Production and study of a plasma confined by a dipole magnet: optical emission spectroscopy and electron energy distribution

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We report a table top experiment to investigate important physical processes in a plasma confined by a dipole magnet. A strong water cooled cylindrical permanent magnet, is employed to create the dipole field inside a vacuum chamber. The plasma is created by electron cyclotron resonance heating, using microwaves of 2.45 GHz. Visual observations (in terms of digital images) of the first plasma, including results of measurements of plasma parameters such as ion density and electron temperature, optical emission spectroscopy and electron energy distribution will be presented in the conference.

1. Introduction

Studies on the properties of a plasma confined by a dipole magnet has been of great interest in plasma physics, since a long time [1–2]. The dipole confinement concept was motivated by spacecraft observations of planetary magnetospheres [3-4]. It is of interest to investigate such a confinement scheme and resulting plasma behaviour in the laboratory. There have been large experiments using superconducting coils to understand underlying complex plasma processes in the dipole plasma [3-4].

In this work we report a compact table top experiment using a permanent magnet to investigate the properties of a plasma confined by a dipole magnet.

2. Experimental set up

In the present experiment, we employ a strong permanent magnet, having a surface magnetic field of ~ 6000 Gauss to create the dipole magnetic field. The magnet is suspended in free space from a top flange in a vacuum chamber and cooled by circulating chilled water. The plasma is heated by electron cyclotron resonance, using microwaves of 2.45 GHz and results in a beta of ~ 2%. The beta can be further increased by using dual frequency heating in the range 6 – 11 GHz using a traveling wave tube amplifier (TWTA), available in the laboratory. The wave powers can be widely varied from a few hundred watts (~ 300 W) in the CW mode to a few kilo watts (~ 7 kW) in the pulsed mode of operation. A schematic of the experimental setup is shown in Fig. 1.

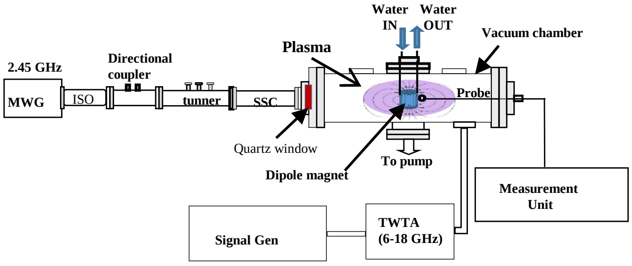

Figure 1. Schematic of the experimental setup SSC: Straight Section, ISO: Isolator, MWG: Microwave Generator.

3. Results

The dipole plasma has been successfully created and the resulting plasma density and electron temperature have been measured in the radial direction. In addition, we have measured the temperature anisotropy of the plasma in a direction parallel and perpendicular to the static magnetic field. We find that the plasma density is peaked a few centimetres away from the magnet and decreases as we go radially outward. The peak plasma density is ~ 1.8×10^{11} cm^{-3} and the electron temperature lies in the range 3 – 14 eV. In addition, optical emission spectroscopy and electron energy distribution function measurements will be presented in the conference.

4. References

[1] Hasegawa, Comments Plasma Phys. Controlled Fusion **1,** 147 (1987)

[2] Birmingham, T. J., Geophys. Res. **74**, 2169-2181 (1969)

[3] Yue Chen, Geoffrey D. Reeves & Reiner H. W. Friedel, Nature Physics **3**, 614 - 617 (2007)

[4] A.C Boxer, R. Bergmann, J.L.Ellsworth, D.T Garnier, J.Kesner, M.E Mauel and P.Woskov. Nature Physics **6**, 207-212 (2010)