Analysis of Elastic Scattering of ^{14}N + ^{90}Zr

K. K. Jena[1], S. K. Agarwalla[2]*

[1]*P. G. Department of Physics and Applied Physics, Bhadrak Autonomous College, Bhadrak-756100, India*
[2]*Department of Applied Physics and Ballistics, Fakir Mohan University, Balasore-756019, India*
** Email : san1612@rediffmail.com*

Experimental results obtained from nucleus-nucleus scattering can be analysed by different optical models. In this paper we use an optical potential constructed in the light of a potential developed by Ginocchio to study the angular distributions of scattering cross-sections of a system in which the projectile ^{14}N is elastically scattered by the target ^{90}Zr near the Coulomb barrier. Theoretical calculations agree with the experimental data for incident energies ranging from 31.2 MeV to 43.3 MeV in centre-of-mass frame. Our effective potential is given by

$$V_{effective}(r) = V_{Coulomb}(r) + V_{nuclear}(r) + V_{centrifugal}(r)$$

The complex nuclear potential is obtained by putting λ=1 in the Ginocchio potential [**1**]. The real part $V_n(r)$ of the nuclear potential assumes the form [**2**]

$$V_n(r) = \begin{cases} -\frac{V_B}{B_1}[B_0 + (B_1 - B_0)(1 - y_1{}^2)], & 0 < r < R_0 \\ -\frac{V_B}{B_2}[B_2(1 - y_2{}^2)], & r \geq R_0 \end{cases}$$

Here, $y_n = \tanh \rho_n$, $\rho_n = (r - R_0)\, b_n$ and slope parameter $b_n = \frac{\sqrt{2mV_B}}{\hbar^2 B_n}$, n = 1, 2.

V_B is the depth of potential in MeV at r = R_0, where R_0 is the radial distance in the surface region of the target nucleus. The parameter B_0 controls the depth of potential at the centre, r = 0. Parameters B_n and V_B together control the slope parameter b_n on either side of R_0. The inbuilt deformation in the real part of nuclear potential at r = R_0 shows *non-trivial behaviour* there. The two parts of the potential corresponding to volume region and surface region (with slopes b_1 and b_2 respectively) are connected together to satisfy analytic continuity at r = R_0. The invoked new feature surprisingly helps us suitably fit the experimental data over a wide range of energies.

Real part $V_n(r)$ of our optical potential with energy E_{CM} = 37.2 MeV is given in Fig.**1** in which the *non-trivial feature* is indicated by an arrow. Imaginary part of the new optical potential has the similar form as that of real part, but the strength differs.

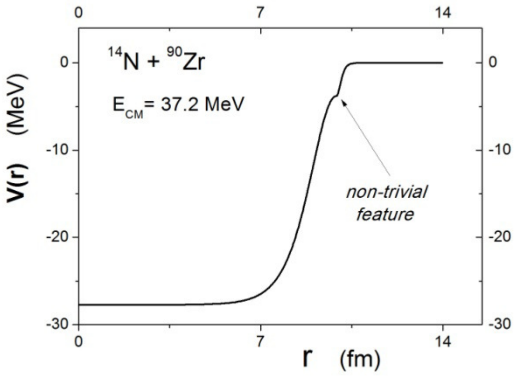


Fig.**1** : Real part $V_n(r)$ of the optical potential at incident energy 37.2 MeV with parameters R_0 = 9.9 fm, B_0 = 27.7 MeV, B_1 = 4.0, B_2 = 0.11 and V_B = 3.8 MeV (neglecting centrifugal term)

