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2P35 - Investigation into the Propagation of Electron Beams of Different Shapes through Gas-Filled Space Using PIC Simulations

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The propagation of moderately high energy (10-100 keV) electron beams through gas-filled tubes has been being long studied for various potential applications, such as microwave generation, EUV/X-ray radiation and surface modification [1-3]. However, it appears that not much attention has been paid to understand the mechanism as to how the e-beam cross-sectional shape affects the breakdown of a gas by beam electron impact ionization and how the self-focusing of e-beam by ion channel as well as eventual formation of instabilities under certain conditions takes place [3].This paper attempts to develop the understanding of such a mechanism by making a comparative investigation into the elecron beam propagation of solid cylindrical and annular electron beams through a gas-filled tube, using PIC simulation, under typical operating pressures (5-50 Pa), beam energies (10-50 keV) and beam currents (10-100 A). Analytical formulation of space-charge limiting current for different beam shapes along with the spatial and temporal evolution of beam envelope and cross-section is presented. It has been found that the accumulation of ion channel triggers instabilities deteriorating the beam quality, which happens much earlier in a solid cylindrical beam than in an annular beam. This has been quantitatively inferred based on the dependene of self-focusing behavior, controlled by the space-charge potential and charge-neutralization factor, on beam shapes. Several results investigating the role of beam and plasma parameters in the electron beam propagation through a gas-filled space have also been preented. It is worth extending the scope of the present simulation to study an e-beam penetrating through such a gas-filled space for beam-plasma convective instability in a beam-plasma amplifier.

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