The Competition between the Shears Mechanism and Core Rotation in a Classical Particles-plus-Rotor Model

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The shears mechanism represents a basically different way to generate angular momentum than the rotation of a core, and in general we will expect an interplay between these two modes. It is then important to establish when and how each of these mechanisms will dominate.

In a previous work[1] we presented evidence that the rotational-like behavior can be interpreted as a consequence of an effective interaction of the form $V_2P_2(\theta)$, between the proton and the neutron blades. To study the competition with the core we consider a term representing its rotational energy

$$E(I) = \frac{\vec{R}^2}{2\Im} + V_2P_2(\theta) \qquad (1)$$

This expression for the total energy looks like the familiar Hamiltonian of the Particle-plus-Rotor Model that we solve in the classical limit by the requirement that at each spin the shears angle minimizes the energy. It is convenient to introduce the dimensionless parameter $\chi = \Im/(j^2/3V_2) = \Im/\mathcal{J}$ that relates the moment of inertia of the core ($\Im$) to the effective moment of inertia of the shears ($\mathcal{J}$) , or in other words, $\chi = E_{2^+}(shears)/E_{2^+}(core)$ the ratio of the energies of an effective 2^+ of the shears to the 2^+ of the core. The minimization condition $(\frac{\partial \hat{E}}{\partial \theta})_{\hat{I}} = 0$ determines the function $\theta(\hat{I}, \chi)$ that gives the shears angle at each $\hat{I}$ for a given χ. From the shears angle it is possible to calculate the core contribution to the total angular momentum. In an effort to present our results in a concise way we introduce a "phase diagram" between shears and core. By characterizing the two phases in terms of their contributions to the **total change** in angular momentum, $\Delta I = \Delta R(core) + \Delta j(shears)$, we can define the transition point when each of the contributions is 50% . This "phase diagram" is shown in the Fig. where the shaded region corresponds to a dominant shears mechanism. When χ is small the system prefers to generate angular momentum by the shears and the transition to core rotation occurs once the spins from the blades is exhausted. As the value of χ increases it is more economical to follow the rotation of the core while the shears contribute less and less to the generation of angular momentum. The transition occurs much earlier than the spin at which the blades close. Qualitatively, we propose to associate a quenching of the shears mechanism when, already at the bandhead ($\sqrt{2}j$), the contribution from the core is more than 50%. This happens at $\chi \sim 0.5$ and using estimates from the Pb region, we have $E_{2^+}(shears) \sim 150\ keV$ requiring $E_{2^+}(core) > 300\ keV$ and a deformation of the core $\epsilon < 0.12$, in good agreement with the experimental observations.

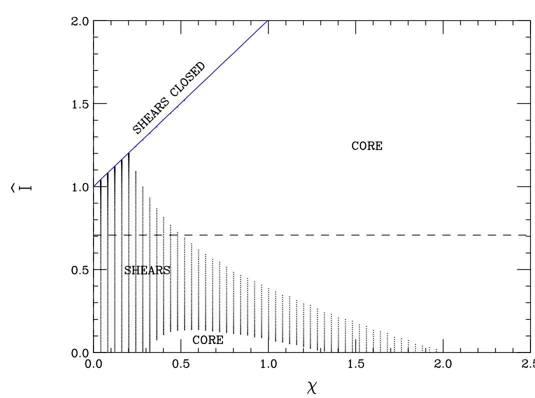

Figure 1: "Phase diagram" between shears and core. The dashed line is the bandhead spin.

References

[1] A.O.Macchiavelli et al., *Phys. Rev.* **C57** R1073 (1998), and *Phys. Rev.* **C58** R621 (1998).