Low energy gamma transitions in the decay of ^{75}Se (from ^{75}As excited states)

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Low energy gamma transitions in the decay of ^{75}Se

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Abstract. The gamma spectrum from the decay of ^{75}Se has been studied using Ge(Li) detectors and coincidence techniques. An 81 keV transition has been observed for the first time in the gamma spectrum and, together with a 24 keV transition, has been reliably measured and placed in the decay scheme. Some evidence is found for a previously unreported transition of energy 15 keV, but the present investigation provides no support for the existence of transitions of energy 469 and 822 keV reported in another Ge(Li) study of this decay.

1. Introduction

The main modes of gamma decay of the excited states of ^{75}As populated by electron capture from ^{75}Se have been well established and are supported by studies made with Ge(Li) detectors by Raeside *et al* (1969) and Paradellis and Hontzeas (1969). These authors provide a comprehensive list of references to earlier experimental work. Theoretical level spectra of ^{75}As have been calculated by Scholz and Malik (1968) and by Imanishi *et al* (1969) using Coriolis coupling models.

Coulomb excitation on ^{75}As has been used by Robinson *et al* (1967) and this work suggested several new weak intensity gamma transitions. Pratt (1971) used a Ge(Li) detector to support two of the proposed transitions at 821 keV and 469 keV.

The Ge(Li) detector studies also revealed some evidence for a gamma transition of 24 keV (Paradellis and Hontzeas 1969) but failed to support a transition of energy 81 keV which was observed by internal conversion measurements (Grigoriev and Zolotavin 1960, de Cröes and Bäckström 1960, Jahn *et al* 1968). The present study was undertaken to use the superior energy resolution of a Ge(Li) x ray detector for the measurement of these weak low energy transitions.

2. Singles spectra

The isotope ^{75}Se was obtained from the Radiochemical Centre (Amersham) in the form of sodium selenite in aqueous solution. Two Ge(Li) detectors were used to measure the gamma ray spectra; the x ray detector had a FWHM of 280 eV at 14 keV and the second detector (used above 100 keV) was a true coaxial diode with an efficiency of 4% and a FWHM of 3·0 keV at 1332 keV. The spectra were recorded with a 4096 channel analyser system equipped with a digital stabilizer.

The relative efficiency and energy calibration for the two detectors was made using sources of ^{152}Eu (Notea and Elias 1970), ^{182}Ta (Sapyta *et al* 1969), ^{109}Cd (Donnelly and Wiedenbeck 1968), ^{57}Co (Konijn and Lingeman 1971) and ^{226}Ra (Dzelepow *et al* 1958, Ewan and Tavendale 1964).

The resulting spectra from the two detectors were analysed using the computer program SAMPO (Routti and Prussin 1969) and the relative intensities obtained were normalized to $I_\gamma(265) = 100$. The energies and intensities are given in table 1 and are the mean values obtained from the spectra taken with both detectors.

Table 1. Energies and relative intensities of gamma rays emitted in the decay of ^{75}Se. Data A, Paradellis and Hontzeas (1969); data B, Raeside *et al* (1969); data C, Venugopala Rao *et al* (1966)

Energy (keV)	Intensity (relative to $I_\gamma(265) = 100$)			
Present work	Present work	A	B	C
14·9 ± 0·5	(34 ± 6)10^{-3}			
24·4 ± 0·2	(63 ± 8)10^{-3}	(44 ± 6)10^{-3}		< 1 × 10^{-3}
66·0 ± 0·1	1·50 ± 0·15	1·72 ± 0·04	1·40 ± 0·4	1·64 ± 0·05
80·8 ± 0·1	(11 ± 3)10^{-3}	< 0·1		
96·7 ± 0·1	5·4 ± 0·4	5·12 ± 0·1	4·83 ± 1	5·33 ± 0·16
121·1 ± 0·1	26·7 ± 3·0	27·7 ± 0·5	29·2 ± 3·0	27·8 ± 0·8
135·9 ± 0·1	95·9 ± 7·0	95·0 ± 1·8	96 ± 10	94·9 ± 2·0
198·5 ± 0·1	2·59 ± 0·2	2·38 ± 0·07	2·25 ± 0·2	2·28 ± 0·05
264·6 ± 0·5	100	100	100	100
279·5 ± 0·6	42·1 ± 0·8	42·0 ± 0·8	42·3 ± 4	43·0 ± 0·9
303·9 ± 0·6	2·11 ± 0·3	2·19 ± 0·07	2·06 ± 0·2	2·39 ± 0·05
373·8	< 5 × 10^{-3}	< 6 × 10^{-3}		
400·7 ± 0·6	18·0 ± 0·4	20·4 ± 0·5	19·2 ± 2	22·3 ± 0·5
418·5 ± 0·5	(17 ± 3)10^{-3}	(23 ± 2)10^{-3}	(20 ± 3)10^{-3}	(32 ± 6)10^{-3}
468·8	< 2 × 10^{-3}	(10 ± 5)10^{-3}		
572·1 ± 0·2	(48 ± 5)10^{-3}	(63 ± 2)10^{-3}	(53 ± 8)10^{-3}	(64 ± 1)10^{-3}
617·5 ± 0·5	(59 ± 7)10^{-4}	(75 ± 2)10^{-4}	(76 ± 10)10^{-4}	(78 ± 2)10^{-4}
821·7	< 2 × 10^{-3}			

2.1. Spectra below 100 keV

In addition to the previously well-established gamma ray transitions at 66 keV and 96·7 keV, the spectra show clearly the gamma rays of energy 24·4 keV (figure 1) and 80·8 keV. In the present work particular care was taken to check on the presence of fluorescent x ray photopeaks which appear in the low energy spectra obtained with small volume Ge(Li) detectors (0·1 cm^3 in the present investigation) due to comparable volumes of other materials within the cryostat in close proximity to the detector. These fluorescent photopeaks are typically those of indium and gold used in the detector mounting.

