Beam formation in a weakly collisional expanding, inductively coupled plasma.

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Abstract

A low-temperature high-density plasma is produced by and inductively coupled radio-frequency source and expands into a larger cylindrical chamber. The expansion leads to a potential drop along the source-chamber axis, which supports the formation of a downstream ion beam with energy on the order of the potential drop.
Axial potential profiles within and immediately downstream of the inductively coupled helicon source of the Njord device have been obtained by an emissive probe and compared with potentials and ion-energy distributions from a retarding field energy analyser (RFEA). We find evidence that an inhomogeneous plasma potential in the production region inside the source gives rise to a wide energy distribution emerging from the end of the source.
This energy distribution forms the starting distribution in an effort to model how it will be affected by downstream momentum and charge-exchange collisions in order to investigate their role in forming an ion beam further downstream. A simple model of collision cross-sections as a function of energy difference between ions and neutrals is obtained by a nonlinear fit to experimental momentum and charge-exchange collisional cross-sections derived by [1] as presented in [2]. At smaller energy differences, the momentum collision cross-section increases such that collisions between particles of similar energy lead to larger particle loss. We apply this more detailed collisional dependence to the measured energy distribution (figure 1a) emerging from the source, in order investigate how this model would affect the development of the given initial distribution. We find indications that collisions between particles of nearly the same energy within the ion distribution may result in a non-symmetric bite-out of the distribution as its 'center-of-mass' follows the potential drop further downstream. Hence the high-energy part can survive as a beam and the less energetic part of the distribution undergoes a faster loss while the downstream plasma is being formed by charge-exchange collisions. Although charge-exchange collisions results in a higher downstream density, the modelled development in figure 1 b) agrees qualitatively quite well with the measured development of the distribution.

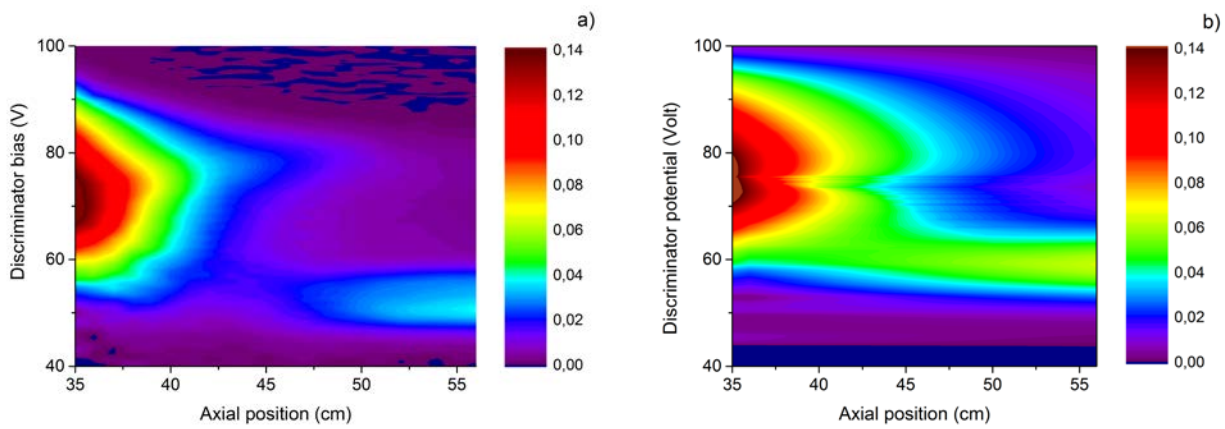

Figure 1. a) Axial development of downstream ion energy distribution measured by a RFEA. b) Modelled development of initial distribution measured at x=35 cm.

References

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