Study of the N=28 shell closure through (d,p) reaction at SPIRAL/GANIL

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The study of the N=28 shell closure far from the valley of stability has been investigated through various complementary experimental techniques which point out to a progressive reduction of the shell gap south to ^{48}Ca (e.g. [1,2]). This magic number is the first arising from the spin-orbit coupling which lowers the $f_{7/2}$ orbital with respect to the $p_{3/2}$ one. Therefore teh shell gap disappearence should be connected to a spin-orbit force reduction. The present work aims at determining the evolution of the $N = 28$ shell gap and the spin-orbit couplings for the p and f orbitals between the ^{49}Ca and ^{47}Ar nuclei. This was achieved by determining the single particle energies in the ^{47}Ar nucleus by using *via* the d(^{46}Ar,^{47}Ar)p transfer reaction.

The radioactive beam of ^{46}Ar at 10A·MeV was produced by the SPIRAL1 facility. Neutron pick-up reactions (d,p) were induced by a 380 μgcm^{-2} thick CD_2 target. The tracking of the secondary beams was achieved by a position sensitive gas filled detector CATS [3] located downstream the target. Protons were detected at backward angles (between 110 and 170 degrees) using the 8 highly segmented MUST telescopes [4]. The energy spectra of ^{45,47}Ar were obtained by using the measured proton energy and angle in MUST. The angular distributions for each identified levels have been used to determine the spin and spectroscopic factors of the levels. Energies and spectroscopic factors of the neutron $p_{3/2}$, $p_{1/2}$ and $f_{5/2}$ states in ^{47}Ar were determined and compared to those in the ^{49}Ca isotones. From this comparison, we deduced a reduction of the $N = 28$ gap by 330(80) keV and spin-orbit weakenings of 8% and 40% for the f and p states, respectively. Extrapolation of this shell gap reduction to ^{44}S and ^{42}Si nuclei nicely explain why intruder configurations dominate in these nuclei. Such large variations for the f and p spin-orbit splittings can consistently be accounted for by the proton-neutron tensor forces and by the density dependence of the spin-orbit interaction at the centre of the nucleus, respectively. This conclusion contrast with the dogmatic picture of the spin-orbit interaction as a surface term only. In an astrophysical context, the presence of low-lying $\ell = 1$ bound states in ^{47}Ar with sizeable spectroscopic factors drastically enhances the (n,γ) cross-section at A=46. In astrophysical environments where a neutron-capture and β-decay process (as the weak r-process in type II supernova) occur, this feauture will quickly shift the matter flow from A=46 to A=48 in the Ar chain, reducing (enhancing) drastically the amount ^{46}Ca (^{48}Ca) which is synthesized by theβ-decay of its progenitor isobar ^{46}Ar (^{48}Ar). We could therefore nicely explain the large abundance ratio of ^{48}Ca/^{46}Ca in the solar system (=53) and in certain refractory inclusions of meteorites (=250).

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