Lifetime measurements of low-lying states in neutron-rich Zn isotopes by the plunger technique

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One of the most critical ingredients in determining the disappearance or appearance of magicity in nuclei far from stability is the evolution of single-particle energies with increasing neutron or proton numbers when moving away from the valley of stability. The three known cases of disappearance of shell effects at N=8, 20 and 28 in neutron-rich nuclei are understood as due to the effect of the tensor part of the nucleon-nucleon interaction. The tensor force is held responsible for the strong attraction between a proton and a neutron in spin-flip partner orbits. A recent generalization of such mechanism foresees a similar behavior also for orbitals with non-identical orbital angular momenta. It is expected that orbitals with anti-parallel angular momenta attract each other and orbitals with parallel angular momenta repulse each other.

In this context neutron-rich nuclei in the vicinity of ^{78}Ni are particularly interesting since they allow to search for anomalies when compared with shell-model predictions. It is predicted, for example, that the Z=28 gap for protons in the *pf*-shell becomes smaller when moving from N=40 to 50 as a consequence of the attraction between the proton $f_{5/2}$ and neutron $g_{9/2}$ orbits and the repulsion between the proton $f_{7/2}$ and the neutron $g_{9/2}$ states. The same argument would also predict a weakening of the N=50 shell gap when depleting the proton $f_{5/2}$ state upon approaching the ^{78}Ni nucleus, due to the diminished attraction between the neutron $f_{9/2}$ and the proton $f_{5/2}$ orbits and the reduced repulsion between the neutron $g_{9/2}$ and the proton $f_{5/2}$ states.

In order to investigate the shell evolution in the vicinity of ^{78}Ni we have performed lifetime measurements for low-lying states in $^{72\text{-}74}$Zn by the differential plunger technique. A cocktail beam of ^{73,74}Zn was produced by the projectile-fragmentation reaction of ^{76}Ge on a ^{9}Be target and separated by the first half of the LISE spectrometer at GANIL. The secondary beam with the energy of 34 MeV/nucleon was bombarding on a secondary CD_2 target to induce inelastic and transfer reactions, and outgoing particles were selected and identified by the second half of LISE. Gamma rays emitted from the reaction products were detected by 8 EXOGAM detectors, which were surrounding secondary target at 45 and 135 degrees relative to the beam direction. The differential plunger technique with ^{9}Be degrader was applied to measure lifetimes of excited states.

The first results of the lifetime measurement in low-lying states in ^{72,73,74}Zn will be reported together with the comparison to results from Coulomb excitation experiments at REX-ISOLDE and GANIL. A picture of the low-energy structure in these isotopes towards the middle of the $\nu g_{9/2}$ orbital will be given via: i) identification of the levels populated with inelastic scattering reaction and ii) determination, in a model-independent way, of the transition probabilities of those levels towards the ground state.