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SOME NEW FEATURES IN THE DECAY OF ^{142}Pr

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Abstract: The ^{142}Pr → ^{142}Nd decay was investigated, and a new gamma ray at 508 keV was found depopulating a level at 2084 keV. On the basis of energy, intensity and coincidence measurements using a Ge(Li) detector, a new decay scheme is proposed. The new level is probably identical to a 3^- level seen in reaction studies.

E RADIOACTIVITY ^{142}Pr [from ^{141}Pr(n, γ)]; measured E_γ, I_γ, $\gamma\gamma$-coin. ^{142}Nd deduced levels, log *ft*. Natural target.

1. Introduction

The decay of ^{142}Pr to levels in ^{142}Nd has been studied by several investigators [1–4]), but only one gamma transition has been observed. The levels of ^{142}Nd have also been investigated through nuclear reactions [5–8]). Levels at 1970 and 2090 keV have been proposed [9]) which are below the beta Q-value of 2163.2 ± 1.8 keV. As part of a program to investigate the level structure of the $N = 82$ isotones, we have restudied the decay of ^{142}Pr in order to observe gamma de-excitation from the above levels.

2. Source preparation

Several mg of Pr_2O_3 were irradiated in the thermal neutron flux of The University of Michigan Ford Reactor for about 24 h. The praseodymium was chemically separated from all other elements using the procedure of Stevenson and Nervik [10]). The pH of the 1 *M* lactic acid elutant used in the rare-earth separation was 3.8. No interfering activities were observed in sources less than 3 d old.

3. Gamma-ray energies and intensities

The gamma spectrum was observed with a 17 cm^3 coaxial lithium-drifted germanium spectrometer. The resolution (fwhm) for the 662 keV gamma ray of ^{137}Cs was 3.1 keV. A typical gamma spectrum for ^{142}Pr is shown in fig. 1. The peak at about 509 keV is shown in detail in the inset in fig. 1. It consists of a new gamma ray at 508 keV plus annihilation radiation. The intensity of the composite peak was

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monitored for three half-lives in order to unambiguously identify it with ^{142}Pr decay. In spectra of mixed sources of ^{142}Pr and ^{22}Na, a shift of the 509 keV peak to the high-energy side was observed further verifying the composite nature of the peak.

The energies and errors of all gamma rays were determined as in earlier work [11]) using standard gamma rays from ^{7}Be, ^{137}Cs, ^{54}Mn, ^{60}Co and ^{88}Y [ref. [12])]. The

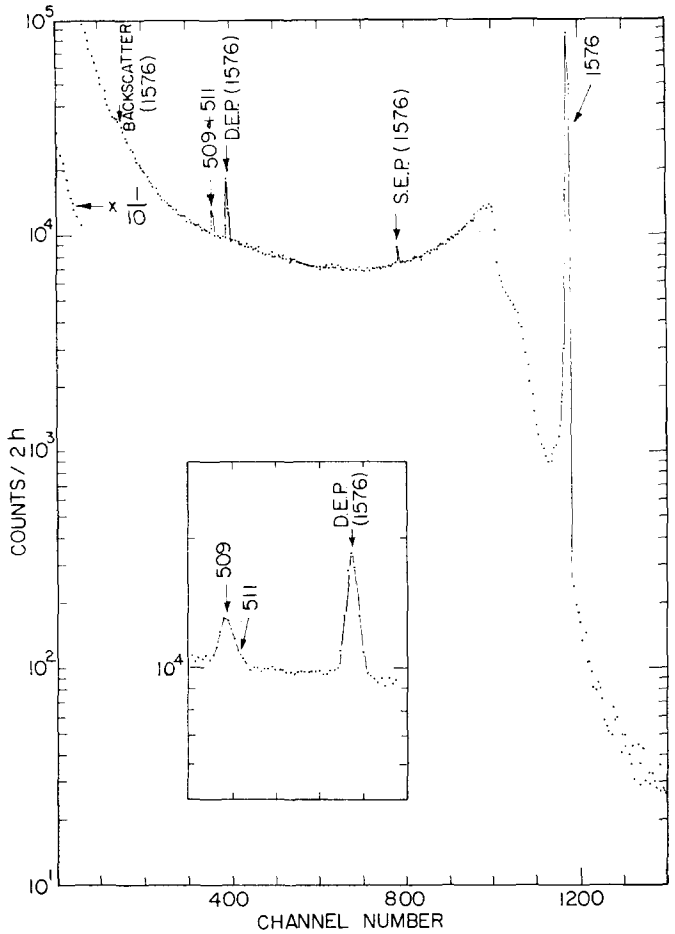

Fig. 1. The pulse-height spectrum of gamma radiation accompanying the decay of ^{142}Pr. The source distance to the 17 cm^3 coaxial Ge(Li) detector was 5 cm. No absorber was used; S.E.P. and D.E.P. represent single and double escape peak, respectively. All energies are in keV.

energy of the gamma ray depopulating the first excited state was determined to be 1575.9 ± 0.2 keV in agreement with the value of 1575.4 ± 0.4 keV measured with the curved-crystal spectrometer at this laboratory by Baer [13]). A value of 508.1 ± 0.8 keV was obtained for the low-energy gamma ray. The large error represents uncertainty in unfolding the 508 and 511 keV gamma rays.

The intensity of the 508 keV gamma ray was found to be 0.67 ± 0.3 relative to an intensity of 100 for the 1576 keV gamma ray. Methods from earlier work [11]) were used. Most of the error resulted from uncertainty in peeling apart the composite peak. A search was made for gamma transitions to the ground state depopulating levels at 1970 and 2084 keV. An upper limit of 0.06 was placed on the intensity of each transition.

