Low-Gravity Fluid Mechanics: A Student Perspective

Álvaro Romero-Calvo
Graduate Research Assistant
Aerospace Engineering Sciences Department
University of Colorado Boulder

UNOOSA Webinars on Hyper/Microgravity Research – Fluid Dynamics
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Ann and H. J. Smead Aerospace Engineering Sciences Department
University of Colorado, **Boulder**

Background

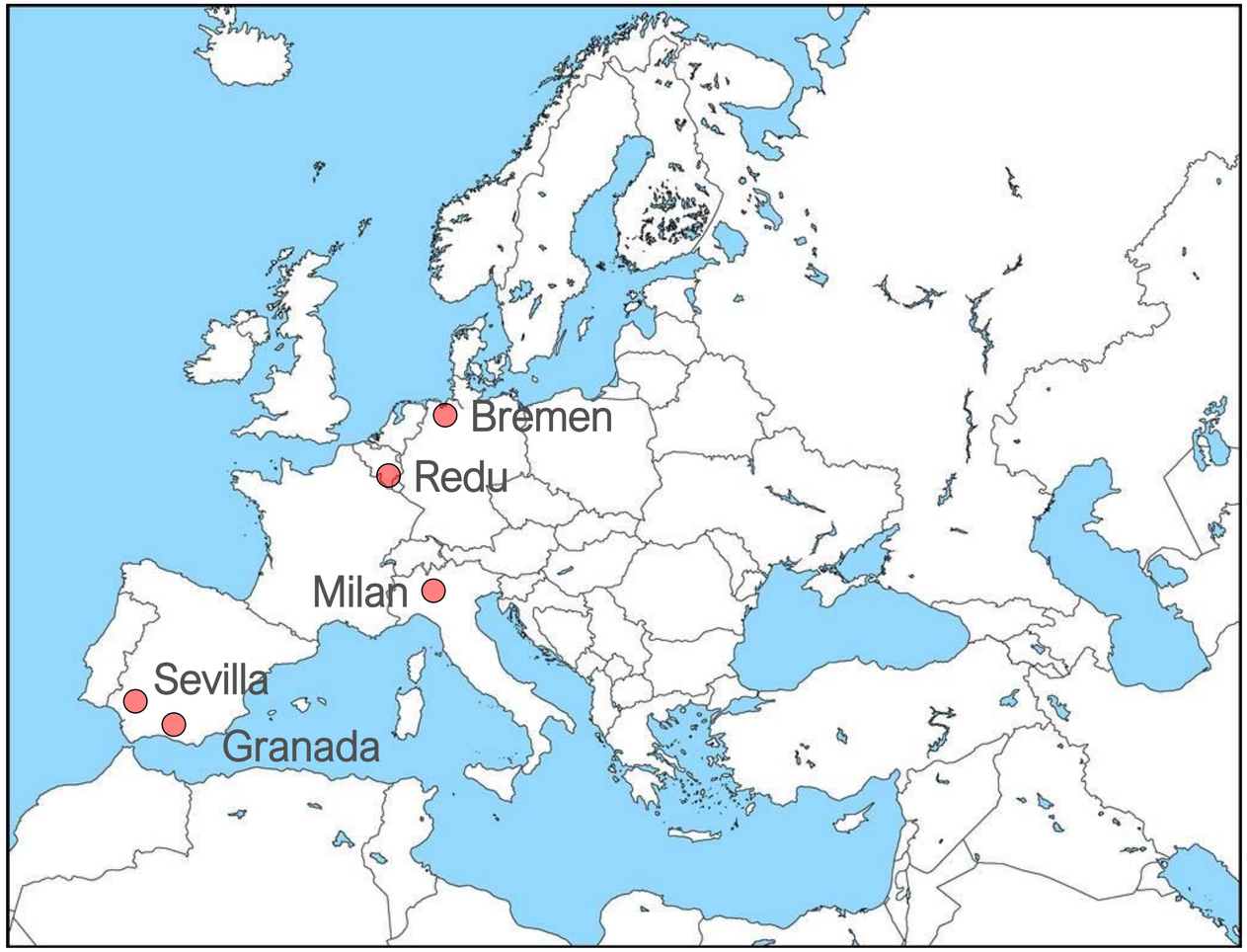
PhD in Aerospace Engineering Sciences

