LIFETIME MEASUREMENT OF EXCITED STATES IN ^{57}Co

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The levels of ^{57}Co were excited via ^{56}Fe(p, γ) reaction. The DSA technique was employed to deduce the lifetimes of nuclear states. The lifetimes of the levels at 2744 keV, 3109 keV and 3178 keV were measured for the first time and found to be 68^{+30}_{-18} fs, 78^{+17}_{-18} fs and 220^{+50}_{-30} fs respectively.

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1. *Introduction*

The electromagnetic properties of ^{57}Co have been studied by several workers [1–9] ihrough ^{54}Fe(α, p), ^{60}Ni(p, α), ^{56}Fe(p, γ) reactions and β^+ decay of ^{57}Ni. The experimental tnformation has been summarised by Auble [10]. A survey of available literature reveals that the lifetimes of most of the levels above 2.7 MeV have not been reported so far. In the present experiment, therefore, the lifetimes of various levels up to 3178 keV excited via ^{56}Fe(p, γ) reaction have been measured using DSA technique. As a result of present study, we have been able to assign for the first time the lifetimes of the levels at 2744 keV, 3109 keV and 3178 keV. Since lifetimes are very sensitive to the wavefunctions, the present experimental results would prove to be very useful in understanding the nuclear structure of ^{57}Co.

2. *Experiment*

Natural and spectroscopically pure Fe target was bombarded with 3.7 MeV protons from Variable Energy Cyclotron at Chandigarh. The beam current was kept around 1 μA on the target. A single spectrum observed at 90° to the beam direction is shown in Fig. 1. The energy of γ-rays were measured at 90° and 0° using a 50 cm^3 Ge(Li) detector and a multichannel analyser. The energy resolution of the detecting system was

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2 keV for 1332 keV γ-ray. The shift in gain was monitored by observing γ-rays from radioactive sources before and after recording the spectrum at each angle. A further check on the gain shift was made with the help of natural background peaks at 1461 keV and

