# Shell Closure at N = 32, 34 in Drip-line Nuclei

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The advancement in production of radioactive beams has facilitated the nuclear structure studies away from the -stability line, especially for the neutron rich nuclei. The structure of the exotic nuclei in the extremes of isospin is characterized by several interesting features. The nuclei toward the drip lines have extremely small separation energy of the outermost nucleons and the Fermi level lies close to the particle continuum. The density distribution shows an extended tail with a diffused neutron skin and neutron halo [1, 2]. The changing magic number is another interesting feature of the nuclei in this mass region. One case of particular interest is the magicity at proton/ neutron number N = Z = 28 and N = 32 and 40 near the neutron drip-line in Ca and Ni-isotopes, which has been a center of discussion for sometime now (see Ref. [3], and the refernces therein). The measurements showed some surprising changes in the nuclear shell structure as a function of proton and neutron number in light nuclei. These observations triggered numerous theoretical investigations, which in turn made new predictions that some magic numbers will disappear and new shell gaps will appear in certain regions of the nuclear chart [4]. The first evidence for the N = 16 magic number in oxygen came from an evaluation of neutron separation energies on the basis of measured masses [5]. The new magic number at N = 32 has been observed experimentally by Kanungo et al. $^{54}$Ca [6] recently. But theoretically, shell model with new effective interaction GXPF1 and monopole component of tensor interaction, predict the shell closure at N = 34 [7]. However, the well established interaction KB3G [8] and the spherical Hartree-Fock calculations with the semi-realistic NN interactions [9] give the shell closer at N = 32. Therefore, it is interesting to investigate the shell closer at N = 32 and 34 for $^{54}$Ca isotope.

In the present investigation we use axially deformed relativistic mean field model with NL3 parameter set. The single particle energy levels of $^{50-54}$Ca even-even nuclei are plotted in Fig. 1. The shell gaps between the levels corresponding to N = 32 as well as N = 34 seem not to be supporting the magicity at these numbers, as is clear from the figure. The shells at N = 32 or 34 are separated by energy $\sim$ 1.6 MeV only, as compared to the gaps of $\sim$ 4.5 MeV at N = 28. Therefore, these numbers donot seem show the magic numbers. The occupation probabilities of the outer most states are shown against each level. The level $1p_{1/2}$ starts getting partially occupied (filled 48%) before $1p_{3/2}$ is filled completely. Also, the level $0f_{5/2}$ is filled upto 19.1%, which further reduces the shell gap at or around N = 32 and

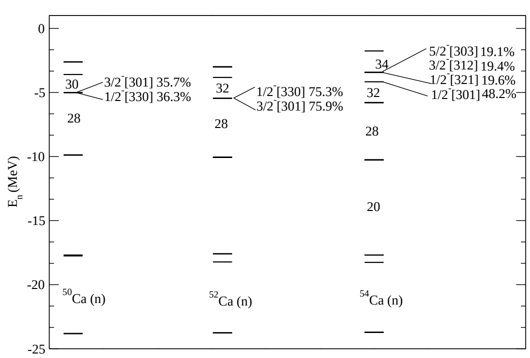


FIG. 1: The neutron single particle energy levels for $^{50-54}$Ca even-even nuclei using NL3 parameter set.

In Fig. 2 the density distributions of the $^{54}$Ca nucleus is plotted. The density profile shows the considerable difference in the neu-

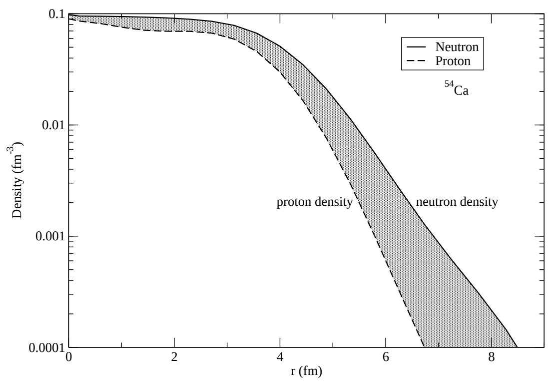


FIG. 2: The density distribution of $^{54}$Ca isotope, using NL3 parameter set.

tron and proton densities at the tail part indicating the prominance of neutron halo and /or skin in this isotope. The neutron density distributions in neutron-rich $^{50-56}$Ca nuclei are found to be widely spread (figure not included here) out in the space and give rise to the formation of neutron halos. It would be interesting to study these neutron-rich nuclei. The detailed investigation of the shell closer and neutron halo /neutron skin and other properties of neutron-rich isotopes is in progress.

In conclusion, the shell gaps at the neutron numbers N = 32 and 34 are not prominent in the presentation calculations. The considerable spread of the density profile gives the insight of the halo and /or skin of neutron for the nucleus considered.

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