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Exploring nuclear structure by binary reactions with stable and radioactive nuclear beams

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The study of neutron-rich nuclei with unusually large neutron/proton ratio is challenging the conventional description of the structure of nuclei. Almost a decade of investigation has established that when moving from the region of β-stability to the drip line, the shell structure undergoes important modifications with the possible disappearance of the usual shell gaps and the emergence of new magic numbers. This behaviour has been attributed to the dynamic effects of the nucleon-nucleon interaction, its density dependence, linked to the reduction of the spin-orbit contribution for more diffuse systems, and the influence of the proton-neutron interaction and of its higher order term, the tensor force. Recently also three-nucleon forces have been invoked in order to justify the stabilization of the nuclear shells. Unexpected shell erosions have been found all over the nuclear chart, together with the appearance of low lying intruder states in supposedly semi-magic nuclei, giving rise to the so-called islands of inversion. One example is the Ni isotopic chain (Z=28) which covers two doubly-closed shells with neutron numbers N=28 and 50 therefore providing an almost unique testing ground for investigating the evolution of the shell structure in neutron rich nuclei.
Binary reactions such as Coulomb excitation, deep-inelastic and multi-nucleon transfer reactions are a powerful tool to populate yrast and non yrast states in neutron-rich nuclei using stable or radioactive nuclear beams, particularly in combination with high resolution gamma-ray detector arrays. Data from the AGATA experimental campaigns together with selected examples from high and low resolution gamma ray spectroscopy detectors will be presented. The status of the SPES radioactive nuclear beams project at LNL will also be illustrated.

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