Neutron Skin in Ni Isotopes

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The neutron density of neutron-rich nuclei is always extended farther than the proton density. Such structure in which neutron density extends more at the larger radius part is known as skin (neutron skin). In case, the tail part of the neutron density is extended more, such nuclei are called halo (neutron halo). The skin is calculated by the difference between neutron and proton densities. The density distributions for the nuclei towards the drip-line are quite different from those for the nuclei at the stability line. A significant character in nuclei at the extreme is the existance of nuclear halos and skins [1]. This exotic property of nuclei in the region was first observed by I. Tanihata et al. [2], experimentally, in 1985 for ^{11}Li. The definition of a halo nucleus is still being debated, but for a nucleus to be halo, at least three basic conditions must be fulfilled [3]: (i) low separation energy of the valance particle (or particle clusters); (ii) a wave function be in a low relative angular momentum state (preferably an s-wave); (iii) decoupling from the core. A large value of N/Z ratio in unstable nuclei produces a large difference in Fermi energy of neutrons and protons and thus, decoupling of neutron and proton distributions appears as halos and skins. The halo structure in nuclei can develop when the system approaches the threshold and the relative motion is not constrained by a strong long-range repulsive force. As a result the tail of the wavefunction extends out well beyond the region of nuclear interaction, generating an unusual outer region of low nuclear density distribution.

Very recently, the measurement of nuclear reaction cross-section for ^{19,20,22}C [4] shows that the drip-line nucleus ^{22}C has halo structure. Also, ^{42,44}Mg nuclei close to neutron drip-line have been predicted as showing halo structure [5, 6]. The nuclei ^{11}Be, ^{19}C, ^{31}Ne are the examples of one-neutron halo [7, 8]. Usually, halo is considered as a long low density tail in the nuclear matter distribution, whereas skin means a significant difference in the values of matter radii for neutrons and protons. The neutron skin, qualitatively, describes an excess of neutrons at the nuclear surface. The neutron skin with a thickness of 0.9 fm was first reported by Tanihata et al. in ^{8}He nucleus [9] and later it was confirmed [10]. Recently, the skin thickness is calculated [11] for ^{208}Pb and its correlation with the slope of

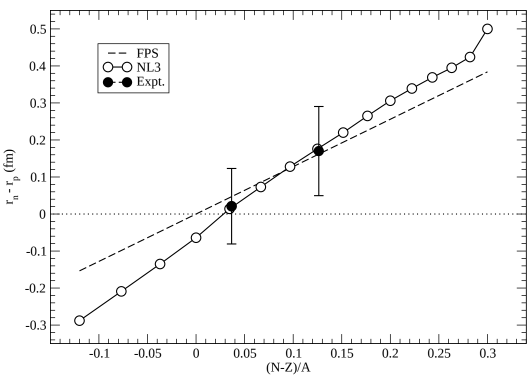

FIG. 1: The neutron skin calculated for $^{70-84}$Ni isotopes with NL3 parameter set. The experimental data is from Batty et al. [12]

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In the present calculations we investigate the skin/halo structure of Ni-isotopes using Relativistic Mean Field (RMF) model with NL3 parameter set. The neutron skin is the difference between neutron and proton matter radii. We plot the skin thickness for a series of Ni-isotopes (as shown in Fig. 1). i The neutron rich nuclei show the skin thickness of 0.2 to 4.5 fm. In the figure the RMF results are compared with the experimental data [12].

Our results for skin thickness are in very good agreement with the experiments. The dashed line in the figure shows the prediction of the model proposed in Ref. [13]. The detailed investigation of the skin thickness is in progress.

References

[1] I. Tanihata, J. Phys. G: Nucl. and Part. Phys. **22**, 157 (1996) 157.
[2] I. TanihataI. et al., Phys. Lett. **B 160**, 380 (1985).
[3] J. S. Al-Khalili, Phys. **651**, 77 (2004).
[4] K. Tanaka, *et al.*, Phys. Rev. Lett., **104**, 062701 (2010).
[5] L. Li, *et al.*, Phys. Rev. **C 85**, 024312 (2012).
[6] S.-G. Zhou, *et al.*, Phys. Rev. **C 82**, 011301(R) (2010).
[7] T. Nakamura, *et. al.*, Phys. Rev. Lett., **103**, 262501 (2009).
[8] A. Di Pietro, *et. al.*, Phys. Rev. Lett., **105**, 022701 (2010).
[9] I. Tanihata, *et al.*, Phys. Lett. **B 289**, 261 (1992);
[10] G. D. Alkhazov, *et al.*, Phys. Rev. Lett., **78**, 2313 (1997).
[11] M. Warda, M. Centelles, X. Viñas, and X. Roca Maza, Acta Phys. Pol. **B 43**, 209 (2012).
[12] C. J. Batty, E. Friedman, H. J. Gils, and H. Rebel, Adv. Nucl. Phys. **19**, 1 (1989).
[13] C. J. Pethick, and D. G. Ravenhall, Nucl. Phys. **A 606**, 173 (1996).