Ground and ISS applications of Particle Image Velocimetry Diagnostics for the PK-4 and PlasmaLab/EkoPlasma Microgravity Complex Plasma Experiments

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Complex (or "dusty") plasmas are four-component plasma systems consisting of ions, electrons, neutral atoms, and charged, micron-sized particles (i.e., "dust"). Because the microparticles are charged, they fully interact with the background plasma. 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.

PK-4 and PlasmaLab/EkoPlasma are the next-generation facilities dedicated to the study of complex plasmas under microgravity conditions. PK-4 is currently onboard the International Space Station (ISS) and PlasmaLab/EkoPlasma is under development and is undergoing both ground-based and parabolic flight testing. Both facilities are designed as flexible, research platforms that can perform a wide variety of experimental studies. The particle image velocimetry (PIV) analysis technique can be used to determine spatial profiles of velocity vectors of the microparticle component of the dusty plasma and, subsequently, velocity space distribution functions. PIV complements individual particle tracking techniques and is particularly useful in the presence of high speed flows or high number densities of particles.

This presentation will discuss the application of the PIV approach as applied to complex plasmas from ground and ISS experiments using examples from the PK-4 laboratory (from both the ground reference module and the flight hardware on the ISS) and parabolic flight experiments using the PlasmaLab/EkoPlasma instrument. Experimental measurements will be presented on the initial formation of the complex plasma in PlasmaLab/EkoPlasma and the observations of shock-structures in PK-4.