→ Low-gravity magnetohydrodynamics

→ Touchless electrostatic potential sensing

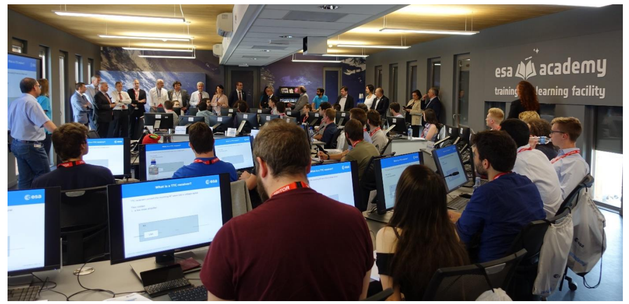
→ President-elect of ASGSR Students

Background



BSc Aerospace Eng., MSc Aeronautical Eng.

MSc Space Eng.



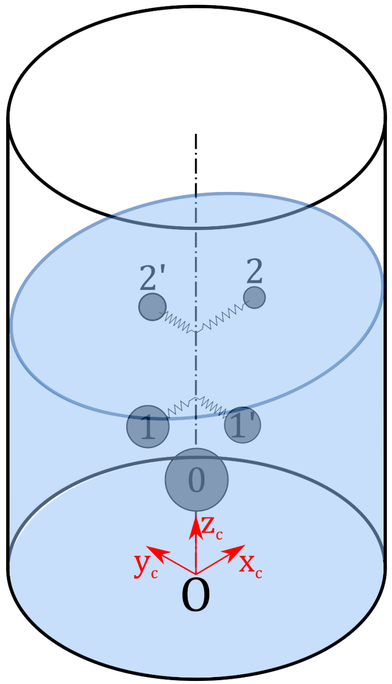
Microgravity research, ESA/ELGRA Summer School

ESA, ELGRA, and Drop Your Thesis! 2017

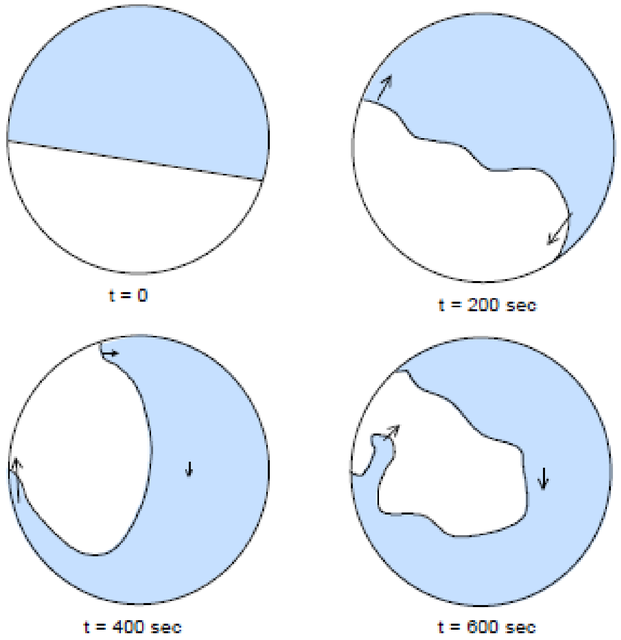
Research Project 1: Magnetic Liquid Sloshing

