German
DLR Aerospace Center

ARCHIVED

News Archive 2010

Twenty-fifth series of German-Russian plasma physics experiments

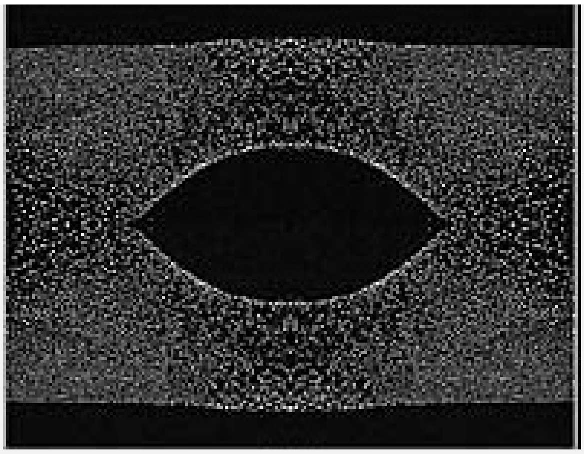
27 January 2010

Cosmonaut Oleg Kotov with the PK-3 Plus experiment

From 27 to 29 January 2010, Russian cosmonaut Oleg Kotov will be running the 25th series of complex plasma physics experiments on the International Space Station (ISS). The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) has funded both the development of the experimental equipment and the research itself. For this experiment series, the PK-3 Plus plasma experiment system has been moved from its previous location, between the Russian 'Zarya' and 'Zvezda' station modules, to the small Russian research module MIM-2 (called 'Poisk', or Search), which docked with the ISS in November 2009. The service life of the PK-3 Plus has also been extended by two years, until the end of 2011.

A permanent home in space

In its old location, the PK-3 Plus and its predecessor, the PKE-Nefedov, which was in service from 2001 to 2005, had to be disassembled and then rebuilt between each experiment series. Five years on, the experiments have found a new, permanent home in the Poisk module. This will result in considerable savings in valuable cosmonaut man-hours – time better invested in research and science. In addition, the parts of the experiment that are subject to wear and tear due to frequent dismantling, such as the tubes, fittings and connectors, will also be protected. Every year, the scientists run two or three series of experiments.



Complex plasma in zero gravity

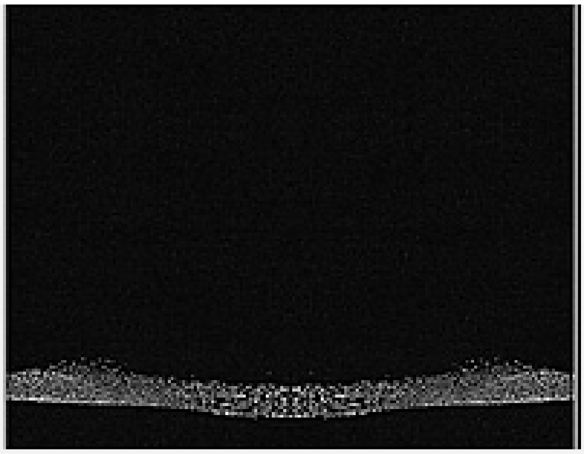
Plasma – the fourth state of matter

Plasmas are electrically charged gases and, after solids, liquids and gases, count as the fourth, least ordered state of matter. They make up lightning and the Northern Lights. In everyday life, we use plasma in fluorescent light tubes, for example. In contrast to pure plasma, complex plasma also contains dust particles.

In the experiments on the ISS , the electrical field between two electrodes converts an inert gas such as argon or neon into a plasma. Particles of a synthetic material, each measuring no more than a few microns across, are then injected into this plasma. The particles become electrically charged by the plasma field and gain the same polarity. Since they repel each other, they form a structurally ordered aggregate which eventually leads to the development of a crystal structure, similar to that of many metals, known as a plasma crystal.

By varying the electrical field and the gas pressure in the plasma chamber, scientists can dissolve or fix the plasma crystal, thus investigating its phase changes. The advantage of this is that the phase changes occur much more slowly than with ordinary materials and the changes in position of each particle can be followed with cameras. This means that the scientists are effectively looking directly inside the material, so they can observe, among other things, the interaction between the particles in the propagating waves and turbulent flows and the segregation of different particle species.

However, the large 3D crystals needed for such investigations can only be created in zero gravity conditions. This is because gravity makes all the particles fall to the bottom of the plasma chamber, so that the complex plasma only forms a thin layer. More than 40 articles on the results of these zero gravity experiments have been published in scientific journals so far.



Complex plasma in a gravitational field

Learning from complex plasmas: applications in materials science

The zero gravity experiments have demonstrated that complex plasmas belong to the group of ‘soft matter’ materials. This group includes colloids, gels and granulates. They are made of molecules, droplets, particles or gas bubbles in the millimetre to nanometre range that are finely distributed in a fluid or gas.

Soft matter is familiar to us from everyday life: milk, foam, toothpaste and sand are all soft matter – and they behave either as a solid or as a fluid. For example, sand can flow into a container and assume its shape just like water, but at the same time, a heavy stone will sit on top of sand without sinking into it, as if it had a rigid surface. The physics of soft matter, especially the prediction of its behaviour, is very important for the development of designer materials.

Spin offs for medicine

The development of the equipment for space and the experiments themselves has resulted in a surprising spin-off in the field of medicine, known as a 'cold plasma torch'. This is a small medical tool that uses cold plasma to sterilise chronic, antibiotic-resistant wounds. It has already been used with success in clinical trials on more than 100 subjects.

The new MIM-2 ISS module

Automated experiments

Each series of experiments consists of three 90-minute runs, usually on three successive days. The research programme is developed and run by the Max Planck Institute for Extraterrestrial Physics (MPE) at Garching and the Institute for High Energy Density (JIHT) of the Moscow Academy of Sciences. Before the experiments are run on the ISS, the teams at MPE and JIHT specify the test runs, write the control software, and test them on training models in Moscow. Only then are they sent up to the ISS for implementation by cosmonauts.

Before the experiments can start, the plasma chamber must have a high vacuum created inside it, which takes two days. The gas and particles can then be loaded into it. The experiments are generally automated, with short video sequences at the beginning to check that everything is proceeding as specified. Especially difficult experiments are often run by the cosmonauts while in voice contact with the scientists. The calibration and control data are then sent to the Moscow space control centre, ZUP, by email, but the scientists have to wait for the videos – the hard drives are sent to Earth along with the returning cosmonauts in the next Soyuz capsule.

Contact

Diana Gonzalez
German Aerospace Center
Space Administration, Strategy and Communications
Tel: +49 228 447-388
Fax: +49 228 447-731
E-Mail: Diana.Gonzalez@dlr.de

Maria Roth
German Aerospace Center
Space-Agency
Tel: +49 228 447-324
Fax: +49 228 447-735
E-Mail: Maria.Roth@dlr.de
