

Ground-based and microgravity studies of dusty plasma instabilities using particle image velocimetry (PIV)

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A dusty (or complex) plasma is a four-component plasma system consisting of electrons, ions, neutral atoms, and charged, nanometer to micrometer-sized particles (i.e., the “dust”). Because these dust grains are charged, they fully participate in the plasma dynamics and can be used to reveal details about transport, instabilities, and charging properties of plasmas. An important feature of dusty plasmas is that in experiments with micron-sized particles, it is possible to directly image both single-particle (kinetic) behavior and collective (fluid) behavior using common techniques such as high-speed video imaging. Once images are recorded, a variety of image analysis techniques such as particle tracking or particle image velocimetry can be used to make measurements of particle or wave transport in these systems. Because the dust particles are massive (as compared to the ions or electrons), on the ground, the dust particles undergo sedimentation and compression to regions where the electric force on the particles is sufficient to counteract the gravitational force. But under microgravity conditions, the particles become suspended throughout the plasma volume and enables studies of small-scale inter-particles forces that are suppressed under gravitational conditions – provided detailed measurements of particle transport can be made.

This presentation will focus on the application of high speed particle image velocimetry techniques to the measurement of instabilities in ground-based and microgravity dusty plasma experiments. The ground-based studies will focus on measurements of dust density waves in the Magnetized Dusty Plasma Experiment (MDPX). The MDPX device is a high magnetic field (up to 4 T) research instrument that has began operating at Auburn University in mid-2014. The addition of the magnetic field offers a new experimental variable for controlling the plasma flows that lead to a variety of dusty plasma instabilities. The microgravity studies will focus on measurements using the PK-4 microgravity laboratory. The PK-4 laboratory is a joint German/Russian user facility for complex (dusty) plasma studies that began operating on the International Space Station (ISS) in late 2014. An initial calibration that demonstrates that PIV analysis techniques can be applied to ground and ISS measurements will be shown.