The challenge of establishing triaxial shapes in nuclei

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Triaxial shapes in nuclei were first formalized by Alexander Sergeevich Davydov in 1958 [1]. They are also inherent in microscopic SU(3) models (usually as prolate irreps with non-zero mu quantum number), formalised by Phil Elliott also in 1958 [2]. Coupling of an unpaired nucleon to a triaxial rotor core followed soon after, also introduced by Davydov (in 1960) [3].

While many instances of triaxial shapes, inferred from particle-core coupling models, are recognized (there are "far too many" states for simple axially symmetric rotations), there is a lack of consensus regarding triaxial shapes in even-even nuclei. The problem is that the relevant data (low-excitation second 2+ states) can also be interpreted equally well as gamma vibrations. Some progress has been made by use of Kumar-Cline sum rules [4,5], albeit lacking sufficient data for construction of fluctuation widths to resolve the issue of static versus dynamic deformation.

The most serious problem facing the proof of nuclear triaxial shapes is the issue of triaxial rotor versus gamma vibrational model interpretations of even-even nuclei: the lowest $K = 4$ bands do not conform to either model. First, their energies are intermediate between expectations of the two interpretations. Second, while B(E2) data support $K = 4 \rightarrow K = 2$ inter-band collectivity, often the $K = 4$ band structures exhibit strong population in one-nucleon transfer reactions (for an extensive discussion and citation of the relevant literature, see ref. [6]). A possible unified interpretation may reside in work done by Mackintosh in the 1960's [7], namely the manifestation of partial hexadecapole character in the lowest-lying $K = 2$ bands established using inelastic scattering of alpha particles.

A review of the situation will be presented. Suggestions for key experiments in even-even nuclei will be made: besides the manifest role of multi-step Coulomb excitation, inelastic scattering and one-nucleon transfer reaction data will be essential to resolve the current ambiguities. Odd-mass nuclei also need to be studied in more detail, especially at low-medium spin, with organization of the data into the "hyper-band" patterns suggested by Meyer-ter-Vehn in the 1970's [8].

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