

# Kinetic Models of Plasma-Particle Charge, Momentum and Energy Transfer under Rarefied Flow Conditions

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One of the most important effects at plasma-particle interaction is associated with gas ionization and presence of electrons and ions in the plasma flow along with neutral molecules. The laws of plasma-particle interaction are determined by accumulation of charges on a particle and creation of local electric field affecting the motion of electrons and ions. In general case, charge, momentum and energy flows depend on spatial electrostatic potential distribution around the particle, and the kinetic description of plasma-particle interaction consists in a combined solution of the Boltzmann equation for the velocity distribution functions of plasma species, and the Poisson equation for the electrostatic potential. However, the solution of the kinetic problem entails great mathematical difficulties, and depending on the parameters of the plasma flow and the particle, special analysis is needed. The following situations are considered:

**Particle in stationary plasma.** Maxwellian, monoenergetic, and cold ions approximations are used for the solution of the kinetic equations. Effect of Debye screening on the intensity of plasma action is considered. Asymptotic analysis is applied to the description of the behavior of particles with thin (strong Debye screening) and thick (weak screening) plasma sheath.

**Thermoemitting particle in plasma.** Method of trajectories analysis is applied to the description of plasma action on the particle under the conditions of weak (negatively charged particle) and strong (positively charged particle) thermal electron emission.

**Particle in subsonic plasma flow.** Corrections due to the particle relative velocity are obtained on the basis of the kinetic theory for an arbitrary plasma screening conditions.

**Particle in hypersonic plasma flow.** Method of direct modeling of the motion of ions is used for the description of the interaction between the particle and hypersonic plasma flow with an arbitrary screening parameters.

Kinetic theory analysis of plasma-particle interaction allows to predict a number of important effects, such as particle charging, increase of particle drag and heat transfer rate due to the contribution of electrons and ions, negative thermophoresis, enhancement of heat transfer to thermoemitting particle, etc.