Spectroscopy of Neutron-rich Nuclei in the A≈60 Region

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At the Legnaro National Laboratories, the combination of the efficient gamma-array CLARA with the large-acceptance magnetic spectrometer PRISMA allows, with its high resolving power and by using multi-nucleon transfer or deep-inelastic reactions, to study medium and high-spin states of neutron-rich nuclei far from stability. The spectroscopic information provided by this setup is complementary to that provided by first generation radioactive beam facilities where one of the main theme of research is the study of nuclear matter with a large neutron excess. It is in fact by now clear that substantial changes in the shell structure of the nucleus are expected when adding neutrons: the known magic numbers disappear, being replaced by new ones, new regions of deformation develop and the interesting phenomena related to the shape phase transition can therefore be investigates under new conditions. The neutron-rich nuclei with A≈50-60 seem to provide all these characteristics: a new sub-shell closure at N=32 has been recently identified [1] whereas the known sub-shell closure at N = 40, evident at Z=28, disappears by removing two or four protons from the spherical ^{68}Ni driving the N = 40 nuclei ^{66}Fe and ^{64}Cr into prolate shapes and giving rise to a new region of deformation [2, 3].

We have populated the neutron-rich nuclei of the A ≈ 60 mass region by accelerating a beam of ^{64}Ni at 400 MeV onto a target of ^{238}U and making use of the CLARA-PRISMA set-up. With the new data, the existence of the N=32 sub-shell closure has been verified through the study of odd V isotopes [4], the knowledge of excited states in neutron-rich Cr up to ^{60}Cr, suggests that ^{58}Cr may be at the shape-phase-transition critical point of the $E(5)$ dynamical symmetry [6] and the spectroscopy of the Fe chain (both even and odd) have been extended up to ^{66}Fe [5]. In this contribution, the new results obtained for all these nuclei will be discussed and shell model calculations will be presented which reproduces quite well the experimental data by allowing excitations into the upper $g_{9/2}$ orbital.

Very recently a new experiment has been performed where, by bombarding a ^{238}U target with a ^{70}Zn beam, the aim was to populate strongly the neutron-rich Fe isotopes and to explore further this new region of deformation. Results from this experiment will be also presented.

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