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Study on depletion of existing shells and formation of new shells in exotic nuclei

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Statement of the Problem: Shell structures in conventional nuclei depend on the spin-orbit splitting of shell model states and their regrouping. In exotic nuclei with more number of neutrons, the disappearance of existing shells and appearance of new shells have been observed. In these nuclei the basic p-n interaction gets modified and as an outcome of this the spin-orbit potential changes. Reduction in splitting of spin-orbit partners has been observed experimentally, which requires a theoretical support.

Explanations: Despite having a limited success RMF theories could not provide a solution for a range of nuclei spanning over several shells. There are some explanations for this phenomenon already in vogue: a) due to large neutron excess for nuclei in the neutron dripline region, the diffuseness of the neutron distribution modifies the spin-orbit interaction, b) the neutron-proton monopole interaction determines the character of the spin-orbit interaction of exotic nuclei that changes the splitting of the partner states, c) inclusion of tensor interaction in the mean-field type calculation causes a change in the spin-orbit interaction which culminates into a change in the splitting of spin-orbit doublet. Non-relativistic mean field theories like HF or HFB with skyrme interaction after inclusion of tensor interaction which reproduces the spin-orbit splitting in ^{40,48}Ca and ^{56}Ni have been used to test the situation in the calcium region.

Findings: Force parameters like SKX, Sly5 KDEOV have shown the diminishing trend of splitting of proton states near Calcium region as more and more neutrons are added to shell closed nuclei. Robustness of shell for Z/N=20 has been observed while N=28 shell disappears in drip line nuclei. A bubble like structure for neutron-rich nuclei may be one of the contenders for the reduction in spin-orbit splitting in this region. Further studies in other shell regions are necessary.

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