Energy-transfer and transport cross sections in dressed electron-ion binary collisions

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Synopsis  An improved formula for the electronic stopping power and an alternative formula for the transport cross-section is derived in terms of the phase-shifts from the scattering of electrons at the ion. The effective transport cross-section is superior to the well-established textbook formula when the ion is much faster than the electrons but may lead to some drawbacks at low projectile energies. The new formula is also used to investigate the stopping power from the ground- and excited-state scattering potentials calculated from self-consistent DFT calculations.

A new formula [1] for determining the electronic stopping power and the transport cross section in electron-ion binary collisions is derived from the induced density for spherically symmetric potentials using the partial-wave expansion. In contrast to the previous one found in many textbooks, the present formula converges to the Bethe and Bloch stopping-power formulas at high ion velocities and agrees rather well with experimental stopping-power data, as shown here for Al, C, and H$_2$O targets. It can be employed in plasma physics and particularly in any application that requires electronic stopping-power values of quasifree electrons with high accuracy.

In addition the ground- and excited-state scattering potentials for the stopping of protons in an electron gas has been investigated. For this sake, the spherical average of the self-consistent electron-ion potential $V(r)$ is calculated for H$^+$ ions in an electron gas system, in order to improve the understanding of the electronic stopping power for conduction-band electrons. The results show different self-consistent potentials at low projectile-energies, related to different degrees of excitation of the electron cloud surrounding the intruder ion. This behavior explains the abrupt change of velocity dependent screening-length of the potential found by the use of the extended Friedel sum rule (FSR). A dynamical interpolation of $V(r)$ is proposed and used to calculate the stopping power for H$^+$ interacting with the valence electrons of Al. The results are in good agreement with TDDFT benchmark calculations as well as with experimental data.

References


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