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GAMMA RAYS IN THE DECAY OF ^{141}Nd

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GAMMA RAYS IN THE DECAY OF ^{141}Nd =

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ABSTRACT

The gamma rays in the decay of ^{141}Nd have been studied with scintillation spectrometers and coincidences. Seven lines have been established with energies of 38, 145, 420, 510, 880, 1150 and 1300 Kev. Their relative intensities are 100, 1.7, 0.6, 9.7, 1.2, 2.3 and 1.5 respectively. The line of 38 Kev is due to K-capture in ^{141}Nd and the line of 510 Kev is due to annihilation radiation from the positrons of ^{141}Nd. The remaining five lines are due to levels in ^{141}Pr. A decay scheme is proposed.

1. Introduction

The gamma ray spectrum in the decay of ^{141}Nd does not seem to be well established. Polak et al [1] found lines of 1140 Kev, 1300 Kev, the 38 Kev X-ray from the K-capture in ^{141}Nd, and the 511 Kev

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1. H.L.Polak, W.Schoo, B.L.Schram, R.K.Girgis, and R.van Lieshout, Nuclear Physics 5 (1958) 271.

gamma ray from the annihilation of the positrons from ^{141}Nd. They did not detect the well known gamma ray of 145 Kev from the first excited state in ^{141}Pr. The positrons of ^{141}Nd have been studied only by absorption[2,3] with the results of 0.7 and 0.8 Mev for the maximum energy.

We made a study of the gamma rays in the decay of ^{141}Nd and found three new lines in adition to the lines found by Polak et al[1]. One of these lines seems to be the 145 Kev line from the first excited state in ^{141}Pr.

2. Experimental Method

Our samples were prepared by irradiating natural Nd in the form of Nd_2O_3. The samples were irradiated with gamma rays from the betatron at the University of São Paulo with a maximum energy of 21 Mev and irradiation time of three hours. They were flown immediately to our laboratory where the measurements were carried out. The reaction producing the isotope is $^{142}Nd(\gamma,n)^{141}Nd$.

The amount of Nd_2O_3 taken for each measurement was the optimum amount needed according to the gamma ray to be studied. It was between 1 g and 8 g. It was spread and compressed over an area of 20 cm^2 having a plastic foil on one side and an Al disc 1 mm thick on the other side. This was placed between two NaI(Tl) crystals facing each other and as close as possible to the samples. We used crystals of 1½" diameter by 1" thickness for the softer gamma rays.

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For the harder gamma rays we used one crystal with the same dimensions as above and another of 3" diameter by 3" thickness. Each detector was connected to a single channel pulse height analyzer and there was a circuit to register the coincidences.

The samples showed the gamma rays from the 2.5 hr ^{141}Nd and the gamma rays from the 1.8 hr ^{149}Nd, since this is also formed by the reaction $^{150}Nd(\gamma,n)^{149}Nd$. We found that the lines of ^{141}Nd were strongly enhanced when they were observed in coincidence with the 38 Kev X-ray, and this was the criterion that we used to decide if a line decaying with a half life between 1.8 and 2.5 hr was from ^{141}Nd or ^{149}Nd. This criterion does not apply to the line of 510 Kev. The lines from ^{149}Nd appeared in coincidence with the X-rays because of the secondary X-rays produced in our relatively thick samples.

We found that the decay of ^{141}Nd had gamma rays of 38, 145, 420, 510, 880, 1150 and 1300 Kev. Their relative intensities were 100, 1.7, 0.6, 9.7, 1.2, 2.3, and 1.5 respectively. The errors in the energies are estimated as 1 % and the errors in the intensities are estimated as 20 %. The intensity measurements are corrected for background, efficiency, geometry, absorption, fluorescence yield, etc. The 38 Kev line comes from the X-ray following the K-capture in ^{141}Nd. The 510 Kev line comes from the annihilation radiation of the positrons from ^{141}Nd.

We found that the 1300 Kev gamma ray was not in coincidence with the 145 Kev gamma ray. The 420 Kev gamma ray was in coincidence with the 880 Kev gamma ray.

3. Discussion

It is very probable that the line of 145 Kev that we found comes from the well known first excited state in ^{141}Pr. The coincidence measurements lead us to the decay scheme in Figure 1. The sum of the energies of the cascade gamma rays is equal to the energy of the cross over gamma ray within the experimental error. The order of the gamma rays of 420 Kev and 880 Kev has been established by the intensity measurements; since their intensities are 0.6 and 1.2, the 880 Kev gamma ray must be lower and have 0.6 K-captures going directly to it.

