MAPHEUS-3: Flight-testing furnaces in microgravity

26 November 2012

There are very few ways of conducting experiments without the influence of Earth's gravity. One of these platforms became available on 25 November 2012, when a rocket was launched from the Swedish Esrange Space Center in Kiruna. The high-altitude sounding rocket MAPHEUS-3 (Materialphysikalische Experimente unter Schwerelosigkeit, Material Physics Experiments under Microgravity Conditions) of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) carried four experiments that were subjected to three and a half minutes of microgravity conditions during the flight. Among other things, the experiments involved melting metal samples in furnaces. The solidified samples were recovered on 26 November 2012 with the help of a snowmobile.

"If we conduct these experiments on Earth, lift forces are exerted on the molten metals," explains Andreas Meyer from the DLR Institute of Material Physics in Space. "When we conduct experiments in microgravity, we can overcome these and observe physical processes without any interference." The small furnaces began heating the aluminium- rich alloys for the ATLAS diffusion experiment before the rocket was launched. Eighty seconds after MAPHEUS-3 lifted off, the various liquefied components mixed in microgravity. "This is a process about which we still know very little." The 'demixing' of molten metals was also a subject of study during the MAPHEUS-3 campaign. With the DEMIX experiment, scientists investigated the behaviour of copper-cobalt alloys during the melting process. "With the results of the MAPHEUS-3 flight, we can revise the existing models for this process and adjust them accordingly," states Meyer. "This demixing process is employed in industry – and so it is also of interest to this sector to test the current models."

Fundamental research with a video camera

For the MEGraMa experiment, researchers from the DLR Institute of Material Physics in Space filmed the impact behaviour of particles with a diameter of less than one millimetre. Four magnets accelerated the spherules in a controlled manner during the flight; in the meantime, a video camera recorded how the spherules lose energy as they collide with one another. "With this, we investigate the behaviour of granular gases," emphasises Institute Director Meyer. "This process is not yet fully understood."

To prepare for the next flight campaign – MAPHEUS-4 – the rocket also carried a newly developed furnace that was subjected to microgravity conditions. Measuring just 40 by 40 by 20 millimetres, it will melt six samples during a flight scheduled for next year. "The smaller the furnace, the lower the amount of energy needed to heat it up." One advantage of this new furnace is that it is 'transparent' to X-rays, which enables the direct study of the changes in composition taking place in the interior of the liquefied metal samples.

Recovered by a snowmobile

The launch was performed by staff from DLR's MObile ROcket BAse (MORABA). "We are, to some extent, responsible for MAPHEUS' 'flight ticket'. In addition to the launch itself, this includes the provision of the launcher and rocket engines, which are developed in-house, as well as the overall integration of the rocket," explains DLR engineer Markus Pinzer. Microgravity was achieved 80 seconds after lift-off at an altitude of 100 kilometres; the rocket reached a maximum altitude of 140 kilometres. After the capsule was returned to Earth by parachute, a team quickly located it, with the experiments on board, and were able to recover it one day after its launch using a snowmobile. "The flight was very challenging, both scientifically and technologically," emphasised Project Manager Martin Siegl from the DLR Institute of Space

Systems. "Complex development work on the experiments, a variety of tests and an intensive preparation phase all culminated in those few minutes of flight." Now it is time to evaluate the acquired data and analyse the resolidified metal samples.

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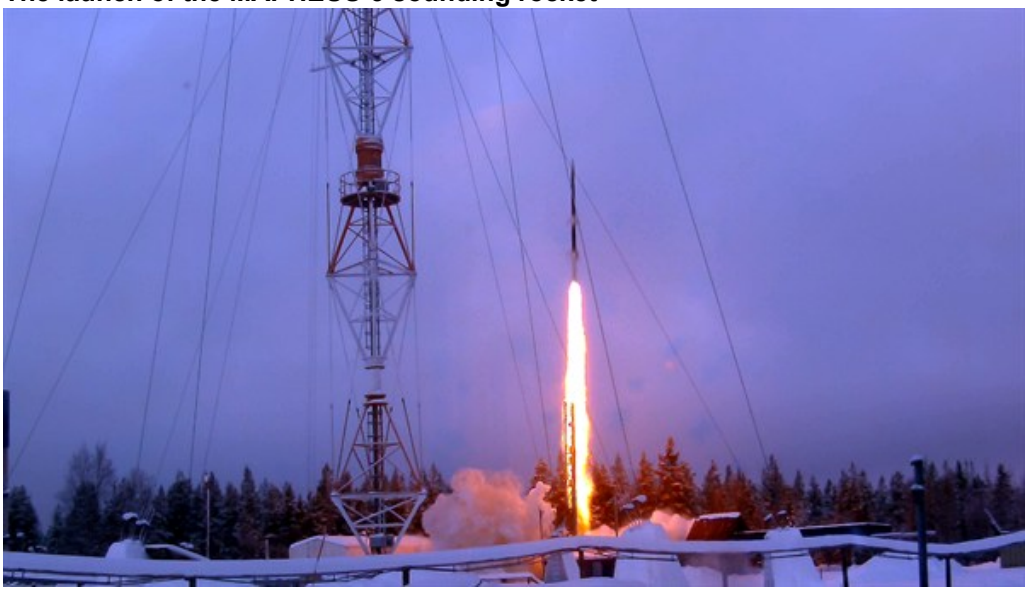
The launch of the MAPHEUS-3 sounding rocket



