New precision decay spectroscopic data on the levels of ^{153}Eu

S.Deepa[1*], K. Vijay Sai[1], R. Gowrishankar[1], P.C. Sood[1], S. Kailas[2] and K. Venkataramaniah[1]

[1] Department of Physics, Sri Sathya Sai University, Prasanthinilayam, A.P. - 515134
[2]Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085
*email: deepa@sssu.edu.in

Introduction

It is well known that nuclei in the mass region 150 < A < 190 have a nonspherical equilibrium shape. The properties of such nuclei, of both even and odd mass are predicted and explained with high accuracy by the unified model. The neighboring nuclei outside the above mentioned region are not as well understood. A study of the excited levels of the odd proton nucleus ^{153}Eu is of special interest because of its position just at the edge of strongly deformed nuclei.

^{153}Sm (46.5 h) and ^{153}Gd (240.4 d) both decay to ^{153}Eu, but as the Q-value of the ^{153}Sm decay is larger - 808 keV compared to 484 keV for ^{153}Gd it allows higher excited states to be studied. A great number of investigations have been published on the levels of ^{153}Eu from the decay studies. However, a careful and concentrated look at the weak gamma transitions would throw much light on the new levels which were not observed in the decay studies but have been indicated in the particle transfer reaction studies.

Experiment

As a part of our programme of exploring the weak gamma transitions in the decay spectroscopy to enrich the decay data, precision electron-gamma spectroscopic investigations have been carried out at the Nuclear Physics laboratory of Sri Sathya Sai University. The radioactive sources of ^{153}Sm were produced by irradiation of ^{152}Sm at BARC, Trombay, India. Measurements were performed using a large volume 60 cc HPGe detector coupled to a PC based 8K MCA for the gamma spectra. A Mini Orange electron transporter coupled to LN_2 cooled special Si(Li) (Beta X) of ORTEC make was used for the conversion electron spectra. The details of the Mini-Orange spectrometer have been discussed elsewhere [1]. Gamma spectroscopy software GAMMA VISION and FIT have been used for the analysis of gamma spectra and a modified version of FIT has been used for the electron spectra analysis. GTOL has been used to fit the experimental data into level scheme of ^{153}Eu.

Results

In Table I, the preliminary results on the precise gamma energies, relative gamma intensities, internal conversion coefficients are shown. A total of 37 and 36 gamma transitions have been reported by Schoetzig et al. [2] and Lepy et al. [3] respectively in their beta decay studies. However, in the present study emphasis is on precision and weak transitions. 52 gamma transitions connecting the levels in ^{153}Eu, including a new level at 569 keV, have been identified and fitted into the level scheme using GTOL. A total of 38 conversion coefficients (ICCs) for 22 transitions of which 22 K, 7 L, 7 M and 2 N have been determined with high precision some of which are being reported for the first time. Unambiguous spin-parity assignments have been made for four of the levels for which there have been no assignments in the literature, based on our experimental ICCs and the BRICC theoretical values. Mixing ratios and B(E2) values have been calculated using the present experimental data. The experimental values of the energies of the negative parity levels and the positive parity states are compared with theoretical calculations using IBFM [4]. The comparison shows that the experimental and theoretical values agree very well. IBFM is found to predict the mixing ratios and BE(2) values quite well in agreement with experiment. In the absence of direct feeding from the ground state $3/2^+$ of ^{153}Sm to the 569.31 keV state (if it is $7/2^+$), feedings from the 694.18 keV $5/2^+$ and the 706.40 keV states through 124.94 keV and

Table I: Data on gamma energies, intensities and Internal conversion coefficients.

E_γ (keV)	I_γ	ICC α_i (K, L, M, N)
69.682 *1*	1673 *12*	K 3.81 *26* L 0.885 *56* M 0.169 *6* N 0.0367 *54*
75.412 *26*	81 *8*	K 0.565 *78* L 0.127 *19* M 0.454 *71*
83.363 *6*	68.02 *50*	K 2.444 *75* L 0.909 *85* M 0.251 *24*
89.50 *12*	66 *6*	K 2.06 *21* L 0.463 *49* M 0.114 *15*
96.79 15	2.52 5	K 1.31 20
97.430 *2*	256.2 *18*	K 0.329 *13* L 0.045 *3* M 0.0083 *8*
103.179 *2*	10000 *54*	K 1.44 *4* L 0.254 *6* M 0.055 *3* N 0.0163 *21*
151.647 *16*	3.43 *14*	K 0.0838 *56*
166.23 *8*	0.27 *3*	K 0.278 *39*
172.839 2	26.12 *27*	K 0.304 17 L 0.058 5 M 0.0159 32
424.62 18	0.662 *15*	K 0.034 6
437.09 *13*	0.662 *15*	K 0.031 *6*
463.781 *43*	4.72 *13*	K 0.0326 *4*
521.19 *16*	2.27 *10*	K 0.0158 *25*
531.44 *1*	23.4 *3*	K 0.0148 *14*
533.43 *2*	11.49 *21*	K 0.0112 *9*
539.06 *3*	8.86 *9*	K 0.0132 *11*
545.539 *78*	0.51 *2*	K 0.017 *5*
555.097 *44*	1.502 *39*	K 0.0412 *48*
584.70 *30*	0.42 *2*	K 0.0154 *55*
596.895 *54*	3.662 *62*	K 0.0204 *22*
609.560 *2*	4.59 *21*	K 0.0398 *32*

137.46 keV gammas respectively have been observed. Decay gammas of energies 471.82 keV and 485.94 keV are also observed to decay to 97.43 keV and 83.37 keV states thus confirming the existence of the level at 569.31 keV.

Table II: Data in support of the new level at 569.31 keV and other new gammas.

New gammas E_γ (keV)	I_γ	Initial level (keV)	Final level (keV)
124.94 *30*	0.386 *95*	694.18	569.31
137.46 *13*	0.161 *12*	706.62	569.31
471.82 *23*	0.195 *13*	569.31	97.43
485.939 *47*	0.182 *13*	569.31	83.37
124.115 *61*	0.530 *11*	760.40	636.47
125.62 *21*	0.724 *13*	760.40	634.74

The 166.23 keV transition connecting the 103 keV $3/2^+$ level to the 269 keV level is found to be of E2 character (from our ICC) thus supporting a $7/2^+$ assignment to the 269 keV level. Similarly the conversion coefficients of the 531 keV transition connecting the 103 keV $3/2^+$ level and the 634 keV level with its M1+E2 character supports a $1/2^+$ assignment to this level. The 682, 713 and 719 keV levels have also been unambiguously assigned spin-parities of $5/2^-$, $3/2^+$ and $3/2^+$ respectively.

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