Multiphase flows in microgravity

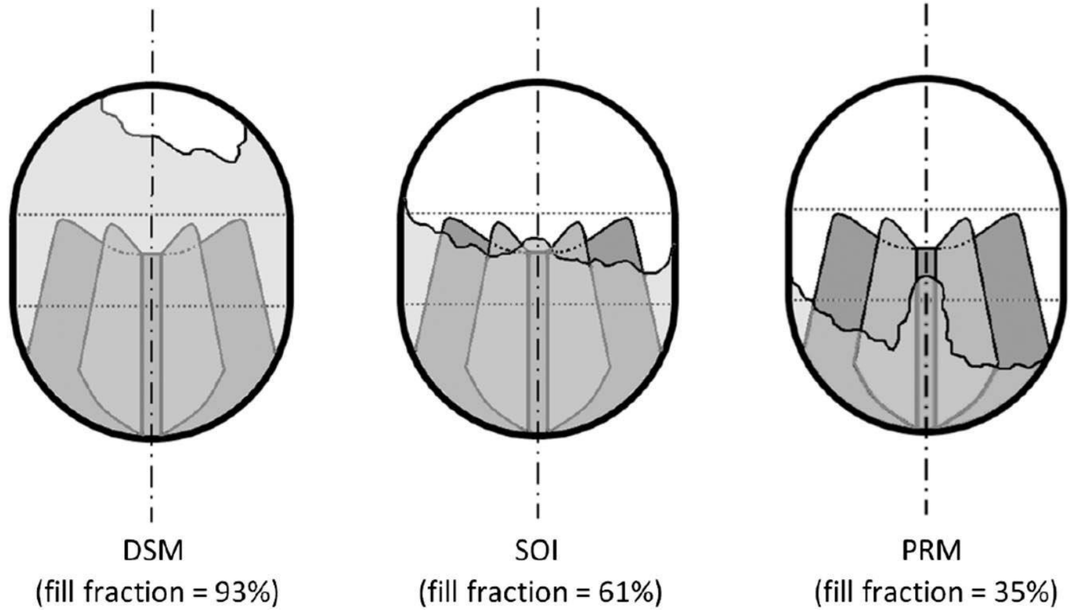
Low-gravity liquid sloshing



High-g sloshing

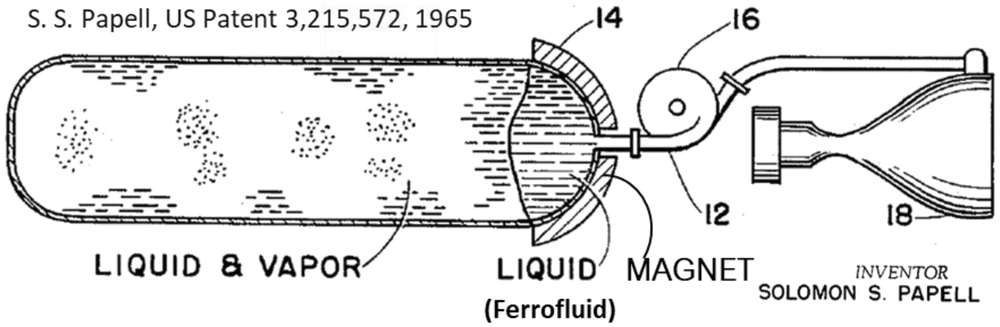


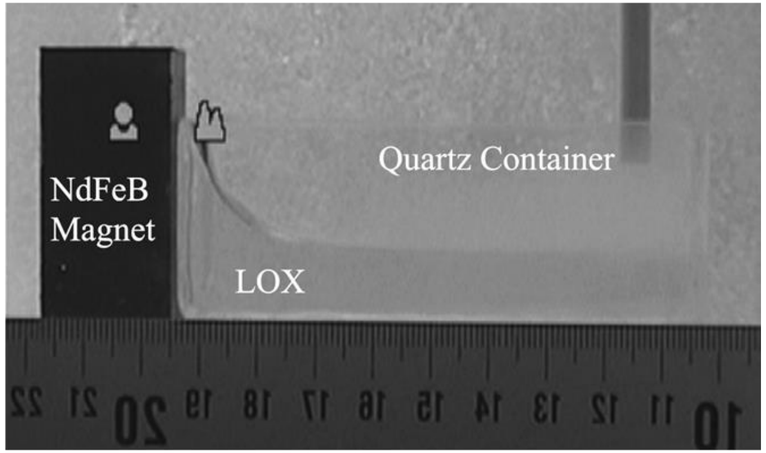
CFD simulation of liquid motion after a settling acceleration of 3.27 X 10-6g_0. F.T. Dodge, 2001



