COMPACT – A new Complex Plasma Facility for the ISS

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Complex plasma is a state of soft matter where micrometer-sized particles are immersed in a weakly ionized gas. The particles acquire negative charges of the order of several thousand elementary charges in the plasma, and they can form gaseous, liquid and crystalline states. Direct optical observation of individual particles allows to study their dynamics on the kinetic level even in large many-particle systems.

Gravity is the dominant force in ground-based experiments, restricting the research to vertically compressed, inhomogeneous clouds, or two-dimensional systems, and masking dynamical processes mediated by weaker forces. An environment with reduced gravity, such as provided on the International Space Station (ISS), is therefore essential to overcome this limitations and to study large and homogeneous 3D many-particle systems. Several laboratories have been or are operated on the ISS (PKE-Nefedov, PK-3 Plus, PK-4) and have proven a valuable tool to acquire a crucial knowledge gain in the field of complex plasmas.

The next generation complex plasma facility COMPACT to be operated onboard the ISS builds upon previous studies and hardware developments (PlasmaLab, Ekoplasma) and is envisaged as an international multi-purpose and multi-user facility that gives access to the full three-dimensional kinetic properties of the particles. The heart of COMPACT will be a novel plasma chamber: the Zyflex chamber [1]. It supports larger particle systems than previous facilities, and can be operated at much lower gas pressures (lower damping). It further includes a variety of innovations that allow to tune, control and manipulate plasma-particle and particle-particle interaction in various ways.

We will present the overall design and research goals of COMPACT (the latter including new directions such as active matter and dust in space), with special focus on the characteristics of the new plasma chamber, supported by plasma simulations and results of experiments performed on ground and during parabolic flights that utilize and demonstrate the novel and unique capabilities of the device and emphasize its value for the proposed COMPACT facility.

[1] C. A. Knapek, U. Konopka, D. P. Mohr, P. Huber, A. M. Lipaev, and H. M. Thomas. "Zyflex": Next generation plasma chamber for complex plasma research in space. *Review of Scientific Instruments*, 92(10):103505, 2021.