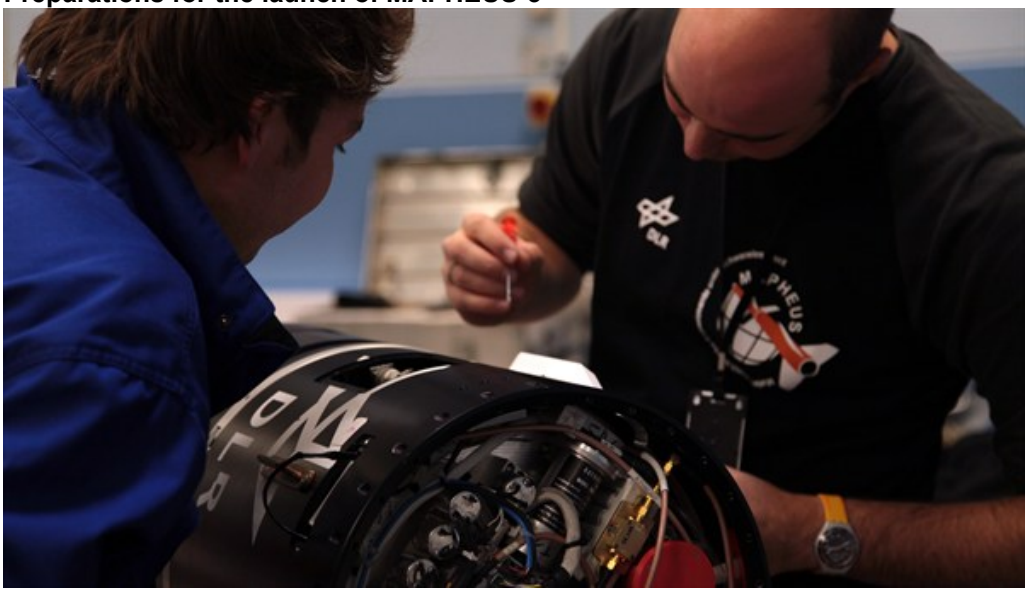
On 25 November 2012, the high-altitude sounding rocket MAPHEUS-3 was launched from the Swedish Esrange Space Center in Kiruna. On board the rocket were four experiments from the DLR Institute of Material Physics in Space. The MORABA mobile rocket base was responsible for the launch.

Granulate gases in the MEGraMa-M experiment

The granulate gases in the MEGraMa-M experiment: When subjected to conditions of microgravity, the spherules float in the brightly lit sample container. The circular electromagnets on the four sides of the container caused the particles to move.

Credit: DLR / Franz Bischof.

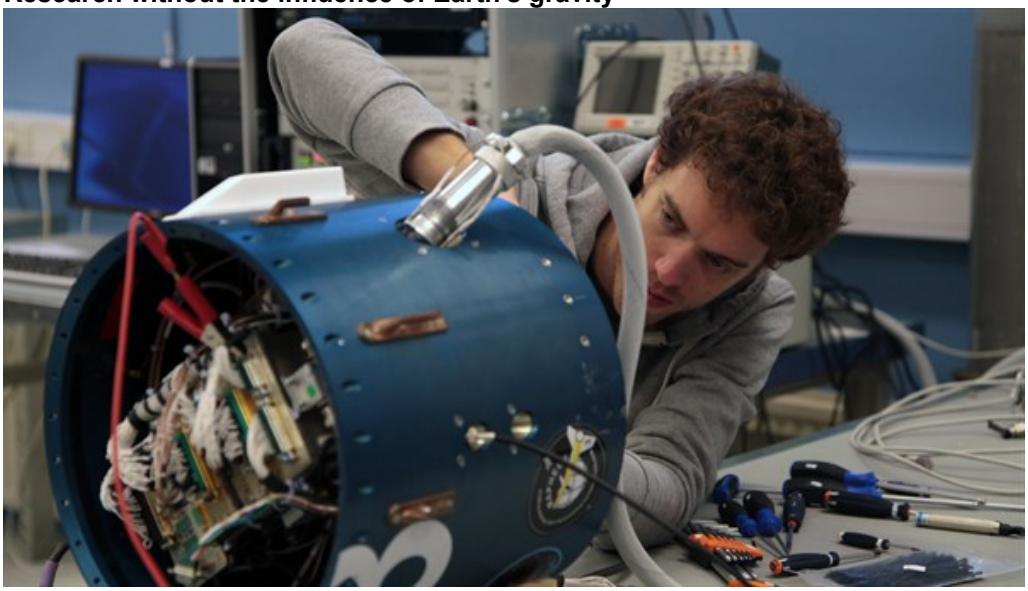
Preparations for the launch of MAPHEUS-3



Engineers at the Mobile Rocket Base or 'MORABA', operated by the German Aerospace Center (DLR), prepare the high-altitude sounding rocket MAPHEUS-3 for take-off.

Credit: DLR (CC-BY 3.0).

Research without the influence of Earth's gravity



For scientists at the German Aerospace Center (DLR), the flight of the high-altitude sounding rocket MAPHEUS-3 is a way of conducting experiments under microgravity conditions. Days before the launch, the rocket and its on-board experiments are prepared for their flight.

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