The low energy spectrum in the region of the 24·4 keV gamma ray (figure 1) shows its position relative to that of indium x rays obtained from the decay of ^{113}Sn. The previously undetected 80·8 keV gamma ray also appears in the low energy spectrum clearly resolved from prominent fluorescent lead x rays. In addition, the spectra taken with the x ray detector revealed some evidence for a transition of energy (14·9 ± 0·5) keV with intensity (3·4 ± 0·6)10^{-2} relative to the $I_\gamma(265) = 100$ which was near the borderline of the statistical significance test used but which would fit energetically between the level at 279·5 keV and the level at 264·6 keV.

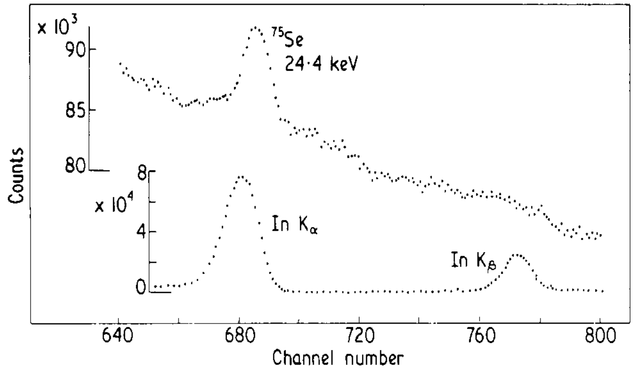

Figure 1. Portion of spectrum taken with the x ray detector showing the 24·4 keV gamma photopeak in relation to the indium fluorescent x rays.

The relative intensities measured for the 81 keV and 15 keV transitions can be used to determine a *B*(E2) value for the 81 keV transition and the *B*(M1) value for the 15 keV transition using the measured data for de-excitation of the 279·5 keV level reported by Robinson *et al* (1967). The *B*(E2) value for the 81 keV transition thus obtained from our data is 10 ± 3 sp units compared with a value of 36 ± 14 sp units deduced by Robinson *et al* (1967) using conversion electron data (Grigoriev and Zolotavin 1960) and assuming a theoretical conversion coefficient.

The *B*(M1) value corresponding to our measured gamma intensity for the 15 keV transition can be deduced using the *B*(E2) value for the 279·6 keV transition and our branching ratio for the 279·6 keV level. Its value of $(0{\cdot}04 \pm 0{\cdot}02)(e\hbar/2Mc)^2$ gives a hindrance factor of 45 ± 23 compared with the single particle estimate.

2.2. Spectra above 100 keV

The spectra taken above 100 keV with the 25 cm^3 detector failed to reveal gamma rays of energy 373 keV (USSR 1966) or 469 keV (Paradellis and Hontzeas 1969, Robinson *et al* 1967, Pratt 1971). Also, it was not possible to detect gamma photons of energies 249 keV, 293 keV, 308 keV, 542 keV and 822 keV seen in Coulomb excitation of ^{75}As (Robinson *et al* 1967). Table 1 includes the maximum intensities of the gamma transitions reported by these previous workers which were not detected in our spectra.

3. Coincidence studies

A gamma–gamma fast–slow coincidence system with a resolving time of 100 ns was used with the two Ge(Li) detectors to confirm the positions in the decay scheme and the relative intensities of the 24 keV and 81 keV gamma transitions. The coincidence spectra are shown in figure 2 and are corrected for chance contributions and for contributions due to Compton events from higher energy gammas falling within the energy gating window. The intensities of the two transitions, deduced from these spectra, are $0{\cdot}06 \pm 0{\cdot}01$ (24 keV) and $0{\cdot}011 \pm 0{\cdot}002$ (81 keV) relative to $I_\gamma(265) = 100$ and are in good agreement with the singles measurements.

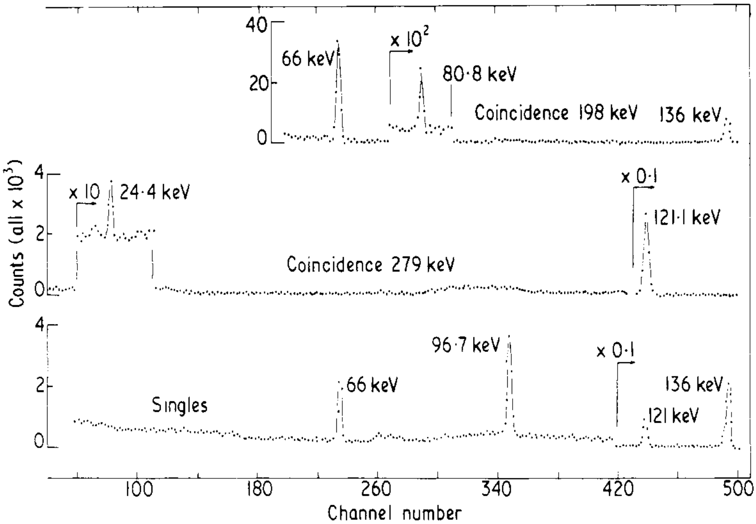

Figure 2. Coincidence spectra with energy gates set on (279·5 ± 5) keV and (198·5 ± 5) keV photopeaks compared with the singles spectrum.

4. Conclusions

A detailed study of the gamma transitions resulting from the decay of ^{75}Se has confirmed the presence of two low energy gamma transitions of 24 keV and 81 keV and has found some evidence for a transition of 15 keV.

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