Gamma and conversion electron measurements in ^{133}Cs

G. V. Sai Manohar[1], Kamal Saurabh Yadav[1], K. Vijay Sai*[1], S. Deepa[2], Dwarakarani Rao[2], R. Gowrishankar and K. Venkataramaniah[1*]

[1]*Department of Physics, Sri Sathya Sai Institute of Higher Learning, Prasanthinilayam 515134*
[2]*Deptartment of Physics, Sri Sathya Sai Institute of Higher Learning, Anantapur*
** email: kvijaysai@sssihl.edu.in*

Introduction

The electron capture decay of the long lived isotope ^{133}Ba is known to populate either directly or through intermediate electromagnetic transitions four excited states in ^{133}Cs. With well separated and comparable relative intensities this isotope has been a source of energy and efficiency calibration standard for both gamma and conversion electron spectrometers. However, the data on the gamma energies and intensities in the literature due to Notea and Gurfinkel [1], Bosh et al [2], Donnelley et al [3] are either using NaI(Tl) or Ge(Li) spectrometers with limited resolutions. Similarly the conversion electron measurements due to Bosh et al [2], Hennecke et al [4] and Avignone et al [5] are also limited by resolution as well as efficiency. With an aim to provide highly precise and accurate data on the gamma as well as internal conversion electron energies and relative intensities for the purposes of energy and efficiency calibration of semiconductor gamma ray detectors and electron spectrometers, we have used our well tested gamma and electron spectrometers that have been established for their best performance conditions.

Experiment

^{133}Ba was obtained from Bhabha Atomic Research Centre, Trombay as $BaC1_2$ in HCl solution. Volatilized sources on 180 μg/cm^2 Mylar were prepared. Insulin was used to define the source area and help in spreading of the source. Measurements were performed using a large volume 60 cc HPGe detector optimized for the detection of weak gamma rays and coupled to a PC based 8K MCA for the gamma spectra. A Mini-Orange electron transporter coupled to a LN_2 cooled Si(Li) detector optimized for the required energy range was used for recording the conversion electron spectra. The details of the electron and gamma spectroscopic systems have been discussed elsewhere. These systems have been proved and used for precision spectroscopic measurements. The details of the electron and gamma spectroscopic systems have been discussed elsewhere. FIT and Gamma Vision have been used for spectral analysis. The relative gamma and conversion electron intensities along with their experimental errors are shown in the Table I where the precision energies of the nine gamma transitions are also presented.

Results and Discussion

The intensities (I_e) of the K, L and M-conversion lines of the gamma transitions relative to the K-conversion line of the intense 356 keV transition were determined. The gamma-ray intensities ($I\gamma$) relative to the 356 keV transition were also obtained from the HPGe spectra. These are listed in Table 1.

Conversion coefficients of the different gamma transitions γ_i and different shells j are given by

$$\alpha_j(\gamma_i) = \frac{N_{e(j)}(\gamma_i)N_\gamma(356)}{N_{e(K)}(356)N_\gamma(i)}\alpha_K(356)$$

where i = 53, 79, 81, 161, 202, 223, 276, 302, and 383 keV and j = K, L and M shells. Using the above prescription, internal conversion coefficients for nine of the transitions have been determined with better precision and accuracy when compared to as available data in Nuclear Data Sheets []. Five L conversion coefficients and three M conversion coefficients are being reported for the first time. Table 2 presents all our experimental data on ICCs of K, L, and M shells for the nine transitions and the corresponding BRICC values for M1 and E2 multipolarities. The

Table 1: Relative gamma and electron intensities in the electron capture decay of ^{133}Ba.

E_γ (keV)	I_γ	I_e
53.238 *3*	3.505 26	K 88.06 *18* L 8.30 *6*
79.771 *29*	4.051 6	K 25.33 *19* L 3.34 *30* M 0.244 *95*
81.079 *1*	52.44 98	K 328.02 *38* L 15.49 *18* M 2.66 *7*
160.616 *3*	0.94 3	K 1.08 *9*
223.185 *5*	0.72 2	K 0.23 *7*
276.366 *1*	11.21 2	K 2.34 *9*
302.813 *1*	29.17 2	K 5.28 *10* L 0.77 *8*
356.003 *1*	100	K 10.00 L 0.32 *2* M 0.118 22
383.844 *2*	14.39 1	K 1.14 *2* L 0.056 *30*

Table 2: Experimental and theoretical conversion coefficients for various γ-transitions in ^{133}Cs.

E_γ (keV)	Experimental ICC	BRICC M1	BRICC E2
53.238	K 5.301 *41* L 0. 499 *5*	4.75 0.6393	6.518
79.771	K 1.32 *1* L 0.174 *16* M 0.0127 *50*	1.473 0.1969 0.004	2.37 1.435 0.3121
81.079	K 1. 32 *2* L 0.0623 *14* M 0.107 *4*	1.406 0.1878 0.0385	2.262 1.333 0.289
160.616	K 0.243 *22*	0.2044	0.2667
223.185	K 0.068 *20*	0.0836	0.0913
276.366	K 0.044 *2*	-	0.0461
302.813	K 0.038 *1* L 0.0056 *6*	0.0373 0.00484	0.0346 0.00607
356.003	K 0.0211 *1* L 0.00068 *3* M 0.00025 *5*	- - -	0.0211 0.00346 0.000721
383.844	K 0.0168 *3* L 0.0083 *4*	- -	0.01684 0.0027

precisely measured gamma energies, intensities and the conversion electron intensities would be of great use in the calibration of semiconductor detectors and electron spectrometers. The precision ICCs of 81, 161 and 223 keV highly retarded transitions would be used to analyze the nuclear structure effects in these transitions to explain the anomalies in their conversion coefficients.

References

[1] A. Notea *et al*., Nucl. Phys. **A107** (1968) 193.
[2] H.E.Bosch *et al*., Nucl. Phys. **A108** (1968) 209.
[3] D.P.Donnelley *et al.*, Phy. Rev. **173** (1968) 1192.
[4] H. J. Hennecke *et al*., Phy. Rev. **159** (1967) 955.
[5] F. T. Avignone *et al*., Phy. Rev. **C1** (1970) 635.
[6] BrIcc v2.2 Conversion Coeff. Online Calculator