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ON THE INFLUENCE OF ELASTIC SCATTERING COLLISIONS ON THE FORMATION OF THE INITIAL STAGE OF VACUUM BREAKDOWN*

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The discovery of explosive electron emission posed a number of actual problems for theoretical and experimental plasma physics [1]. One of the fundamental problems is directly related to the study of fast processes at the initial stage of vacuum gap breakdown. An extensive explosive electron emission experimental base allows to unequivocally state that the cathode plasma expansion from the cathode to the anode occurs with high velocities of about $\sim 2 \cdot 10^6$ cm/s, which significantly exceeds typical thermal velocities of initial explosion plasma components [2]. If we consider the cathode plasma as a whole, then the question arises: what exactly leads to the positive metal ions accelerations from the cathode towards anode? This phenomenon is known also as an “anomalous” ions transport [3].

In a number of researches, it was shown that "anomalous" ions acceleration is caused by the electrodynamic forces. This explanation is called an electric potential "hump" hypothesis [4]. However, some other reasons can potentially contribute to "anomalous" ions acceleration that are not related to electrodynamics [4]. In particular, it is believed that electron-ion and ion-ion elastic scattering collisions provide the directed velocity to ions in order to move towards anode.

In the paper [5], it was shown for the first time based on a self-consistent kinetic model of a multicomponent plasma that the "anomalous" ion dynamics is accomplished by the appearance of a nonstationary electric potential “hump”, which leads to a continuous acceleration of ions towards anode. In addition, it was shown that this process is essentially collisionless. In further papers (e.g. [6]) the same mechanism was also observed with respect to a multi-component cathode plasma. Thus, it is argued that non-electrodynamic processes play a secondary role or simply insignificant during the cathode plasma expansion into the gap. In the present work, the contribution of ion-ion collisions to the "anomalous" character of ion acceleration and the overall current transfer at the initial stage of vacuum breakdown formation is elucidated.

In this paper, we include elastic collisions between ions in previous collisionless kinetic model in the form of collision integral in BGK approximation. This model’s improvement allows to elucidate the collisional effects between ions on the overall picture of the initial stage of vacuum breakdown development.

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