

Revisiting the β -decay of ^{139}Ba

L. S. Danu^{1,*}, P. K. Joshi², D. C. Biswas¹, S. Mukhopadhyay¹, A. Goswami³,
P. N. Prashanth¹, L. A. Kinage¹, R. K. Choudhury¹, and Balraj Singh⁴

¹Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, India

²Homi Bhabha Centre for Science Education, TIFR, Mumbai 400085, India

³Radiochemistry Division, Bhabha Atomic Research Centre, Mumbai 400085, India and

⁴Department of Physics and Astronomy, McMaster University, Hamilton, Ontario L8S 4M1, Canada

1. Introduction

Spectroscopy of ^{139}La is important for understanding the collective and the single particle states as it is one of the nuclei with $N = 82$ shell closure [1]. The energy levels of ^{139}La had been investigated either by the EC (electron capture) of ^{139}Ce or by the β -decay of ^{139}Ba [2]. As the Q_{EC} for ^{139}Ce is 270 keV, only the ground and the first excited states in ^{139}La are populated, thus only a limited information can be established from this decay-mode. On the other hand in ^{139}Ba : approximately 99.7% of its β decay populates the ground and the first excited states in ^{139}La , only a small fraction populates the other levels. These facts have been reflected in the scarcity of detailed experimental information on other/higher excited levels of ^{139}La , which has led to certain discrepancies in the previous works [2]. In the present work, the β -decay of ^{139}Ba has been investigated, to obtain information on the energy levels and associated γ -rays of the daughter ^{139}La .

2. Experimental Details

The ^{139}Ba sources were produced by irradiating enriched ^{138}Ba (99%) in the CIRUS and DHRUVA Reactor facilities at BARC, Mumbai. Approximately 40-mg of samples in form of $\text{Ba}(\text{NO}_3)_2$ were irradiated in a thermal neutron flux of $\sim 5 \times 10^{13}$ n/cm²sec. The γ -ray detection system consisted of four Compton suppressed Clover HPGe detectors. All of the four detectors were placed at a distance of 25-cm from the source, and the angular separation between each of the detectors was 36°. Standard NIM modules (including INGA modules) were used for processing the energy and the timing signals. The data acquisition was carried out using the CAMAC based LAMPS software. The master gate for the data acquisition was generated by the 'OR' of the Compton suppressed timing signals from all four Clover detectors. The

TAC signals were also generated and subsequently recorded along with the γ -ray energies.

3. Data analysis and results

The RADWARE software package was used to analyze the data [4]. The γ - γ matrices were built by selecting different regions of the TAC spectrum to estimate the true and the chance coincidence. The energies and relative intensities of the twenty-six γ -ray transitions associated with the β -decay of ^{139}Ba have been measured precisely.

A. Decay-scheme of ^{139}Ba

The decay-scheme for ^{139}Ba , along with the level energies, β -decay feedings to various levels I_β , and the log ft values, obtained in the present work is shown in Fig. 1. The spin-parity assignments, and M1 for 165.85 gamma are from Ref [2]. The γ -rays with energies of 1043 and 1691 keV, which were proposed in the earlier works [2], have been found to be associated with contaminants in our analysis (see Sect. 3 B). These two γ -rays are thus not included in the decay-scheme. For 1894 keV γ -ray we could only report the upper limit, hence this transition is shown by dashed line in Fig. 1.

B. The 1043-and 1691-keV γ -rays

According to the latest ENSDF compilation [2], the 1043 and 1691 transitions are in coincidence with the 166 keV transition. In the present work however; the 1043 and 1691 keV transitions were observed in strong coincidence with other γ -rays in addition to the 166 keV γ -ray (chance coincidence due to the high intensity of the 166 keV transition).

Fig. 2(a) and Fig. 2(b) show gated spectra, with gates on the 1043 and 777 keV transitions, respectively. The coincidence relations, and the relative intensities of the γ -rays in the gated spectra in Fig. 2. clearly indicate that the 1043 keV γ -ray corresponds to the β -decay of ^{82}Br ($T_{1/2} = 35.30$ h) [5]. The spectra gated on the 1691 and 603 keV γ -rays are shown in Fig. 3(a) and Fig. 3 (b). The coincidence relations and the relative intensities of

