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LETTER TO THE EDITOR

e–He atoms elastic scattering at intermediate energies

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Abstract. The differential cross section obtained in the plane wave approximation for the elastic scattering of electrons of energy equal to and greater than 200 eV by helium atoms are in good agreement (within about 10%) with the recent experimental data.

Recently Jansen *et al* (1976) have measured absolute differential cross sections (DCS) for the elastic scattering of electrons by helium atoms in the angular range 5°–55°, at impact energies between 100 and 3000 eV. They have concluded that for impact energies greater than 200 eV the most preferable theory is the optical model (OM) theory of Byron and Joachain (1974) at lower energies and the eikonal-Born series (EBS) theory of Byron and Joachain (1973) at higher energies. Such a conclusion seems to be based on good agreement (within about 10%) between the theoretical results and the experimental data at scattering angles between 5° and 55°. However, at large angles, a comparison of the above mentioned theoretical results with the experimental data of Bromberg (1969, 1974) and Sethuraman *et al* (1974) shows that EBS theory yields overestimation while OM theory grossly underestimates the cross sections. Through this letter we wish to point out that one single approximation, namely the plane wave approximation (PWA), with energy dependent polarization potential, yields good agreement (within about 10%) at all the scattering angles and for the impact energies equal to and greater than 200 eV.

In the PWA, the DCS is given by (Jhanwar and Khare 1974, 1975):

$$I(\theta) = (f_{B1} - g)(f_{B1} - g + 2f_{dp}), \tag{1}$$

where f_{B1} and g are the first Born and Ochkur exchange scattering amplitudes, respectively. f_{dp} is the second-order scattering amplitude in the Born approximation and is due to a dynamic polarization potential. Although f_{B1} and g are not sensitive to the choice of the ground state wavefunction, for comparison we employ the same wavefunction as taken by Byron and Joachain (1973). To calculate f_{dp} we take for the polarization potential

$$V_{dp}(r) = -\frac{\alpha_1 r^2}{(r^2 + d^2)^3} - \frac{\alpha_2 r^4}{(r^2 + d^2)^5}, \tag{2}$$

where α_1 and α_2 are the dipole and quadrupole polarizabilities, respectively, of the helium atom and d is an energy dependent parameter. It may be noted that the dipole and the quadrupole part of (2) vanish as r^2 and r^4 and tend to zero at the origin.

Table 1. Differential cross sections for the elastic scattering of electrons by helium atoms (in unit of a_0^2).

Angle \ E(eV)	200	300	400	500	700	1000
5	0·154(1)†	0·111(1)	0·898	0·779	0·654	0·571
10	0·108(1)	0·743	0·599	0·520	0·432	0·353
15	0·779	0·523	0·415	0·350	0·268	0·193
20	0·566	0·371	0·283	0·228	0·159	0·103
25	0·415	0·262	0·190	0·146	0·940(−1)	0·561(−1)
30	0·306	0·185	0·128	0·940(−1)	0·569(−1)	0·321(−1)
35	0·227	0·131	0·868(−1)	0·617(−1)	0·357(−1)	0·193(−1)
40	0·170	0·939(−1)	0·600(−1)	0·415(−1)	0·232(−1)	0·122(−1)
45	0·123	0·683(−1)	0·423(−1)	0·287(−1)	0·157(−1)	0·810(−2)
50	0·986(−1)	0·505(−1)	0·305(−1)	0·204(−1)	0·109(−1)	0·556(−2)
60	0·600(−1)	0·290(−1)	0·170(−1)	0·111(−1)	0·582(−2)	0·292(−2)
70	0·385(−1)	0·179(−1)	0·103(−1)	0·605(−2)	0·343(−2)	0·171(−2)
80	0·260(−1)	0·118(−1)	0·668(−2)	0·429(−2)	0·220(−2)	0·108(−2)
90	0·185(−1)	0·823(−2)	0·463(−2)	0·296(−2)	0·151(−2)	0·749(−3)
110	0·107(−1)	0·466(−2)	0·260(−2)	0·166(−2)	0·843(−3)	0·415(−3)
130	0·722(−2)	0·313(−2)	0·174(−2)	0·111(−2)	0·563(−3)	0·277(−3)
150	0·563(−2)	0·244(−2)	0·135(−2)	0·861(−3)	0·437(−3)	0·215(−3)

† The number in brackets indicate the powers of ten.

Hence, (2) may be regarded as a better potential in comparison to that taken by Jhanwar and Khare (1975) which does not vanish at the origin. It may further be noted that the polarization potential of Byron and Joachain (1974, equation (2.95)) goes to infinity at the origin which cannot be justified. To obtain d we follow Jhanwar and Khare (1974) and get $d = 0{\cdot}75\, k/\Delta$ where k^2 is the incident electron energy and Δ is the mean excitation energy of the target. The values of α_1, α_2 and Δ are the same as taken by the above authors. It may be emphasized that $V_{dp}(r)$ as given by (2) does not contain any arbitrary parameter.

The present values of DCS are shown in table 1. A comparison of the results with the experimental data of Jansen *et al* (1976), Bromberg (1969, 1974) and Sethuraman *et al* (1974) shows that at practically all angles greater than 5° and impact energies $E \geqslant 200$ eV, the difference between the theory and the experiments is within about 10%. Furthermore, table 2 shows that the present results for the real part of the forward scattering amplitude are in best agreement (within 3%) with the results obtained using the dispersion relation (Bransden and McDowell 1970).

Table 2. Real part of the forward scattering amplitude for the elastic scattering of electrons by helium atoms

Investigation \ E(eV)	200	300	400	500
Dispersion relation (Bransden and McDowell 1970)	1·71	1·48	1·36	1·29
Present	1·67	1·47	1·36	1·29
EBS theory	1·54	1·39	1·30	1·24
OM theory	1·44	1·32	1·25	1·21

Finally we conclude that the plane wave calculations, which are extremly simple in comparison to the OM and EBS calculations, yield reliable cross sections for the elastic scattering of electrons by helium atoms for $E \geqslant 200$ eV.

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