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REMARK ON Y4 MOMENTS *

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Qualitative behavior of Y_4 moments arises from simple considerations of aligned wave functions.

Recently there were reported measurements of Y_4 moments of deformed nuclei [1] which showed interesting behavior: positive moments at the beginning of the deformed region going to negative at the end. A simple view, to be described here, indicates how this comes out of detailed calculation, such as was done by the above authors with Harada's technique [2].

The basic principle is that the residual interaction tends to correlate the particles spacially. This can be done most effectively when there are four valence particles, two neutrons and two protons, because of the exclusion principle. The position of this cluster then defines a z-axis in an intrinsic frame, and a set of rotational states can be generated. In the intrinsic frame the cluster will have not only a quadrupole moment but higher moments as well, according to

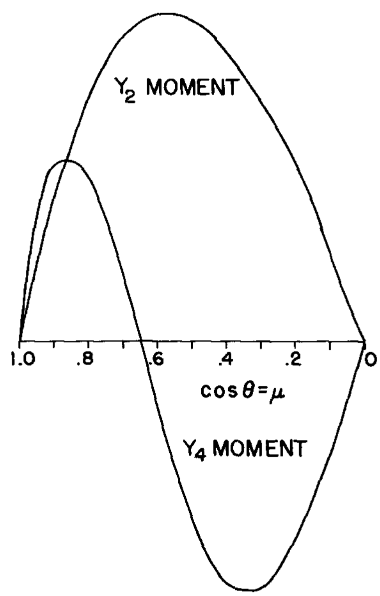

Fig. 1. The intrinsic Y_2 and Y_4 moments of a uniform density covering the polar caps of an aligned nucleus. Density distribution extends from cos θ = 1 to cos θ = $=\mu$.

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$$\rho(\Omega) \approx \delta(\Omega - \hat{z}) = \sum_{L \text{ even}} Y_L^0(\Omega) \cdot \sqrt{\frac{2L+1}{4\pi}}$$

where of course the finite spread in ρ cuts off sufficiently high multipoles.

When filling a major shell, added particles are placed in orbitals as close to the z-axis as possible. Eventually the equatorial orbitals are filled to make a spherically symmetric distribution again with shell closure. Thus the L-th moment of a shell filled to an angle $\cos\theta = \mu$ should go as

$$\int_\mu^1 \mathrm{d}x P_L(x)$$

as shown in the figure.

Harada's method considers, besides the moment of the valence particles, a Y_4 deformation of the core. Microscopic calculation for medium heavy nuclei indicates that a Y_4 moment polarizes the core only $\frac{1}{2}$ - $\frac{3}{4}$ as effectively as Y_2, and higher moments have negligible effect on the core.

We would expect that in very heavy nuclei the Y_4 and higher moments would be more effective with $k_f R$ becoming larger.

A systematic study of Y_4 moments would provide an interesting test of many-particle many-hole wave functions. Wave functions for nuclei such as ^{40}Ar, thought to have particles along an intrinsic z-axis and holes in the median plane, would give a coherence to the E2 moment and an interference to the E4 moment.

For the rare earth region, the above reasoning indicates that the wave functions would be deformed before the onset of rotational spectra at Sm. Thus the nuclei Nd and Ce would have relatively strong Y_4 transition strengths.

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RELATION BETWEEN THE OPTICAL POTENTIAL FOR SPHERICAL AND DEFORMED NUCLEI *

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It is shown that when the contribution of the strong collective states to the optical potential is removed by treating them explicitly through solution of the coupled equations describing the scattering, the resulting optical potential is valid for both spherical and deformed nuclei over a broad mass range in the rare earth region. In a search for the nuclear shape in the deformed region, this has the very important effect of removing the optical parameters from the list of free parameters.

The elastic scattering cross sections of spherical and deformed nuclei are qualitatively different even for such close neighbors as ^{148}Sm (spherical) and ^{154}Sm (deformed). This is illustrated for 50 MeV alpha particles [1] in fig. 1. The slope is steeper and the amplitude of the oscillations smaller for the deformed nuclei. This difference reflects the stronger coupling to the excited states in the deformed nucleus. As a convenient measure of the coupling to the 2^+ state one can use the reduced transition probability B(E2), which is about five times larger for ^{154}Sm than ^{148}Sm. The optical potential that reproduces the elastic scattering accordingly must be, and is, quite different in the two cases. The optical parameters for the elastic scattering are shown in table 1 (first and last lines) and the solid curves in fig. 1 are the corresponding cross sections.

Conceptually, the optical potential was introduced to reduce an infinite-channel problem to a one-channel problem (the usual optical model for elastic scattering) or a few-channel problem

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