give the relative gamma ray intensities found in the present measurement. A filled (open) circle at the tip of an arrow means that the required coincidence relationships between this transition and all (some of) the lower-lying transitions shown in the figure have been found.

states can be deduced since the other factors entering the theoretical expression for the branching ratio cancel each other. From the experimental branching ratio and the energies of the E1 transitions considered one obtains an admixture of about 17% of the configuration $\frac{7}{2}^-$[523] in the lower $\frac{7}{2}^-$ state. This result is in fair agreement with the mixing ratio (19%) obtained in a Coriolis coupling calculation performed according to Winter *et al* (1971).

In ^{161}Tb where the sequence of the negative-parity band heads is reversed an admixture of 18% has been evaluated by Zylicz *et al* (1966) analysing the population of the mixed states in the beta decay of ^{161}Gd.

Levels of the $K^\pi = \frac{1}{2}^+$ rotational band have been found up to $I = \frac{9}{2}$. A tentative assignment is proposed for the $I = \frac{11}{2}$ level. An open problem associated with the interpretation of this band is the explanation of the value obtained for the decoupling parameter (see the detailed discussions in the papers of Diamond *et al* 1963 and of Tippett and Burke 1972). In the present study a more reliable value of $a = 0{\cdot}06 \pm 0{\cdot}02$ was deduced for this parameter from the five experimental level energies. The level spacings within the $\frac{1}{2}^+$[411] band found in the neighbouring nuclei of Ho and Tm reveal a decoupling parameter $a \simeq -0{\cdot}8$. A possible explanation for the result in ^{159}Tb might be given by taking into account the hexadecapole deformation ϵ_4 of the nucleus considered. For negative values of ϵ_4, as obtained from the calculation of the equilibrium deformation (Ekström and Lamm 1973), an appreciable $\Delta N = 2$ mixing between the orbitals $\frac{1}{2}^+[411]$ and $\frac{1}{2}^+[660]$ may result. A calculation on the basis of the Saxon–Woods potential (see Ehrling and Wahlborn 1972, figure 10) shows that the value of the decoupling parameter for the $\frac{1}{2}^+[411]$ band might change towards the positive region. However, a quantitative estimation of this effect in ^{159}Tb depends very sensitively on the values of various model parameters.

References

Boyno J S and Huizenga J R 1972 *Phys. Rev.* C **6** 1411–24
Bunker M E and Reich C W 1971 *Rev. Mod. Phys.* **43** 348–423
Diamond R M, Elbek B and Stephens F S 1963 *Nucl. Phys.* **43** 560–97
Ehrling G and Wahlborn S 1972 *Physica Scripta* **6** 94–108
Ekström C and Lamm I-L 1973 *Physica Scripta* **7** 31–48
Funke L *et al* 1972 *Nucl. Phys.* A **190** 576–96
Tippett J C and Burke D G 1972 *Can. J. Phys.* **50** 3152–71
Tuli J K 1973 *Nuclear Data Sheets* B **9** 435
Winter G *et al* 1971 *Nucl. Phys.* A **176** 609–25
Winter G, Funke L, Kemnitz P and Sodan H 1973 *Nucl. Phys.* A **199** 1–13
Zylicz J, Hansen P G, Nielsen H L and Wilsky K 1966 *Nucl. Phys.* **84** 13–24