SHELL EVOLUTION AND E2 COLLECTIVITY: NEW SPECTROSCOPIC INFORMATION*

Content

The way how the complex nuclear forces form atomic nuclei from their constituent protons and neutrons represents the core topic of nuclear structure research. The evolution of nuclear structure across the nuclear chart is dominated by the evolution of single-particle orbitals as a function of the numbers of protons and neutrons that make up the nuclei. The understanding of shell evolution has been pushed especially by the Tokyo group around T. Otsuka. It is supported by vast experimental evidence in particular from the structure of neutron-rich nuclei that have become accessible due to new facilities for intense beams of radioactive ions. Recently, the concept of Type II Shell Evolution has been introduced. It emphasizes, that the effective single-particle energies of nucleon orbitals systematically depend on the nucleonic configuration in each individual nuclear state due to the mutual interaction between the nucleons. This general mechanism can be particularly pronounced in key-nuclei with certain numbers of protons and neutrons, for which Type II Shell Evolution may lead to drastic nuclear structure effects such as even shape coexistence and first-order shape phase transitions like in the chain of Zr isotopes [1].

We report here on the first evidence [2] for shape coexistence caused by Type II Shell Evolution which is firmly based on the measurement of absolute E2 transition rates. The data have been obtained in high-resolution inelastic electron scattering spectroscopy of the nucleus $^{96}$Zr at the Superconducting Darmstadt Linear electron Accelerator (S-DALINAC). The data [2] will be presented and the mutual impact of proton and neutron valence-shell configurations will be discussed with respect to the formation of collective structures. Further information on the proton-neutron degree of freedom of collective valence-shell excitation can be obtained from the properties of the scissors mode in deformed nuclei. While it originates from the nuclear quadrupole deformation its dominant decay mode is by enhanced M1 transitions due to its isovector character. In fact, the E2 decay strength of the scissors mode of deformed nuclei has been unknown until recently. We have recently measured the (small) E2 decay strength of the $^1_2$ band head of the scissors mode to the ground state band by γ-ray polarimetry in Nuclear Resonance Fluorescence [3]. The data will be presented and discussed.

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