A Woods-Saxon Optical-Model Description of 14N Elastic and Inelastic Scattering from 27Al and 28Si

著者	Yamaya T., Morita S., Hirota J. I., Kotajima K., Shinozuka T., Onodera T., Sato K., Ohi T., Fujioka M.
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Yamaya T., Morita S., Hirota J. I., Kotajima K.*, Shinozuka T.**, Onodera T.*,
Sato K.*, Ohi T.* and Fujioka M.**
Department of Physics, Faculty of Science, Tohoku University
Department of Nuclear Engineering, Tohoku University*
Cyclotron and Radioisotope Center, Tohoku University**

Optical model potentials generated by double folding a realistic G-matrix interaction with projectile and target density distributions have been generally successful in reproducing elastic scattering angular distributions for light heavy ions. However, test of its applicability to heavy-ion inelastic scattering and light heavy-ion with excited break-up channel in the low-lying state have been limited. On the other hand, it has been suggested that heavy-ion elastic scattering is sensitive only to the tail region of the nuclear potential due to the strongly absorbing nature of the interaction. It has be also suggested that the only physical information which may be extracted from an analysis of heavy-ion elastic scattering is the strong absorption radius and the value of the real nuclear potential at this radius.

In the present work, measurements of the elastic and inelastic scattering of ^{14}N from ^{27}Al and ^{28}Si are reported, together with a Woods-Saxon optical-model analyses of the elastic scattering data for ^{27}Al and ^{28}Si. $^{14}N^{5+}$ beam were accelerated with the 680 type AVF cyclotron to energy of 84 MeV. Currents of up to 3 charge nA of $^{14}N^{5+}$ were obtained on the target. The small beam spot on the target was obtained collimating with a beam collimeter to get good angular resolution. For the ^{27}Al and ^{28}Si targets, self-supporting ^{27}Al and ^{28}Si foil with thickness of approximately 100 $\mu g/cm^2$ were used. A laboratory angular range from 10° to 35° was covered in 0.75 steps with a position sensitive solid state detector and two totaly depleted silicon surface barrier detectors. The detector system is consist of a telescope with two ΔE detectors and a position detector behind these ΔE silicon detectors. The elastically and inelastically scattered ions from the target were detected at four angles at same time by use of this system. Mass identification was obtained using a particle identification circuit. The 1.78 MeV ^{28}Si level was strongly pupolated in this experiment. In the Fig. 1, the angular distribution for the ^{28}Si 1.78 MeV level is shown together with those for the elastic data of ^{28}Si and ^{27}Al. The angular distribution for this excited state displays substantially stronger oscillation as compared with the data at E = 53 MeV.1) As a test of the Woods-Saxon optical-model parameters determined in the elastic scattering analysis, the DWBA calculation were made in which the optical model parameters listed in table 1 were used to generate the distorted waves. The DWBA calculation were made with the computer code DWUCK. The optical model potential parameters E18 labeled by Cramer et al.2) were taken for ^{27}Al target. These parameters have been derived from fitting the DWBA calculation to the ^{16}O + ^{28}Si elastic scattering data at E = 215.2 MeV. As can see in Fig. 1, the DWBA calculation for ^{27}Al is in agreement with the elastic data. For ^{28}Si, we used the optical model parameters obtained by Kohno.$^{3)}$ For inelastic scattering for 1.78 MeV 2^+ of ^{28}Si, quadrupole potential deformations were included in these calculations through a multipole expansion of the radius, where $R = R_0|1+\Sigma_{LM}\beta_L Y_L^M(\theta,\phi)|$. Cross section calculation was made without Coulomb excitation. The results of the DWBA calculation for 1.78 MeV, 2^+ of ^{28}Si level is also presented compare with the data in Fig. 1. The DWBA predictions have been normalized to the experimental data. The magnitudes of the deformation parameter β, determined from the normalization of the theoretical curve to the data, are 0.10 ± 0.02 for ^{28}Si. The present analysis is insensitive to the sign of the deformation. The calculated deformation length, βR is 1.46 ± 0.07 fm, however, the value obtained present data is 0.7 ± 0.15. In general, the DWBA calculations describe the slope, phase, and magnitude of the oscillations in the experimental data rather well, however, the DWBA calculation for 1.78 MeV ^{28}Si does not represent the data at large angles. The DWBA analysis for present data and the experiment for lighter mass target go on well.

References

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Table 1. Optical-model potentials using Woods-Saxon type.

Target	V_0 (MeV)	r_r (fm)	a_r (fm)	W_0 (MeV)	r_i (fm)	a_i (fm)	r_c (fm)
^{27}Al	11.76	1.36	0.658	50.69	1.25	0.40	1.4
^{28}Si	60	1.147	0.527	14	1.164	0.929	1.0

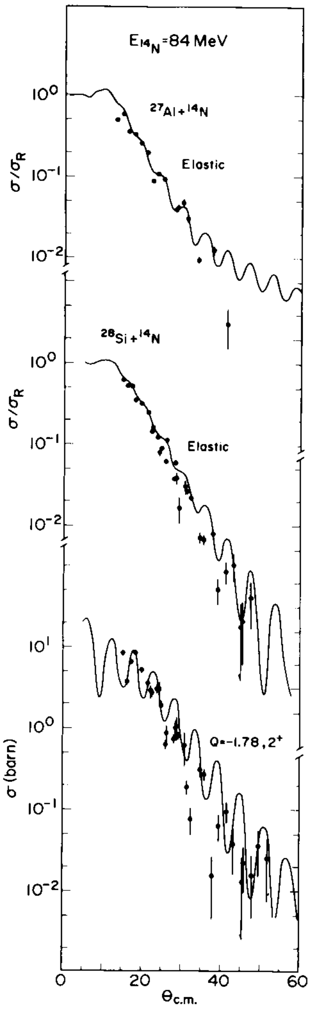

Fig. 1. σ/σ_R for the elastic scattering of ^{14}N + ^{27}Al and ^{14}N + ^{28}Si, and inelastic scattering cross section for $^{28}Si(^{14}N,^{14}N)^{28}Si^*$ (1.78 MeV,2^+) reaction at E = 84 MeV. The solid curves represent the DWBA calculations using the optical model parameters of table 1.