Eur. Phys. J. A **1**, 237–239 (1998)

**THE EUROPEAN PHYSICAL JOURNAL A**


*Short note*

# Superdeformed triaxial band in $^{167}$Lu

C.X. Yang[1], X.G. Wu[1], H. Zheng[2], X.A. Liu[1], Y.S. Chen[1], C.W. Shen[1], Y.J. Ma[2], J.B. Lu[2], S. Wen[1], G.S. Li[1], S.G. Li[1], G.J. Yuan[1], P.K. Weng[1], Y.Z. Liu[2]

[1] China Institute of Atomic Energy,Beijing 102413, People's Republic of China
[2] Department of physics,Jilin University,Changchun 130023, People's Republic of China

Received: 6 October 1997

Communicated by B. Herskind

**Abstract.** A new rotational band has been observed in $^{167}$Lu by $^{152}$Sm ($^{19}$F,4n)reaction at the HI-13 tandem accelerator of CIAE in Beijing. The high spin transition energies of the new band are almost identical to the triaxial superdeformed bands recently discovered in $^{163}$Lu and $^{165}$Lu. This new band is predicted as a triaxial superdeformed band by total routhian surface calculations.

**PACS.** 21.10.Re Collective levels – 23.20.Lv Gamma transitions and level energies – 27.60.+j 90 $\leq A \leq$ 149

A new approach in superdeformation physics is the discovery of the triaxial superdeformed bands in rare earth nuclei [1–3]. It is interesting to note that the high-spin transition energies of the triaxial SD bands in $^{163}$Lu[1-2] and $^{165}$Lu[3] are almost identical and both of the triaxial SD bands in $^{163}$Lu and $^{165}$Lu are built on $i_{13/2}$ proton [660 1/2] Nilsson state.

The high-spin structure in $^{167}$Lu has been investigated by gamma-gamma coincidence experiments with six com pton suppressed HPGe-BGO spectrom eters and a HPGe planner detector. The nucleus $^{167}$Lu was populated through the $^{152}$Sm($^{19}$F,4n)$^{167}$Lu reaction at beam energies of 85 and 87 Mev with targets consisted of a stack of two self-supported 98.4% enriched $^{152}$Sm foils with a thickness of 1.0 mg/cm$^2$ and a 2.0mg/cm$^2$ 152Sm foil with 10mg/cm$^2$ lead backing respectively. The beam was provided by HI-13 tandem accelerator of China Institute of Atomic Energy, Beijing. A total of 120 million coincidence events was accumulated. Most of the previously known transitions in $^{167}$Lu [4] could be observed in our experiment. A new weakly populated rotational band with seven g-transitions fed into the positive parity bands, 1/2[405] and 5/2[402], has been established. The partial level scheme is shown in Fig. 1. The gated-spectra on the photo peaks of individual transitions for the new rotational band show that all of the transitions in the new band are in coincidence with each other and with most of the transitions which are involved in [402 5/2] and [411 1/2] band. The linking transitions between the new band and the [411 1/2] and [402 5/2] band are found to be the 561,323 and 547 kev. The sum-gate spectrum gated on the transitions of the SD band from 551 to 753 kev is shown in Fig. 2a, from which one can

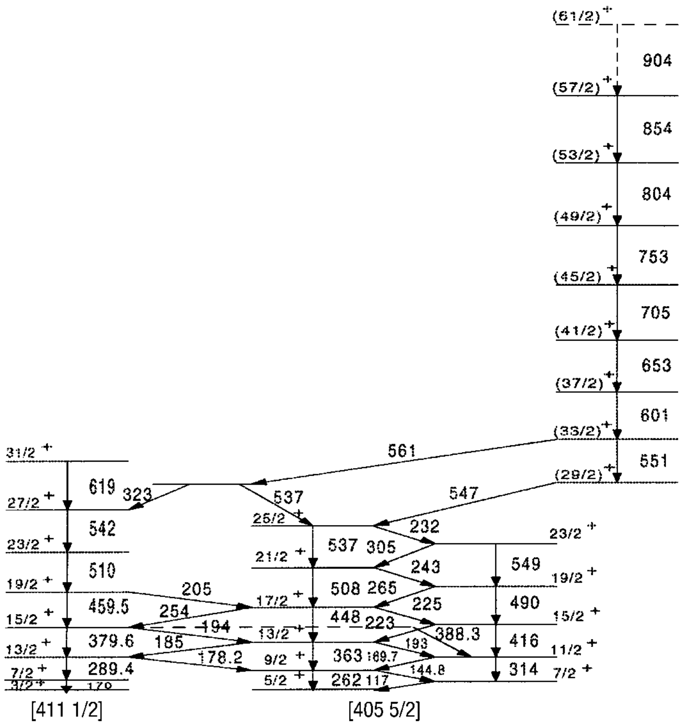


**Fig. 1.** Partial level scheme of $^{167}$Lu

easily find that the low energy transition members, such as 117, 145, 169, 193, 223, 225, 243, 265, ... kev from the [402 5/2] band, are clearly seen and some transitions, such as 289,379 and 459 kev transitions from [411 1/2] band, can also be seen. The transitions of the SD band is shown

