Complex/Dusty plasmas – complementing research under microgravity conditions

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Following the dynamics of a multi-body system on the individual particle kinetic level provides the full access to the equation of motion of the system and allows therefore new insights into its physics. Complex/dusty plasmas as a model system of classical condensed matter have unique and convincing properties which make such fundamental investigations possible:

- microparticles as proxy-atoms of the fluid and crystalline states can be observed on the most fundamental – the kinetic – level of individual particles.
- Very low damping of microparticles in the background gas/plasma allows even virtually undamped systems.
- Time scales of microparticles for relevant processes are in the range up to 1000 Hz are easy to observe with standard equipment.

Gravity strongly affects the behavior of complex plasmas due to the high mass of the microparticles. It forces the microparticles into 2-D, quasi-2-D and stressed 3-D systems. With these imperfect systems, fundamental studies of the complex plasma are still possible, and the list of results is long covering basic properties (particles charging, pair interaction, waves and shock waves, etc.), kinetic studies of liquids and solids (liquid-solid phase transitions in 2D and stressed 3D, 2D crystals and crystallization dynamics, defect propagation, etc.), driven systems (hydrodynamic instabilities, shear flow and heat transport in 2D systems, etc.) and anisotropic interactions (active and anisotropic particles). However, many research topics need a homogeneous and isotropic 3D distribution of the microparticles in the bulk plasma. This makes experiments under microgravity conditions mandatory to explore this very special state of matter in its entirety.

Therefore, complementing research is performed on parabolic flights with airplanes and sounding rockets as well as on the International Space Station ISS. Since more than 20 years the ISS is used as a platform with the Plasma Crystal laboratories PKE-Nefedov (2001-2005), PK-3 Plus (2006-2013) [1-3] and PK-4 (since 2014) [4-6].

We will present the highlights of this research as well as recent results from the European-Russian PK-4 laboratory.

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