Optical Potential for the p-Shell Heavy Ion Scattering

著者	Yamaya T., Satoh O., Kotajima K., Seki H., Shinozuka T., Fujioka M.
journal or publication title	CYRIC annual report
volume	1987
page range	35-37
year	1987
URL	http://hdl.handle.net/10097/49398

I. 7 Optical Potential for the p-Shell Heavy Ion Scattering

Yamaya T., Satoh O., Kotajima K.*, Seki H.*, Shinozuka T.** and Fujioka M.**
Department of Physics, Faculty of Science, Tohoku University
Department of Nuclear Engineering, Faculty of Engineering, Tohoku University*
Cyclotron and Radioisotope Center, Tohoku University**

In the surface region of nucleus-nucleus potential where a short-range attraction force begin to at inside nuclear radius, the cross sections in the elastic scattering are expected to be so sensitive that perceive a somewhat of a weak surface-type potential adding to the strong central potential. As a surface-type potential, a spin-orbit force arising from the valence nucleon(s) of the nucleus is commonly thought. The spin-orbit potential for the heavy ion scattering is much weaker in proportion to $1/A_p^2$ than that for light ions scattering[1)], where A_p is a projectile mass. However, the experimental evidence has been accumulating that a spin dependent effect is much stronger for the transfer reaction.

Elastic and inelastic scattering of ^{12}C, ^{13}C, ^{14}N and ^{16}O projectiles on ^{28}Si have been studied at corresponding bombarding energies to the scattering in region of the vicinity of the strong absorption radius. Optical model and microscopic double-folding model analyses have been performed in order to define the nature of the optical potential depending on the projectile nuclei. For the analyses with the phenomenological optical model potential, the shallow potential such a central real potential depth V_R = 10 MeV is not adequate to reproduce both the elastic and the inelastic scattering data because of the unrealistic effective interaction deduced from the shallow potential for the elastic scattering. A distinction with a difference between the central potentials of the spinless projectiles ^{12}C and ^{16}O and the projectiles with spin, ^{13}C and ^{14}N, was found in the elastic scattering analyses. For the inelastic scattering data, the results of the DWBA calculations using the optical potential obtained from the elastic data well reproduce the data of the spinless projectiles ^{12}C and ^{14}N but not reproduce the data for ^{13}C and ^{14}N projectiles. A spin-orbit term of the Thomas-shape as an "effective spin-orbit potential" was introduced to the optical model calculation of ^{13}C and ^{14}N elastic scattering. It is a consequence of the introduction of the spin-dependent potential that the central potential of all four 1p-shell projectiles are nearly equal for the elastic scattering data and the angular distributions of the DWBA calculation also reproduced the measured inelastic cross sections for ^{13}C and ^{14}N projectiles.

Usual strongly absorbing heavy-ion optical potentials which yield good fit to low energy data have a central imaginary well depth 1/2 - 1/4 of a real depth. In the present analyses, the ratios of the W_0/V_0 and the $W_{1/2}/V_{1/2}$ are plotted in Fig. 1, where $V_{1/2}(W_{1/2})$ indicate the depth of the real (imaginary) potential at the strong absorption radius $R_{1/2}$. Both ratios of W/V at R = 0 and $R_{1/2}$ were almost 1/2 for ^{12}C and ^{16}O but were unusual values for ^{13}C and ^{14}N in the six- adjustable parameter analyses (except for the spin-orbit term). As the result of the analyses with the nine-adjustable parameter (including the spin-orbit term), both ratios W/V at the radius R = 0 and $R_{1/2}$ are about 1/2 for all four projectiles. That is, by introducing the spin-dependent potential, the ratios of W/V = 1/2 keep a good balance in the nearly equal central potential for all four 1p-shell projectiles.

A necessary of the spin-dependent force in the scattering system ^{13}C and ^{14}N + ^{28}Si was also suggested by the analyses using microscopic double-folding calculations[2], as same as the analyses using the phenomenological optical model. This results is shown in Table 1.

References

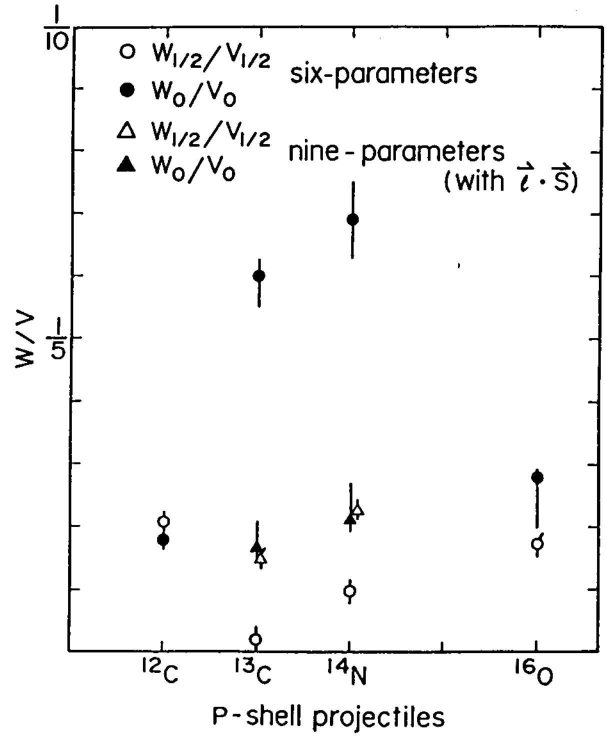
1) Amakawa H. and Kubo K.-I., Nucl. Phys. A266 (1976) 521.

2) Sakuragi Y., Yahiro M. and Kamimura M., Prog. Theor. Phys. Suppl. 89 (1986); Sakuragi Y., private communication.

Table 1. Optical potential parameters in the double-folding calculations.[a]

Ions	N_R	W_I (MeV)	r_I (fm)	a_I (fm)	V_{so} (MeV)	r_{so} (fm)	a_{so} (fm)	χ^2/N
^{12}C	0.74	43.90	1.12	0.55				8.6
^{13}C	1.0	17.25	1.26	0.73				6.9
(with l.s)	0.74	66.28	0.97	0.87	-0.78	1.40	0.32	4.9
^{14}N	0.97	12.06	1.28	0.65				9.7
(with l.s)	0.87	63.62	0.93	0.83	0.32	1.30	0.52	11.2
^{16}O	0.80	59.31	1.15	0.49				8.8

a. Charge radius is r_c = 1.0 fm.



1/10
W/V
1/5
W1/2/V1/2
W0/V0
six-parameters
W1/2/V1/2
W0/V0
nine-parameters
(with l · s)
12C
13C
14N
16O
P-shell projectiles

Fig. 1.