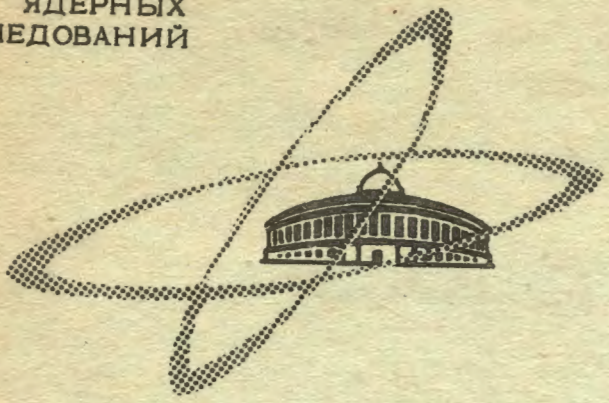
ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ
Дубна



E6 - 3905

A.Z.Hrynkiewicz, J,Styczeń, Z.Szeglowski
W.Waluś

DIRECTIONAL CORRELATIONS OF GAMMA CASCADES IN ^{160}Dy

1968

E6 - 3905

A.Z.Hrynkiewicz, J,Styczeń, Z.Szeglowski
W.Waluś

DIRECTIONAL CORRELATIONS OF GAMMA CASCADES IN ^{160}Dy

Introduction

The excited levels of ^{160}Dy are populated by β - decay of ^{160}Tb with the half-life of 72.4 days. The decay of ^{160}Tb and the level scheme of ^{160}Dy have been studied in numerous investigations. In a number of them directional correlations of gamma cascades were measured (1-9). In the recent works of Jaklevic et al./ 9/ and Vzral et al./ 10/ Ge(Li) detectors were used, which made it possible to reveal some previously unreported gamma transitions, and to determine transition energies and their relative intensities more exactly. Jaklevic et al. performed coincidence and directional correlation measurements using Ge(Li) and NaJ(Tl) detectors and settled several ambiguities in spin assignments. At the present time the level scheme of ^{160}Dy is well established up to 1400 keV and the positive parity states are well understood as belonging to the K = 0 ground state rotational band and the K = 2 γ- vibrational band. There are still some unresolved problems concerning negative parity states, not all of the spin assignments being unambiguously settled.

In the present work directional correlation measurements are reported which have been performed to obtain an additional information about the spin values of the 1264 keV, 1386 keV, and 1399 keV states of ^{160}Dy .

Experimental Procedure

The ^{160}Tb activity was obtained in a reactor in the neutron capture process ^{159}Tb(n, γ)^{160}Tb . The measurements using a liquid source in the form of an aqueous solution of $TbCl_3$ were started more than 1 year after the irradiation, i.e. when no appreciable impurities of other isotopes were present. The directional correlation experiments were performed using a coaxial Ge(Li) detector with a sensitive volume of ca. 13 cm^3 and a 2" x 2" NaI(Tl) detector.

The Ge(Li) detector was mounted in a fixed position, the scintillation detector was movable, its position being automatically changed every 5 minutes. The resolving time of a transistorized fast-slow coincidence circuit was set at 50 ns and energy resolution of the germanium detector was 4 keV at 662 keV. The coincident gamma spectra from Ge(Li) , gated by appropriate peaks of the NaI spectrum were stored for three counter setting angles 90°, 135° and 180° in different parts of the memory of a 4096 channel pulse-height analyser. The solid angle correction for the Ge(Li) detector was determined experimentally using known directional correlation functions for ^{169}Tm .

Results

The directional correlation measurements were performed for the following cascades: 1178 keV - 87 keV, 1272 keV - 87 keV, 1003 keV - 197 keV, 1115 kev - 197 keV, 299 keV - 879 keV and 299 keV - 966 keV. In Table 1 the correlation coefficients obtained in the present work are listed in comparison with those determined by Jaklevic et al./9/ and with theoretical predictions. The theoretical coefficients are calculated assuming pure multipolarity E1 or E2 of the involved transitions. Reasonable admixtures of M2 or M1 do not affect the conclusions concerning spin assignments of the investigated states. For the cascades involving the 87 keV 2.05 ns intermediate state the correlation coefficients were correct-

Table 1 Directional Correlation Coefficients

Cascade (keV) (gate energy underlined)	Experimental				Theoretical		
	Jaklevic et al.		Present work		Spin Sequence	A_2	A_4
	A_2	A_4	A_2	A_4			
1178–87	+0·220(33)	−0·087(47)	+0·260(44)	−0·153(146)	2–2–0	+0 250	
1272–87	+0·294(54)	−0·032(92)	+0·196(60)	−0·040(30)	3–2–0	−0 072	
1103–197			+0·244(50)	−0·03(14)	4–4–2	+0 196	0
1115–197			−0·258(39)	+0·04(18)	3–4–2	−0 141	
298·5–879·5	−0·088(15)	−0·020(22)	−0·065(24)	−0·002(70)	2–2–2	−0 054	
298·5–966·0	+0·264(14)	−0·033(23)	+0·218(20)	−0·120(60)	3–2–2	+0 015	
					2–2–0	+0 251	
					2–3–0	−0 072	

ed for the attenuation of the directional correlation using the attenuation factors G_2 = 0.75 (10) and G_4 = 0.503 (50) taken for the source of the same form from the paper of Jaklevic et al.

