SEARCH FOR HYPERDEFORMATION IN U ISOTOPES*

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(Received December 1, 1998)

The ^{232}U nucleus was studied in order to search for a hyperdeformed band built upon the third minimum of the fission barrier. Upper limits for the percentage population of a hypothetical hyperdeformed band relative to the ground state band are given.

PACS numbers: 21.10.–k, 23.20.Lv, 27.90.+b

Actinide nuclei having Z $\simeq$ 92 and N $\simeq$ 142 are predicted to have both super- and hyper-deformed minima lying at excitation energies $\sim$ 3 MeV above the ground state [1]. This arises from the large shell correction energy for this neutron number at 2:1 deformation and for both proton and neutron numbers at 3:1 deformation, superimposed upon a coulomb flattened liquid drop energy. The hyperdeformed minimum ($\beta_2 \simeq 0.85$) is predicted to lie very low in ^{230}U and ^{232}U at 3.3 and 3.0 MeV respectively and has a very asymmetric bi-nuclear configuration, hence a large octupole deformation ($\beta_3 \simeq 0.6$). A number of experiments have been performed on these

* Presented at the XXXIII Zakopane School of Physics, Zakopane, Poland, September 1–9, 1998.

Uranium nuclei [2–5] and evidence has been found for the existence of hyperdeformed states in neighbouring nuclei [6,7].

We performed an experiment using the AFRODITE array at the National Accelerator Centre, Faure, South Africa to search for the existence of a rotational band built on the hyperdeformed minimum in the ^{232}U nucleus using the ^{232}Th (40 MeV α,4n) ^{232}U reaction. The array consisted of eight clover detectors and six segmented LEPs detectors at the time of the experiment resulting in a total granularity of 56 individual detectors, and a maximum absolute efficiency of 12 % at 80 keV. If the hyperdeformed minimum is octupole deformed then the decay sequence will be dominated by E1 transitions with an energy in the range 50 - 150 keV and an energy difference of around 5 keV. These E1 transitions will have small internal conversion for $I \leq 20\,\hbar$, the corresponding E2 transitions being almost totally converted. Due to its high absolute efficiency at 50 - 150 keV the AFRODITE array is ideally suited to study these transitions.

During the experiment a total of 2.5×10^8 triples events was recorded. The data were sorted into a $\gamma\gamma\gamma$ cube. The top part of figure 1 shows the ground state band of ^{232}U brought back from the cube through a sum of double gates on the labelled transitions. In order to search for a hyperdeformed band a sum of double gates on a series of predicted transition energies of the hyperdeformed band was applied to the cube. A large number of these sets of gates were generated by varying the value of the moment of inertia and the cube was gated on each set of transitions. However, no clear evidence for the existence of a hyperdeformed band was seen.

In order to test the sensitivity of the experiment a Monte Carlo simulation was carried out. An assumed hyperdeformed band was populated at a varied fraction η ranging from 0.5 to 5 percent of the ground state (yrast) band population. The resulting gamma cascades were corrected for internal conversion and the spectrometer response was folded in. The background was modelled empirically to reproduce the experimental background in the $\gamma\gamma\gamma$ cube. The bottom panel of figure 1 shows the simulated ground state band brought back using the same set of gates as the experimental band in the top panel. Figure 2 shows four different simulations of the assumed hyperdeformed band with values $\eta = 0.5$, 1, 2, and 5 percent. It is clear that at a population level of $\eta = 0.5$ - 1 percent the experiment is no longer sensitive enough to pick out the signal of the hyperdeformed band from the background. It should be noted that the simulation does not take into account the very real possibility of a decay out of the third minimum by fission. This would reduce the number of gamma-rays detected and thus give an even lower intensity than the simulation.