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Single-particle structure of neutron-rich N=40 nuclei

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The region around neutron-rich N=40 nuclei has recently attracted a lot of interest. The high-lying 2+ state in 68Ni and its small transition probability to the ground state are a result of the N=40 harmonic oscillator shell gap between the fp shell and the 1g9/2 orbital. This shell gap is reduced for the more neutron-rich Fe and Cr isotopes; both the N=40 isotones 66Fe and 64Cr show an increase in quadrupole collectivity. This behavior is caused by quadrupole correlations which favor energetically the deformed intruder states from the neutron g9/2 and d5/2 orbitals. In the shell model the increase in B(E2) values and the decrease in 2+ excitation energy can be reproduced if the neutron g9/2 and d5/2 intruder orbitals are included in the model space.

Spectroscopic studies of neutron-rich nuclei around N=40 have been performed at the NSCL utilizing the S800 spectrometer and the GRETINA gamma detector array. The study focused on the one-neutron removal reactions from 68Ni and 64,66Fe. The longitudinal momentum distribution of reaction residues indicates the angular momentum of the removed nucleon, and spectroscopic factors can be extracted from the measured cross section for the population of individual states in the odd-mass residual nucleus. An experimental challenge in this region of the nuclear chart is the occurrence of low-lying isomeric states resulting from the neutron g9/2 intruder orbital. This experiment employs a new technique of combined prompt and delayed gamma-spectroscopy allowing to quantify the occupancy of the intruder neutron g9/2 and d5/2 orbitals in 68Ni and 64,66Fe. Comparison of the measured spectroscopic factors with large-scale shell model calculations show a significant occupation of the intruder orbitals across the N=40 sub-shell gap. Therefore the existence of a new “Island of Inversion” at N=40 has been experimentally verified for the first time.

Primary author: Dr WIMMER, Kathrin (Central Michigan University)

Presenter: Dr WIMMER, Kathrin (Central Michigan University)

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