Investigation of Magnetized Dusty Plasmas in the Laboratory and Near-Earth Space Environment

Alireza Mahmoudian[(1)], Wayne Scales[(1)], and Haiyang Fu[(2)]

(1) Bradley Department of Electrical and Computer Engineering, Virginia Tech, USA
(2) School of Information Science and Technology, Fudan University, Shanghai, China

The field of dusty plasmas has become a vigorous and established area of research for a number of decades now. In this work, two computational models are mainly developed to study possible plasma turbulence during the charged aerosol release experiments in space plasmas. Meanwhile, its applications for magnetized dusty plasmas for complex plasma research with upcoming experiment facilities at Auburn University is considered. Two new hybrid and full fluid two-dimensional computational models have been developed to investigate instabilities in nonuniform magnetized dusty plasmas. The magnetic fields have been applied to study the effect on plasma wave excitation.

The first objective of this work is to consider the motion and dynamics of dust cloud produced by shuttle exhaust or rocket release on large scales. The plasma instabilities excited by density gradient directed against gravity and along ambient drift as a result of dust charging process, has been studied to explain the large-scale density fluctuations. The model was also employed to explain instabilities associated with both head and trail that depending on meteoroid mass and entry conditions can be observed optically as well as by radar backscattering. The relation between observed brightness and ablated meteoroid mass varies with the atmospheric conditions and with meteoroid parameters such as altitude, entry speed, size and composition. Because of this variation physical parameters like the bulk density cannot be inferred completely from the observations. So this study may lead to better understanding of the parameters of meteor.

Another important application will be in the category of laboratory dusty plasmas. New laboratory facilities are under development, which will have the capability to study the role of magnetic fields in dusty (complex) plasma environments. The self-consistent models developed in this work have the capability of describing the dust charging process, unmagnetized and magnetized plasma dynamics and wave excitation in an inhomogeneous magnetized dusty plasma environments. A charging model has been adopted to deal with the dust grain charging process. The localized dust clouds produce electron density depletion due to the dust charging process. Electron/ion magnetization will play an important role for excitation mechanism, the ambipolar electric field, and dust density fluctuation amplitude perpendicular to the magnetic field. The ambipolar electric field provides the energy source for exciting the dust acoustic wave and lower- hybrid shear-driven/dust lower-hybrid drift instability.