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EXPERIMENTAL AND THEORETICAL STUDY OF ION BEAM NEUTRALIZATION BY PLASMA

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Producing an overdense background plasma for neutralization purposes with a density that is high compared to the ion beam density is not always experimentally possible. We show experimentally [1] and making use of particle-in-cell simulations [2,3] that even an underdense background plasma with a small relative density can achieve high neutralization of intense ion beam pulses if enough electrons are available to neutralize the ion beam space charge on plasma boundaries. Using particle-in-cell simulations, we show that if the total plasma electron charge is not sufficient to neutralize the beam charge, electron emitters are necessary for effective neutralization but are not needed if the plasma volume is so large that the total available charge in the electrons exceeds that of the ion beam [2]. Several regimes of possible underdense/tenuous neutralization plasma densities are investigated with and without electron emitters or dense plasma at periphery regions, including the case of electron emitters without plasma, which does not effectively neutralize the beam. Over 95% neutralization is achieved for even very underdense background plasma with plasma density 1/15th the beam density. We compare results of particle-in-cell simulations with an analytic model of neutralization and find close agreement with the particle-in-cell simulations.

We present experimental results on charge neutralization of a high-perveance 38 keV Ar beam by a plasma produced in a Ferroelectric Plasma Sources (FEPSs) discharge [1]. By comparing the measured beam radius with the envelope model for space-charge expansion, it is shown that a charge neutralization fraction of 98% is attainable with sufficiently dense FEPS plasma. The transverse electrostatic potential of the ion beam is reduced from 15V before neutralization to 0.3 V, implying that the energy of the neutralizing electrons is below 0.3 eV.

References

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Primary author: Dr STEPANOV, Anton (PPPL)

Co-author: Dr KAGANOVICH, Igor (PPPL)

Presenter: Dr KAGANOVICH, Igor (PPPL)

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