German
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Tenth plasma crystal experiment series on board the ISS

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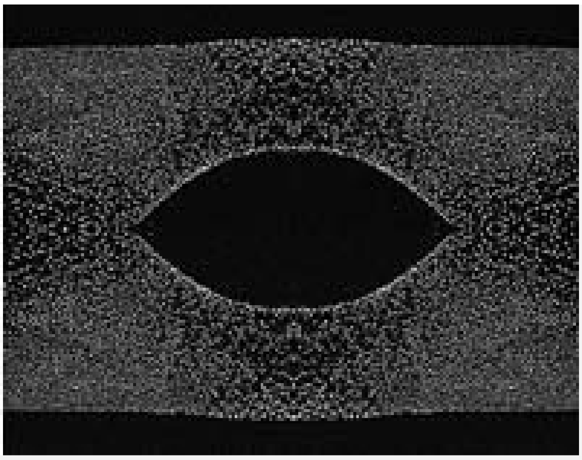
Additional research to be conducted during parabolic flights

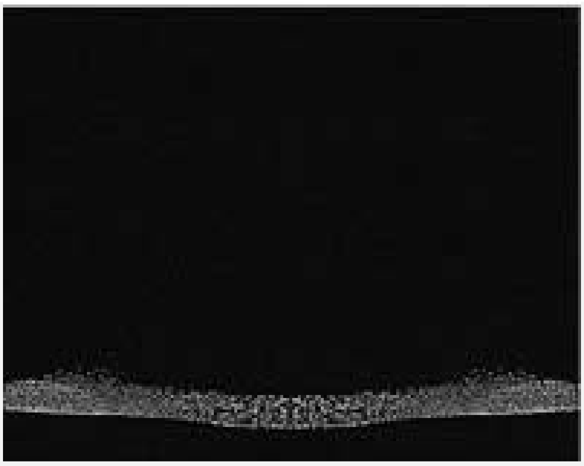


Electrically charged plasma in an experiment chamber in weightlessness

This February, additional experiments using the PK-3 Plus lab facility will be conducted during the 13th parabolic flight campaign of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt) in Bordeaux. Ever since the plasma crystal phenomenon was discovered in the mid-1990s, DLR's Space Agency (Raumfahrt-Agentur) has been supporting the scientists at MPE using funds made available by the German Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie; BMWi).

German researchers took the initiative for the first experiment on board the space station

Experimental proof of the formation of plasma crystals was obtained for the first time at MPE, in 1994. Since 1996, the Garching-based researchers have been conducting further experiments in this field under conditions of weightlessness on board sounding rockets and parabolic flights. Almost simultaneously, the Moscow-based Joint Institute for High Temperatures (JIHT) of the Russian Academy Sciences started to plan similar experiments for the MIR station that were carried out between 1998 and 1999. In 1998, the two institutes decided on a future collaboration, with the German side committing to developing the experimental facilities and the Russian side to taking care of transporting them to the space station and operating them. The experiments in space are planned and evaluated jointly by the two institutes.



Electrically charged plasma in an experiment chamber under gravity conditions

The PKE experiment facility, developed at MPE under the direction of Professor Dr Gregor E. Morfill, became operational in March 2001, marking the start of scientific research activities on board ISS. In the meantime, 'PK-3 Plus' has now been taken into use on the space station as the second-generation complex plasma experiment facility. During the 'Astrolab Mission', from July to December 2006, Germany's long-duration astronaut Thomas Reiter also conducted plasma crystal experiments in space. The scientific results obtained under conditions of weightlessness have so far led to more than 40 publications in international journals alone.

Parabolic flights to prepare for service in space

During February's parabolic flight, the scientists will have a high-resolution, high-tech camera at their disposal, allowing them to investigate the plasmas in even more detail. During the weightlessness phases, which last for about 20 seconds each, short-duration experiments are carried out, for instance involving the collision and interpenetration of two particle clouds. Even though physical processes take place at a much slower rate in complex plasmas than in real crystals, some of these processes are still so fast that they cannot be registered in detail using conventional video cameras. Using the high-tech camera, the researchers will be able to observe their experiments using up to 1 000 images per second. Later, the same method will also be used on board the space station.

The PK-4 experiment facility during a test flight in weightlessness

During the same parabolic flight, the next-generation experiment facility 'PK-4' will also be deployed. The device, which has been built by the European Space Agency, ESA, needs to undergo trials before it is taken to the space station. It will then be integrated into the Columbus module of the ISS, where it is expected to be in service from 2010 onwards. The PK-4 plasma chamber is especially well suited to investigating the flow characteristics of liquid plasmas. The next-generation experiment that will succeed PK-4 is already on the horizon as well: DLR is currently funding the development of a completely new kind of plasma experiment chamber that will give a substantial boost to the scientific potential of the experiments.

In the meantime, JIHT has shown interest in extending the PK-3 Plus experiment on board ISS beyond its initially agreed end date of December 2009. However, this would involve relocating the experiment facility to the small Russian experiment module MIM. MIM will be taken to the ISS this autumn, where it will be docked to the transfer compartment between the Russian modules 'Zarya' and 'Zvezda', which currently accommodates PK-3 Plus.

Complex plasmas - an ideal model for basic research in physics

Cosmonaut Valery Tokarev with the PK-3 Plus experiment on board the ISS

A plasma is an ionised gas. Apart from ions - electrically charged atoms or molecules - it consists of free electrons and a neutral gas component. It is considered to be the fourth state of matter, distinct from gaseous, liquid and solid matter. Over 99 percent of the observable matter in the universe exists in the plasma state.

Complex plasmas are categorised as soft matter, a group that also includes colloids and foams. They are formed when plasmas also contain dust particles. In nature, they appear as interstellar molecular clouds, planetary ring systems or the tails of comets, for instance. In a laboratory, complex plasmas are formed by injecting microparticles. In the case of the PK-3 Plus experiment facility, these consists of plastic spheres with a diameter of just a few microns. In the plasma, they are all electrically charged with same charge sign. By trying to create as large a distance as possible between each other, they organise themselves structurally, ultimately leading to their periodic arrangement in a crystal structure.

In a laboratory on Earth, the plasma particles are deposited in a strictly two-dimensional layer due to the effects of gravity. A weightless environment is therefore ideal for plasma crystal research. By modifying the experimental parameters and the influence of external forces, the plasma structure can be manipulated. This makes it possible to produce structural analogues of gases and liquids, to simulate phase transitions such as melting or freezing, or to study interface phenomena and wave propagation. In addition to purely basic research, practical applications of plasmas also present themselves. Plasma medicine, for instance, is based on using the bactericidal effect of plasmas for the treatment of chronic wounds.

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