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The Child Langmuir Illusion

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It is a commonly held belief that the beam current extracted from an ion source varies with the applied extraction voltage with a V^(3/2) power law as defined by the space charge limited Child Langmuir equation. However, recent experiments and modelling work have shown that the reason for the apparent V^(3/2) relationship is not caused by space charge limited extraction, but instead the experimentally observed power law is caused by changes in the shape of the plasma meniscus and collimation on the extraction electrode. At lower extraction voltages the measured beam current is divergence limited.
Due to computational limitations previous attempts to model this effect either rely on analytical equations to represent the plasma (e.g IBSimu), or they rely on combining a Particle in Cell (PIC) model of the plasma with a beam tracing model to track the beam through the extraction gap. Combining models or relying on analytical equations always leave questions about the reliability of the overall results. Here we present a single PIC model that is capable of modelling both the plasma meniscus and beam transport in the extraction gap in a single model using a variable density mesh in VSim. A single PIC model for extraction and beam transport provides strong proof that the origin of the V^(3/2) relationship for plasma ion sources is caused by meniscus focussing and collimation, not by space charge limited extraction. Excellent correlation between the PIC model, IBSimu and experiment is shown for low current Ar+ beams.
The maximum beam current and plasma densities that are currently computationally feasible to simulate are investigated for 2D3V Axisymmetric and full 3D variable density mesh PIC models in VSim.

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Yes

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