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Measurement of the very-forward-angle neutron elastic scattering and PHITS simulation for neutron shielding/超前方散乱角における中性子弾性散乱の測定と PHITS による中性子遮蔽計算

Thursday, 16 November 2023 15:00 (2 hours)

In equation of state of nuclear matter, constraints on parameters of the symmetry energy $S(\rho)$ are important for understanding of the nuclear many-body system which is related to various astrophysical phenomena. The symmetry energy is essential for the neutron matter ($\delta \sim 1$ where δ is degree of asymmetry), but it is less certain than the symmetric nuclear matter ($\delta \sim 0$). It is known that there is a linear correlation between the slope parameter and neutron skin thickness δR in ^{208}Pb[1]. δR can be written as the difference of the neutron and proton RMS radii. However, the uncertainty of the neutron radius in ^{208}Pb is still large, while its proton radius is precisely determined by electron scattering.

Proton elastic scattering (PES) is one of the powerful probes in determining the density distributions. In the case of PES, the cross sections at very forward angles which is sensitive to the nuclear radius, are mainly caused by the Coulomb scattering. It is difficult to extract the information of the neutron radius. Therefore, we proposed an experiment of the neutron elastic scattering (NES) to precisely determine the neutron radius in ^{208}Pb.

Recently, we have performed a measurement of the NES at very forward angles (4, 7 degrees) in ^{208}Pb and ^{40}Ca. We have designed a new setup with neutron beams at 63 MeV generated by the ^{7}Li(p, n)^{7}Be reaction. To identify scattered neutrons of NES, Time of Flight (ToF) method and Pulse Shape Discrimination (PSD) method have been applied to the measurement of NES.

We have performed the measurement of angular distribution of NES at $\theta_{c.m.} = 4.098,\ 4.571,\ 6.981,\ 7.458$ degrees of ^{208}Pb(n, el) scattering and $\theta_{c.m.} = 4.199,\ 4.683,\ 7.152,\ 7.640$ degrees of ^{40}Ca(n ,el) scattering. However, angular distribution that we have measured has large statistical errors compared to theoretical requirements. Major factor in the large statistical errors is background neutrons. To distinguish between the background neutrons and the scattered neutrons in ^{208}Pb and ^{40}Ca, beam collimation and neutron shielding were essential. Neutron shielding for the experimental setup was calculated by Particle and Heavy Ion Transport code System (PHITS)[2]. In this poster presentation, the details of the experimental setup and feasibility test with PHITS will be discussed.

References

[1] X. Roca-Maza, M. Centelles, X. Viñas et al., “Neutron Skin of ^{208}Pb, Nuclear Symmetry Energy, and the Parity Radius Experiment”, Phys. Rev. Lett. 106(25), (2011), pp. 252501.

[2] T. Sato, Y. Iwamoto, S. Hashimoto et al., “Features of Particle and Heavy Ion Transport code System (PHITS) version 3.02”, J. Nucl. Sci. Technol. 55(5-6), (2018), pp. 684-690.

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