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The Directional Correlation of the 496 keV-123.7 keV Gamma-Gamma Cascade in ^{131}Cs

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The directional correlation of the 496 keV-123.7 keV gamma-gamma cascade was measured with NaI(Tl)-Ge(Li) coincidence system and the spin assignment of ½ for the 123.7 keV level was given.

I. Introduction

A neutron deficient cesium nucleus ^{131}Cs exhibits rather complex level scheme and it is quite troublesome to interpret these levels both theoretically and experimentally[1]. The decay scheme of ^{131}Ba proposed by Kelly and Horen[2] is shown in Fig. 1. Bodenstedt *et al.*[3] had saggested spin 1/2 for the 123.7 keV level, and Horen *et al.*[4] assigned spin 3/2 or 5/2 to the 123.7 keV level. Hirose and Hisatake[5] studied gamma-gamma directional correlation

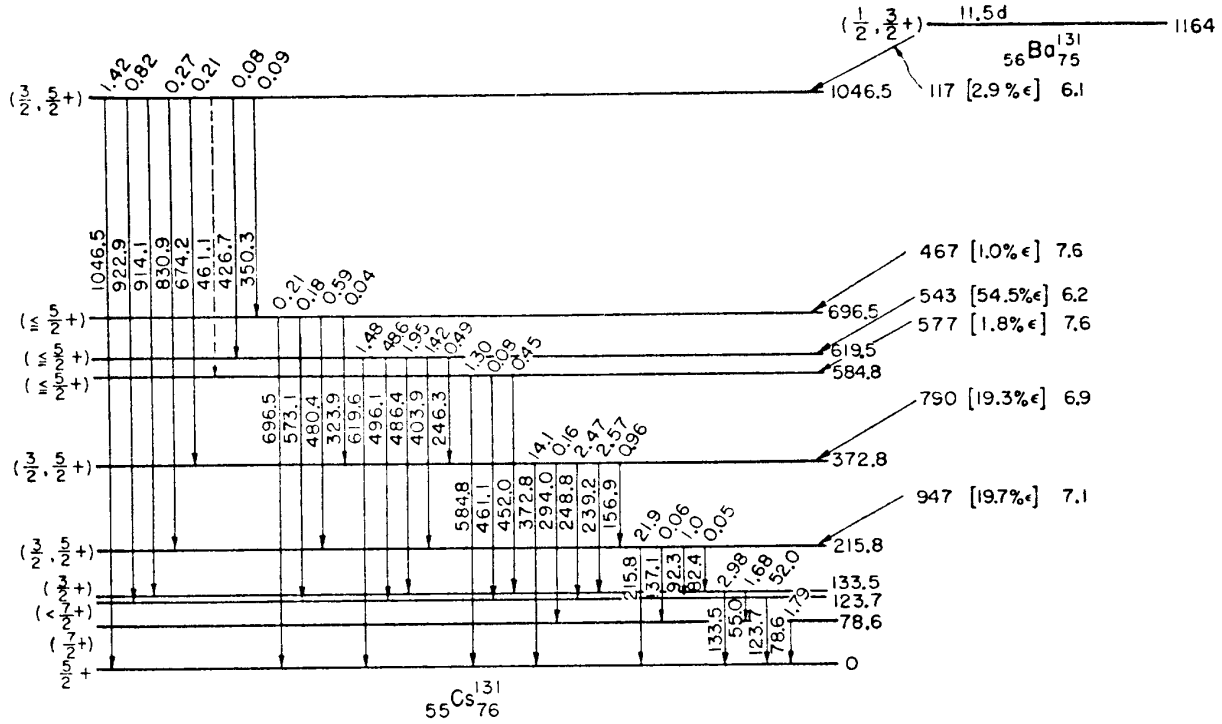

Fig. 1. Decay scheme of ^{131}Ba proposed by Kelly and Horen[2].

