The γ-Ray Spectrum Following the β−-Decay of 147Nd

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The still existing discrepancies in the γ-ray spectrum accompanying the β−-decay of 147Nd could be cleared up by careful measurements with high-resolution Ge(Li)-detectors. It could be shown that these discrepancies are caused by radioactive impurities of 148mpm thus excluding several energy levels and γ-ray transitions reported in earlier papers. The experimental level scheme is compared with the predictions of intermediate coupling theory.

Introduction

The level scheme of 147Pm produced after the β−-decay of 147Nd (T\textsubscript{1/2} = 11.1 d) has been investigated by many authors\textsuperscript{1-11} during the past years. By these investigations excited states of 147Pm at 91, 410, 489, 531 and 686 keV have been established step by step. The spin and parity assignments for these levels have been found to be 5/2+, 3/2+, 5/2−, 5/2+ and 5/2+ respectively, while the spins for the ground-states of 147Nd and 147Pm have been directly measured as 5/2− and 7/2+. The negative and positive parity of these two states ensue from shell-model considerations. All the levels mentioned hitherto as well as the appertaining values for spin and parity can be assumed to be sure (see Ref.\textsuperscript{9}).

Moreover, Hill et al.\textsuperscript{6} found γ-ray transitions with 589 and 680 keV. Therefore, they introduced an additional 680 keV level, which decays either directly or via a (589–91) keV cascade to the ground state of

\begin{thebibliography}{9}
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The measurements of Singh et al.\textsuperscript{10} and Canty et al.\textsuperscript{11} also support this result. In some studies\textsuperscript{1-3, 7, 8}, however, there is no hint on the existence of the 680 keV state. Besides, some authors\textsuperscript{3, 9, 10} propose a level at 720 keV, which is depopulated via a (310–410) keV cascade or directly via a 720 keV \( \gamma \)-transition to the ground state of \(^{147}\text{Pm}\), while in other papers\textsuperscript{1, 2, 7} there is no evidence of an energy level at 720 keV. Finally, Singh et al.\textsuperscript{10} found a 300 keV \( \gamma \)-ray emission which because of their investigations should be associated with the decay of \(^{147}\text{Nd}\). This \( \gamma \)-ray transition, however, was not mentioned in all earlier papers.

Because of these discrepancies it was thought worthwhile to re-examine the \( \gamma \)-ray spectrum following the \( \beta^- \)-decay of \(^{147}\text{Nd}\) with high-resolution Ge(Li)-detectors in order to eliminate these conflicting observations.

Experimental Methods and Results

Samples of 1 mg \( \text{Nd}_2\text{O}_3 \) enriched to 97.5\% \(^{146}\text{Nd}\) were irradiated at a neutron flux of \( 9 \cdot 10^{13}/\text{cm}^2\text{s} \) in the FR2 reactor in Karlsruhe. The desired \(^{147}\text{Nd}\)-activity is produced with a cross section of 2 barns when irradiating \(^{146}\text{Nd}\) approximately 1–2 days. In the case of longer neutron irradiation the following process has to be considered:

\[
^{146}\text{Nd} + n \xrightarrow{(2 \text{ barns})} ^{147}\text{Nd} \xrightarrow{\beta^-} ^{147}\text{Pm} + n \xrightarrow{(120 \text{ barns})} ^{148}\text{Pm} \quad \xrightarrow{(110 \text{ barns})} ^{148m}\text{Pm}.
\]

The disturbing activities \(^{148}\text{Pm}\) and \(^{148m}\text{Pm}\) have half-lives of \( T_{1/2} = 5.4 \text{ d} \) and \( T_{1/2} = 42 \text{ d} \) respectively. Indeed most authors took up the measurements a week or more after irradiation in order to avoid interfering radiation of short-lived impurities (\(^{149}\text{Pm}; \ T_{1/2} = 53 \text{ h} \) and \(^{151}\text{Pm}; \ T_{1/2} = 28 \text{ h} \)), but they did not consider possible perturbations resulting from the long-lived nuclides \(^{148}\text{Pm}\) and \(^{148m}\text{Pm}\). It was suspected that the inconsistencies in the \( \gamma \)-ray spectrum of \(^{147}\text{Nd}\) originate in the presence of \(^{148m}\text{Pm}\) in the Nd-sources. To check this suspicion in this work several radioactive sources were used which were produced by irradiating \(^{146}\text{Nd}\)-samples for 1, 2, 14 and 21 days. All \( \gamma \)-spectroscopic measurements on the various sources were carried out with high resolution Ge(Li)-detectors in conjunction with multi-channel analyzers.

The \( \gamma \)-spectrum shown in Fig. 1 is typical of a \(^{147}\text{Nd}\) source which was gained by exposing \(^{146}\text{Nd}\) to a neutron flux of \( 9 \cdot 10^{13}/\text{cm}^2\text{s} \) for 2 days. These measurements were repeated at intervals of 3 days during 6 weeks, with the same source. Neither number and energy of the \( \gamma \)-rays nor the relative intensities of the individual transitions varied