Kinetic theory of a multicomponent cathode plasma expansion process in a planar vacuum diode

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The phenomenon of vacuum breakdown has been widely explored over the past decades. From the fundamental point of view an attention here is payed to the fact why do ions move towards the increasing electric potential (from the cathode to the anode) [1]. This phenomenon is called an "anomalous ion acceleration". It was also noted that the typical average ion velocities correspond to kinetic energies of tens and even hundreds of electron volts, while the characteristic thermal energies do not exceed units of electron volts [2]. This paper presents a theoretical explanation to the phenomenon of anomalous ion acceleration in vacuum diodes. The explanation is given from first principles of collisionless physical kinetics. The proposed theoretical interpretation convincingly proves that the main mechanism of anomalous acceleration of cathode plasma ions is the collisionless motion of ions in a self-consistent electric field. The emerging non-trivial field configuration (area of a non-stationary virtual cathode) at the initial stage of the development of the process creates an advanced movement of electrons, similar to that in diodes with predominant electron emission. The simulation also indicates differences in the motion of singly and multiply charged ions as the cathode plasma expands and their resulting contributions to the initial stage of vacuum breakdown development.

[1] Nikiforov G A 2011 *Vzrywnaya elektronnaya emissiya* (Moscow: Fizmatlit)
[2] Plutto A A 1960 *Zh. Exp. Teoret. Fiz.* **39** 1589–1592