Eur. Phys. J. A **2**, 331–332 (1998)

THE EUROPEAN PHYSICAL JOURNAL A
© Springer-Verlag 1998

Short note

Conversion electron measurements of ^{152}Nd

Y. Toh[1], S. Yamada[2], A. Taniguchi[2], Y. Kawase[2]

[1] Department of Physics, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan
[2] Research Reactor Institute, Kyoto University, Kumatori-cho, Sennan-gun, Osaka 590-0494, Japan

Received: 14 April 1998
Communicated by D. Schwalm

Abstract. Multipolarities of γ-rays in ^{152}Nd have been studied by conversion electron measurements in the β^- decay of ^{152}Pr. The praseodymium activities were obtained by the thermal neutron fission of ^{235}U and followed with the on-line isotope separator KUR–ISOL. Conversion electrons and γ-rays were measured with a Si(Li) detector and a HPGe detector, respectively. The two γ-rays, 226 keV and 285 keV, were decided to have the multipolarities of the E1 transition. The spins and parities of the 1600 keV and 1542 keV levels were determined to be 3^+ and 2^+, respectively.

PACS. 23.20.N Internal conversion and extranuclear effects – 23.20.-g Electromagnetic transitions

It is interesting to study the systematics of the neutron-rich neodymium isotopes because they belong to the transitional region from the spherical to the deformed nuclei at the neutron number $N \simeq 90$. There were not so many studies of neodymium isotopes having the neutron number $N \geq 92$ owing to experimental difficulties. Recent improvements of experimental equipment made it possible to obtain detailed information in this region. Previous studies on this region revealed some band structures and transition rates; ^{152}Nd ($N = 92$) by T. Karlewski *et al.* [1] and M. Hellström *et al.* [2,3]; ^{154}Nd ($N = 94$) by Y. Kawase *et al.* [4] and Y. Toh *et al.* [5]. The present measurement is one of the systematical studies on the neutron-rich nuclei by using KUR–ISOL. By conversion electron measurements, one can determine multipolarities of γ-rays and the obtained information is useful for understanding details of nuclear structures.

The ^{152}Pr activities were prepared by mass separation of fission products produced by the thermal neutron fission of ^{235}U (30 mg, 0.7 mg/cm^2) by using the KUR-ISOL [6]. The fission products were transported with a He + N_2-jet system to a surface-ionization ion source. A small amount of the O_2 gas was added to the He + N_2-jet to improve the ionization efficiencies for rare-earth elements [7,8]. After ionization, the PrO^+ ions were mass-separated by means of a 45° magnetic sector field. The activities of $A = 152$ isobars were collected on an aluminized Mylar tape of the transport system for 6.5 s (the half-life of ^{152}Pr is 3.24 s) and measured for 6.5 s after being transported to a measuring port mounted 20 cm below from the collecting port. The γ-rays and conversion electrons in the daughter decay of ^{152}Nd $\rightarrow$ ^{152}Pm (the half-life of ^{152}Nd is 11.4 m) were reduced by adopting this time sequence. A total counting time was about 40 hours. Conversion electrons and γ-rays were measured with a cooled Si(Li) detector(500 mm^2 $\times$ 3 mm^t) and a HPGe detector(32.5 %), respectively. The energy resolution is 2.4 keV FWHM at 300 keV for the Si(Li) detector and 1.84 keV FWHM at 1332 keV for the HPGe detector. The geometry of the detector system was calibrated on-line, using the γ-rays with known multipolarities in the β^- decay of ^{146}La $\rightarrow$ ^{146}Ce which emits two intense γ-rays of 258 keV (pure E2: $2^+ \rightarrow 0^+$) and 410 keV (pure E2: $4^+ \rightarrow 2^+$) in the ground state band. Furthermore, off-line calibration was also performed using the γ-rays of 121.8 keV, 244.7 keV and 344.3 keV in the decay of ^{152}Eu.

The K, L and M-shell conversion electron lines of the 164 keV γ-ray (pure E2: $4^+ \rightarrow 2^+$), and the K-shell line of the 285 keV γ-ray are shown in Fig.1. The conversion electron line of the 72 keV γ-ray in the ground state band (pure E2: $2^+ \rightarrow 0^+$) is covered with X-rays of ^{152}Nd and ^{152}Pm in the spectrum. There is no visible conversion electron line in the higher energy part. The K line of the 164 keV γ-ray was used for the calibration together with γ-rays of ^{146}La and ^{152}Eu. The theoretical values of E1, E2, M1 and M2 internal conversion coefficients were taken from At. Data Nucl. Data Table [9]. The K conversion coefficients were obtained as follows : $\alpha_K = 1.4(\pm 0.3) \times 10^{-2}$ for the 285 keV γ-ray, $\alpha_K = 2.2(^{+1.0}_{-2.2}) \times 10^{-2}$ for the 226 keV γ-ray and $\alpha_K = 1.7(^{+1.3}_{-1.7}) \times 10^{-2}$ for the 297 keV γ-ray. Although the conversion electron of the 285 keV γ-ray is weak, it was possible to decide the E1 character of the 285 keV γ-ray(see Fig.2). The lines for the 226 keV