Our results corroborate the spin assignments I = 2 keV the 1264 keV and 1358 keV states and I = 3 for the 1286 keV state. For the 1386 keV states I = 4 is established. Moreover, the spectrum coincident with the 197 keV gate (Fig. 1) confirms the existence of the 872 keV transition, tentatively introduced by Vzral et al. [10]. Its absolute gamma intensity determined by comparison with the known intensities of the 1003 keV, 1102 keV, and 1115 keV lines, is equal to 0.24 (6) %.

Discussions

The I = 2 assignment for the 1358 keV state excludes the interpretation of this state as the second member of the K = 2 rotational band built on the two-quasiparticle state at 1264 keV. A comparison of the calculated ratios of reduced E1 interband transition probabilities with the experimental value does not allow to determine the K quantum number for this state unambigously although the K = 0 and K = 1 assignments seem more preferable [9]. In this situation it is difficult to make a definite conclusion concerning the nature of this state.

The I = 4 spin value for the 1386 keV state being established in the present paper, an attempt can be made to determine the K quantum number for this state. In Table 2 experimental ratio of reduced E1 transition probabilities from the 1386 keV state to the γ-vibrational band [11] is compared with the theoretical ratios for various K values. The K = 1 can be ruled out immediately. The presence of the 1102 keV transition to the 4^+ state of the ground state rotational band favours the assignment K = 2 as in the case of K = 3 this interband transition would be K-forbidden with $\Delta K - L = 2$.

Table 2

Ratios of reduced probabilities of E1 transitions from the 1386 keV state to the γ -vibrational band

$B(231, 4K \to 42) / B(337, 4K \to 32)$			
Experimental	Calculated		
	K = 1	K = 2	K = 3
0.77 (25)	4.83	0.53	0.54

In this case the 1386 keV state would be the third member of the $K = 2^-$ band built on the 1264 keV state. The 1286 keV state is probably the second member of this band, its K value being redetermined to be equal to 2 in the recent experiment on inelastic scattering of deuterons /11/. It is quite possible that the 1408 keV state with the probable spin and parity assignments 5^- also belongs to the same band. The strong distortion of this band might be caused by the presence of a 2^- state at 1358 keV and a 3^- state at 1399 keV/12/.

The level scheme of ^{160}Dy based on previous data and on the results of the present work is shown in Fig. 2.

The authors wish to thank Professor G.N.Flerov for the good working conditions in his Laboratory and for his interest in this work.

References

1. G.Bertolini, M.Bettini, E.Lazzarini. Nuovo Cim. 3, 1162 (1956).

2. S.Ofer. Nuclear Phys., 5, 331 (1958).

3. R.G. Arns, R.E. Sund, M.L. Wiedenbeck. Nuclear Phys., 11, 411 (1959).
4. W. Kundig. Helv. Phys. Acta, 34, 125 (1961).
5. W. Michaelis. Nuclear Phys., 44, 78 (1963).
6. S.L. Gupta, N.K. Saha. Nuclear Phys., 70, 203 (1965).
7. C. Günther, G. Strube, U. Wehmann, W. Engels, H. Blumberg, H. Luig, R.M. Lieder, E. Bodenstedt, H.J. Körner. Zeit. Phys., 183, 472 (1965).
8. K. Venkata Reddy, B.B. Venkatapathi Raju, R.V. Rama-Mohan, Swami Jnanananda. Phys. Rev., 138, B33 (1965).
9. J.M. Jaklevic, E.G. Funk, J.W. Mihelich. Nuclear Phys., A99, 83 (1967).
10. J. Vrzal, P. Galan, T.I. Galanova, J. Liptak, J. Urbanec, M. Finger. JINR Preprint P6-3312, Dubna (1967).
11. T. Grotdal, K. Nybø, T. Thorsteinsen, B. Elbek. Nuclear Phys., A110, 385 (1968).
12. G.T. Ewan, R.L. Graham, J.S. Geiger. Nuclear Phys., 22, 610 (1961).

Received by Publishing Department
on May 31, 1968.

