Physical nature of electrons with anomalous energies in Fast atmospheric discharges

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Extensive number of experimental studies connected with runaway electrons beams generation convincingly shows the existence of the electrons group with energies above the maximum voltage applied to the discharge gap [1-3]. Such electrons are also known as electrons with "anomalous" energies. Their fraction of the total number of runaway electrons usually does not exceed 10%. The existence of such high-energy group of fast electrons in principle cant be explained in terms of simplified theoretical models of macroparticles (PIC) or with different hydrodynamic approaches. In this presentation, we propose novel method for the modelling of gas discharge with runaway electrons explaining the appearance of anomalous energies [4]. The method we use is based on fundamental principle of physical kinetics, namely, we describe the ensemble of fast electrons with the distribution function. Its evolution obeys Boltzmann kinetic equation, while the motion of heavy particles (positive and negative ions, and neutrals) is described in terms of hydrodynamic drift-diffusion approximation widely used today in plasma discharge physics. The dynamics of self-consistent electromagnetic field is taken into the account by adding complete Maxwells equation set to the resulting system of equations. For the first time our kinetic-hydrodynamic hybrid model made possible explaining the existence of "anomalous" energies in the spectrum of fast electrons, and accurately predicting fast electrons number of particles in gas discharge of the certain configuration [5]. The model we consider also provides some essential details on the formation of runaway electron beams with respect to different experimental conditions. The numerical results we obtain fit the existing experimental data for discharges in air and sulfur hexafluoride at atmospheric pressure [6].

[l] E.H. Baksht et al., Phys. Wave Phen. **18**, 44 (2010).
[2] A.V. Kozyrev et al., Laser. Part. Beams **33**, 183 (2015).
[3] E.H. Baksht, Journal. Phys. D **43**, 305201 (2010).
[4] V.Y. Kozhevnikov et al., EPL **112**, 15001 (2015).
[5] A. Kozyrev et al., EPL **114**, 45001 (2016).