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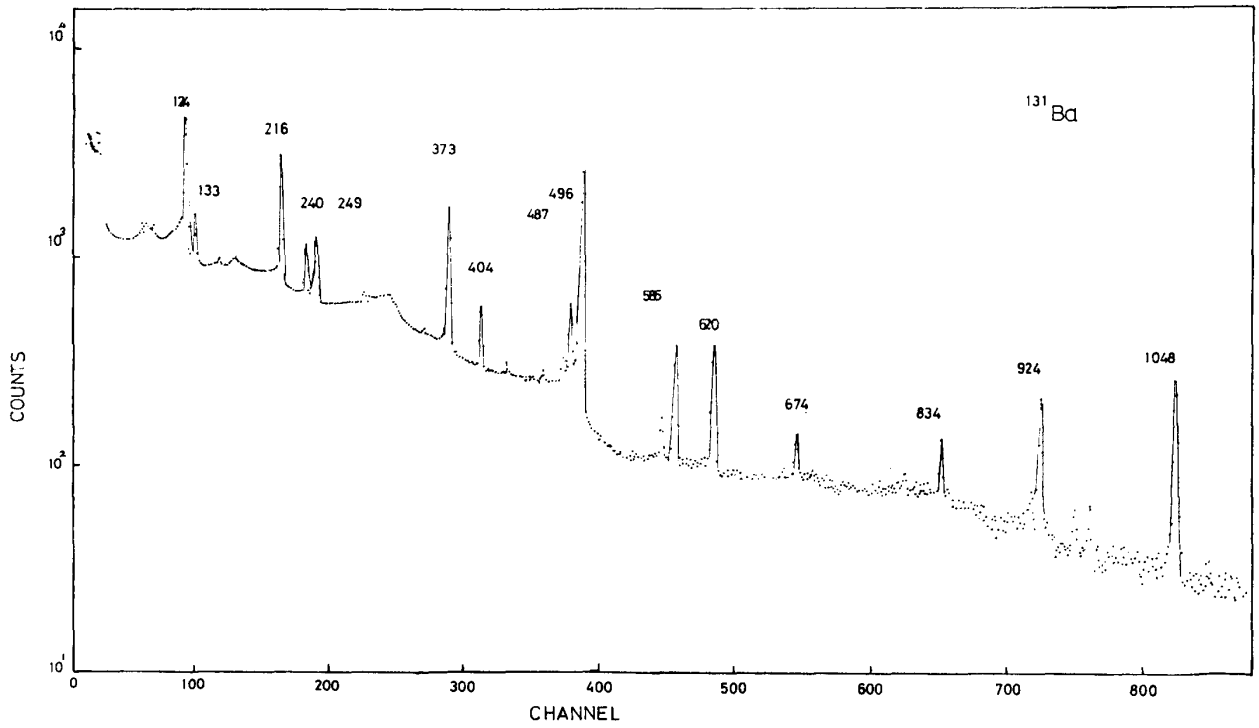

Fig. 2. Gamma-ray specrum of ^{131}Ba measured with a 22 cm^3 Ge(Li) detector.

of the 924 keV-123.7 keV cascade in ^{131}Cs and concluded the possibility of spin assignment of 1/2 for the 123.7 keV level would be probably excluded. Sen *et al.*[6] reported conversion e-γ directional correlation measurements only compatible with spin 5/2 for the 123.7 keV level. Furthermore, Fechner *et al.*[7] performed the 496 keV-123.7 keV angular correlation experiments and assigned unique spin for the 123.7 keV level using a conventional two-detector apparatus which was equiped with a 3.7cmϕ×5.1cm NaI (Tl) crystal and a 3cm^2 ×0.5cm Ge(Li) planar diode.

In this work, we intended to datermine the unique spin assignment for 123.7 keV level in ^{131}Cs.

II. Experimental procedures

1. SOURCE PREPARATION

The ^{131}Ba sources were produced by irradiating samples of barium nitrate (enriched to 48.3% in ^{130}Ba) with neutrons in the Research Reactor of Kyoto University at Kumatori for 80 hours. The power of the reactor was 5 MW and the neutron flux density was 4.65 ×10^{13} n/cm^2·sec. The irradiated samples were disolved into about 0.1 N hydrochloric acid and then the solution was transferred to a cylindrical source container of acryl resin of 2 mm in diameter and 4 mm in height.

2. APPARATUS

Single spectra of gamma-rays were measured with an ORTEC 22 cm^3 coaxial type Ge (Li) detector and coincidence spectra gated by the pulses from a 7.62 cmϕ×7.62 cm NaI (Tl) detector were also taken.

The angular correlations were measured with a fast-slow coincidence system having a resolving time of $2\tau=100$ ns. An RCA 8054 photomultiplier tube mounted with the 7.62 cm $\phi\times$7.62 cm NaI (Tl) crystals and the 22 cm^3 Ge (Li) coaxial diode were used as detectors. The measurements were made for two different sets of angles, (90°, 120°, 150°, 180°) and (90°, 115°, 135°, 165°), by obtaining coincidence spectra of Ge(Li) detector on each quarter division of the display of a 400-channel pulse-height analyzer. The results obtained from individual set of angles were normalized properly. The details of the coincidence system is described elsewhere[8].

