Study of level scheme of ^{87}Zr

P. Banerjee[1],* S. Ganguly[2], H.P. Sharma[3], M. Pradhan[1], S. Chakraborty[3], R. Palit[4], V. Nanal[4], R.G. Pillay[4], S. Saha[4], J. Sethi[4] and S. Chatterjee[1]

[1]*Nuclear Physics Division, Saha Institute of Nuclear Physics, Kolkata -700064, INDIA*
[2]*Deptartment of Physics, Chandernagore College, Hooghly, West Bengal*
[3]*Banaras Hindu University, Varanasi, INDIA*
[4]*Tata Institute of Fundamental Research, Mumbai - 400085, INDIA*
** email: polash.banerjee@saha.ac.in*

Introduction

The Zr nuclei (Z=40) with 43<N<50 show large variations in shape. The nuclei ^{83,84}Zr are reported to have large deformations while those with N closer to 50 have a spherical structure. ^{87}Zr with N=47 lies in the transitional region between the deformed and spherical shapes. Although this nucleus has been studied up to fairly high spin states ($43/2^-$), there is very little information regarding the deformation or the structure of the states. The present work is an attempt to study the structure of the nuclear states in ^{87}Zr.

Experiment

Excited states in ^{87}Zr were populated in the reaction ^{60}Ni+^{31}P at E=112.5 MeV at the BARC-TIFR Pelletron at TIFR, Mumbai using the Indian National Gamma Array (INGA). The detectors were arranged at several forward and backward angles and at 90^o to the beam direction. The target consisted of a 270 μg/cm^2 enriched (>95%) ^{60}Ni deposited on 9.3 mg/cm^2 Au. About 4x10^{10} two and higher-fold γγ-coincidence events were sorted into different matrices for analysis of the data.

Results

The level scheme of ^{87}Zr obtained in the present work is shown in Fig. 1. Thirteen new gamma rays and three new levels have been added to the level scheme. The new levels are the 6713, 8269 and 11404 keV states in the negative parity band. The new transitions are the 442, 498, 539, 740, 741, 1240, 1311, 1400, 1408 and 1427 keV transitions in the negative parity and 749, 1235 and 1566 keV γ-rays in the positive parity band. Besides, all previously gamma rays reported in Ref. [1], including a tentatively placed 1243 keV γ-ray, have been confirmed. Figure 2 shows a representative gated spectrum showing placement of some of the new transitions in the negative parity band.

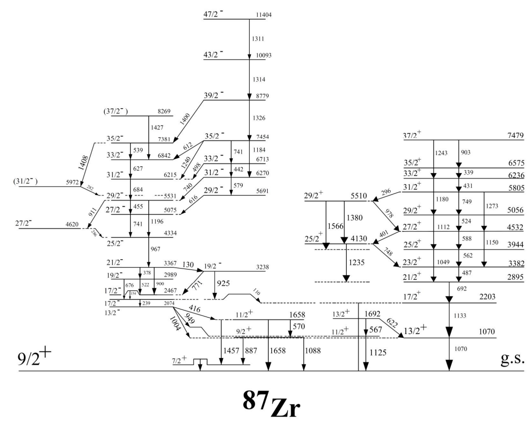

Fig. 1. Level scheme of ^{87}Zr from the present work.

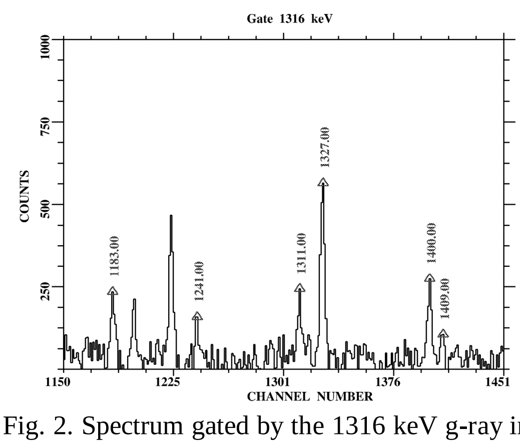

Fig. 2. Spectrum gated by the 1316 keV g-ray in the negative parity band.

The directional correlation (DCO) of γ -rays de-exciting the 2895, 3382, 3944, 4532 and 6236 keV states belonging to the positive parity band were obtained as described in Ref. [2]. All these DCO ratios lead to a negative multipole mixing ratio as shown in Table 1 below. The mixing ratios lie within the range -0.09 to -0.20 indicating small E2 admixtures. However, the negative values do not indicate an oblate deformation in the present case.

E_x (keV)	E_γ (keV)	R_{DCO}	Level lifetime (ps)	B(M1) (μ_0^2)	B(E2) (e^2fm^4)
3382	487	0.34(2)	1.05(23)	0.45 (12)	-
3944	562	0.42(5)	1.41(34)	0.21 (7)	-
	1049				30(8)
4532	588	0.36(5)	1.10(25)	0.16 (5)	-
	1150				83(20)
6236	431	0.45(5)	-	-	-

Level lifetimes have been estimated for three states at 3382, 3944 and 4532 keV using the Doppler shift Attenuation technique. The lifetime data were analysed using the code LINESHAPE [3]. Lifetimes for higher energy states are being estimated at present and would be reported later. The present lifetime results lead to small B(M1) values using the gamma-ray branchings and multipole mixing ratios obtained in this work. Also, the reduced E2 transitions probabilities signify small quadrupole deformations. Even the largest B(E2) value of 83±20 e^2fm^4 (3.6 W.u.), obtained for the 1150 keV transition, indicates lack of collectivity.

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