Surface properties in neutron-rich semi-infinite nuclear matter

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We study the neutron distribution and its surface properties using the neutron-rich semi-infinite nuclear matter in the framework of the relativistic mean field (RMF) theory [1]. Regarding neutron-rich semi-infinite nuclear matter as an extreme situation of heavy nuclei, a large difference of distribution between proton and neutron is expected in surface region.

In the semi-infinite nuclear system, the nucleon and meson fields have translational invariance in x- and y-directions, but depend on z coordinate due to nuclear surface [2]. The Dirac equation should be solved under suitable boundary conditions, namely the Dirac wave function becomes plane-wave in deep inside of semi-infinite nuclear matter at $z \longrightarrow -\infty$ and has exponential fall off at $z \longrightarrow \infty$.

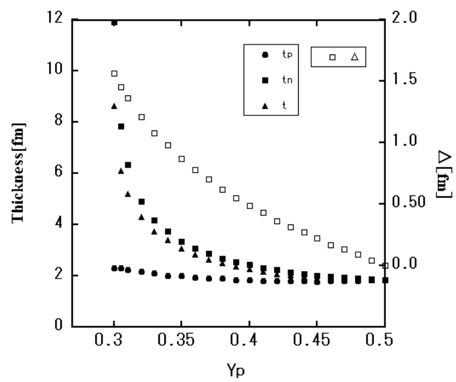

Figure 1: Surface properties for the range of Y_p from 0.5 to 0.3. t_p, t_n,t are proton thickness, neutron thickness and nuclear thickness, respectively. Δ is a distance of half density between proton and neutron.

We show the results of the surface thickness and the distances of half densitiy between proton and neutron in Fig.1. Y_p is a proton fraction, which is defined as $Y_p = \rho_p(z = -\infty)/\rho(z = -\infty)$. For charge symmetric case $Y_p = 0.5$, we get $t = t_n = t_p = 1.84$[fm] and for charge asymmetric case $Y_p = 0.3$[fm], we obtained the results that $t = 8.65$[fm], $t_n = 11.9$[fm] and $t_p = 2.31$[fm]. It is found that charge asymmetry makes t and t_n thicker significantly. Meanwhile, the distance between proton and nuetron half density Δ become larger slightly that $\Delta = 1.56$[fm] for $Y_p = 0.3$. Neutron and proton densities in surface region are shown in Fig. 2. We can see that neutron densities spread over the proton surface and neutron skin emerges. For Y_p =0.3, the neutron skin is stretched out extremely [3]. For $Y_p \leq 3$, the RMF calculation is not converged.

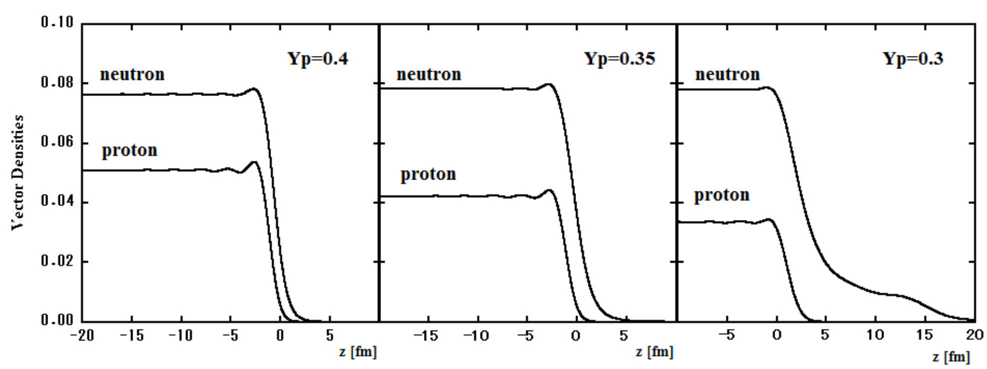

Figure 2: Proton and neutron densities for $Y_p = 0.4$, 0.35 and 0.3.

References

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[3] N. Fukunishi, T. Otsuka, and I. Tanihata, Phys. Rev. **C48**, 1648 (1993).