Complex plasma research on the International Space Station (overview and novel directions)

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Complex plasmas are plasmas containing solid particles typically in the micrometer range. These microparticles are highly charged and become an additional, dominating component of the plasma. Complex plasmas are ideal model systems to study strong coupling phenomena in classical condensed matter. They offer the unique opportunity to go beyond the limits of continuous media down to the fundamental length scale of classical systems - the interparticle distance - and thus to investigate all relevant dynamic and structural processes using the fully resolved motion of individual particles, from the onset of cooperative phenomena to large strongly coupled systems.

Unlike “regular” plasma species the charged microparticles are strongly affected by gravity. An electric field in the sheath or a temperature gradient are usually employed to compensate for gravity, which provides favourable conditions to study 2D or stressed 3D systems on ground. However, in order to perform precision measurements with large isotropic 3D systems in the bulk plasma, microgravity conditions are absolutely necessary.

Since 2001 this research under microgravity conditions has continuously been performed on the International Space Station ISS within the Russian/German(European) Plasmakristall(PK)-Program. In long-term research laboratories PKE-Nefedov (2001-2005), PK-3 Plus (2006-2013) and PK-4 (2014-ongoing), fundamental processes in liquid or crystalline complex plasmas as well as generally in plasma physics were addressed. Highlights are: refinement of theory of ion drag, electrorheological plasmas, lane formation or phase separation in binary mixtures, crystallisation and melting, wave propagation, shear flow and transition to turbulent motion.

In this presentation we will review important results from microgravity experiments and will discuss the perspectives for future research.

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