Plenary Session: Electromagnetism in Natural Plasmas: from the Upper Atmosphere to Space

Waves in the Earth's Plasma Environment*

G. Ganguli
Plasma Physics Division
Naval Research Laboratory
4555 Overlook Ave. SW, Washington, DC 20375
Tel: 202 767 2401, Fax: 202 767 0631, e-mail: gang@ppd.nrl.navy.mil

From the early spacecraft measurements it became evident that the Earth's plasma environment is filled with oscillations of electric and magnetic fields in a broadband frequency and wavelength spectrum. The origin of these waves has been and continues to be a topic of intense research in space plasma physics. The challenges associated with the analysis are that the space environment is subject to external forcings which are dynamic in nature, and hence the equilibrium (more accurately, the steady state) is never perfect. In addition, the environment is highly inhomogeneous with localized regions in which the background parameters such as density, velocity, pressure, etc., may vary rapidly in space. Often the inhomogeneities are characterized with hugely disparate scale sizes which further complicate the analysis. The natural response of a plasma system with spatial inhomogeneties is to relax the gradients and move towards a thermodynamic equilibrium. In a collisionless environment this relaxation is achieved by the emission of waves. The richness and the variety of the waves in the space plasma environment are also because of the presence of multi ion species and dust particulates. The dust particulates could be of meteoric origin in the near Earth region and of cosmic origin far from Earth. The character of the waves is electrostatic or electromagnetic depending on the ratio of the plasma kinetic pressure to magnetic pressure (i.e., $\beta = nkT/(B^2/8\pi)$). Closer to Earth where β is small the waves are mostly electrostatic in nature and the wave energy is predominantly in the kinetic energy of the plasma dielectric (i.e., the particle sloshing motion). Far from Earth where β is large the waves are mostly electromagnetic in nature and the wave energy is divided equally between the kinetic and field energy components of the waves. However, conversion of electrostatic wave modes into electromagnetic wave modes in the near earth region is possible as evidenced by the well-known VLF saucer phenomenon (James, J. Geophys. Res., 81, 501, 1976) and the lower hybrid solitary structure phenomenon (Shuck, P., J. Bonnell, and P. Kintner, IEEE Transactions on Plasma Science, 31, 1125, 2003).

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