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Tom W. Bonner Prize in Nuclear Physics Talk: Symmetries and Simple Patterns in Nuclei[1]

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Nuclei are complex many-body objects that display remarkably simple patterns and regularities, both for a given nucleus and across regions of nuclei. The juxtaposition of these two facets of nuclear structure is reflected in two general, and complementary, approaches to their description – a microscopic (femtoscopic, of course) perspective in terms of the motions of the individual nucleons and their interactions, and a macroscopic view of the nucleus as a whole, in terms of its shapes, symmetries, and collective behavior. The first part of this talk will discuss the simple patterns nuclei exhibit and interpret them in terms of symmetries, such as those of the Interacting Boson Approximation (IBA) model, elementary collective modes, changes in shell structure, and quantum phase transitions in the equilibrium structure. It is also possible to approach structural evolution in nuclei with an extremely simple, more microscopic, perspective focusing on the competition of the most important residual interactions, pairing and the valence proton-neutron ($p-n$) interaction. While this is not a substitute for a comprehensive theoretical treatment, which remains a challenge and goal of nuclear theory, such an analysis leads to simple approaches, such as the N_pN_n scheme and the P-factor, that correlate large amounts of nuclear data, can guide estimates of unknown nuclei, and which are highly sensitive indicators of changes in shell structure and of nuclei that exhibit behavior deviating from normal tends. Finally, empirical means of extracting information on the critical valence $p-n$ interaction will be discussed and the systematic behavior of these interaction strengths will be linked to shell structure on the one hand, and the onset and development of collectivity on the other.

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