

“Unsociable” Electrons Help Optimizing Plasma Devices

Advanced kinetic theory and simulation reveal complex structure of electron velocity distribution function in plasma devices.

November 1st, 2006

Wednesday 2:00pm

[Invited Session QI2: Basic Plasma Physics II](#)

Philadelphia Marriott Downtown Grand Salon CDE (room)

Research on low-pressure plasma devices has revealed new insights into the plasma behavior. It is a common assumption that electrons with different energy in plasma “socialize” due to collisions and form an equilibrium Maxwellian electron velocity distribution function (EVDF). In such EVDF, the number of electrons with given kinetic energy w is independent of the direction of electron motion (isotropy) and is proportional to $\exp(-w/T)$, where T is the electron temperature. Recent experimental, theoretical and numerical studies revealed that this assumption is, in general, incorrect. In low-pressure discharges, electrons do not have time to “socialize”; they retain their “differences” according to origin and individual life-time experience. As a result, the EVDF may have a complex form, as shown, for example, in Fig.1. For the first time, it has been demonstrated that the EVDF is noticeably anisotropic. The “unsociability” of electrons in low-pressure plasma devices makes them a remarkable tool for many applications, because it gives the opportunity to selectively control populations of electrons with different energies. This is how one can increase, for example, production of selected active radicals in plasma processing reactors, light emission from plasma light sources, or thrust in plasma propulsion systems. Understanding and controlling the electron population helps optimizing plasma devices for material processing, high-intensity lighting, electric propulsion, etc.

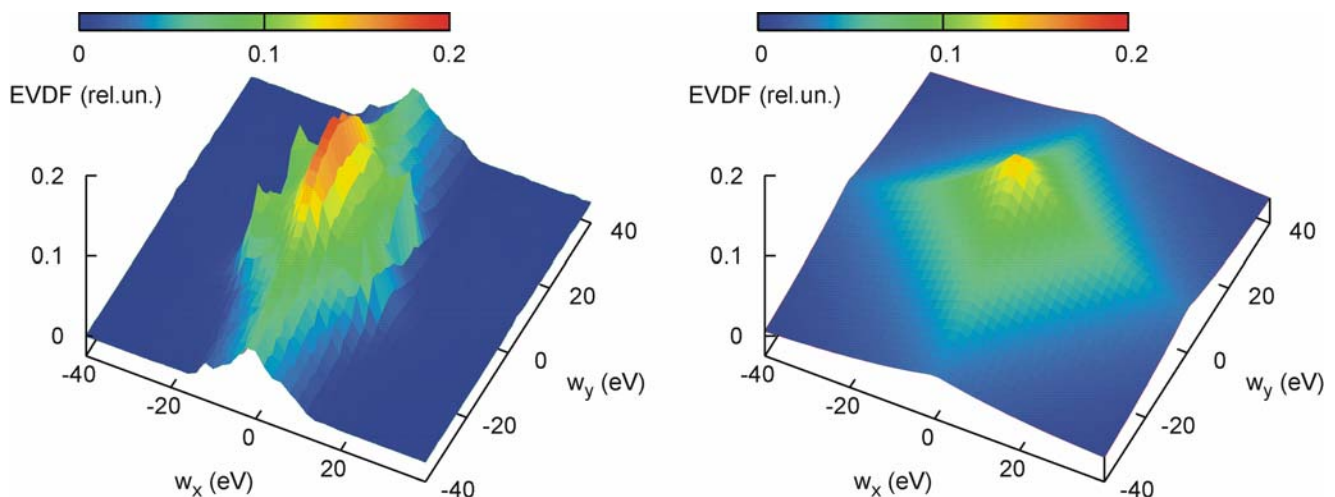


Fig. 1. Complex structure of a strongly anisotropic EVDF in the channel of a Hall thruster discharge (left) versus an isotropic Maxwellian EVDF (right). More details are in [1].

I. Kaganovich Press Release

Recent 2005 Workshop on Nonlocal, Collisionless Electron Transport in Plasmas held at Princeton Plasma Physics Laboratory has updated and summarized the progress in the topic and discussed future directions in the field. All presentations from the Workshop are available [online](#). Special issue of IEEE Transactions on Plasma Science published invited papers from the Workshop [2].

Further information:

[1] I. Kaganovich, Y. Raitses, D. Sydorenko, and A. Smolyakov, “Kinetic effects in Hall thruster discharge”, [invited paper at 2006 APS DPP](#), submitted to Phys. Plasmas (2006).

[2]. [Special Issue](#) of invited papers of 2005 Workshop on Nonlocal, Collisionless Electron Transport in Plasmas, IEEE Transactions on Plasma Science **34**, N3, June 2006.

Contact:

Igor Kaganovich, Plasma Physics Laboratory, Princeton University, (609) 243 3277,
ikaganov@pppl.gov

Dmytro Sydorenko, Department of Physics, University of Alberta, Canada, (780) 492-7284,
sydorenk@ualberta.ca