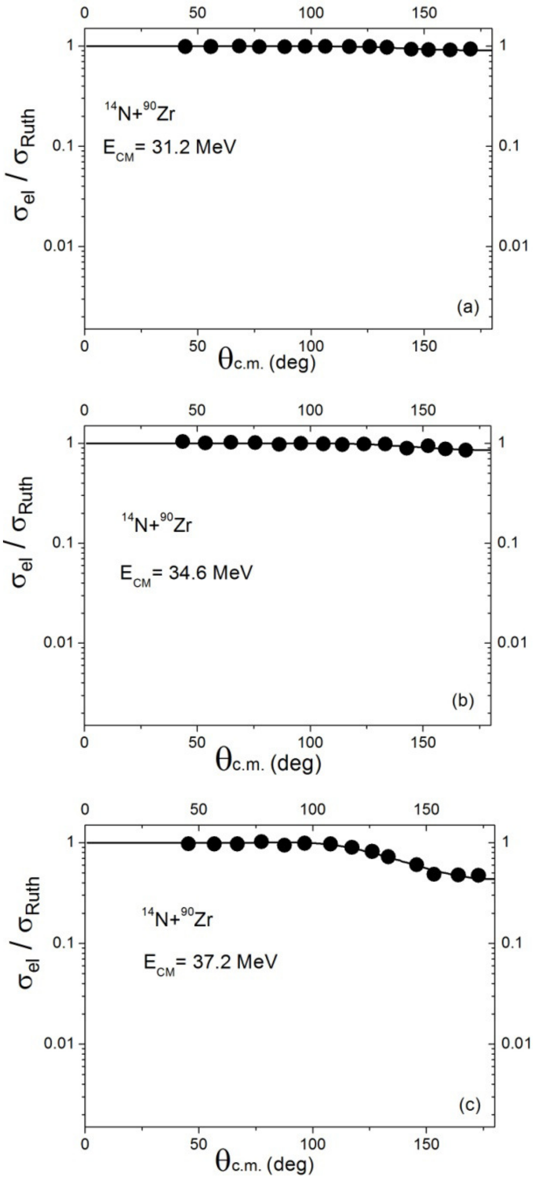
Table – 1 : *Energy-dependent parameters*

Energy (MeV)	**V_B** (MeV)	**B_0** (MeV)	**V_{BW}** (MeV)	**W_2**
31.2	2.46	25.0	0.6	0.60
34.6	4.0	22.2	0.4	0.40
37.2	3.8	27.7	0.14	0.14
38.9	2.5	28.4	0.35	0.35
43.3	2.2	29.8	0.45	0.45

Neglecting the contribution of centrifugal term, the analysis of ^{14}N + ^{90}Zr elastic scattering deals in 10 parameters out of which 6 parameters remain energy independent while fitting the calculated angular elastic scattering cross-sections with the experimentally measured values obtained from Ref.[**3**]. The energy-independent parameters are found to remain unaltered at R_0 = 9.9 fm, R_{0W} = 10.7 fm, B_1 = 4.0,

$B_2 = 0.11$, $W_0 = 3.5$ MeV and W_1=1.0. The other four parameters that vary with incident energies are mentioned in **Table-1**. The value of Coulomb radius parameter (r_C) is taken to be 1.25 fm. All the five fittings are depicted in Fig.**2**.

Our optical potential has significantly fewer parameters. Mallick et al. [**4**] using this potential were able to fit remarkably well the experimental results of the differential scattering cross section of $^{16}O+^{28}Si$ over a large range of energy.



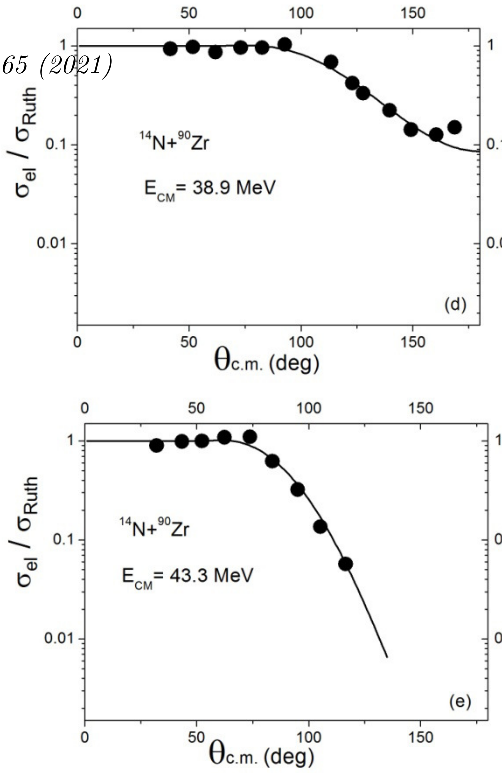


Fig.**2**(a-e) : Angular variations of scattering cross-sections of $^{14}N+^{90}Zr$ at different incident energies. Theoretically calculated results are represented by solid curves and the experimental values are represented by solid dots.

Our theoretical calculations in this paper also better agree with the experimental data for the whole energy range as compared to the fittings by M. E. Williams et al. [**3**].

References

[**1**] J. N. Ginocchio, Ann. Phys 152,203 (1984)

[**2**] B. Sahu, G. S. Mallick and S. K. Agarwalla, Nucl. Phys. A 727, 299 (2003)

[**3**] M. E. Williams et al., Phys.Rev.C11(1975) 3

[**4**] G. S. Mallick, S. K. Agarwalla, B. Sahu and C. S. Shastry, Phys. Rev. C73 (054606) 2006