Exploration of Nuclear Matter Distribution of the s-d Shell Nuclei with the Elastic and Inelastic Scattering of 65 MeV Polarized Protons

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Here we report for the first time the regular dependence of the analyzing power on mass number in the s-d shell nuclei. Using the 65 MeV polarized proton beam from the RCNP (Osaka) cyclotron,[1] we have measured analyzing powers of the elastic and inelastic scattering on almost all the s-d shell nuclei (^{16}O, ^{20}Ne, ^{24}Mg, ^{25}Mg, ^{26}Mg, ^{27}Al, ^{28}Si, ^{29}Si, ^{30}Si, ^{31}P, ^{40}Ar). In fig. 1. elastic scattering analyzing powers of even-even nuclei show steep rises between θcm=25° and 30° where the first diffraction peaks are observed in the differential angular distribution. The C.M. angle of this sharp rise shifts forward as the target mass number A increases. An overall fitting using the optical model or coupled channel code ECIS is in progress.

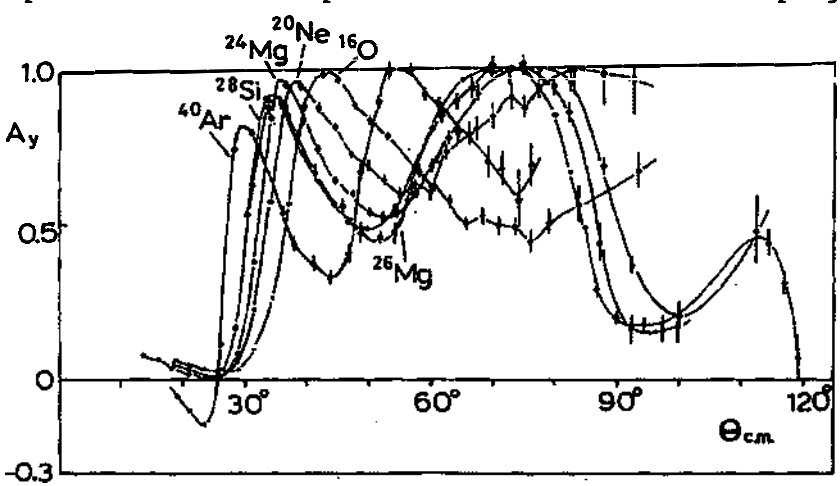

Fig.1. Target mass dependence of the elastic analyzing power
The line drawn througth the experimental data are only for eye guide.

In fig. 2. and fig. 3. we show an optical model analysis for ^{28}Si and the dependence of the steep rise angle on the potential parameter. From this preliminary analysis we can infer that the angle of this steep rise depends mainly on the nuclear radius of the real part of the optical potential. This phenomena can be understood intuitively by considering that this steep rise angle corresponds to the first diffraction maximum angle and considering $\lambda=2R\sin\theta$ (λ: wave length of the incident proton, R: the nuclear radius, θ=C.M. angles) or using the spin-orbit perturbation theories.[2,3] According to the Rodberg's square well theory, the variation $\delta\theta$ of the steep rise

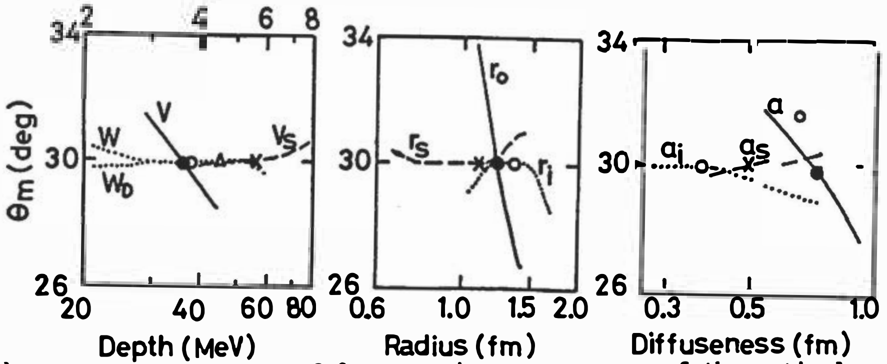

Fig.2. The dependence of θm on various parameters of the optical potential, where θm's are defined by the following equation

$A_y(\theta m)=(A_y^{min}(\sim 24°)+A_y^{max}(\sim 35°))/2$

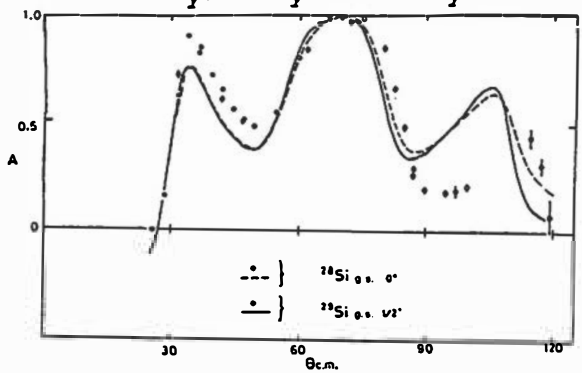

Fig.3. The comparison of the coupled-channel calculation with experimental results for elastic analyzing power of adjacent nuclei.

angle is obtained by the condition qR=const. ($q=\sqrt{k^2+K^2-2Kk\cos\theta}$, $K=\frac{\sqrt{2m(E-V)}}{\hbar}$)

$$\delta\theta=-\frac{q^2}{Kk\sin\theta}\frac{\delta R}{R}+\frac{K-k\cos\theta}{2Kk\sin\theta}\frac{\sqrt{2m}}{\hbar}\frac{\delta V}{\sqrt{E-V}}$$

For ^{28}Si target we can obtain

$$\delta\theta=0.64\frac{\delta R}{R}+0.14\frac{\delta V}{|V|} \qquad (\theta=\frac{\pi}{6})$$

This result surprisingly corresponds to the numerical calculation of the fig. 2.

It can be concluded that we have now come to a stage to propose another way to explore the nuclear matter distribution by using the polarized proton beam.

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