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Shell structure around 78Ni : Beta-decay studies of neutron-rich 77Cu

The magic numbers, originated by the large shell gaps in the energy spectrum of the single-particle states, represent a fundamental quantity governing nuclear structure. They can be reproduced using a single-particle harmonic oscillator potential with a strong spin-ortbit interaction and they are predicted to change for large N/Z ratios. Exotic nuclei close to the shell closures on the neutron drip-line play an important role on nuclear shell structure studies since they allow to search for possible modifications of magic numbers with increasing N/Z ratio. The tensor component, one of the non-central components of the effective nucleon-nucleon interaction, is expected to modify the relative single particle energies when one goes further from stability on the neutron drip line [1,2]. It is expected an attraction for orbitals with anti-parallel spin configuration and a repulsion for orbitals with parallel spin configuration. The change of the shell structure due to the tensor mechanism has been recently discussed in different mass regions [3, 4]. The magic numbers at N=20 and 28 disappear with increasing neutron number and new magic numbers at N=14, 16 and 32 seem to appear. It is also predicted that the Z=28 gap for protons in the pf-shell becomes smaller moving from 68Ni to 78Ni as a result of the attraction between the f5/2 and the g9/2 orbits and repulsion between the f7/2 and g9/2 configurations.

In the case of Cu isotopes the changing of effective single-particle energies comes directly from the attraction between the πf5/2 and the υg9/2 orbits and the repulsion between the πf7/2 and the υg9/2 orbits. Recent calculations in the fpg shell seems to indicate that the Z=28 shell gap gets reduced by about 0.7 MeV when filling the neutron g9/2 orbital [5]. The same Shell Model calculations together with the effect of the tensor force performed for the neutron-rich Cu isotopes predict a lowering of the πf5/2 state causing an inversion of the πf5/2 -πp3/2 effective single-particle states when approaching 78Ni. This inversion has been recently confirmed by nuclear spin and magnetic moment measurements for 75Cu by identifying its spin of the ground state as I= 5/2 [6].

Aim of the present proposal is to identify experimentally the location of such low-lying excitations as test of the microscopic interaction in the fpg shell model space.
Unlikely to its neighboring isotope 75Cu [7], no evidence for isomerism was found in 77Cu according to the fragmentation study of 86Kr at 140 MeV/a at the Coupled Cyclotron Facility of NSCL/MSU [8]. Therefore, the nuclei of interest will be populated via beta-decay of the 77Ni through the in flight fragmentation of 86Kr beam at 350 MeV/nucleon. Fragments will be separated in-flight using the BigRIPS facility. The detailed information on the experimental settings will be given in the presentation.

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