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Understanding proton-neutron mixed symmetry from microscopic internucleon interactions

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The atomic nucleus is perhaps the best-studied two-component quantum system in nature. When the two components (protons and neutrons) occupy different valence spaces, collective excitations of the valence-shell particles can arise which exhibit pronounced two-fluid character, and it is a fundamental problem to understand the microscopic origin of these "mixed-symmetry" (MS) states. Since they are formed from a collective coupling of valence proton/neutron subsystems, MS states are expected to provide a unique probe of the effective valence shell proton-neutron interaction and be particularly sensitive to shell structures. In nearly-spherical nuclei in the mass A=90 and A=130 region, MS states are manifested as collective isovector quadrupole excitations and have recently received considerable experimental attention. This talk will focus on a theoretical program which attempts to describe and understand MS states from a microscopic shell model approach in which the low-momentum internucleon interaction $V_{\mathrm{low}\,k}$ is taken as the starting point. This work provided a comprehensive picture of MS states in an odd-mass nearly-spherical nucleus and played an instrumental role in the first experimental identification of MS states in such a nucleus, ^{93}Nb. I will further discuss how the predicted evolution of MS properties reveals a restoration of collective MS structure in the mid-shell region, providing the first explanation for the existence of pronounced collective MS structures in weakly-collective nuclei. Throughout I will highlight the close connection between this work and ongoing experimental efforts.