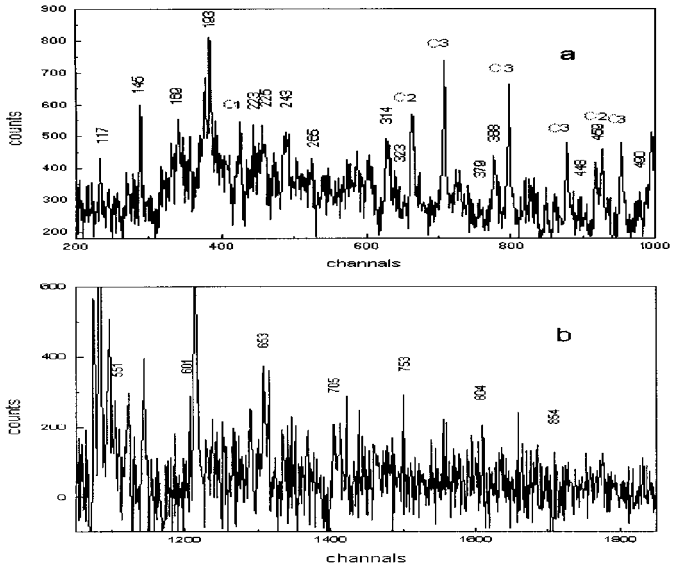


**Fig. 2.** Spectra of g-rays related to the SD band in $^{167}$Lu **a** Sum-gate spectrum gated on transitions of the SD band from 551 to 753 kev. All peaks labelled with transition energy are related to the [411 1/2] and [402 5/2] band. Contamination from [541 1/2], [514 9/2] and [404 7/2] band are marked with c1,c2 and c3 respectively. **b** Same as the spectrum a except that some clean gates from the [411 1/2] and [402 5/2] band are included

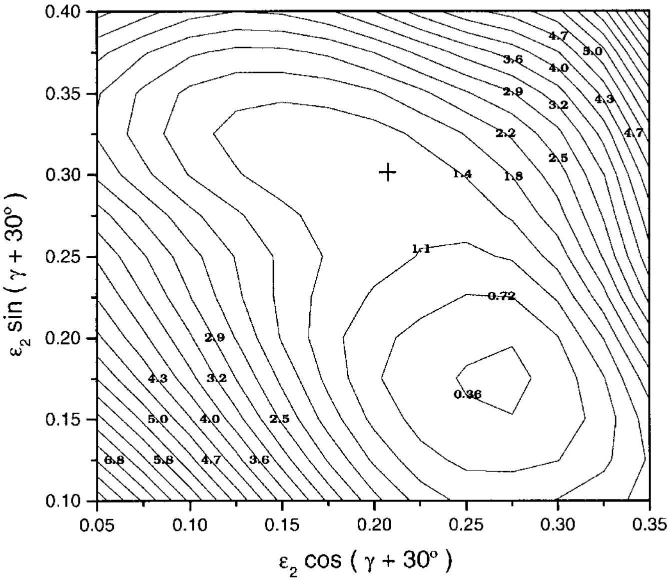


**Fig. 4.** Total routhian surface calculation for $i_{13/2}$ proton [6601/2] configuration of $^{167}$Lu at $\hbar\omega$ = 0.15 Mev, the plus symbol at $\varepsilon_2 \approx 0.36$, $\gamma \approx 26$ ($\varepsilon_4 \approx 0.035$) indicates a local minimum showing a strongly deformed shape with a large triaxial asymmetry

in Fig. 2b. The statistics are very poor, even few clean gate from the two positive bands are included in this part of the spectrum. In comparison with the neighboring isotopes, this newly found weakly populated band in $^{167}$Lu is most likely built on $i_{13/2}$ proton[660 1/2] Nilsson state. Fig. 3 shows that the dynamic moments of inertia deduced from the g transition energies of the new band in $^{167}$Lu are very close to those of the SD bands in $^{163}$Lu and $^{165}$Lu. It indicates that the $^{167}$Lu nucleus with the odd proton based on $i_{13/2}$ [660 1/2] Nilsson state may have similar deformation with the SD bands in $^{163}$Lu and $^{165}$Lu. It is of interest to note that the transition energies of the upper part of the SD band in $^{167}$Lu are almost identical with those in $^{163}$Lu and $^{165}$Lu.