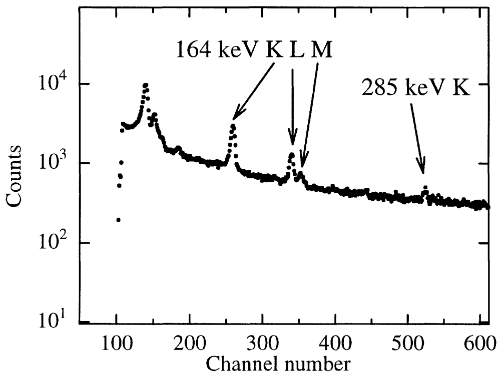

Fig. 1. A part of a conversion electron spectrum in the β^-decay of ^{152}Pr. The K, L and M-shell lines of the 164 keV transition ($4^+ \rightarrow 2^+$) and the K-shell line of 285 keV are seen

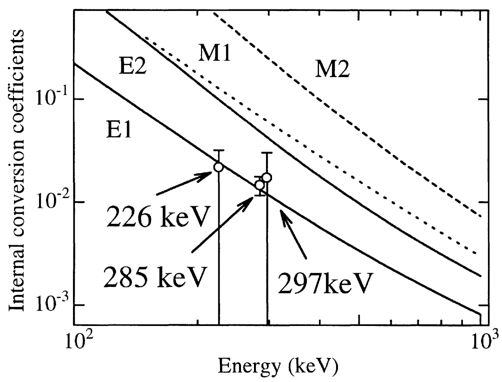

Fig. 2. The internal conversion coefficients of the 226 keV, 285 keV and 297 keV transitions. The values for 226 keV and 297 keV transition are evaluated by the upper limits. The theoretical values are taken from At. Data Nucl. Data Table [9]

and 297 keV γ-rays are not seen in Fig.1, but the upper limits could be deduced from the measured spectrum. The 226 keV γ-ray was decided to be E1 from the upper limit. Though the 297 keV γ-ray is difficult to identify due to a large statistical error, the E1 assignment is most possible. Present results of the E1 assignments are in contradiction to the report that the 226 keV and the 285 keV γ-rays had the M1 character, which was deduced from the intensity ratio of γ-rays and X-rays [2].

The dominant β^- transition in the decay of ^{152}Pr populates the 1827 keV level in ^{152}Nd with a branching of $\geq$ 40% leading to a logft value of $\leq$ 4.6. This transition is interpreted as an allowed unhindered β^- transition (a spin-flip transition), which takes place at the transition between the two Nilsson states $\nu 3/2^-[532\downarrow]$ and the $\pi 5/2^-[532\uparrow]$ in this region. The configuration of 1827 keV level would be the two-quasiparticle state ($\nu 3/2^-[532\downarrow] + \nu 3/2^-[521\uparrow]$) $I^\pi = 3^+$ or ($\nu 3/2^-[532\downarrow] + \nu 3/2^+[651\uparrow]$) $I^\pi = 3^-$ according to the Nilsson diagram. The spin and parity of the ground state of the parent nucleus ^{152}Pr is proposed to be 4^- by M. Hellström *et al.* [3]. The negative parity is expected for the 1827 keV level because the parity dose not change in the case of the allowed unhindered β^- transition. The 226 keV and the 285 keV E1 transitions deexcite from the 1827 keV level to the 1600 keV and 1542 keV levels. Therefore, we propose $I^\pi = 3^+$ and $I^\pi = 2^+$ for the 1600 keV and 1542 keV levels, respectively. Since The 297 keV from 1897 keV level to 1600 keV is also presumably assigned as E1, the level at 1897 keV is expected to be 4^-. These assignments are different from previous results [1–3], in which the spins and parities of the 1600 keV and 1542 keV levels were suggested to be $I^\pi = 3^-$ and $I^\pi = 2^-$, respectively, from the branching of the depopulating γ-rays or the M1 characters of the 226 keV and 285 keV γ-rays.

Since the KUR-ISOL have been improved to provide the intense beam of ^{152}Pr, the better statistic will be obtained for conversion electron, γ - γ coincidences, γ - γ angular correlation measurements. We are providing for the detailed measurements on ^{152}Nd successively. Measurements of ^{154}Nd are also planned to obtain the systematical data of the band structure with different neutron numbers.

We would like to thank Prof. emeritus Kotoyuki Okano for his encouragement.

References

1. T. Karlewski et al., Z. Phys. A**330**, (1988) 55
2. M. Hellström et al., Phys. Rev. C**46**, (1992) 860
3. M. Hellström et al., Phys. Rev. C**47**, (1993) 545
4. Y. Kawase et al., Z. Phys. A**330**, (1988) 231
5. Y. Toh et al., Z. Phys. A**355**, (1996) 345
6. K. Okano et al., Nucl. Instr. and Meth. **186**, (1981) 115
7. Y. Kawase et al., Nucl. Instr. and Meth. B**37/38**, (1989) 116
8. A. Taniguchi et al., Nucl. Instr. and Meth. in Phys Res. A**351**, (1994) 378
9. F. Rösel et al., At. Data Nucl. Data Tables **21**, (1978) 91