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Effect of temperature anisotropy on electrical conductivity in a dipole plasma

Ayesha Nanda, and Sudeep Bhattacharjee
Department of Physics, Indian Institute of Technology, Kanpur
e-mail (speaker): ayesha@iitk.ac.in

Electrical conductivity has been a topic of research since few decades and has evolved with investigation on different types of plasma like atmospheric dynamo[1], quantum plasma[2], strongly coupled plasma[3] and its behaviour has been looked in details like propagation vector[4], charged impurities[5], magnetic reconnection[6]. Many pioneering works[1-6] have been carried out with plasma confined in a uni-directional magnetic field. Recently temporal variation of conductivity has been achieved for a dipole field (non-unidirectional) in ionosphere[7] with typical treatment as has been done earlier with other magnetic field configurations.

We report electrical conductivity results from a table top dipole plasma device[8,9] fabricated with a permanent magnet for particle confinement and uses ECR heating for plasma generation. In this work, apart from the magnetic geometry, particle drifts arising due to curved field lines and temperature anisotropy is considered to address the physics of the real problem in totality.

A mathematical model is formulated using Navier Stoke's equation by including all possible particle drifts. The electron - neutral collision frequency depends on the directionality due to temperature anisotropy and the statistical nature is conserved by averaging it over the normalised electron energy distribution function[10]. The conductivity dyad is retrieved from the Ohm's law. Although the dyad has nine components, but there are eleven terms, two arising from the coupling between static magnetic field and wave electric field components.

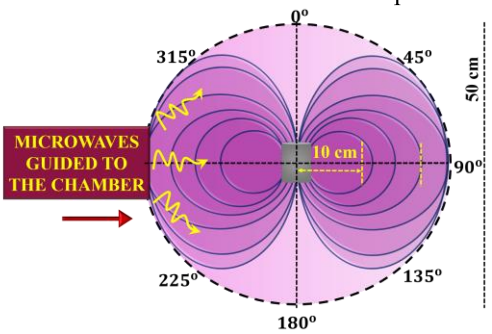

Fig. 1. Cross sectional sketch of the experimental chamber showing the spread of electromagnetic waves.

The cross-sectional sketch of experimental chamber showing the spread of microwaves is shown in Fig 1. Magnetic field and plasma parameters (like plasma (electron) density and temperature) were measured employing gaussmeter and Langmuir probe respectively for calculating components of conductivity dyad. The electron energy distribution was calculated by Druyvesteyn technique to modify the electron – neutral collision frequency.

Temperature profile shown in Fig. 2(a) reveals that there exists some degree of anisotropy until ∼ 8 cm and beyond that plasma becomes more isotropic with slight variations. Temperature anisotropy significantly influences Pedersen conductivity as observed in Fig. 2(b). With increasing neutral pressure, Pedersen conductivity increases due to hindrance in electron motion along the field because of greater number of collisions.

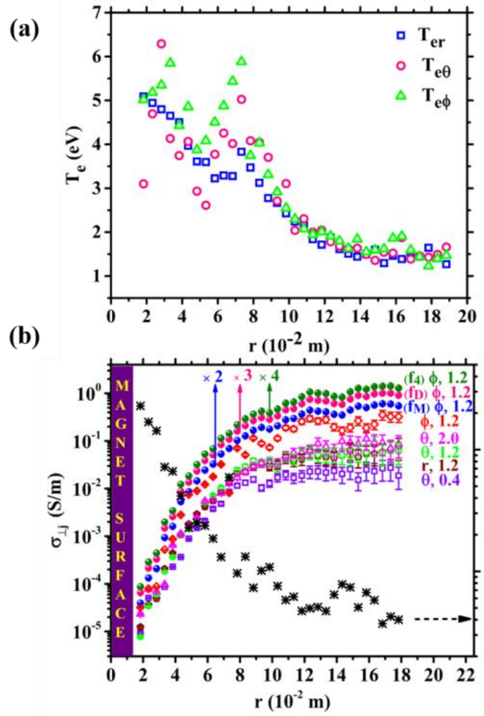

Fig. 2. (a): Temperature anisotropy profiles at 1.2 mTorr pressure, and (b) Pedersen conductivity (left y - axis) for $j \rightarrow r, \theta, \phi$) at different neutral pressures (in mTorr) unfolded for modified collision parameter from different EEDF: measured (open symbols), Maxwellian, f_M (blue), Druyvesteyn, f_D (pink), f_4 (olive green); Hall parameter along $\hat{\phi}$ (right y - axis) (black) are plotted against the radial distance (in cm) at a fixed polar angle 90°.

The effect of temperature anisotropy on various conductivity terms like Pedersen, Hall and longitudinal in a dipolar magnetic field at various spatial positions will be presented in details in the conference.

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