Technical University Munich
School of Engineering and Design
Professorship of Human Spaceflight Technology

Task Description Engineering Project

Conceptualization and Design of a Magnetohydrodynamic Vortex Induced Photobioreactor Experiment for Education

Topic Description:

The Magnetohydrodynamic Vortex-Inducing Photobioreactor Experiment (MVIPER) is a project devised by a student team from the Technical University of Munich (TUM). It has been selected for participation in a parabolic flight campaign in September 2025 as part of the ESA Academy Experiments Programme 2024/2025 by the European Space Agency.

MVIPER aims to advance bioregenerative life support systems for future crewed long-term space missions. The project investigates a novel photobioreactor (PBR) concept for microalgae cultivation in space, where the conductivity of the algae nutrient solution is utilized to create a magnetohydrodynamic (MHD) drive within a circular reactor geometry. The driving force is the Lorentz force, which arises when the conductive liquid is exposed to an electric and perpendicular magnetic field, propelling the liquid. With the induced swirling motion, a vortex is created within the PBR chamber, enabling phase separation by forcing the liquid to the outside and gas bubbles to the inside, where a stable liquid-gas interface forms. As an advantage, the new PBR technology would require no moving parts and no membranes for phase separation in space, which can reduce the maintenance time and the mechanical stress on the algae.

The ESA Academy Flight Experiment at TUM also includes outreach and education activities. In this context, throughout the Engineering Project, students shall be encouraged to learn and replicate the basic magnetohydrodynamic mechanisms that will be studied in this parabolic flight experiment. Following the introduction, the students should come up with so-called Do-It-Yourself (DIY) experiment concepts based on the principles of magnetohydrodynamics they learned about. Here, the focus is to come up with simple project ideas that demonstrate the core experiment principles while utilizing materials available at home or easily accessible through commercial vendors and considering safety.

Tasks:

- At the beginning, the students get familiar with the basics of magnetohydrodynamics and the MVIPER experiment
- In a group of 2 to 4 participants, the students will come up with design ideas and develop their concepts into more mature designs
- During the design and development phase, the students will work autonomously in groups and hands-on to advance their ideas (guidance from MVIPER members and teaching staff is provided when necessary)
- At the end, the students will present their final experiment design, ideally with a working experiment, and material on how to market and popularize their experiment so that it can further educate upcoming scientists and students.

If you are interested in working on this Engineering Project, please write a mail to thesis.hsp@ed.tum.de stating your interest and motivation for the project in a couple of sentences.