Universal, exclusive role of seniority and shape coexistence at closed shells

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A leading issue in the study of the nuclear many-body problem is establishing concise, unified schemes of organization for excited states.

The structure of closed-shell nuclei has passed through a number of stages of evolution.

The first principle of organization was due to Maria Goeppert Mayer who recognized [1] that an even number of nucleons couple to angular momentum zero. This feature became formalized with the introduction of a short-ranged pairing force with both diagonal and off-diagonal matrix elements, resulting in Cooper pairs [2]. This led to the quasispin scheme [3], which incorporated the seniority quantum number. This has reached its epitome in the manifestation of high-j seniority structures and the description of B(E2) values expressed in closed algebraic form based on the quasispin-tensor structure of the E2 operator [4].

Following behind this development of a quasispin (seniority) scheme for organizing high-j dominated structures in singly closed shell nuclei, shape coexistence emerged as an important scheme for further organizing the structure of closed shell nuclei, especially in mid-open shell regions. This has been covered in a number of focused reviews [5]. It identifies the strongly collective structures in closed shell nuclei as resulting from deformation. It has isolated collectivity in the spherical structures as weak and limited to one-phonon strength for L = 2 and 3, and non-collective structures to (multi-j) broken-pair and one-particle-one-hole states.

A leading question that remains: "Is this organizational scheme complete?" Some recent results in closed shell nuclei will be placed into a unified scheme that suggests this question can be answered in the affirmative. In particular, the application of the seniority scheme to closed-shell nuclei dominated by medium-j and low-j orbital filling will be presented.

There appears to be a universal scheme of organization now in hand, in terms of just the above-defined concepts. Leading questions and experimental tests will be identified.

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