§13. Atomic Data Evaluation for He^+ and Neutral Atom Collisions

Shevelko, V.P., Tolstikhina, I.Y. (P.N. Lebedev Phys. Inst.),
Tawara, H. (NIFS, MPI for Nucl. Phys.),
Song, M.-Y., Yoon, J.-S. (NFRI),
Kato, D., Murakami, I.

Charge-changing cross sections of atomic processes involving H and He particles and their ions with neutral atoms are needed in many applications related with controlled thermonuclear fusion research (plasma heating by injection of neutral-particle beams, plasma diagnostics using a probe-beam attenuation), industrial plasmas, astrophysics, physics of upper atmosphere and others. Experimental data and theoretical calculations of electron capture and ionization cross sections are presented in many books and review articles[1-14]. It was shown that the first-order perturbation theory can be applied for cross-section calculations at relatively high impact energies, especially, for collisions of bare ions (protons and He^{++} ions). At low collision energies, molecular-orbital theories are usually applied but the accurate predictions can be made only when the problem can be reduced to a three-body problem, i.e., one electron in the field of two Coulomb centers. The most complicated for consideration are collisions involving dressed projectiles at intermediate energy when electrons of both colliding particles participate in the process[15-17].

In this work, extensive numerical calculations were performed for the following charge-changing processes involving He^+ projectiles colliding with neutral atoms, namely, of one-electron capture into the projectile ions

$$He^+ + A \rightarrow He + A^+, \quad (1)$$

and one-electron ionization of target atoms,

$$He^+ + A \rightarrow He^+ + A^+ + e, \quad (2)$$

for A = H, He (including $He^*(1s2s)$), Ne, Ar, Kr, and Xe atomic targets, using various models and computer codes valid for low and high impact energies. Then combining these results with available experimental data, a set of the recommended data are presented in a closed analytical form for a wide energy range of He^+ energy over 0.1 keV/u < E < 10 MeV/u using a fitting by power polynomials. In the case of He^+ + He collisions, the influence of the metastable 1s2s states of He atoms on the charge-changing and ionization cross sections was studied in details.

Frequency of symmetric resonance charge exchange between $He^+(1s)$ ions and high Rydberg He(1s*nl*) atoms becomes an issue of studies for temperature measurements of neutrals in partially ionized divertor plasmas. Theoretical investigation of the charge exchange cross sections at collision energies below 1eV is ongoing.

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