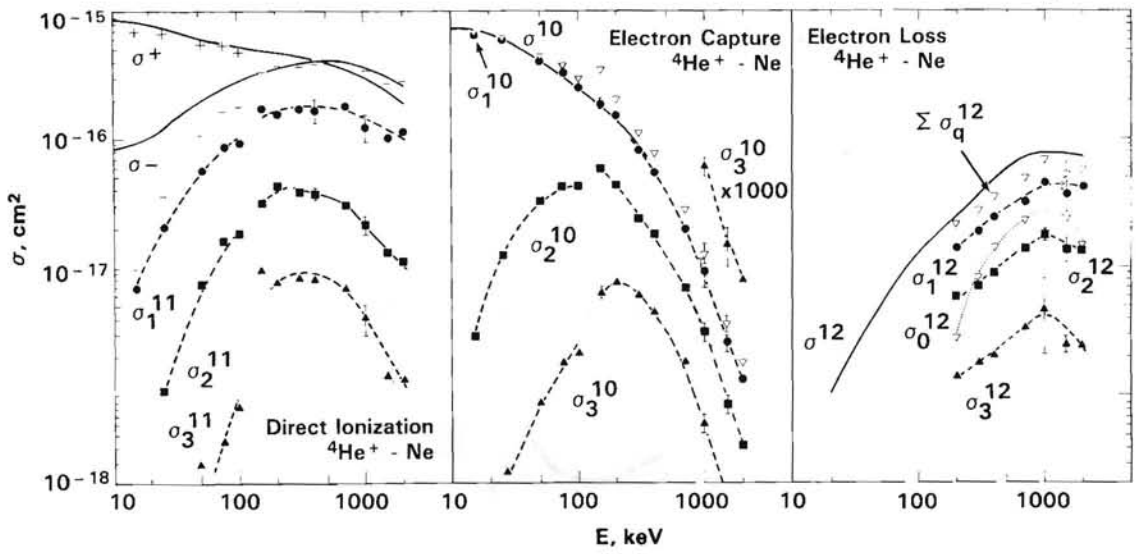

FIGURE 2. Cross Sections for Ionization of Neon by He^+ Impact. Total yield of target ions σ_+: + present data, —— Rudd et al. 1985; total yield of electrons σ_-: - present data, —— Rudd et al. 1985; direct single-, double-, and triple-target ionization σ_q^{11} (q = 1, 2, 3): ●, ■, ▲; total single electron capture cross section σ^{10}: ∇ present data, —— Rudd et al. 1985; single-, double-, and triple-target ionization resulting from single capture collisions σ_q^{10} (q = 1, 2 3) = ●, ■, ▲ total electron loss cross section σ^{12}: —— Rudd et al. 1985; single-, double-, and triple-target ionization resulting from electron loss collisions σ_q^{12} (q = 1, 2, 3): ●, ■, ▲.

STRUCTURED ION IMPACT: DOUBLY DIFFERENTIAL CROSS SECTIONS

R. D. DuBois

Electron emission occurring as a result of "clothed" ion impact (where the projectile contains electrons of its own) on atomic and molecular targets is difficult to model theoretically. Not only must the target ionization induced by a partially screened projectile nuclear charge be calculated, but projectile ionization induced by a neutral target also must be considered. In addition, it is possible that simultaneous ionization of the collision partners can occur. The doubly differential cross sections that we have traditionally measured in our laboratory are the sum of these individual electron production mechanisms. However, in a new series of experiments, we have measured the electron emission in coincidence with a projectile that has been ionized, thus making it possible to separate and identify electrons resulting from these various mechanisms.

In 1985, coincidence doubly differential cross sections were measured for 400 to 750 keV/atomic mass unit (amu) He^+ impact on He, Ne, Ar, Kr, and H_2O. Cross sections were measured for selected angles and for electron energies ranging from 10 to 1000 eV. A representative example of these data, recently published in Physical Review Letters (DuBois and Manson 1986), is shown in Figure 1. Because of the coincidence mode of measurement, the total electron emission (dotted curve) has been subdivided into its target emission (△) and its projectile emission (◇) components. The most interesting findings were that, although projectile emission is effectively responsible for the entire electron loss peak observed in the electron emission spectrum near 250 eV (as was expected), target ionization does not account for the total electron emission spectrum at lower electron energies (a totally unexpected discovery). A sizable percentage of these low-energy electrons were shown to originate as a result of simultaneous projectile/target ionizations (see, for example, the discussion in "Target Ionization by Helium Ion Impact" in this report). Similar features were observed for all targets and impact energies that were studied.

