Possibility of Ion Acceleration in ECR Produced Expanding Plasma

A. Verma, A. Ganguli, D. Sahu, R. Narayanan and R. D. Tarey

Centre for Energy Studies, Indian Institute of Technology Delhi, New Delhi, India 110016

Of the different mechanisms that have been used for ion acceleration for thruster application, helicon wave thrusters have gained considerable attention [1]. It is well known that in helicon thrusters, the main acceleration is given by a double layer that forms near the junction of the source chamber and an expansion chamber, in an axially converging-diverging magnetic field. It is noteworthy however, that in spite of their high efficiency in producing high density plasmas, ECR based ion thrusters have not received significant attention [2]. This may be due to the fact in the few studies conducted till now on ECR based thrusters it has not been possible to observe double layer formation. This paper revisits this problem using a somewhat different magnetic field configuration.

The experimental system is very similar to that used for helicon thrusters. It consists of a long cylindrical vessel (dia. 85 mm, length 356 mm) that opens into another much larger diameter (~ 50 cm) expansion chamber. Permanent ring magnets have been employed for producing the magnetic field in the source chamber, and in the expansion chamber as well. Within the source chamber an ECR zone is formed, immediately followed by an *on-axis magnetic null*, beyond which the magnetic field exhibits converging-diverging behavior [3]. Argon plasma is produced using 300 Watts of microwave power (2.45 GHz) ≤ 0.1 mTorr.

Typical measurements at 0.1mTorr, reveal evidence for strong bulk electron heating ($T_e \sim 40$ eV) along with fairly high plasma density ($n \sim 3.8\times10^{11}$ cm^{-3}). This is accompanied by very high plasma potentials ($V_p \sim 250$ V). Both, the high electron temperature and the plasma potential are quite unusual for ECR plasmas that are generated in *similar configurations*. The significance of the role of the magnetic field geometry in the present experiments can be gauged from the fact that n, T_e, and V_p all peak in the vicinity of magnetic null, before decreasing smoothly along the axis ($n \sim 3\times10^{10}$ cm^{-3}, $T_e \sim 10$ eV and $V_p \sim 100$V typically ~ 35 cm away from null). These results indicate that the high axial plasma potentials in the present configuration can be exploited suitably for efficient ion acceleration. Further work along these lines is already underway.

References:

1. C. Charles, J. Phys. D: Appl. Phys. **42,** 163001 (2009).
2. Cannat et al. Phys. Plasmas **22**, 053503 (2015).
3. A.Ganguli et al. Plasma Sources Sci. Technol. **25,** 025026 (2016).