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On the ion beams and energetic electrons through a current-free double layer (CFDL).

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In Current-Free Double Layers (CFDLs), ions are accelerated from higher potentials (upstream) to lower potentials (downstream) regions. As CFDLs are self-consistent and not maintained by external currents, the electrons play a crucial role in the total charge balance of the CFDL. CFDLs and ion beams are readily observed at the intersection between the source and the expansion chamber in inductively coupled helicon plasma devices with suitable configurations of expanding magnetic field and low pressures. In the Njord device at University of Tromsø, the ion beam formation has been studied for nearly a decade, with some focus on the influence of the downstream magnetic field. For instance, permanent magnets around the source outlet has been investigated and found to increase downstream density and particle flux. For the diagnostics of ions, we have applied both retarding field energy analyzers (RFEAs) and Laser Induced Fluorescence (LIF) for comparison. PIC simulations have been performed in order to understand the energy spread of the ions as measured by the RFEA.

We found that both large plasma potential and field-of-view significantly affect the ion distributions, in addition to the well-known effect of RF oscillations in the plasma potential. For the investigation of high-energy electrons, the RFEA was set up in electron-collection mode and found to provide temperatures in agreement with measurements by Langmuir probes. Electron distributions with high-energy tails were observed in the downstream region, and they appeared along the magnetic field lines from the outer radial part of the source. These highly energized electrons are able to overcome the potential barrier of some 20 Volt and hence contribute to the charge balance, in addition to the downstream electrons that are accelerated from the downstream to the upstream regions.