Effect of permanent magnets on plasma confinement and ion beams from a helicon plasma source

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The experiments in this work was carried out to investigate how permanent magnets (PM) affect the confinement and ion beam properties in an inductively coupled plasma expanding from a helicon source. PMs were added around the exit port of the plasma source, and the effect was investigated experimentally by measuring the ion distribution using a Retarding Field Energy Analyser (RFEA). The plasma parameters obtained with and without the PMs were compared. It was found that the downstream plasma density can in some cases be doubled with PMs mounted. On the other hand, the ion beam velocity was reduced with a factor of typically 0.9. However, because of the increased ion beam density the ion beam flux increased by a factor of up to 1.5.

1. Introduction

In inductively coupled helicon discharges, an ion beam can form at the intersection between the plasma source and the expansion chamber in a diverging magnetic field [1]. The magnetic field in which the plasma expands from the source into the diffusion chamber plays an important role in generating the sharp potential drop, a so-called current-free double layer (CFDL), which again forms the ion beam. For most helicon sources, an axial magnetic field is produced by DC current coils around a cylindrical source. The field lines expand from the source into the source chamber.

In the source of the Njord device [2] a 30 cm long Pyrex glass cylinder with a radius r = 6.9 cm is coupled to the diffusion chamber through a port with radius 10 cm and length 8 cm. Simulations of the expanding magnetic field show that the field lines leaving the edge of the source are crossing the port wall. This field geometry leads to loss of electrons and affects the confinement of the plasma as well as the ion beam generated by the CFDL. In this work, we installed permanent magnets around the circumference of the port and investigated their effect on the plasma confinement and ion beam energy an –flux.

2. Experiment and results

Radio Frequency (RF) power between 100 W and 800 W was fed to a saddle antenna wrapped around the Pyrex tube, underneath a pair of magnetic field coils which generated a maximum axial magnetic field of about 200 G. A stainless steel ring supporting 18 neodymium magnets (Grade N42) was placed around the circumference of the port. Argon gas was fed to the end of the source tube, to provide working pressure between 0.6 μbar and 1.1 μbar for which an ion beam is generated.

A RFEA was used to obtain plasma and beam density, as well as plasma potential and beam energy [3]. Plasma parameters were obtained with and without PMs. Ratios of densities, potentials, as well as beam energy and fluxes could then be derived. It was found that at RF power P > 600 W the downstream plasma density within the beam could be doubled with PMs mounted, while the beam velocity decreased by typically a factor 0.9.

However, the higher ion beam density resulted in a significant increase of the ion beam flux. In Figure 1, the ratio of ion beam fluxes as a function of power is shown.

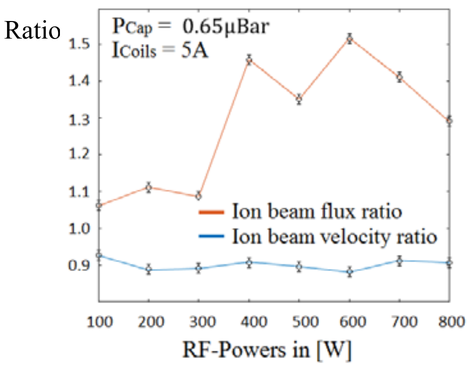

Figure 1. Center ion beam velocity ratio and ion beam flux ratio versus RF-power at pressure $P = 0.65m$Bar and magnetic coil current $I_{Coils} = 5$ A.

3. References.

[1] C. Charles and R. Boswell, Phys. Plasmas **11** (2004) 1706.

[2] H. Byhring et al., Phys. Plasmas **15** (2008) 102113.

[3] N. Gulbrandsen et al., Phys. Plasmas **22** (2015) 033505.