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Short note

Single-step link of the superdeformed band in ^{143}Eu

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Abstract. A discrete γ-ray transition with an energy of 3360.6 keV deexciting the second lowest SD state in ^{143}Eu has been discovered. It carries 3.2 % of the full intensity of the band and feeds into a nearly spherical state which is above the I = 35/2$^{(+)}$, E$_x$=4947 keV level. The exact placement of the single-step link is, however, not established due to the specially complicated level scheme in the region of interest. The energy of the single-step link agrees well with the previously determined two-step links.

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During the last decade superdeformed (SD) shapes in rotating nuclei have been observed in the mass regions $\approx$ 130, 150, 190 [1,2] and 80 [3]. The linking transitions between the SD bands and the normally deformed (ND) states have, however, been harder to identify and have been one of the greatest challenges in the study of superdeformation.

Recently, with modern Ge arrays it has been possible to identify single-step linking transitions and to localize the SD bands in a few nuclei in the mass 130 [4] and 190 [5,6] regions. The situation is, however, more complicated for the ^{143}Eu nucleus. The SD band in this nucleus lies at a higher energy as compared to the mass 130 region and it has a higher spin as compared to the mass 190 region. These facts make the identification of the single-step linking transitions in ^{143}Eu harder than the known cases in the other regions.

One possible way of studying the linking transitions is to assume that a significant fraction of the decay goes via cascades of two γ-ray transitions (two-step link) and to search for the corresponding discrete sums of the two γ-ray energies. In our earlier paper [7] several discrete sum energies were identified in ^{143}Eu and the lowest SD state was proposed to lie at I=(35/2), E$_x$=8582 keV.

In order to further study the linking transitions in this nucleus a large data set was collected using the EUROGAM II array [8] in Strasbourg. Excited states in ^{143}Eu were populated in the reaction ^{110}Pd(^{37}Cl,4n)^{143}Eu with a beam energy of 160 MeV. The ^{110}Pd target was enriched to 98.9% and consisted of three thin foils with a total thickness of 1.1 mg/cm^2. With a trigger requirement of seven or more γ rays in prompt coincidence (before Compton suppression) a total of 1.8×10^9 Compton-suppressed events with an average fold of 4.4 were collected. A much compressed version of the data set was stored on magnetic hard disks for fast access and sorting [9].

The ND level scheme of ^{143}Eu is known from ref. [10,11]. The irregular and very complex structure of the level scheme is typical of a nearly spherical, slightly oblate nucleus. Starting at E$_x$ = 4.2 MeV a sequence of collective states with triaxial deformation is also observed coexisting with the spherical states. The study of the triple and quadruple gated spectra shows that the SD band feeds into the spherical near-yrast states bypassing the triaxial states, which lie about 1 MeV above the yrast states in the feeding region. This result is also in agreement with the recent quasicontinuum study [12] of the SD transitions in this nucleus.

Figure 1a shows the high energy part of a γ-ray spectrum with double gates on the 22 transitions [7] of the SD band in ^{143}Eu. A peak at 3360.6(7) keV is clearly observed at a 5.5 σ level with a FWHM of 10.1 keV. Since this line is in coincidence with the SD band and some of the ND states (see below) we propose that it is a one-step link to a ND state. The intensity of the 3360.6 keV line represents 3.2 % of the total intensity in the SD band and is an order of magnitude smaller than the weakest placed transitions in the ND level scheme [11]. There is also another peak at 2418.9(9) keV which is a candidate for a single-step link (seen only at a 3.3 σ level).

Once a single-step linking transition is observed a big challenge is to localize it in the level scheme. We determined the SD state from which the 3360.6 keV transition deexcites by studying double gated spectra where one gate was set on

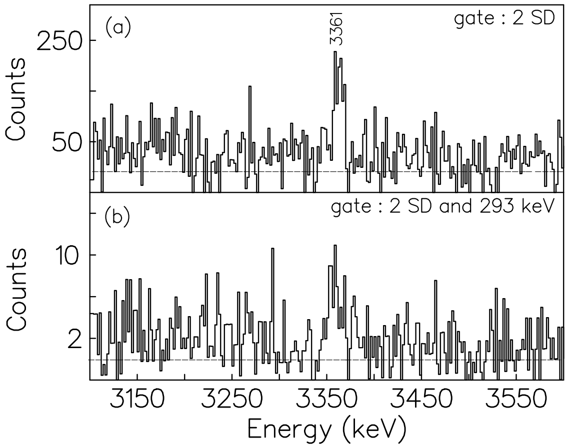

Fig. 1a,b. The high energy part of a γ-ray spectrum (a) coincident with three SD band members. The lower spectrum (b) has two gates on the cleanest SD transitions and a gate on the 293 keV line. A fraction of the total projection is subtracted as background

one of the three lowest transitions in the SD band, namely the 483, 547 or 609 keV transitions and the second gate was set on any of the few clean, higher lying transitions in the band. The result is that the 3360.6 keV transition is seen in the spectra gated by the 609 and 547 keV transitions, whereas it disappears in the spectrum gated by the 483 keV transition. Therefore we propose that the 3360.6 keV linking transition depopulates the SD state just below the 547 keV transition, i.e. the second lowest observed state of the SD band.

Figure 2 shows the low energy part of a triple gated spectrum. It has two gates on the cleanest transitions in the SD band and a gate on the 3360.6 keV high energy line. The 159, 176 and 293 keV transitions are in a cascade in the ND level scheme and the 293 keV transition lies highest in excitation energy. The 3360.6 keV line is also clearly seen in the spectra gated on these lines (see fig. 1b for the 293 keV gate). The 182 keV transition deexcites a $23/2^+$, 2813 keV state and it collects nearly all the intensity coming from above. The intensities of the strongest peaks of fig. 2 were determined and corrected for internal conversion. Normalizing to the strength of the 182 keV transition, the 159 and 176 keV transitions carry 93 % and 92 % of the intensity, respectively, while the intensity of the 293 keV transition is only 38 %. Thus, we conclude that the 3360.6 keV transition does not directly populate the $35/2^{(+)}$, 4947 keV state from which the 293 keV transition decays. It rather populates a higher energy level which partially decays into the 4947 keV level and partially down to the $33/2^+$, 4654 keV level from which the 176 keV transition decays. Above E_x=4947 keV, the level scheme of ^{143}Eu becomes particularly complicated and the decay paths feeding into this state are very branched making it difficult to locate the linking transition. An identification of a few other single-step links would be of great help for reaching more conclusive results.

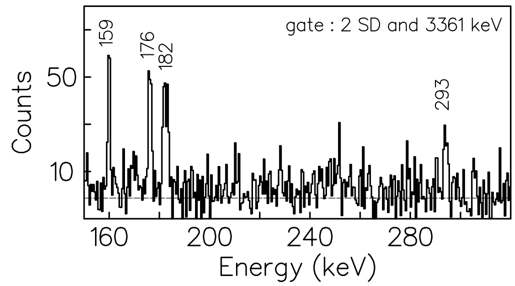

Fig. 2. A triple gated spectrum from which a fraction of the total projection is subtracted as background and it is corrected for the relative detector efficiencies

It is worthwhile to mention that the energy of the single-step link agrees very well with the sum energies identified as two-step links in the previous work [7], where energies between 3187-3925 keV were reported. Furthermore, 4 out of 6 sum peaks reported earlier are observed in this experiment at a 2-4 σ level. Their energies agree within the error limits of 4-5 keV.

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