Measurement of $B(E3)$ moments in octupole nuclei

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The $E3$ moment can be regarded as the most straightforward measure of odd order mass deformations as it is predominantly isoscalar, very collective and in first order independent of quadrupole deformation. Although dynamic charge distortions strictly cannot be distinguished from static deformation, the description of the $E3$ moments connecting the ground state positive parity and lowest negative parity band in ^{226}Ra [1] in terms of a rotating static octupole moment is a very attractive one. In contrast, large fluctuations are observed in ^{148}Nd [2,3] which can be approximately accounted [3] by a model of a one-phonon octupole vibration coupled to the quadrupole ground band. This interpretation is consistent with the behaviour of the energy levels, where the difference in aligned angular momentum, $\Delta i_x = i_x^- - i_x^+$, at the same rotational frequency ω, is equal to zero, as expected, for octupole deformed nuclei in the $Z \approx 88$, $N \approx 134$ mass regions [4,5] and equal to $3\hbar$ in the case of octupole vibrators in the $Z \approx 58$, $N \approx 88$ mass region [6]

This interpretation is derived, however, from the behaviour of the energy levels and except for the case of ^{226}Ra mentioned above has never been verified by direct measurement of $E3$ moments for the octupole radium and thorium nuclei. We propose to measure the $B(E3)$ for the $0^+ \rightarrow 3^-$ transition in several nuclei whose energy level behaviour is consistent with octupole deformation: ^{218,220}Ra and $^{220-224}$Th.

In the proposed experiment the heavy nuclei of interest will be slowed to 5-10 MeV/A, deflected through a small angle, and passed through a Coulex foil of thickness 10 mg/cm^2. The probabilities for population of the 2^+ and 3^- states are typically 10^-3 and 5.10^-6 respectively. The scattered ions are collected in a composite Si-Ge spectrometer (e.g. GREAT) that measures their decay properties. Conversion electrons are detected in the Si implantation detector, or surrounding Si elements; γ-rays are detected in the RISING Ge array surrounding GREAT. The identification is by Recoil Decay Tagging in which the characteristic energy of the α-decay provide a unique fingerprint for the nucleus being investigated. If the implantation detector has 2000 pixels, then the nuclear lifetimes can be as long as 2000/R where R is the total implantation rate. Note that the detectors upstream of the Coulex foil define the incoming trajectory; the outgoing trajectory is determined by the Si pixel definition. Doppler shift corrections can be made to both conversion electrons and γ-rays.

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