COULOMB EXCITATION STUDIES IN ^{127}I

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A low energy proton beam has been used to measure the B(E2) values of different levels in ^{127}I via Coulomb excitation process. The de-excitation gamma ray yields were measured with a 50 cm^3 Ge(Li) detector placed at 55° to the incident proton beam. The iodine target was prepared by pressing KI into pellet form. The proton beam of 3.7 MeV energy was used to excite the levels at 202.8, 375.0, 418.0, 629.0 and 745.5 keV in ^{127}I. The measured values of B(E2) for the above levels are compared with the previous measurements available in literature.

1. Introduction

The low lying states of ^{127}I have been extensively studied via radioactive decay [1,2], by inelastic neutron scattering [3,4] and Coulomb excitation studies [5,6]. Ward et al. [5] determined the B(E2) values by Coulomb excitation up to 745.0 keV level using 35-55 MeV ^{16}O beams. They proposed that the gamma-ray of energy 619 keV arises from a new proposed level at 676.5 keV, which was later confirmed to arise from a $\frac{3}{2}^+$ level at 619 keV by inelastic scattering [3] and radioactive decay studies [1,2]. Renwick et al. [6] used 6-11 MeV alpha beam for Coulomb excitation studies in ^{127}I. The 418.0 keV level observed by Ward et al. [5] and in radioactive decay studies could not be observed by Renwick et al. [6]. Also the B(E2) values determined by Renwick et al. [6] differ considerably from those of Ward et al. [5].

Rustgi et al. [7] carried out theoretical calculation for ^{127}I nucleus on the basis of the intermediate coupling version of the Unified Model. Rustgi et al. [7] allowed the odd proton to occupy the $2d_{5/2}$, $1g_{7/2}$ and $2d_{3/2}$ single particle levels and considered up to three quadrupole phonons of vibration of the even core. The energy levels, spins and B(E2) calculated in general, explain the experimental results.

The Coulomb excitation studies reported in this work, were, therefore, undertaken to arrive at more consistent results of reduced E2-transition probabilities. The levels of ^{127}I have been excited with 3.7 MeV protons via Coulomb excitation.

2. Experimental procedure

The experiment was performed at the Variable Energy Cyclotron, Chandigarh. The energy of the proton beam was kept at 3.7 MeV and the beam current was held in range of 100-200 nA to avoid large dead time corrections. A well collimated beam spot of approximately 3 mm diameter was made to fall on a target pellet of hydraulically pressed spectroscopically pure 99.99% KI powder, placed at the centre of a cylindrical target chamber and held with the help of a tantalum holder. The target-to-detector distance was kept equal to 15 cm.

The de-excitation gamma rays of ^{127}I were detected with a 50 cm^3 Ge(Li) detector having an energy resolution of 2.5 keV for the 1332 keV gamma ray of ^{60}Co. For the determination of B(E2) values, the detector was placed at 55° to the beam direction in order to minimize the angular distribution effects. The data were recorded with a ND-100 multichannel analyser.

The absolute photopeak efficiency for the Ge(Li) detector in the energy region 100-1000 keV was determined using a mixed NBS standard containing ^{125}Sb, ^{154}Eu and ^{155}Eu and a standard source of ^{152}Eu. The efficiency was determined to an accuracy of better than 2% over the energy range mentioned above. The measurements for efficiency were made keeping the geometry the same as used in the Coulomb excitation experiment.

3. Results and discussion

The peaks observed in the gamma ray spectra obtained at various incident proton energies were assigned to the transitions from the known levels of ^{127}I (fig. 1) and also to the background. A typical gamma-ray spectrum recorded is shown in fig. 2. The gamma rays of 593.94 and 618.4 keV were hard to analyse because of interference from the Compton edges due to higher energy gamma rays.

The thick target gamma-ray yields measured for various Coulomb excited states of ^{127}I were corrected for detector efficiency, gamma-ray absorption in target

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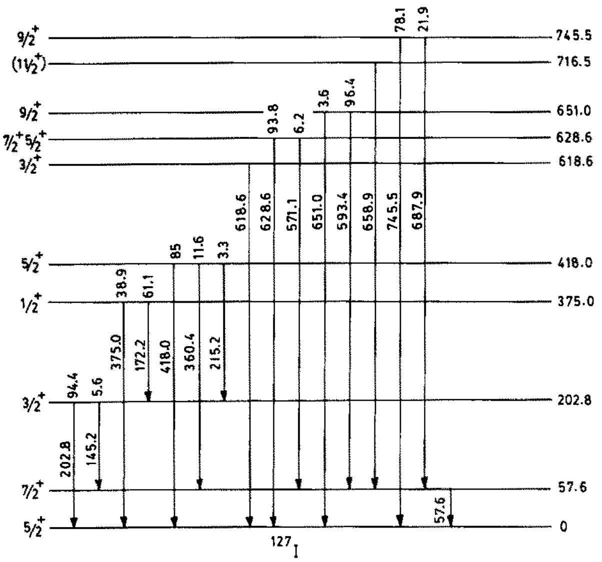

Fig. 1. The level scheme for ^{127}I.

and the target chamber, internal conversion, and cascade transitions feeding the level interest from the higher levels.

The reduced transition probabilities B(E2) were determined from the thick-target gamma-ray yields per incident charge (Y/I) using the following relation given by Alder et al. [8].

$$\frac{Y}{I}=\frac{1.602\times10^{-19}}{fq}\left[\frac{(1+\alpha_{\mathrm{T}})N}{\overline{W}(\theta)\epsilon_{\gamma}}-T_{\mathrm{c}}\right]$$

where, in general, the fractional abundance f of the isotope concerned converts the observed gamma-ray yield to the one from the 100% enriched isotope ($f=1$ for iodine). ϵ_{γ} is the absolute detector efficiency. The factor T_c, which accounts for the population of the concerned level due to feeding through cascade transitions from the higher excited levels, was calculated from the data for each case. The quantity $\overline{W}(\theta)$ takes into account the anisotropy in the gamma-ray angular distribution, and assumes a unity value at 55° to the beam direction.