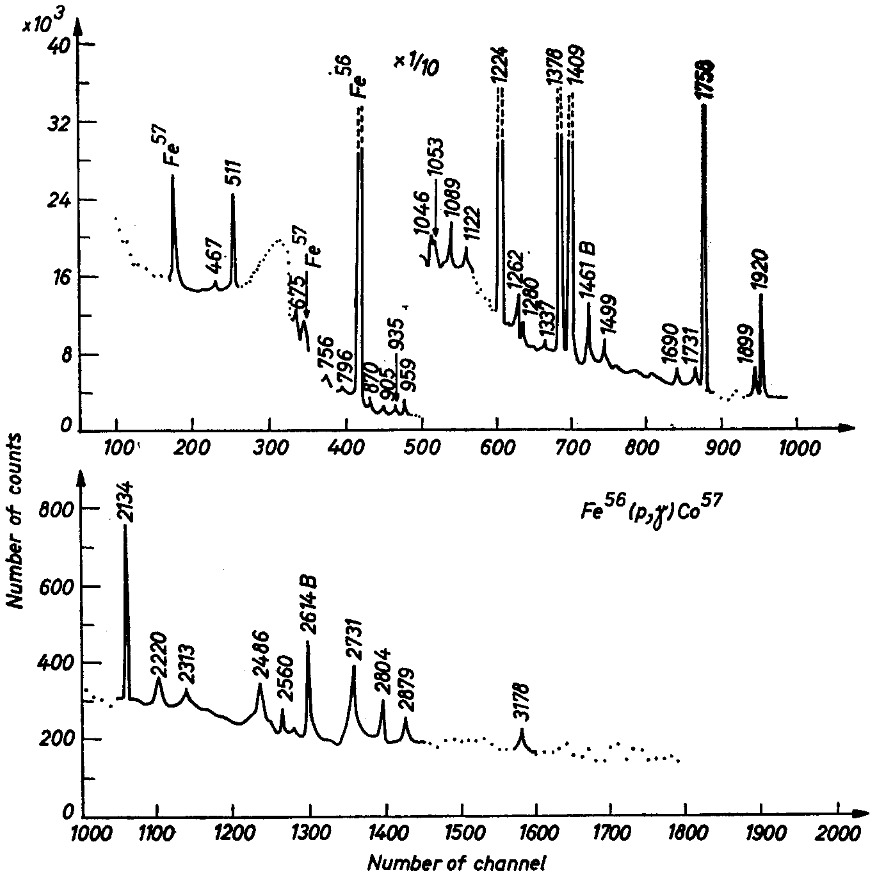

Fig. 1. Gamma ray spectrum of $^{56}Fe(p, \gamma)$ reaction at 90° with respect to the beam direction. The peaks marked with B are due to background. The energies at the peaks are rounded up to 1 keV

2614 keV due to ^{40}K and ^{208}Tl respectively. The computer code SAMPO [11] was used to determine the centroids of photopeaks at 0° and 90°. The radioactive sources ^{56}Co, ^{60}Co and ^{137}Cs were used for energy calibration.

3. *Lifetime measurement*

The energy of γ-ray observed at angle θ from the beam direction emitted from an ensemble of nuclei formed at time $t = 0$ with initial velocity along Z axis (i.e. the beam direction), is given by

$$E_\theta = E_{90}[1 + \beta(0)F(\tau)\cos\theta], \tag{1}$$

where $F(\tau)$ is attenuation factor and $\beta(0)$ is the Z component of the velocity (v/c) of the recoiling nucleus. Since the recoiling nucleus in capture reactions moves in forward direction, $\beta(0)$ is, therefore, just the recoil velocity of centre of mass. The experimental values of $F(\tau)$ for different γ-transitions were calculated with the help of the observed energy shift (E_0-E_{90}) and the equation (1).

Theoretical values of $F(\tau)$ vs τ were obtained from the calculations based on LSS theory [12] of stopping power, taking into account Blaugrund correction [13] for nuclear