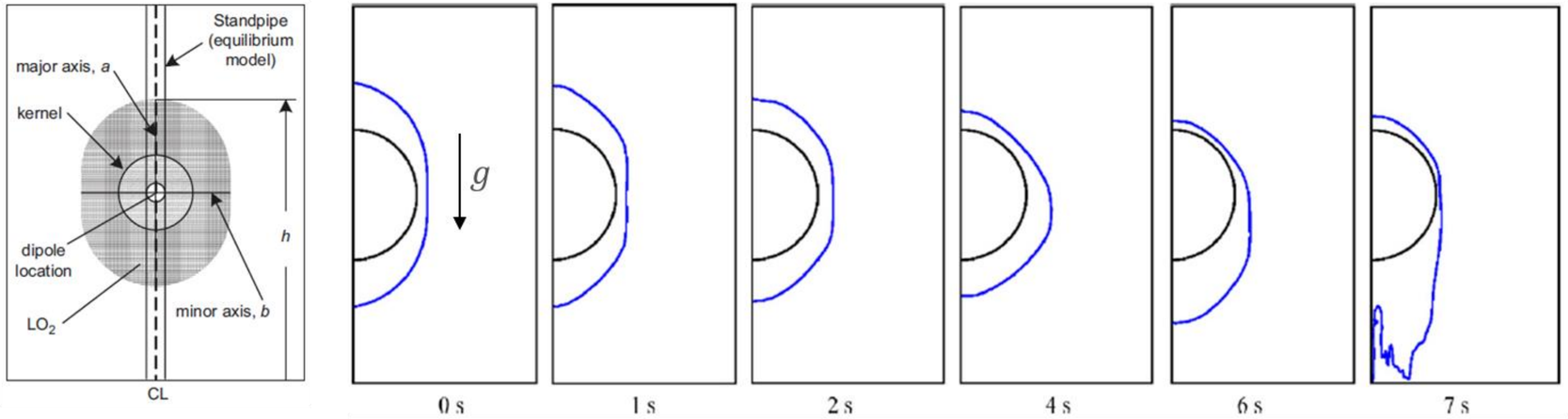
Cassini propellant management device. Lee and Stupik, 2017.

