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Shell evolution and nuclear forces

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Magic nuclei are cornerstones of nuclear structure. Due to the presence of large shell gaps between occupied and valence shells, they are spherical, have large excitation energies and weak excitation probabilities. They are often more abundant than other nuclei in the universe, play key roles in explosive nucleosynthesis, and could bind superheavy nuclei despite the large repulsive coulomb interaction.

Our vision of immutable magic numbers, whatever the proton to neutron ratio, has been drastically changed these last years. In particular it has been demonstrated that the neutron magic numbers 8, 20 and 28 were vanishing far from stability. In parallel new magic numbers appear as N=16.

These discoveries arose with the advent of radioactive ion beam facilities worldwide as well as progresses in detection systems. They pose fundamental questions [1] such as: which parts of the nuclear force drive these modifications of shell closures? Are such effects observed throughout the chart of nuclides, or are they limited to medium mass nuclei? To which extent nuclear forces are changing when approaching the drip line ? What are the consequences of these shell modifications for explosive nucleosynthesis for modeling halo nuclei and for the existence of superheavy nuclei?

Recent experimental studies (transfer, knock-out, beta-decay and isomeric studies) were used to probe the three body force, the spin-orbit interaction and the behavior of nuclear forces at drip line. The impact of such discoveried will be put in perspective with the questions raised above.

[1] O. Sorlin and M.-G. Porquet Phys. Scr. T 152 (2013) 014003