E150p

New Measurements Of The Force Distribution Inside The 'Void' Of A Complex Plasma In Microgravity

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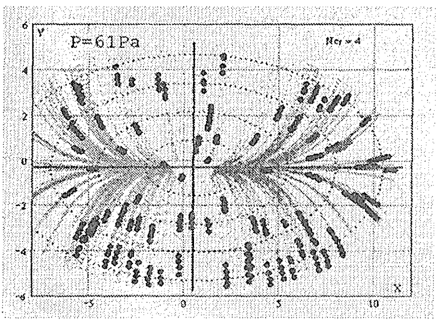
COMPLEX PLASMAS IN MICROGRAVITY

'PKE-Nefedov' is a complex ('dusty') plasma experiment facility onboard the International Space Station ISS since 2001 [1]. It contains a rf plasma chamber where micron-sized 'dust particles' (plastic spheres) can be injected into an Argon plasma at a pressure of 10 – 200 Pa. The particles gather an electric charge of 10^3-10^4 electrons each and arrange, under certain conditions, in a regular structure, a so-called plasma crystal. A sheet of laser light illuminates a plane of particles which is observed with two CCD cameras and recorded onto video tapes. The tapes are later returned to Earth by the cosmonauts where the stored data (movies) are analyzed. This allows to study the behavior of micro-particles inside a plasma by analyzing their positions and trajectories, which yields the forces acting on the particles. The advantage of the experiment in space is the opportunity to measure the small forces. In ground-based experiments the dominating force is always gravity.

In most of the complex plasma experiments in microgravity a particle-free region in the center of the discharge plasma is present that was first observed in experiments done by MPE on ballistic rocket flights. Also 'PKE-Nefedov' shows in most experiments the 'void'. The presence of the void was unexpected and several theories competed in its explanation. The difficulty of deciding which explanation is favorable is due to a lack of information about the interior of the void, because it is – unfortunately – empty.

EXPLORING THE VOID

In some early experiments with PKE-Nefedov on the ISS we succeeded in bringing particles into the void from which they were expelled immediately. These experiments were repeated in another experiment session in space with different plasma parameter settings. By analyzing the trajectories of these particles we can conclude on the forces acting on the particles. The velocity profiles in horizontal and vertical direction show linear behavior with respect to the center of the void, the elliptical boundary between particles and void forming an equipotential line of the effective potential energy inside the void. Parabolic fits show a good agreement with the observed trajectories (fig.1).



Together with computer simulations we can now assume that the force that is responsible for the void formation is the drag force of the ions that are produced in the center of the discharge and that are streaming outwards to the rf electrodes, pushing the particles also outwards and leaving a void in the center.

1. M. Kretschmer, *PKE-Nefedov Homepage*, http://www.mpe.mpg.de/pke