Magnetic liquid sloshing



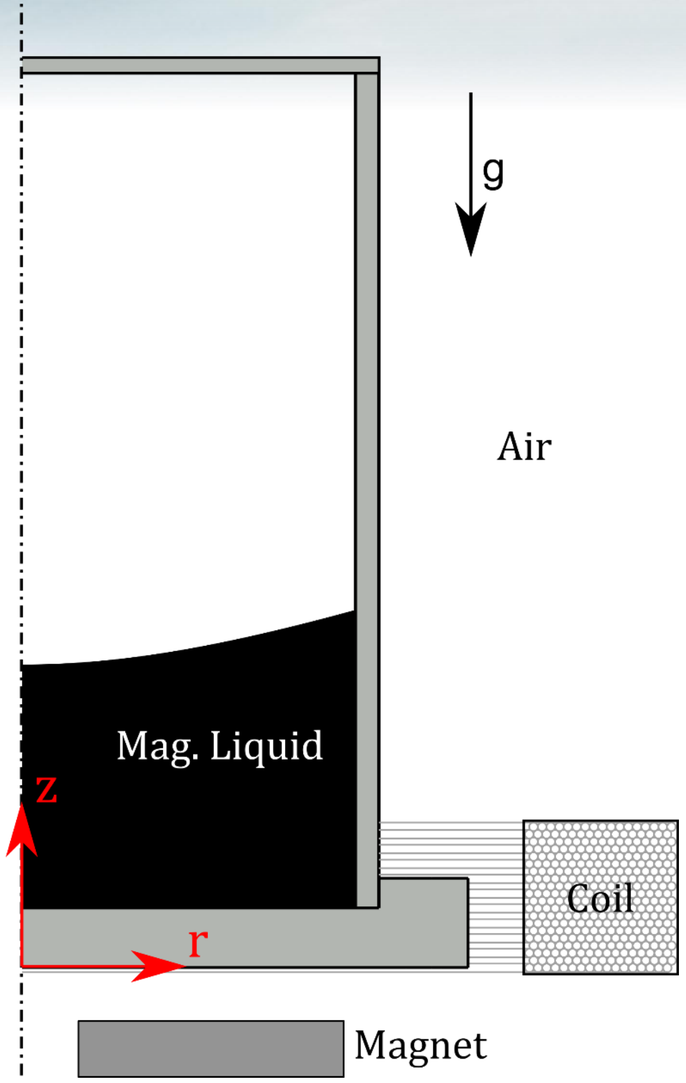


Marchetta and Winter, *"Simulation of magnetic positive positioning for space-based fluid management systems"*, 2010



Marchetta et al., "*Magnetic retention of LO2 in an accelerating environment*", 2008

ESA Drop Your Thesis! 2017 & UNOOSA DropTES 2019



- The **oscillatory dynamics** of partially filled containers in **microgravity** are well-known since the 1960s, but the **magnetic interaction** remained unexplored

- We assumed:
