MAPHEUS-9-Payload

DLR Institute of Materials Physics in Space

MARS – Metal-based Additive Manufacturing for Research and Space Applications

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Additive manufacturing – also referred to as '3D printing' – is a technology which manufactures goods by successively adding small amounts of a given material until the designated geometry is complete. In its beginnings it was predominantly used for rapid prototyping and design studies. As this technology matures it becomes more and more affordable as a production process, and for a wider range of products too. Hence, it has aroused interest in the aerospace sector, especially in order to increase the availability of spare parts for many different aircrafts on locations all over the world. Or - thinking of manned spaceflight beyond low earth orbit – it might be used to reduce the payload for tools and supplies immensely, and thus save weight, fuel, and money.

In this research project we aim to selectively laser melt metals in microgravity. In this manufacturing process thin layers of a metallic powder are applied and selectively melted to the printed body by laser irradiation. Layering and melting are performed alternatively until the product is complete. Besides space-proofing this technology in general, the most challenging task in a low- or microgravity environment is to successfully handle the raw metal powder and to apply a high-quality powder layer. With less or even no gravity there is less or no driving force maintaining the powder in a dense packed layer until the melting is completed. In this project we addressed these tasks and designed a rocket payload able to print certain test objects on a spaceflight aboard the MAPHEUS sounding rocket. Pre-testing of powder handling was already performed during parabolic flights. The aim of the experiment is to validate the 'assisted deposition' of powder layers in microgravity, using different metal powders, with special interest in printing parts from metallic glasses

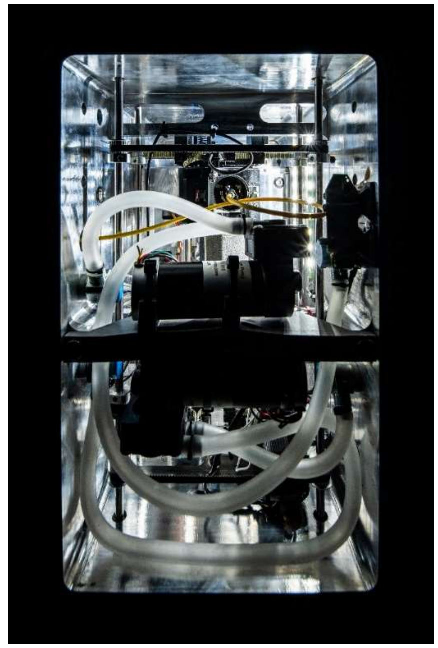

Abbildung 1: Links: MARS Nutzlast mit geöffneter Außenstruktur. Rechts: Blick in die Druckkammer.

SOMEX – Soft Matter Experiments

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Abbildung 2: SOMEX Experimentmodul

Soft-matter systems are complex materials common in everyday applications such as food and cosmetics. They are characterized by a mesoscopic structure, typically being composed of micrometer-sized entities in solution. This encompassed a large class of materials from granular matter, foams, biological tissues and cell or bacteria colonies, and colloidal suspensions forming larger aggregates.

Since these systems are, by definition, two-phase systems, density mismatches can become relevant, depending on the specific system under study and the physical phenomena of interest. Examples are the bulk dynamics of microswimmer suspensions that serve as model systems for biological fluids, or agitated granular materials, among others. In these cases, experimental studies under microgravity allow to access parameter regimes that cannot reliably be reached on ground.

The study of soft-matter characteristics relies on a common set of diagnostics. Owing to their mesoscopic structure and soft mechanical properties, visible-light microscopy combined with particle tracking, static and dynamic light scattering, and microfluidic/microrheology techniques are most useful, possibly also combined to obtain complementary information. Hence, with a limited set of experimental concepts, a wide range of physical properties in a wide range of physical model systems can be addressed.

In SOMEX, a modular experiment environment is developed that is suitable to be used on microgravity platforms such as the MAPHEUS sounding rocket, and that consists of interchangeable soft-matter sample cells that can be combined with different optical measurement devices.

The second flight of SOMEX comprises a part on granular matter and a part on microswimmer suspensions. The granular part investigates the basic principles of light scattering by large particles, in order to quite literally shed light on the role of surface roughness in interpreting the measurements on the dynamics of agitated granular matter.

