RCNP EXPERIMENT E336

PROPOSAL FOR EXPERIMENT AT RCNP

13 July 2009

TITLE:

Simultaneous determination of proton and neutron distributions by "generalized" proton elastic scatterings

SPOKESPERSON:

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RUNNING TIME:

(p, n) Detector setup	1.0 days
(p, n) Data runs	5.0 days
(p, p) Detector setup	1.0 days
(p, p) Data runs	2.5 days

In total, we request 9.5 days.

BEAM LINE: Ring : N0 course for (p, n)
Ring: WS course for (p, p)

BEAM REQUIREMENTS:

Type of particle	Polarized / unpolarized protons
Beam energy	150 MeV
Beam intensity	$\geq$ 300 nA after 1/3 pulse selection
Any other requirements	time width $\leq$ 250 ps halo-free, small emittance

BUDGET:

Experimental expenses	2,000,000 yen
Travel plans	10 participants should be supported by RCNP.

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SUMMARY OF THE PROPOSAL

Nowadays, the neutron skin is attracting a renewed interest. The thickness of the neutron skin is indicated to be closely related to the equation of state of nuclear matter and also to the analysis of atomic parity-violation experiments. The neutron-skin thickness can be deduced from the difference in the density distributions of protons and neutrons. The former can be reliably obtained by the electron scattering. Precise determination of the neutron density distribution has recently been enabled by progress in the microscopic description of the proton elastic scattering making use of the improved relativistic impulse approximation. On the other hand, in the case of unstable nuclei, it is much more difficult to determine the proton distribution by the electron scattering measurement. We have no effective method to determine the density distributions and neutron-skin thickness of unstable nuclei at present.

Here, we aim at developing a new method to determine both proton and neutron distributions simultaneously by using "generalized" proton elastic scatterings. The idea is built on the the equality between the proton elastic scattering and the (p, n) reaction to the isobaric analogue state (IAS). Assuming the isospin symmetry, the IAS has an identical structure to the ground state of the target nucleus. Thus, (p, n) IAS reaction can be regarded as an "elastic scattering generalized in the isospin space". The (p, n) IAS reaction is essentially sensitive to the isovector density $\rho_n(r) - \rho_p(r)$, whereas the (p, p) elastic scattering reflects the isoscalar density $\rho_n(r) + \rho_p(r)$. By the combined analysis of these two reactions, we can determine both proton distribution and neutron distribution in principle.

We propose to measure the (p, p) elastic scattering and the (p, n) IAS reaction from ^{116}Sn, ^{120}Sn and ^{124}Sn at 150 MeV. In the theoretical analysis, these two reactions are be treated consistently within a single framework. We will generalize the analysis procedure for the proton elastic scattering into the isospin space by using a well-established relativistic version of the Lane model. Validity of the principle and analysis procedure will be examined by comparing the deduced proton and neutron distributions of Sn isotopes with those previously obtained by the electron scattering and the proton elastic scattering.