New levels in ^{175}Lu from the beta decay of ^{175}Yb

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Introduction

There has been a renewed interest in the excited states of the rotational nucleus ^{175}Lu. ^{175}Lu has two radioactive parents, ^{175}Yb and ^{175}Hf with Q_β and Q_{EC} 470.1 and 686.8 keV respectively. The decay scheme of ^{175}Yb as given in the latest Nuclear Data Sheets [1] consists of only three excited states upto 396 keV. However, as the ground state spin of ^{175}Yb is $7/2^-$ there is definitely a probability of β feeding to some of the levels in ^{175}Lu reported in the particle transfer reaction studies. Further there has been no precision data on the internal conversion coefficients (ICCs) of most of the transitions. With this objective, as a part of our precision measurements with particular emphasis on weak transitions in the decay spectroscopic studies, a new level scheme of ^{175}Lu from the beta decay of ^{175}Yb is being proposed with new and precision data on level energies, gamma energies, intensities and ICCs.

Experiment

Sources of ^{175}Yb prepared by thermal neutron irradiation of Yb_2O_3 powder at Bhabha Atomic Research Centre, Mumbai, dissolved in HCl solution were obtained. 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 [2]. 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 decay scheme of ^{175}Yb.

Results

Members of the ground state rotational band 7/2[404] up to $11/2^+$ and the band heads and some members of the rotational bands based on 5/2[402], 1/2[541] and 9/2[514] up to an energy of 415 keV (Q = 470 keV) in ^{175}Lu have been observed in the 4.185 day beta decay of ^{175}Yb. More emphasis was laid on locating weak transitions in order to supplement the data from particle transfer reaction studies. **Five new levels** at 343.38, 353.48, 412.39, 414.98 and 432.74 keV are being reported for the first time from the beta decay of ^{175}Yb with strong supporting evidence of inter and intra band transitions and in some cases even their ICCs. A total of fifteen gamma transitions out of which nine are new are being reported with high precision in their energies and intensities. A total of 24 ICCs corresponding to thirteen gamma transitions, out of which twelve of K, six of L and six of M, have been determined very precisely. Fourteen of the twenty four ICCs are being reported for the first time and the remaining ten ICCs are being reported with improved precision as compared to NDS data. The precision of the electron and gamma intensities have been tested with the bench mark method. Normalized Peak to Gamma (NPG) method has been used where the ICC of the normalizing transition (mostly pure) is taken from BRICC [3] values. The new level at 343.38 keV is supported by the 343 keV transition to the $7/2^+$ ground with an M1+E2 character. A 353.35 keV gamma with a α_K = 0.0142(16), E1+M2 character provides evidence for the new level at 353.48 keV. Three transitions of energies 89.64, 318.85 and 433.4 keV connecting the new level at 432.74 keV and the $5/2^+$, $9/2^+$ and $7/2^+$ levels with M1+E2, M1+E2 and M1 multipolarities respectively are in support of a $7/2^+$ assignment for this level. Similarly the 163.25 keV transition between the new 414.98 keV level and the $11/2^+$ level with its E1+M2 character is indicative of a

$9/2^-$ assignment to this new level. An E2 transition of energy 298.78 keV from the new level at 412 keV is used to assign $13/2^+$ character to this new level.

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References

[1] M. S. Basunia, Nuclear Data Sheets **102** (2004) 719
[2] Dwaraka Ranirao, et al. Appl. Radiat. and Isotop. **66** (2008) 377
[3] http://physics.anu.edu.au/nuclear/bricc/

Table 1: Gamma energies and intensities in the beta decay of ^{175}Yb to the levels of ^{175}Lu, in comparison with the latest NDS [1]. Data in the columns 4 and 5 represents the experimental ICCs from the present work in comparison to the theoretical ICC values [3] respectively. The last column gives the unambiguously assigned multipolarities.

E_γ (keV) present	I_γ (NDS)	I_γ (present)		ICC (present)	Theoretical BRICC values		Multi-polarity
113.807 (2)	29.4 (2)	30.53 (21)	K	1.86 (15)	M1 2.12	E2 0.742	M1+E2
			L	0.358 (26)	M1 0.327	E2 0.998	
			M	0.119 (2)	M1 0.0735	E2 0.247	
137.671 (6)	1.79 (12)	1.62 (3)	K	1.04 (9)	M1 1.233	E2 0.461	M1+E2
			L	0.22 (9)	M1 0.19	E2 0.424	
			M	0.055 (1)	M1 0.0427	E2 0.1046	
144.876 (1)	5.11 (5)	5.12 (2)	K	0.143 (10)	E1 0.11	M2 6.49	E1+M2
			L	0.036 (4)	E1 0.01744	M2 1.688	
			M	0.018 (3)	E1 0.00392	M2 0.399	
251.510 (4)	1.31 (19)	1.31 (1)	K	0.090 (1)	M1 0.231	E2 0.0875	E2
			L	0.034 (4)	M1 0.0351	E2 0.0340	
			M	0.0079 (2)	M1 0.00789	E2 0.0082	
282.5250 (3)	46.6 (3)	46.6 (4)	K	0.021 (1)	E1 0.0239	M2 0.67	E1+M2
			L	0.0058 (4)	E1 0.0030	M2 0.137	
			M	0.0023 (4)	E1 0.00067	M2 0.032	
396.3292 (8)	100.0 (15)	100.0 (5)	K	0.0445 (13)	E1 0.00896	M2 0.228	E1+M2
			L	0.0093 (4)	E1 0.00131	M2 0.043	
			M	0.0026 (2)	E1 0.00029	M2 0.0099	

Table 2: New levels and gammas in ^{175}Lu from the beta decay of ^{175}Yb

Level energy (keV)	J^π	E_γ (keV) present	I_γ (present)	ICC (present)	BRICC values	
343.38 (8)	$5/2^+$	343.0 (3)	0.061 (4)	0.106 (14)	M1 0.09979	E2 0.0375
353.48 (13)	$5/2^-$	353.35 (24)	0.149 (8)	0.0142 (16)	E1 0.0117	M2 0.3266
412.39 (7)	$13/2^+$	160.73 (1)	0.013 (1)	-	-	-
		298.78 (3)	0.022 (1)	0.058 (8)	E2 0.05447	M3 1.782
414.98 (18)	$(9/2^-)$	61.7	>2.66 (21)		E2 18.13	M3 1867
		163.25 (1)	0.035 (2)	0.091 (15)	E1 0.0803	M2 4.247
432.74 (8)	$7/2^+$	89.64 (4)	0.16 (1)	3.9 (5)	M1 4.191	E2 1.211
		318.85 (3)	0.019 (1)	0.120 (14)	M1 0.1215	E2 0.0456
		433.4 (2)	0.072 (5)	-	-	-