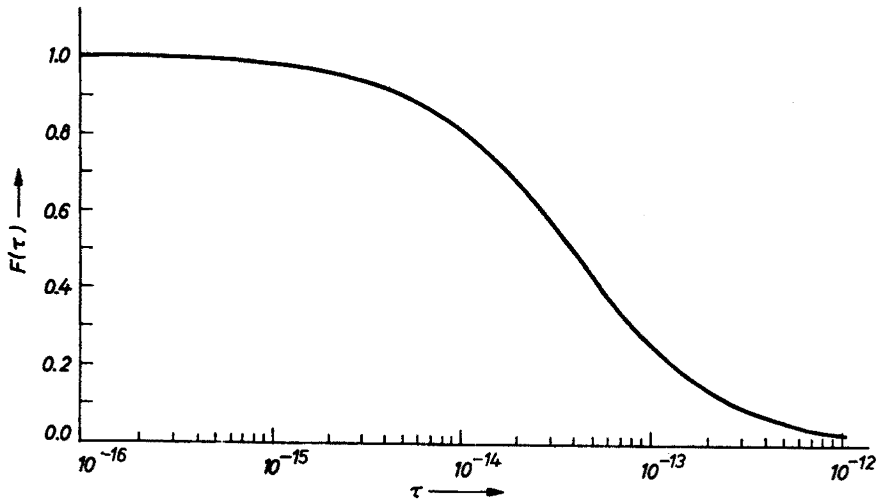

Fig. 2. Theoretical curve of $F(\tau)$ vs τ for ^{57}Co recoiling in ^{56}Fe

TABLE I

Energy and lifetime of the levels in ^{57}Co

E_{level} (keV)	E_γ (keV)	Lifetime (τ) in fs		
		Present	Ref. [1]	Ref. [4]
1223.5	1223.5	78^{+12}_{-10}	75^{+9}_{-11}	84 ± 18
1690.4	1690.4	190^{+30}_{-20}	350 ± 30	260^{+120}_{-90}
1757.7	1757.7	380^{+45}_{-40}	450 ± 50	360 ± 70
1898.5	1898.5	85^{+13}_{-10}	155 ± 15	120 ± 30
1919.7	1919.7	30^{+8}_{-6}	32^{+4}_{-5}	30 ± 20
2133.5	2133.5	400^{+100}_{-40}	585 ± 65	—
2312.5	1089.0	200^{+40}_{-20}	275^{+75}_{-55}	320 ± 90
2486.2	2486.2	98^{+22}_{-18}	81^{+13}_{-11}	36^{+14}_{-11}
2560.3	2560.3	500^{+300}_{-90}	750^{+150}_{-130}	—
2731.0	2731.0	140^{+10}_{-20}	240^{+30}_{-25}	110 ± 30
2743.8	1053.4	68^{+30}_{-18}	—	—
2803.6	2803.6	58^{+12}_{-10}	99^{+21}_{-17}	40 ± 20
2879.3	2879.3	160^{+30}_{-22}	140^{+60}_{-45}	50 ± 20
3108.6	1730.9	78^{+17}_{-18}	—	—
3177.5	3177.5	220^{+50}_{-30}	—	—

scattering. The theoretical curve for $F(\tau)$ vs τ is shown in Fig. 2. The lifetimes of the levels were obtained with the help of this curve and the experimental values of $F(\tau)$. The errors in the lifetimes of the levels given in Table I correspond to the experimental errors in $F(\tau)$, due to uncertainty in the photopeak locations. Since the recoil velocity of ^{57}Co nuclei is very low ($v/c = 0.15\%$), where the nuclear stopping predominates, therefore, an additional error (up to 20%) may be attributed to the results, due to the uncertainty in the nuclear stopping theory.

4. Results

The levels reported in earlier investigations were observed in the present study as shown in Fig. 3. The lifetimes of the levels extracted in present work are summarised in Table I. The lifetimes of the levels at 2744 keV, 3109 keV and 3178 keV are completely new mea-

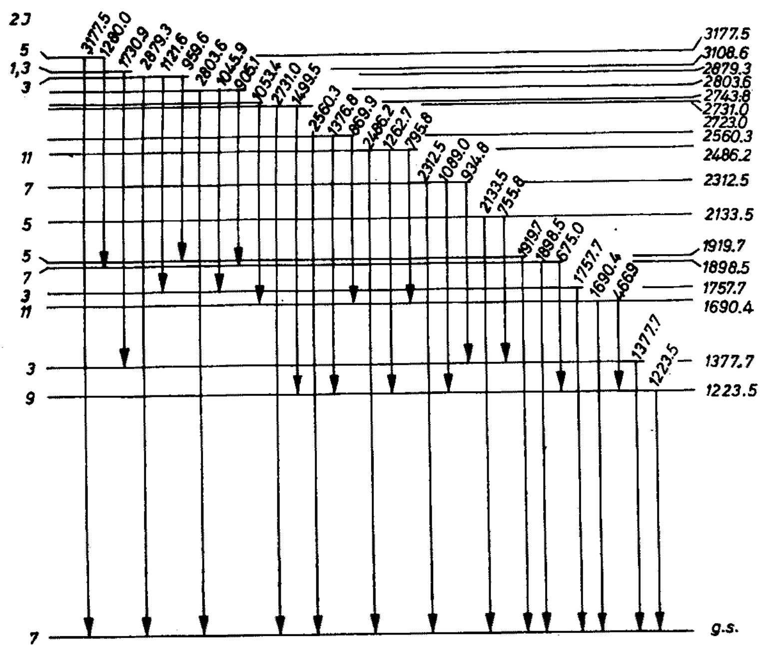

Fig. 3. Level scheme of ^{57}Co

surements. The lifetimes of 1899 keV and 2731 keV states sare more in agreement with the values reported by Burton and McIntyre [4] than with the values of Dayras et al. [1], while the lifetimes of 2486 keV are 2879 keV states are in agreement with the values reported by Dayras et al. [1] and disagree with the values reported by Burton and McIntyre [4].

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Editorial note. This article was proofread by the editors only, not by the authors.

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