QUANTUM MECHANICS OF ELECTRONS AT PLASMA BOUNDARIES*

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Macroscopic objects in contact with an ionized gas accumulate electrons more efficiently than ions leading to a quasi-stationary electron film at plasma boundaries which strongly affects the bulk of bounded plasmas via sheath formation, surface-supported electron-ion recombination, and secondary electron emission from the surface. A microscopic description of the build-up and fate of the electron film on par with the kinetic modeling of the bulk plasma is however still missing. As a first step in this direction, we recently proposed to treat the charging of surfaces in contact with an ionized gas as a physisorption process in the polarization-induced external surface potential of the plasma boundary[1,2]. Using a simple microscopic model for the electron-surface interaction we calculated the electron sticking coefficient and desorption time for an ideal surface of a metallic boundary[2]. The sticking coefficient turned out to be rather small but the product sticking coefficient times desorption time was of the order expected from our phenomenological study of the charging of grains in low-temperature gas discharges[1]. In the meantime we set up a quantum-kinetic rate equation to investigate physisorption of electrons at dielectric boundaries where phonon-induced up- and downward cascading in the manifold of bound electron surface states may occur[3]. In addition, multi-phonon processes turn out to be important for dielectric boundaries making, in some cases, the desorption time particularly long. Even for graphite, where two-phonon processes suffice, the desorption time of an image-bound electron is already of the order of 0.0001s. Since surface charges play a critical role in dielectric barrier discharges, determining whether the discharge is in the filamentary or diffusive mode, we also calculated, employing quantum-kinetic techniques based on Keldysh Green functions, the secondary electron emission coefficient due to de-excitation of metastable molecules in front of dielectric plasma boundaries. Our contribution to the ICOPS 2010 gives an overview of our microscopic approach and a summary of the results obtained so far.

1. F. X. Bronold et al., “Surface states and the charge of a dust particle in a plasma”, Phys. Rev. Lett. 101 (2008), 175002.
2. F. X. Bronold et al., “Physisorption kinetics of electrons at plasma boundaries”, Eur. Phys. J. D 54 (2009), 519.
3. R. L. Heinisch et al., “Phonon-mediated desorption of image-bound electrons from dielectric surfaces”, submitted to Phys. Rev. B (2010).

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