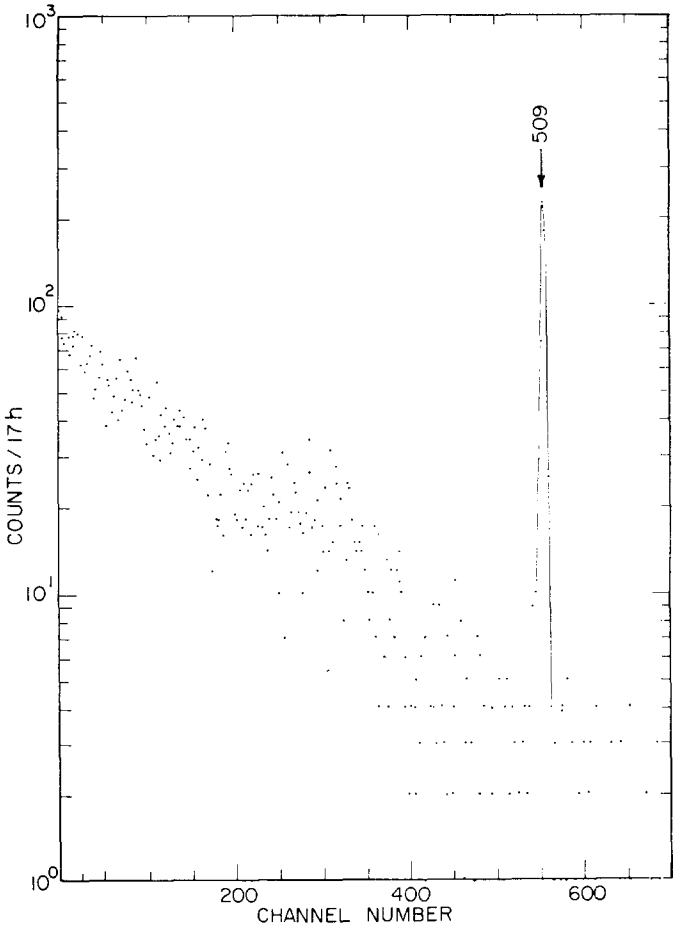

Fig. 2. The pulse-height spectrum of gamma radiation in coincidence with the 1576 keV gamma ray. All energies are in keV.

4. Gamma-gamma coincidence measurements

Gamma-gamma coincidence studies were carried out using a 7.6 cm × 7.6 cm NaI(Tl) detector and the Ge(Li) detector. The coincidence resolving time was about 50 nsec. The spectrum observed in coincidence with the 1576 keV gamma ray is shown in fig. 2. The multi-channel analyser was gated from the NaI spectrometer and

a true-to-chance ratio of 2 was used. The spectrum is corrected only for chance coincidences.

Coincidences were observed only with the 508 keV gamma ray. Comparison with a single spectrum taken under identical conditions proved that the coincidence peak originated from the 508 keV gamma ray and not annihilation radiation. A search was made for gamma rays depopulating a level at 1970 keV. From our coincidence data, an upper limit of 0.05 was placed on decay from the above level to the 1576 keV level.

5. Decay scheme and discussion

The decay scheme based on the results of this investigation is shown in fig. 3. The energy of the first excited state was determined to be 1575.9 ± 0.2 keV in disagreement with the value of 1572 keV recently accepted by the nuclear data group [9]).

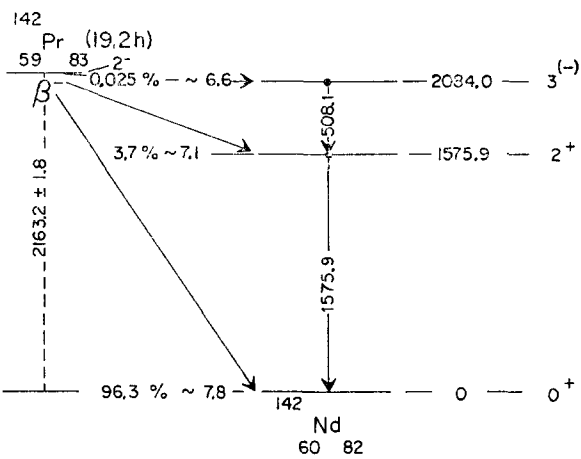

Fig. 3. The decay scheme of ^{142}Pr from the present studies.

A new gamma ray at 508 keV was observed in coincidence with the gamma ray at 1576 keV. We thus propose a new level with an energy of 2084.0 ± 0.9 keV. No evidence was seen for population of a level at 1970 keV observed in (d, d') scattering [7]). The relative intensity of beta rays feeding the ground and first excited states was obtained from the work of Langhoff *et al.* [4]). The log *ft* assignment for the 2084 keV level was calculated from our intensity measurements and found to be 6.6. A lower limit for the log *ft* of beta decay to the 1970 keV level was determined to be 8.8.

The assignment of the 1576 keV level is shown to be 2^+ from Coulomb excitation [8]), and the assignment of the ^{142}Pr ground state is known to be 2^- from a direct spin measurement [14]) and the first-forbidden unique character [2]) of the beta transition feeding the ^{142}Nd ground state. The spin of the 2084 keV level is thus limited to 1, 2 or 3. The absence of a transition from this level to the ground state favors a spin of 3,

and the low log ft value weakly favors a negative parity. Our 2084 keV level is probbably identical to the 3^- level observed in (α, α') [ref. [5])] and (d, d') [ref. [7])] scattering and a level observed by Krehbiel [6]) in the decay of a 16.5 μsec isomeric state in ^{142}Nd. The energy of the gamma ray seen by Krehbiel was 525 keV in comparison with our value of 508 keV. The possibility thus exists that our state at 2084 keV is not the same as the one seen by Krehbiel [6]).

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