Exploring the evolution of the shell structure by means of deep inelastic reactions

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Magic numbers are a key feature in finite Fermion systems since they are strongly related to the underlying mean field. The study of the evolution of the shells far from stability is therefore of high interest since such information can be linked to the shape and symmetry of the nuclear mean field. The study of nuclei with large neutron/proton ratio allow to probe the density dependence of the effective interaction. Changes of the nuclear density and size in nuclei with increasing N/Z ratios are expected to lead to different nuclear symmetries and excitations. Recently it has also been shown that the tensor force play an important role in breaking and creating magic numbers being a key element of the shell evolution along the nuclear chart.

The study of nuclear structure far from stability, which mainly rely on the availability of radioactive nuclear beams, can complementary be addressed by means of high intensity beams of stable ions. Deep-inelastic and multi-nucleon transfer reactions are a powerful tool to populate yrast and non yrast states in neutron-rich nuclei. Particularly successful is here the combination of large acceptance spectrometers with highly segmented γ-detector arrays. Such devices, eventually complemented by large coverage particle detectors, can provide the necessary channel selectivity to identify very rare signals. An example is the CLARA γ-ray detector array coupled with the PRISMA spectrometer at the Legnaro National Laboratories (LNL). Large data sets have been recently collected for nuclei close to the N=28, 40 and 50 shell closures. The obtained results complement studies performed with current radioactive beam (RIB) facilities. The data clearly show the evolution of the effective single particle energies in very good agreement with the predictions of the mean field model with tensor interaction. New experimental information has been obtained on a wide range of nuclei close to the N=28, 40 and 50 shell closures allowing the population of medium and high-spin yrast states. The excited states of the N = 50 isotones, extended down to Z=31, and of N=51 isotones, extended down to Z=34, have been used to test the predictions of the shell evolution based on the effects of the tensor interaction as well as of the different effective interactions.