Extraction of Neutron Density Distribution in ^{120}Sn from Proton Elastic Scattering at 200 – 400 MeV

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We have systematically measured angular distributions of differential cross sections ($d\sigma/d\Omega$) and analyzing powers (A_y) of elastic scattering from ^{58}Ni and ^{120}Sn with the polarized proton beam from the ring cyclotron of the Research Center for Nuclear Physics (RCNP) at E_p = 200, 250, 300, and 400 MeV. It has been shown that the relativistic impulse approximation (RIA) can well explain the ^{58}Ni data by using density distributions of the target nucleus deduced from the charge densities obtained in electron scattering and taking into account nuclear medium effects for the meson–nucleon coupling constants and meson masses[1].

For $N \neq Z$ nuclei such as ^{120}Sn, we cannot expect the same density distributions for neutrons and protons, which have been assumed for ^{58}Ni. Proton elastic scattering is sensitive to both density distributions and the interaction inside the target nucleus. We can apply the proton scattering to deduce the neutron density distribution by assuming the same medium effects for the ^{120}Sn nucleus as for ^{58}Ni, since the proton density distribution is restricted by the charge distribution measured by electron scattering. As the first trial, we adopt the realistic neutron density defined by the formula;

$$\rho_n(r) = \rho_p^{\rm elec}(r) + \left[\rho_n^{\rm RH}(r) - \rho_p^{\rm RH}(r)\right], \qquad (1)$$

where $\rho_p^{\rm elec}$ is the realistic point proton density deduced from the charge distribution, $\rho_p^{\rm RH}$ and $\rho_n^{\rm RH}$ are the relativistic Hartree (RH) calculations for proton and neutron, respectively. Fig.1(a) presents the realistic point proton density distributions deduced from electron scattering for various tin isotopes. Realistic neutron distributions are displayed in Fig.1(b). Neutron distribution in ^{120}Sn has an increase at the nuclear center, since the $3s_{1/2}$ shell is thought to be closed in a simple shell model.

Experimental data and model calculations for the elastic scattering from ^{120}Sn at 200, 250, 300, and 400 MeV are shown in Fig.2. Solid circles are our data. Only statistical errors are included. Dotted lines are the original RIA calculations[2] without medium modifications except for Pauli blocking effects using RH densities, while solid lines in the same figures represent RIA calculations with medium effects and realistic densities described above. Fit to the data is improved in all energies. Dashed lines indicate RIA IA2 calculations by Tjon and Wallace[3]. Discrepancies among the models are observed at large scattering angles. This tendency is enhanced in the Q-parameter predictions as shown in Fig.3. Thus we are now preparing to measure Q-parameters for both ^{58}Ni and ^{120}Sn to check various models, to fix the medium effects at intermediate energies, and to extract the neutron density distribution in the ^{120}Sn nucleus.

References

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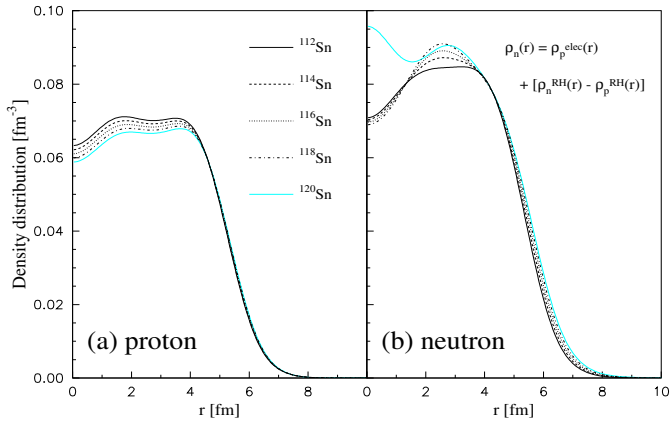

Figure 1: (a) Density distributions of point protons for various tin isotopes are interpolated(extrapolated) from the charge distributions. (b) Realistic density distributions of point neutrons are evaluated from the point proton distributions.

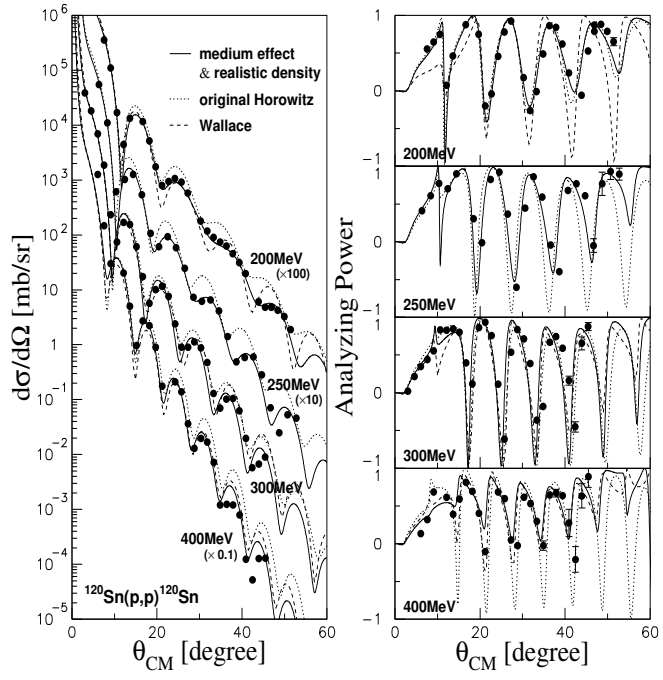

Figure 2: Various model calculations of cross sections and analyzing powers of proton elastic scattering from ^{120}Sn at E_p = 200, 250, 300, and 400 MeV are shown. Dotted lines are the original RIA calculations of Horowitz *et al.* Solid lines indicate the RIA calculations using medium effects and realistic densities. Dashed lines are the RIA IA2 calculations by Wallace *et al.* Large discrepancies among these models are founded at large scattering angles.

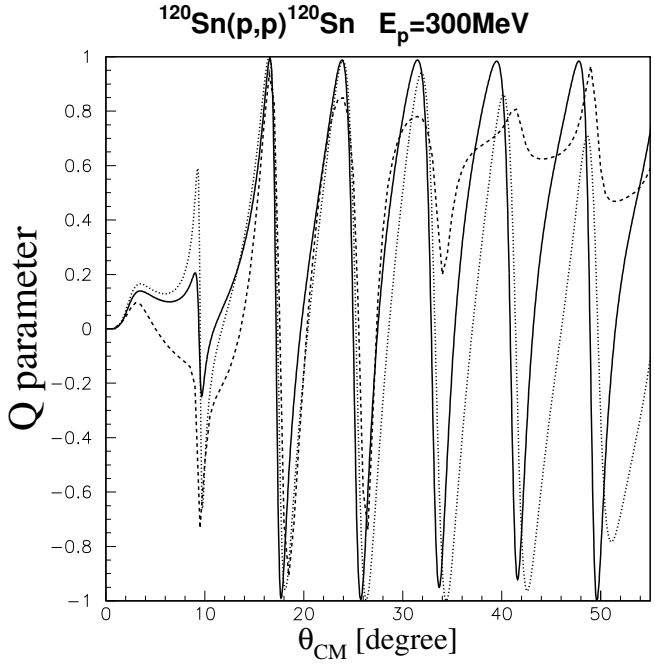

Figure 3: Q-parameter predictions by various models are shown for proton elastic scattering from ^{120}Sn at E_p = 300 MeV. Line type conventions are the same as Fig.2. There are notably large discrepancies at large scattering angles.