The microswimmer experiment uses partially coated “Janus” particles that are driven by strong light fields in order to mimic the active motion of bacteria. The studies in microgravity will allow to create this active motion in the three-dimensional system free of sedimentation, and to address theoretical predictions of the phase behavior of active systems.

GRASCHA - Granular Sound Characterization

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The experiment GRASCHA measures sound and shock-wave propagation in granular materials, specifically in bidisperse glass bead packings at low confinement pressure. Thanks to microgravity, the hydrostatic pressure gradient, which obfuscates such measurements on ground, vanishes, allowing well-defined investigation of the elastic and nonlinear mechanical properties of the packing, as close as possible to the loss of rigidity (unjamming). After a surprisingly strong pressure-dependence of the effective sound speed was measured on Mapheus-8 in 2019, new measurements are now planned at even lower static pressure, as well as measurements of the full frequency response and shear waves.

Abbildung 3: GRASCHA – Experimentaufbau

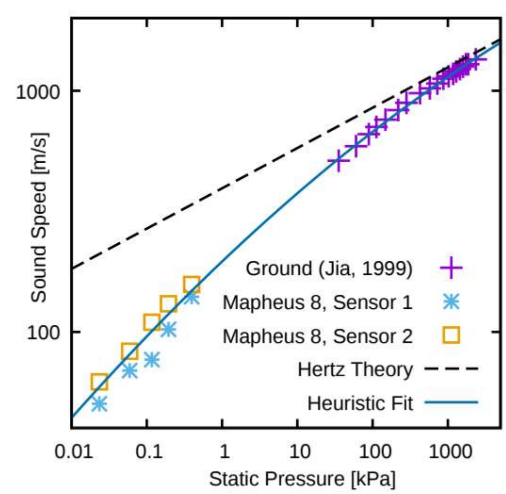

Abbildung 4: GRASCHA – erste Resultate zur Schallgeschwindigkeit

DLR Institute of Aerospace Medicine

GraviPlax – A primitive multicellular organism reveals mechanisms driving cancer development

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Background:

The GRAVIPLAX experiment contributes to our understanding of the role of gravity on cell polarity, which in case of loss is associated with carcinogenesis. The organism we use in the Graviplax experiment is the simplest multicellular animal, which consists only of an upper and lower cell epithelium. Despite the simple structure of the organism and the few cell types, all the major gene groups involved in the loss of polarity in cells are found in *Trichoplax adherens*, and thus the knowledge can be applied to higher organisms. The Mapheus 9 experiment is an important milestone in the collaboration between DLR, University of Veterinary Medicine Hannover (TiHo) and Australian scientists from La Trobe University in Melbourne.

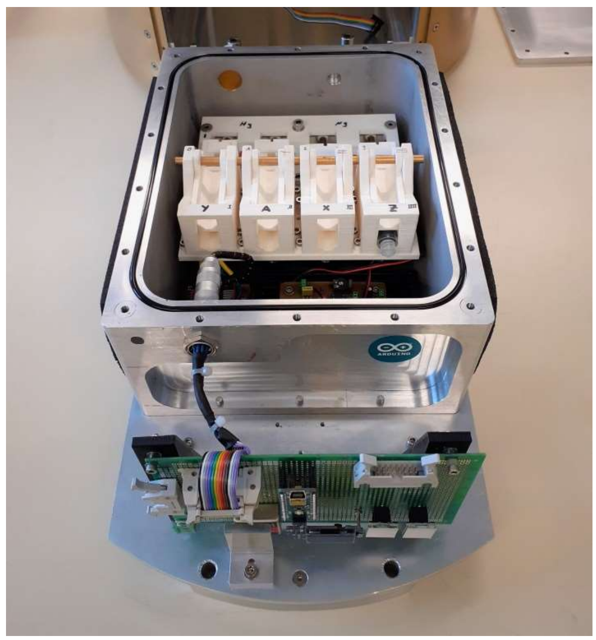

Figure 1: Graviplax experiment insert: four samples with *Trichoplax adherens* are chemically fixed at defined times during the rocket flight

Experiment:

During the flight of MAPHEUS 9, two groups of organisms will be chemically fixed to obtain the changes in genetic information induced by altered gravity: (hypergravity during launch and microgravity during free fall). The samples will be compared to 1*g* ground controls.