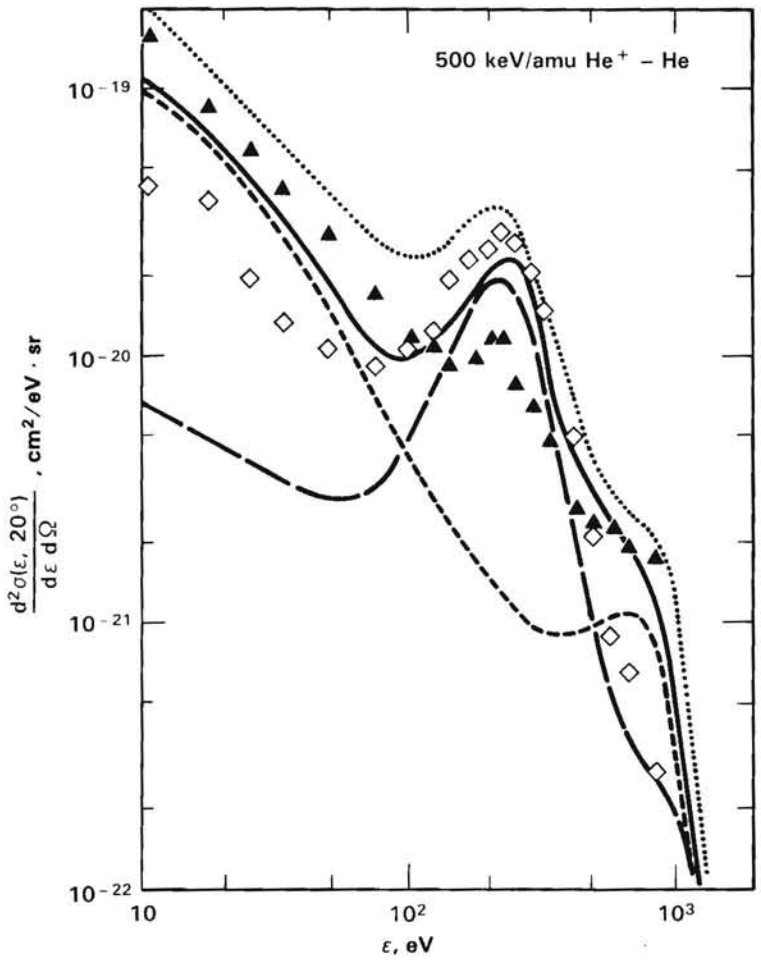

FIGURE 1. Doubly Differential Cross Sections for 500 keV/amu He^+ - He Collisions. The laboratory electron emission range is 20°. Total electron emission:.....exp, _____ theory; target electron emission: ▲exp, ---- theory; electron emission associated with projectile ionization; ◇ exp, – – – theory.

Also included in Figure 1 are theoretical calculations made using the Born approximation. A comparison of the calculations with the experimental data shows that target ionization and pure projectile ionization are handled fairly well theoretically but that simultaneous projectile/target ionization is drastically underestimated. This comparison also provides information about charge transfer to the continuum, which is assumed to account for the discrepancy between the experimental and theoretical target ionization cross sections near 250 eV. Thus these data have already provided insights into future improvements of the theoretical procedure used to calculate "clothed" ion impact ionization cross sections.

Future work is planned for H^0 impact, where it is anticipated that simultaneous projectile/target ionization will play a less significant role.

REFERENCE

DuBois, R. D. and S. T. Manson. 1986. "Coincidence Study of Doubly Differential Cross Sections: Projectile Ionization in He^+ - He Collisions." Phys. Rev. Lett. 57:1130-1132.