Collective Excitations of Deformed Nuclei and Their Coupling to Single Particle States

J. F. Sharpey-Schafer[1]

[1]Physics Department, University of Western Cape,
Belleville, South Africa

Traditionally [1] the collective excitations of deformed even-even nuclei, that give rise to intrinsic band heads within the pairing gap, have been regarded as β ($K^\pi = 0^+$), γ ($K^\pi = 2^+$) and octupole ($K^\pi = 0^-$ to 3^-) vibrations. However the properties of the lowest excited 0_2^+ states in deformed nuclei do not generally have the properties of a β vibration [2]. The low-lying 0_2^+ states in transitional rare earth nuclei have been shown [3, 4] to be $2p - 2h$, or $4qp$, neutron states involving the [505]11/2$^-$ Nilsson orbit extruded by the deformation to the Fermi surface from the filled $h_{11/2}$ shell. This is demonstrated by the blocking of the coupling of [505]11/2$^-$ neutrons in odd-A nuclei to their core 0_2^+ states in N=88 and N=90 nuclei [4].

This experimental observation leaves γ and octupole vibrations as the remaining collective states within the pairing gap. It demonstrates that nuclei, in general, are stiff to $K^\pi = 0^+$ vibrations along the symmetry axis, even in transitional regions where the nuclear shape is changing rapidly. It also demonstrates the futility of expecting non-microscopic theories to be able to describe 0_2^+ states if the effects of Pauli blocking cannot be included in the models.

In this presentation we will review the experimental data on $K^\pi = 2^+$ "γ-bands" in deformed nuclei, built both on alignments in even-even nuclei and coupling to single particles in odd-A nuclei.

References

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