The values of B(E2) were obtained from gamma-ray yields per incident particle at 55° from the expression.

$$\frac{Y}{I}=\epsilon\mathrm{B(E2)}\uparrow\left[\frac{4.819\times10^{-19}Na}{A}\left\{\frac{A_2}{A_1+A_2}\right\}^2\right.$$
$$\left.\times\frac{A_1}{Z_2^2}\int_0^{E_{\max}}(E-\Delta E')f_{\mathrm{E2}}(\eta_i,\zeta)\frac{\mathrm{d}E}{\mathrm{d}E/\mathrm{d}X}\right]$$
$$\times10^{-4}.$$

The various symbols in the above equation carry the usual meaning as described by Alder et al. [8]. The branching ratios for the various observed transitions from the concerned excited states and corresponding conversion coefficients were obtained from the literature [9,10]. The factors f_{E2} (η_i, ζ) were obtained by interpolations of the values tabulated by Alder et al. [8]. We used Bethe's relation for the stopping power of KI for protons. The calculations of B(E2) were carried out with a DEC 20 computer, evaluating the integral numerically.

The contribution to the observed gamma-ray yields arising owing to compound nucleus formation was computed theoretically using the code CINDY and was

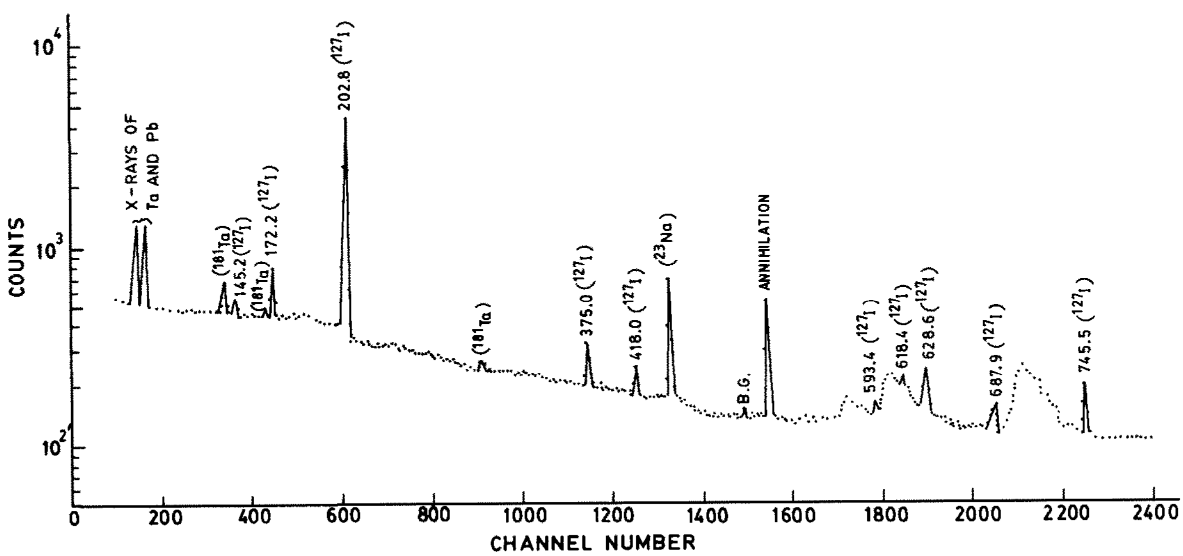

Fig. 2. The spectrum of gamma-rays obtained from a natural KI target bombarded with a 3.7 MeV proton beam.

Table 1
E2 transition probabilities of levels of ^{127}I

Level energy (keV)	B(E2)↑ (e^2 cm^4 $\times 10^{-50}$)			
	j^π	Present	Renwick et al. [6]	Ward et al. [5]
202.8	$\frac{3}{2}^+$	4.9 ± 0.4	4.3 ± 0.5	3.3 ± 0.5
374.9	$\frac{1}{2}^+$	3.7 ± 0.3	2.7 ± 0.3	2.9 ± 0.4
418.0	$\frac{5}{2}^+$	1.1 ± 0.1	-	0.72 ± 0.11
618.4	$\frac{3}{2}^+$	-	0.18 ± 0.04	-
628.6	$\frac{7}{2}^+, \frac{5}{2}^+$	9.0 ± 0.8	8.3 ± 1.2	8.7 ± 1.3
651.0	$\frac{9}{2}^+$	-	2.3 ± 0.3	2.35 ± 0.35
716.5	$(\frac{11}{2}^+)$	-	-	-
745.5	$\frac{9}{2}^+$	12.0 ± 1.1	12.0 ± 1.3	13.5 ± 2.0

found to be less than 1% for $A > 100$ as compared to that owing to Coulomb excitation process [11]. Direct reaction effects at these low energies are known to have negligible contributions and therefore, were not considered. The experimentally determined B(E2) along with the previous measurements are shown in table 1. The B(E2) values for the levels 203, 629 and 745 keV are more close to those of Ward et al. [5] compared to those measured by Renwick et al. [6]. The B(E2) value of 375.0 and 418.0 keV levels are found to be higher than the previous measurements. Transition probability values B(E2) for 651.0 and 618.0 keV levels could not be measured because of the weak gamma ray transitions associated with these levels and the resulting difficulty of measurements because of high Compton background under these peaks.

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