  - Incompressible, inviscid, Newtonian, **magnetic** liquid in a **cylindrical** container
  - Subjected to an **inhomogeneous** magnetic field generated by a coil in **microgravity**
  - **Axisymmetric** geometry, loads, and BCs

- Which are the **equilibrium**, **stability**, and **modal** properties in the presence of a **magnetic settling force**?

Need for (i) model, and (ii) **validation experiments**

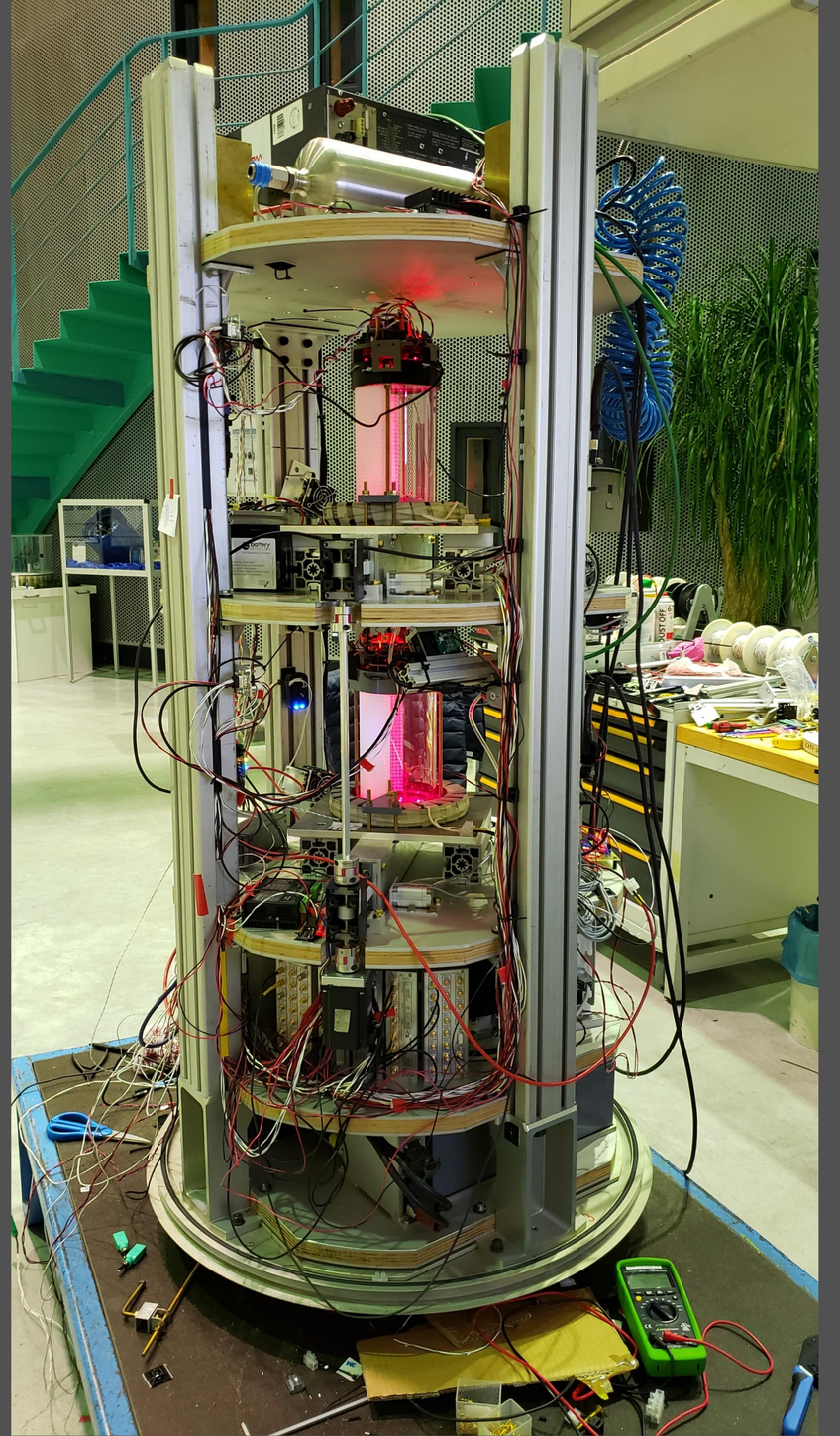
Á. Romero-Calvo et al., *"StELIUM: A student experiment to investigate the sloshing of magnetic liquids in microgravity"*, 2020

