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POTENTIALS FOR He^+ + Ar and He^+ + Ne DEDUCED FROM ELASTIC SCATTERING DATA

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In the classical impact parameter approximation for spherically symmetric scattering the reduced differential cross section

$$\rho = \theta \sin\theta\, \sigma(\theta, E)$$

is a function only of the reduced scattering angle

$$\tau = E\theta,$$

with correction terms that are negligible in forward scattering.[1] We have replotted together two sets of data for the elastic scattering of He^+ on Ne and Ar: the results of Aberth and Lorents[2] in the energy range 10 to 600 eV and those of Fuls, Jones, Ziemba and Everhart[3] in the range 25 to 100 keV. In the latter case we have employed the total pseudoelastic cross section (irrespective of the final charge state or excitation level of the He) as best representing the deflection of the projectile He^{++} as it passes through the field of the scatterer. The data show great internal consistency, providing empirical confirmation of the scaling law and allowing the potential to be deduced.

Over a very extensive part of the whole range, the scattering data can be reproduced very well by a simple screened coulomb repulsive interaction. Effects of shell structure are prominent in the screening, which can be expressed by the simple exponential forms

$$V_{rep}(Ar) = \frac{2e^2}{r}\left[8e^{-r/c_M} + 8e^{-r/c_L} + 2e^{-r/c_K}\right],$$

$$V_{rep}(Ne) = \frac{2e^2}{r}\left[8e^{-r/c_L} + 2e^{-r/c_K}\right]. \tag{1}$$

In Table I we compare the screening lengths c_i deduced from these data with the predictions of a simple hydrogenic model in which they are related to the closed-shell ionization potentials I_i:

$$c_i = a_0(I_H/I_i)^{1/2} \tag{2}$$

Table I

	Shell	$(c_i/a_0)_{exp}$	$(c_i/a_0)_{calc}$
Ar	M	.90	.93
	L	.14	.18
	K	$\ll c_L$	.057
Ne	L	.70	.79
	K	.055?	.107

At small reduced angles, the scattering data deviate from the pure repulsive scattering predicted by (1) in the direction corresponding to an attractive force, and the He^+ - Ar data show a clear rainbow feature at τ_r = 32 eV-deg from the same source. We have tried to fit (a) the deviation from the simple repulsive curve and (b) the rainbow angle τ_r by using a polarization term with screening as the outermost shell of the target is penetrated:

NA
On

$$V_{pol} = -\frac{\alpha e^2}{r^4}\left[1 - e^{-r/c_j}\left(1 + \frac{r}{c_j} + \frac{r^2}{2c_j^2} + \frac{r^3}{6c_j^3}\right)\right], \quad (3)$$

where $c_j = c_M(Ar)$, $= c_L(Ne)$. The resulting estimates of the polarizability α are given in Table II and compared with Dalgarno and Kingston's calculated values.[4]

Table II

	α(rainbow)	α(deviation)	α(calculated)
Ar	1.85 Å^3	1.65 ± .10 Å^3	1.64 Å^3
Ne	--	.41 ± .04 Å^3	.395 Å^3

References

1 F. T. Smith, R. P. Marchi, and K. G. Dedrick, Phys. Rev. 150, 79 (1966)

2 W. Aberth and D. C. Lorents, Phys. Rev. 144, 109 (1966)

3 E. N. Fuls, P. R. Jones, F. P. Ziemba, and E. Everhart, Phys. Rev. 107, 704 (1957)

4 A. Dalgarno and A. E. Kingston, Proc. Roy. Soc. A259, 424 (1960)