*Electronic address: lsdanu@barc.gov.in

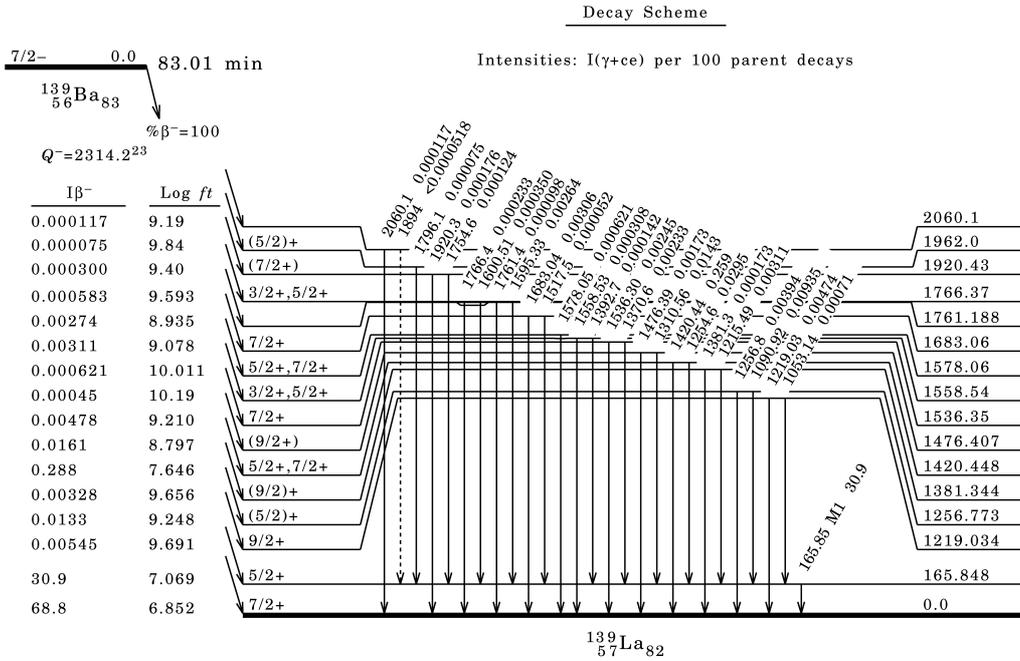


FIG. 1: Decay-scheme of ^{139}Ba from present work. (see Sect. 3 A. for details)

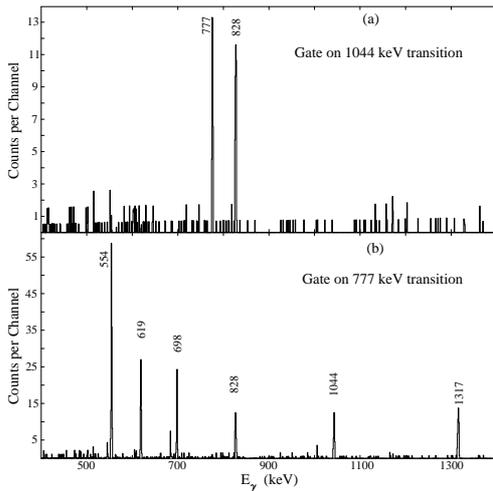


FIG. 2: Coincident spectra, showing a gate on the 1043 and 776 keV γ -transitions.

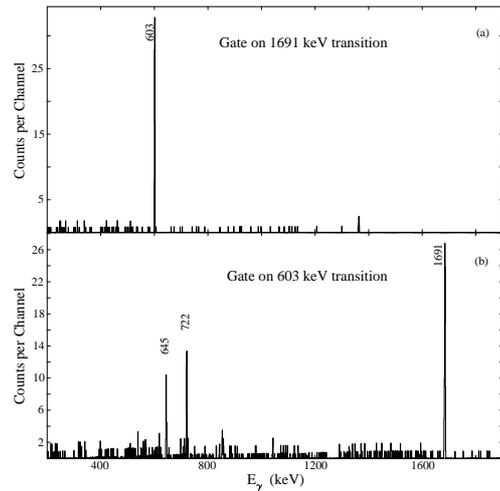


FIG. 3: Coincident spectra, showing a gate on the 603 keV γ -transitions.

the γ -rays in the gated spectra in Fig. 3, corresponds to the β -decay of ^{124}Sb ($T_{1/2} = 60.20$ d) [5].

Acknowledgments

The authors would like to thank CIRUS and DHRUVA reactor staff, IUAC INGA group, Dr. R. Acharya, A. K. Sikdhar, for their support during the experiments. We also acknowledge Dr. A. Chatterjee for his suggestion's in the data analysis.

References

- [1] G. Berzins *et al.*, Nucl. Phys. A **128**, (1969) 294.
- [2] T. W. Burrows, Nucl. Data Sheets **92**, (2001) 623.
- [3] John. C. Hill and M. L. Wiedenbeck, Nucl. Phys. A **119**, (1968) 53.
- [4] <http://radware.phy.ornl.gov/>
- [5] ENSDF database at www.nndc.bnl.gov