III. Results and discussion

A single spectrum of gamma-rays measured with Ge(Li) detector is shown in Fig. 2. As it is seen, 123.7 keV and 133.5 keV peaks as well as 486.4 keV and 496.1 keV peaks are well resolved owing to high resolution of the detector.

A coincidence spectrum gated by the 486.4 keV and 496.1 keV composed peak of NaI (Tl) detector are presented in Fig. 3. From the photo-peak areas of the 123.7 keV gamma-rays, the directional correlation was calculated and shown in Fig. 4. A solid line drawn in

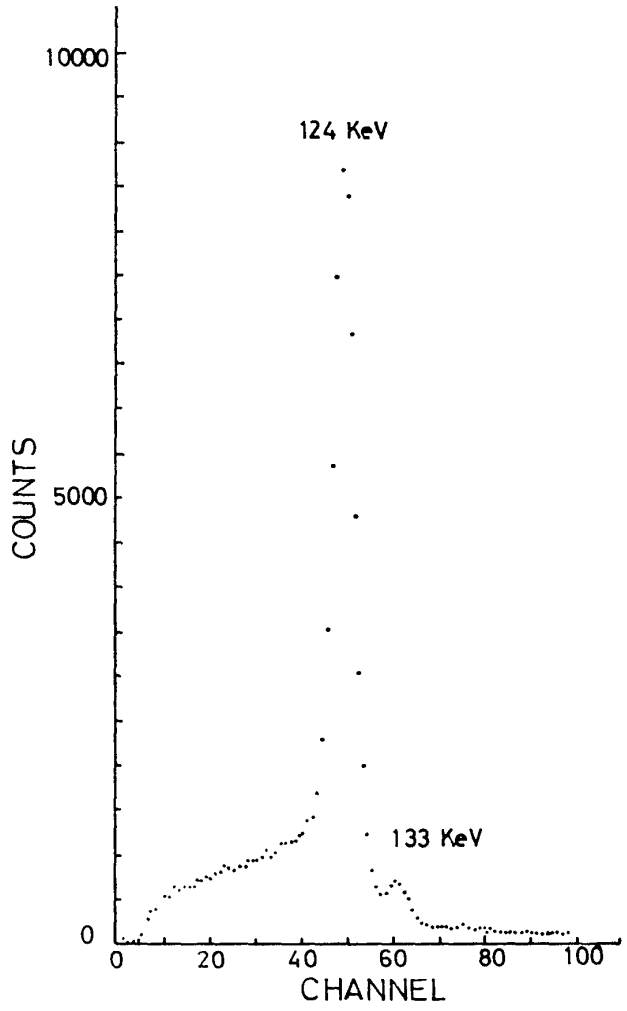

Fig. 3. Gamma-ray spectrum of ^{131}Ba in coincidence with the 486.4 keV and 496.1 keV gamma-rays.

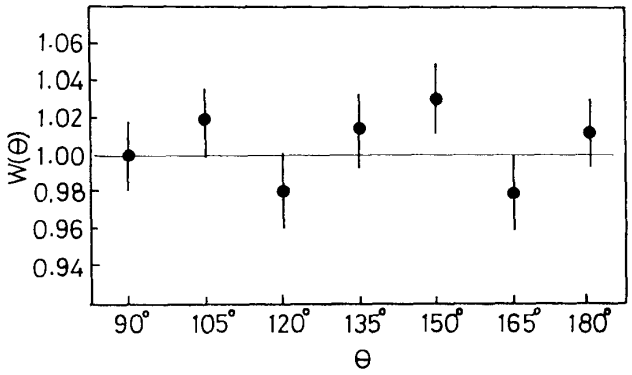

Fig. 4. Directional correlation of the 496 keV–123.7 keV gamma–gamma cascade. The solid line represents the least-squares fit of the experimental data.

the figure represents the least-squares fit of the experimental data. This analysis provids an angular correlation function as

$$W(\theta)=1+(0.004\pm0.011)P_2(\cos\theta)-(0.004\pm0.019)P_4(\cos\theta).$$

The present results are in good agreement with that of Fechner *et al.*[7], and spin assignment of 1/2 for the 123.7 keV level has been confirmed. The spin value of 1/2 for the 123.7 keV level has to rely upon the E2 purity of the 123.7 keV transition which is further stressed by Hasselgren *et al.*[1]. The 404 keV–92keV γ–K directional correlation measurement perfomed by Hasselgren *et al.*[1] also yields spin of 1/2 for the 123.7 keV level. The 1/2 state at 123.7 keV is well accepted as being of collective nature[7),9)] and is interpreted as a 1/2 phonon state predicted by Kisslinger and Sorensen[10].

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