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Magnetization of electrons and ions and their influence on dusty plasmas

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The presence of solid, charged particulate matter in plasmas, i.e., so-called "dusty" or "complex" plasmas, has been the subject of researchers for several decades. Since the earliest considerations of these systems, from the observations of dust in comet tails, the investigations of the planetary rings of the outer planets of the solar system, and the transport of dust on airless bodies such as the moon and meteors, there has been increasing understanding of the coupling between a background plasma and charged dust particles. With the first observations of dust formation in processing experiments and the start of dedicated laboratory studies of the properties of dusty plasmas starting in the early 1990's, it became possible to perform detailed investigations of the interactions between the dust particles and the plasma.

The majority of early laboratory studies of dusty plasmas focused on the suspension of the dust particles in regions of the plasma where the gravitational and electrostatic forces on the grains are balanced. However, by the early 2000's, advances in the design and operation of compact, superconducting magnets up to 5 Tesla enabled the study of dusty plasmas in regimes where the dynamics of the dust particles is dominated by magnetized electrons and ions.

In April, 2014, the Magnetized Dusty Plasma Experiment (MDPX) device began scientific operations at Auburn University [1, 2]. The MDPX device consists of a superconducting, 4-Tesla magnet system that has a 1.57 m long, 0.5-m diameter open bore and a set of insertable vacuum chambers that allow a wide range of experimental conditions to be explored. Using this flexible platform, dusty plasma studies have revealed new phenomena associated with magnetic field effects in dusty plasmas including: the shear induced melting of plasma crystals at high magnetic fields [3], the discovery of imposed dusty plasma ordering at high magnetic field [4,5] new observations of plasma self-organization and pattern formation at high magnetic field [6,7,8], the modification of dust acoustic waves in strongly magnetized plasmas [9], and changes in the cyclic growth of nanoparticles in chemically active plasmas [10]. Many of these observations correlate with the transition to either electron or ion magnetization; i.e., the criterion where a charged particle can complete a gyro-orbit without encountering a collision.

This presentation will provide an introduction to the study of dusty plasmas under the influence of high magnetic fields. The presentation will define the key criteria for magnetization and will demonstrate, through experimental and computational studies, that the dynamical properties of dusty/complex plasmas can be modified at the threshold of electron and ion magnetization.

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