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Ion effects on the space charge limited emission for particle-in-cell simulations

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Space charge limited (SCL) emission is of fundamental importance to vacuum electronic devices, where the self-field of emitted charges limits the maximum current density being emitted from a cathode surface. Traditional modeling of SCL emission using the Child-Langmuir law primarily focuses on electron dynamics, neglecting the role of ions, which can significantly influence emission dynamics. In this work, we extend a previously developed simple SCL algorithm for implementing the Child-Langmuir law at the surface grid in particle-in-cell (PIC) simulations to study ion effects. The presence of ions introduces new dynamics, affecting the steady-state current, the evolution of surface electric fields, and the transient behavior of SCL emission. Using the 1-D electrostatic PIC code, XPDP1, developed by the Plasma Theory and Simulation Group (PTSG), we investigate these ion-induced modifications and test the influence of ions on the SCL emission algorithm. The extended algorithm ensures an accurate computation of the surface electric field via Gauss's law to resolve the space charge contribution from both ion motion and electron emission, and the findings will be discussed in detail.

Footnotes

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Region represented

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