Comment on "Observation of the Striking Departure from Velocity Proportionality in Low-Energy Electronic Stopping"*

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On their recent energy loss measurement of a hydrogen projectile in He gas, Golser and Semrad¹ reported a significant deviation below 20 keV of the electronic stopping cross section from the projectile velocity v -proportionality. The common argument of the v -proportionality of the electronic stopping cross section at low energy is based on the constant-density electron-gas model of Lindhard and Scharff.² The purpose of this comment is to point out two considerations. First, inelastic processes in ionic collisions at low to intermediate energies (below ~ 25 keV/amu) are now well recognized^{3,4} by atomic physicists because of complex events in which many channels simultaneously interplay as a sensitive function of a combination of collision energy, coupling strengths, and energy defects among relevant channels as collision dynamics significantly vary from one system to another. Therefore, a simple model such as an electron-gas model would not be expected to provide universally accurate results for inelastic cross sections or stopping cross sections in this energy regime. Consequently, the v -proportionality is no longer always valid. Second, the general trend found by Golser and Semrad¹ can be reasonably well reproduced by reconstructing stopping cross sections of He and H₂ for protons from compiled cross section data and supplemental calculations, .

Figure 1 shows stopping cross sections for He and H₂ reconstructed from available data.⁵⁻⁷ In this evaluation, He(2¹S), He(2¹P), He(3¹S), and ionization channels and H₂(1s, $n = 2$), H₂(1s, 3s), and ionization channels are included for each case as the primary energy loss processes, with respective mean energy loss values of 20.6 eV, 21.2 eV, 22.9 eV, 24.6 eV, 12 eV, 14 eV, and 16.1 eV. Dominant charge transfer states lie energetically next to the initial H⁺ + He and H⁺ + H₂ channels. The corresponding charge transfer cross sections are known to be the largest by several orders of magnitude of all the inelastic processes in this energy region.^{5,6} However, no effect of charge transfer is included in the present evaluation. Cross sections to other highly excited states are known to be smaller by several orders of magnitude, although the corresponding mean energy losses are somewhat larger than those included. These highly excited states are also excluded from the present evaluation. The present result for He is qualitatively in very good accord with the measurement of Golser and Semrad¹ while that for H₂ satisfies the v -proportionality reasonably well;

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from our point of view, the departure from the v-proportionality is not striking, but is rather expected.

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Figure Caption

Fig. 1. Stopping cross sections of He and H₂ for protons. Lines are the present results. Solid line: He; broken line: H₂. Symbols are experimental data of Golser and Semrad for He (Ref. 1).

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Fig. 1

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