The intensity of the 145 Kev gamma ray is 1.7. If we correct this for the conversion coefficient measured by Zorzoli [4] we get 2.4, which agrees well with the value of 2.3 for the gamma ray of 1150 Kev.

The spin and parity of the ground state of ^{141}Pr has been found from measurements [5] to be $5/2^+$. The spin and parity of the first excited state [6] is probably $7/2^+$. From our data and the decay scheme in Figure 1, the most likely spins and parities for the second and the third excited states are $3/2^+$ and $5/2^+$ respectively.

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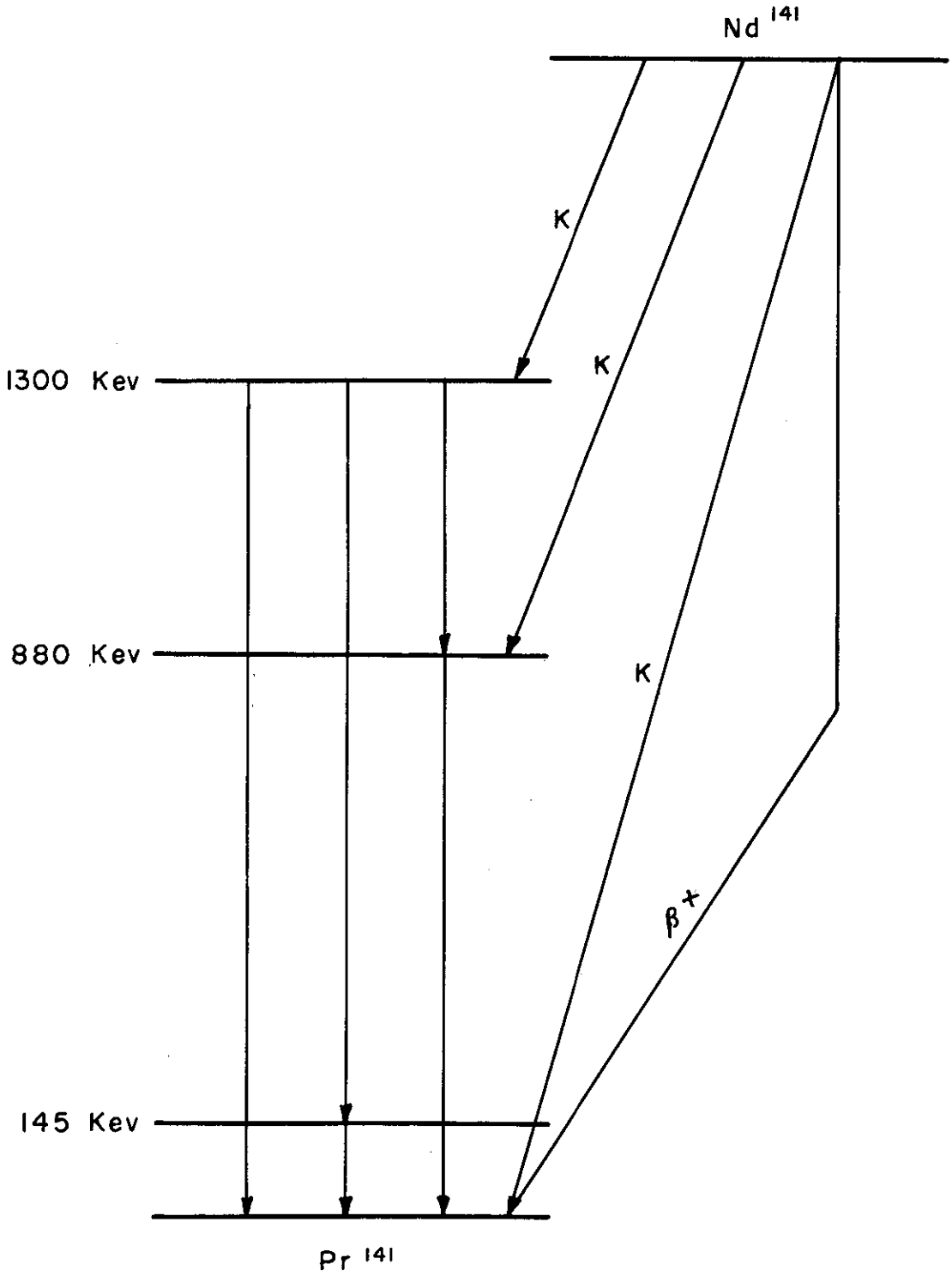

Figure 1
The proposed decay scheme of ^{141}Nd