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CONF-8708101--4

BNL--40149

DE87 014391

A Study of the structure of ^{162}Dy through the (n,γ) and (n,e−) reactions.

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Abstract. The level structure below 2MeV in ^{162}Dy has been investigated using the ^{161}Dy (n, γ) ^{162}Dy and ^{161}Dy (n, e−)^{162}Dy reactions. The results for the positive parity excitations are discussed within the framework of an IBA-2 calculation.

Introduction.

The exceptional precision and sensitivity of the gamma ray and conversion electron spectrometers GAMS and BILL at the Institut Laue-Langevin is widely recognized as providing a unique capability to study in detail the location and decay modes of intrinsic excitations in collective nuclei. In the current study, these techniques have been applied to the nucleus ^{162}Dy in order to investigate the validity of the characteristic set of predicted properties of well deformed nuclei which has emerged from the IBA-1 approach, [1,2] and to extend this comparison to the IBA-2 framework, where it has only recently become practicable to perform calculations for nuclei near the middle of the N = 82 - 126 shell.

Experiment.

The gamma rays from the $^{161}Dy(n,\gamma)^{162}$ Dy reaction have been studied over the energy range of 30 - 2000 keV with the GAMS 1,2 and 3 curved crystal spectrometers at the high flux reactor of the ILL and via Ge detector measurements on a thermal neutron beam at the Brookhaven HFBR. Conversion electron spectra over the same energy range were recorded with the iron free, β spectrometer BILL at ILL. A detailed level scheme for ^{162}Dy has been constructed by combining the results of these measurements with those from an earlier average resonance capture (ARC) study [3)] which serves to guarantee the completeness of the set of low spin states under discussion.

Interpretation.

The Hamiltonian used in the IBA-2 calculations was of the form

$$H = E(n\nu + n\pi) + KQ\nu.Q\pi + K\,(Q\nu.Q\nu + Q\pi.Q\pi) + K_L\, L.L + M$$

where M represents the Majorana operator, whose strength was adjusted to place the 1^+ mixed symmetry state at around 3MeV. The remaining parameters took the following values E = 150keV, K = 2K = -40keV; K_L = 4.5 keV.In addition, the parameters X_ν and X_π, which characterise the structure of the quadrupole operators $Q\nu$, $Q\pi$, were chosen as -0.2 and -0.9 respectively. The E2 operator was then taken as $T(E2) = e(Q\pi + Q_\nu)$ where a boson effective charge e = 0.12e.b yields the correct absolute magnitude of $B(E2; 2^+_g \to 0^+_g)$ and $B(E2; 2^+_\gamma \to 0^+_g)$.

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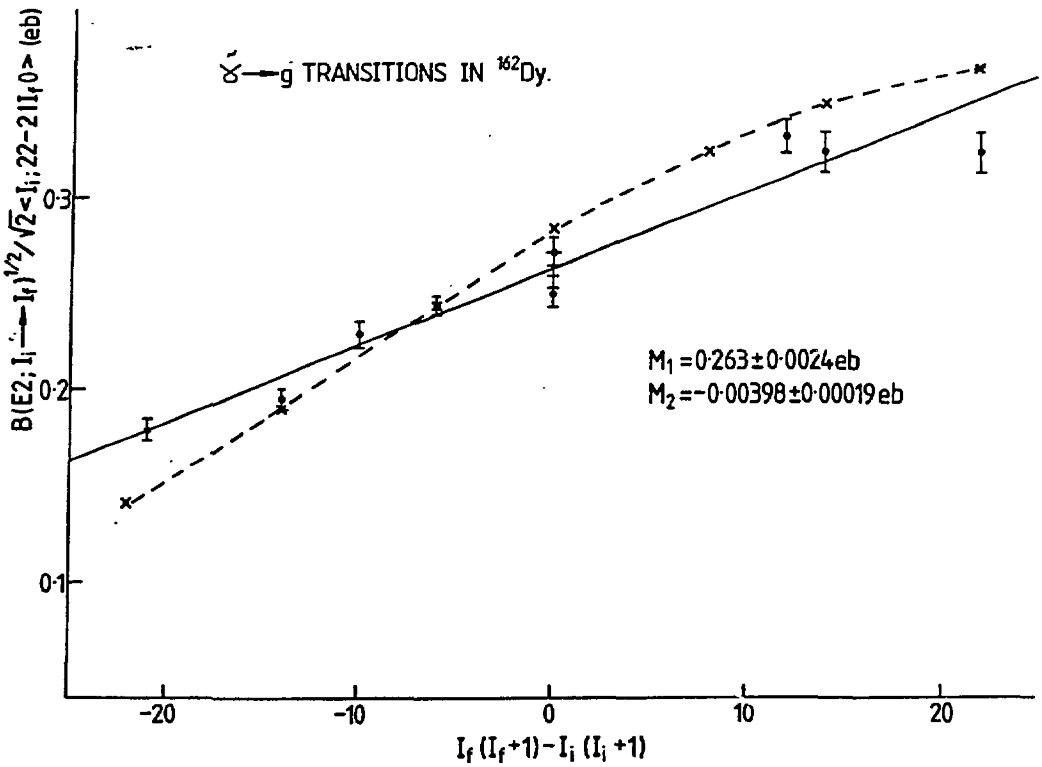