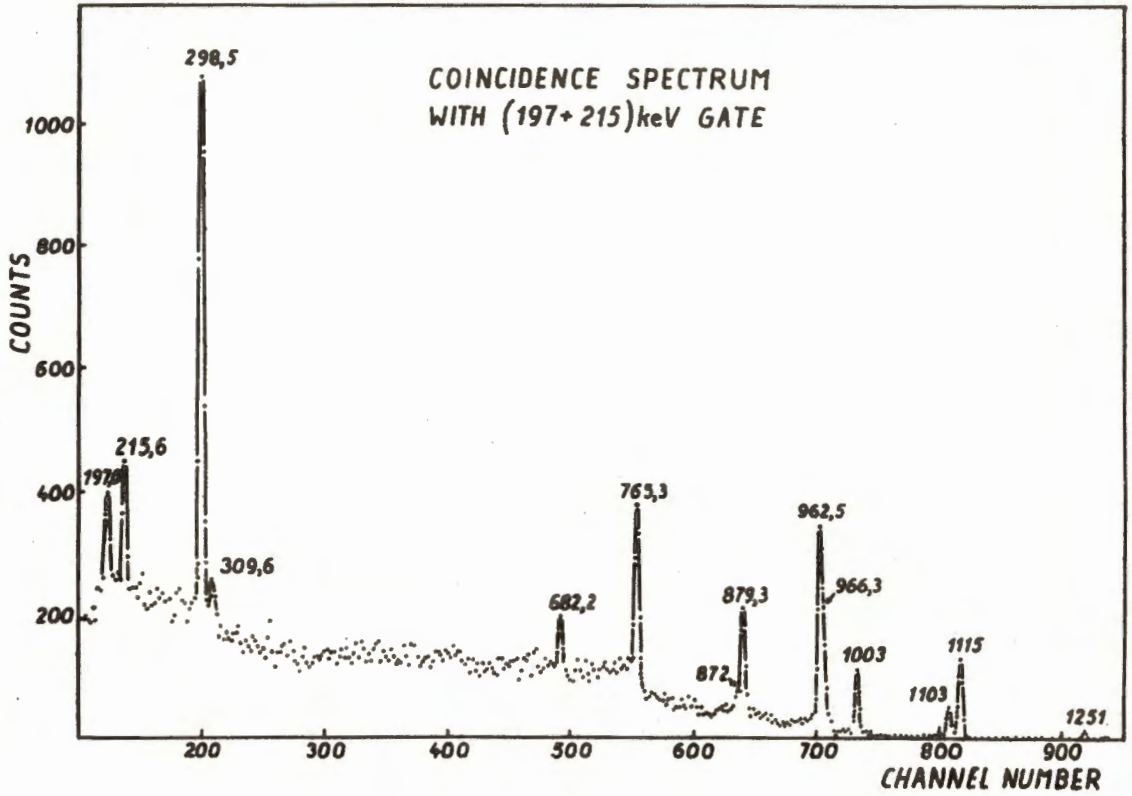


Fig. 1. Coincidence spectrum obtained with a Ge(Li) detector using the 197 keV NaI gate.

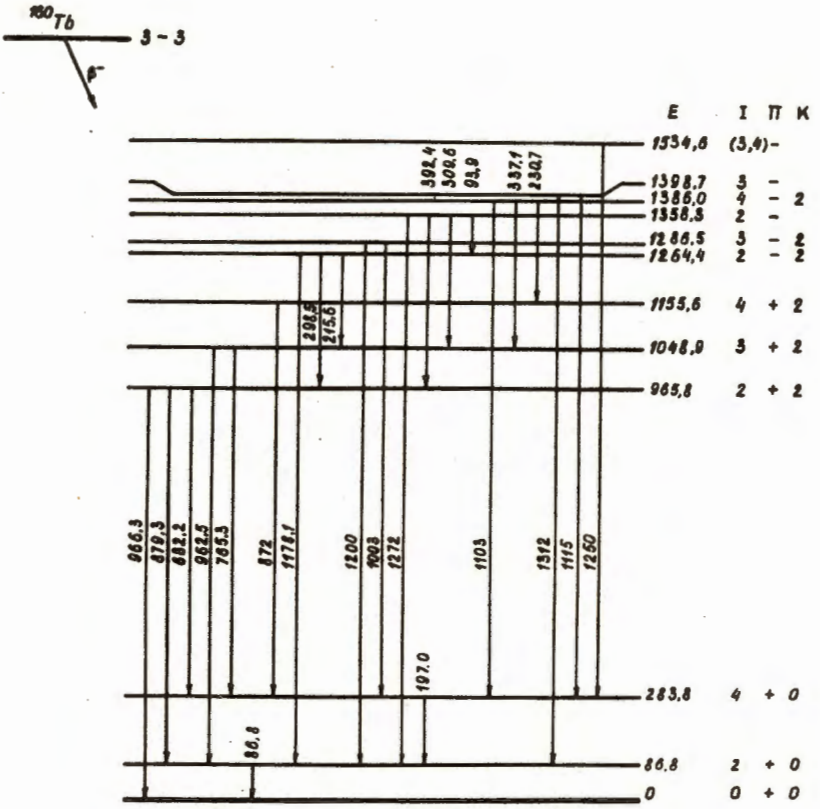


Fig. 2. Level scheme of ^{160} Dy .