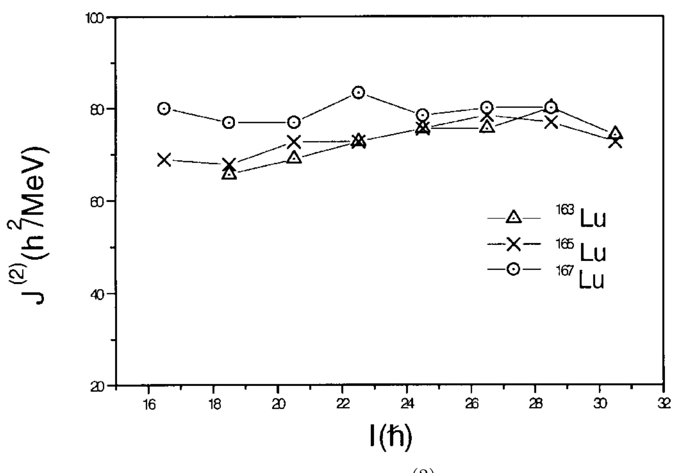


**Fig. 3.** Dynamic moments of inertia $J^{(2)}$ vs. spin I for the $i_{13/2}$ proton [660 1/2] band in $^{163}$Lu, $^{165}$Lu and $^{167}$Lu

A theoretical analysis of the structure of $^{167}$Lu, $^{165}$Lu and $^{163}$Lu is carried out by detailed calculations of total routhian surfaces for the specific proton configuration $i_{13/2}$ [660 1/2] with Nilsson potential. It is found as a general feature that strongly deformed local minima of nonaxial symmetry coexist with a well deformed global minimum. The results are in agreement with total potential energy surface calculations [1] for $^{163}$Lu and $^{165}$Lu, namely the second minima are found at $\varepsilon_2 \approx 0.4$ and $\gamma \approx 18$. The result for $^{167}$Lu is shown in Fig. 4. The plus symbol indicates a much shallow local minimum at $\varepsilon_2 \approx 0.36$ and $\gamma \approx 26$ showing a strongly deformed shape with a large triaxial asymmetry, which probably corresponds to the observed new band in $^{167}$Lu. The hexadecapole deformation parameter $\varepsilon_4 \approx 0.035$ was taken in all calculations, as the same as that in [1].Therefore, the weakly populated new band in $^{167}$Lu is classified as a triaxial superdeformed band. It should be pointed out that the formation of these triaxial local minima is mainly associated with the neutron shell effect and only partly with the driving of the odd proton in the $i_{13/2}$ [660 1/2] orbital.

This work is supported by the National Natural Science Foundation of China, and the Science Foundation of Nuclear Industry of China.

## References

1. H. Schnack-Petersen, R. Bengtsson, R.A. Bark, P. Bosetti, A. Brocksted, L.P. Ekstrom, G.B. Hagemann, B. Herskind, F. Ingebretsen, H.J. Jensen, S. Leoni, A. Nordlund, H. Ryde, P.O. Tjjm and C.X. Yang, Nucl. phys. A **594**, 175 (1995)
2. W. Schmitz, C.X. Yang, H. Hübel, A.P. Burne, R. Musseler, N. Singh, K.H. Maier, A. Kuhnert and R. Wyss, Nucl. Phys. A **539**, 112 (1992)
3. W. Schmitz, H. Hübel, C.X. Yang, G. Baldsiefen, G. Frölingsdorf, D. Metha, R. M¨sseler, M. Neffgen, P. Willsau, J. Gascon, G.B. Hagemann, A. Maj, D. Müller, J. Nyberg, M. Piiparinen, A. Virtanen and R. Wyss, Phys. Lett. B **303**, 230 (1993)
4. C.H. Yu, G.B. Hagemann, J.M. Espino, J.D. Garrett, R. Chapm an, D. Clarke, F. Khazaie, J.C. Lisle, J.N. Mo, M. Bergström, J. Lyttkens and H. Ryde, Nucl. Phys. A **511**, 157 (1990)