FIG 1:- Mikhailov Plot for γ - g Transitions in ^{162}Dy.

The calculated E2 transition strengths from the γ and β bands are compared with the experimental results in Fig 1 and Table 1. Note that the current experiment has succeeded in determining the position of the $K\pi = 0^+$ (β) bandhead as being at 1398.04 (1) keV, by virtue of both its gamma decay to the ground and gamma bands, and its E0 decay to the ground state.

The γ -> g transition strengths are compared with theory in the form of a Mikhailov plot in Fig 1. This demonstrates the fact that bandmixing effects are automatically incorporated in the IBA results. However, it is interesting to note the appearance of a marked non-linearity in the calculated points at the higher values of the abscissa. This feature suggests that the assumption of simple two band mixing, inherent in the Mikhailov formalism, is becoming invalid in these cases. Similar effects were observed in earlier IBA-1 studies, but, in that case, they occurred at significantly lower values of N and x.

Table 1 shows that the calculation also provides a reasonably good description of the decays from the β band. The most striking feature here is the confirmation of the dominance of transitions to the gamma band, over those to the ground band. In addition, the calculation yields for the intrinsic matrix elements between the bands, the values γ ->g:β ->γ:β -> g = 0.25: 0.21: 0.06 e.b. emphasising the weakness of β -> g strengths relative to γ -> g. A direct empirical estimate of the intrinsic matrix elements from the β band can be obtained from the decay of the 4^+_β state, estimating the intraband strength on the basis of the ground state intrinsic quadrupole moment. This results in the relative empirical values 0.25: 0.14: 0.10 e.b.

The second excited 0^+ state located in the (p,t) reaction[5] at 1670 keV has not been identified in the current study. The calculation places this band at 1780 keV. No candidate as yet exists for the $K\pi = 4^+$, two - phonon excitation predicted at 1872 keV: The experimental 4^+ band at 1535 keV has been shown [6] to be dominated by the 3/2 [521] + 5/2 [523] two neutron configuration. This suggests that, as in the case of ^{168}Er, such an excitation, if any observable component of it exists, must lie at an energy >2 MeV.

Finally, it should be remarked that the IBA-2 framework can also be used to address the question of M1 properties, by virtue of its explicit separation of the neutron and proton degrees of freedom. Indeed, it has recently been shown[7] that the current and similar calculations are indeed capable of reproducing the observed B(M1) strengths over a range of well deformed nuclei.

Research supported under U.S. D.O.E. Contract No. DE-AC02-76CH00016.

TABLE 1

Relative B(E2) values from states of the 0+(β) band in ^{162}Dy.

Transition[a]		Relative B(E2; I_i -> Ig)	
I_i	$I^\pi{}_f$,K	IBA-2	Exp
0+	2+,0	4.2	6.1
	2+,2	100	100
2+	4+,0	>.1	28
	2+,2	35	34
	3+,2	134	110
	4+,2	100	100
4+	6+,0	0.28	0.22
	2+,2	0.0005	0.095
	4+,2	1.6	0.70
	5+,2	4.8	1.2
	2+,0'	100	100

a) The I -> I transitions to the ground band were measured to have multipolarities consistent with pure M1 and have therefore been excluded. The transitions to the γ band have been assumed pure E2.

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