Monopole-effects on symmetric and antisymmetric couplings of protons and neutrons

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As a general feature of two-fluid quantum systems, excited states in atomic nuclei can be constructed in a proton-neutron symmetric or mixed-symmetric way. In near vibrational nuclei the building block of mixed-symmetric states is the one-phonon quadrupole-collective isovector valence-shell excitation $2^+_{1,ms}$ [1]. In a most simple picture, such states can be understood to be generated by mixing unperturbed proton and neutron phonons via the residual proton-neutron interaction [2]. Therefore the study of mixed-symmetric states delivers direct information on the residual proton-neutron interaction in the valence shell and provides a tool to explore the evolution of the residual interaction towards e.g. extreme values of isospin.

In the framework of the generalized seniority scheme we present a simple expression for the valence proton-neutron interaction V_{pn} in atomic nuclei near closed shells consisting of a monopole and a quadrupole term. The monopole component of the residual interaction is approximated by double differences of binding energies only. We show that the energetic splitting between the lowest lying $J^{\pi}=2^+$ states of symmetric and mixed-symmetric character in even-A nuclei is well reproduced in almost all experimentally known cases (see Fig. 1 for one example), including nuclei where the effective number of valence particles is put to zero at subshells. The only free parameter, the quadrupole strength parameter κ turns out to be surprisingly constant in the mass region A=50 to A=150, yielding a good approximation for absolute values of V_{pn} near closed shells. We show applications on new data from neutron scattering with monoenergetic neutrons on the nuclei $^{68,70}Zn$ where an unusual abrupt drop in the excitation energy of the mixed-symmetric components is found towards the possible subshell at N=40. We draw conclusions on the minimal repelling of the lowest-lying symmetric and mixed-symmetric 2^+_1 states in even-A nuclear systems.

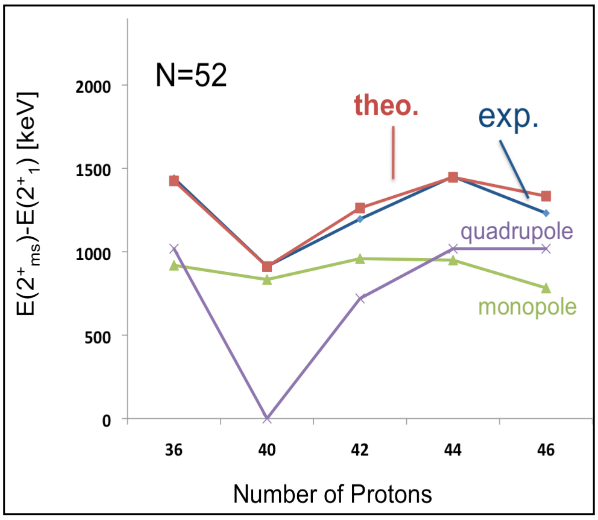

Fig. 1 Energy differences of the lowest lying 2^+ states of symmetric and mixed-symmetric character for N=52 isotones from experiment and theory, together with the contribution of monopole and quadrupole part of V_{pn} .

[1] N.Pietralla, P.von Brentano, A.F.Lisetskiy, Prog. Part.Nucl.Phys. 60, 225 (2008)

[2] T. Ahn et al., Physics Letters B 679 (2009) 19–24