Determination of neutron skin thickness via measurements of σ_I and σ_{CC} of Ni isotopes

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The exploration of the equation of state (EOS) of nuclear matter forms one of the most intriguing topics in nuclear physics, wherein the investigation of the basic properties of atomic nuclei plays a key role in the understanding of its parameters. Thus far, our abundant knowledge of stable nuclei has suitably constrained the parameters of the EOS for symmetric nuclear matter[1]. However, the behavior of nuclear matter as a function of the difference of neutron and proton numbers, which is quite important to understand extremely asymmetric nuclear matter such as neutron stars and the cores of supernovae, is unfortunately more elusive. In order to obtain a better understanding of the EOS of asymmetric matter, it is essential to study the symmetry term of the EOS. Previous theoretical studies have indicated that the determination of neutron skin thickness ΔR as a function of the asymmetry parameter $\delta(\equiv (N-Z)/A)$ yields crucial information to constrain the symmetry energy coefficient of the EOS[2]. In this regards, extensive studies have been carried out on stable nuclei thus far to determine ΔR[3], and a number of data sets have been obtained in the range of δ from 0 to 0.23; however, the data in the wider range of δ are desirable to set a narrower constraint. In this study, we measured the interaction cross sections σ_I and charge-changing cross sections σ_{CC} for $^{58-78}$Ni at the RIBF. The matter radii of Ni isotopes can be deduced from σ_I with the use of Glauber model[4] and point-proton radii can be deduced from σ_{CC}[5]; consequently, the neutron skin thickness of unstable nuclei can be obtained from our measurements in this study.

The experiments were performed at the RIBF facility operated by the RIKEN Nishina Center and the Center for Nuclear study, University of Tokyo. A primary beam of ^{238}U (maximum intensity of around 30 pnA) with incident beam energy of 345A MeV and Be production targets were utilized to produce $^{58-78}$Ni secondary beams with energies around 260A MeV. The σ_I values were measured by means of the transmission method[6] and the BigRIPS fragment separator[7] was used as a spectrometer to identify the incoming and outgoing particles of those nuclides that remained unchanged from the original incident beam. The schematic of the experimental setup is shown in Fig. 1. The particle identifications for the analysis of cross sections are based on the $\Delta E - TOF - B\rho$ method. In order to measure σ_{CC}, the large acceptance ion chamber was set at F5 to identify the particles that did not show change in the proton number compared with that of the incident beam. Additional reaction targets and MUlti Sampling Ion Chambers (MUSICs)[8] were set at F11, which enabled us to deduce the σ_{CC} value of the beam transported through zero-degree pectrometer (ZDS). Data analyses for σ_I and σ_{CC} are in progress.

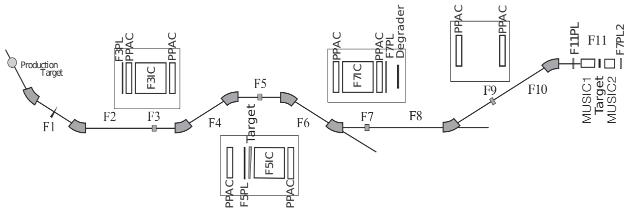

Fig. 1. Schematic of experimental setup.

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