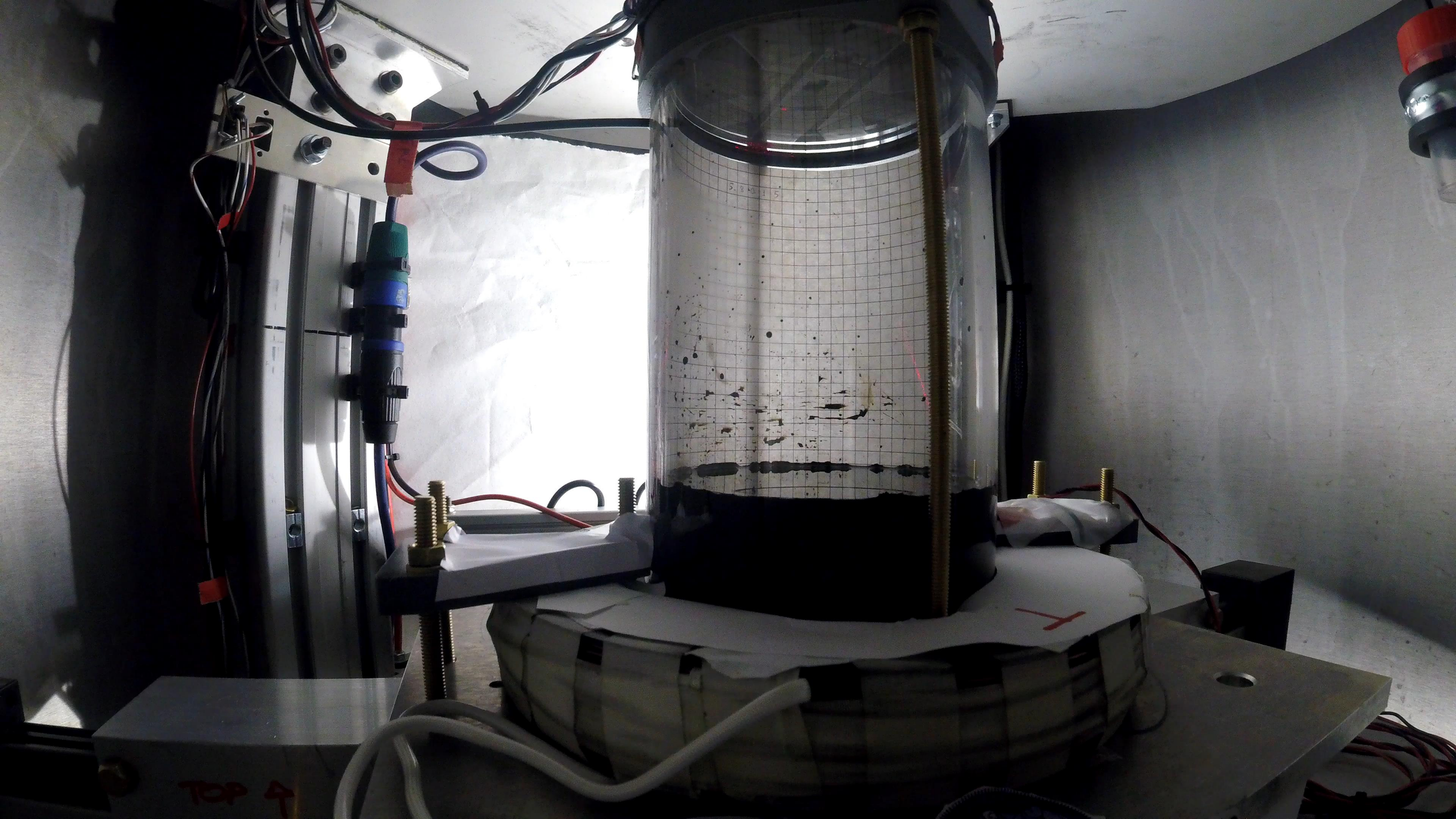
UNOOSA

UNOOSA DROPTES PROGRAMME

StELIUM

UNIVERSITY OF SEVILLE - POLITECNICO DI MILANO - UNIVERSITY OF COLORADO

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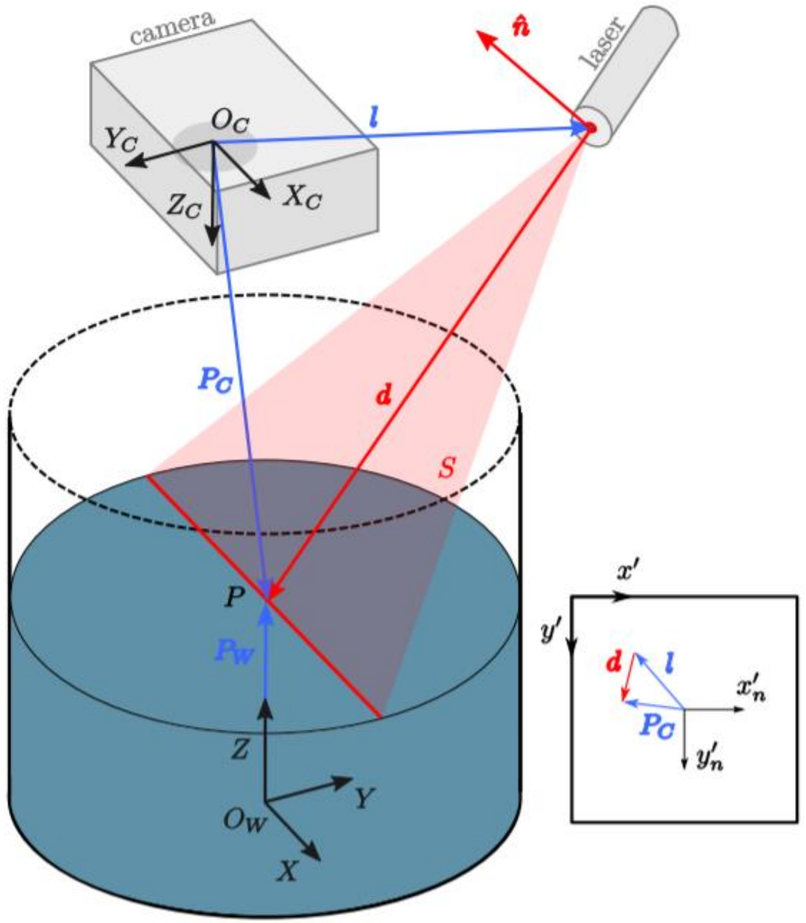
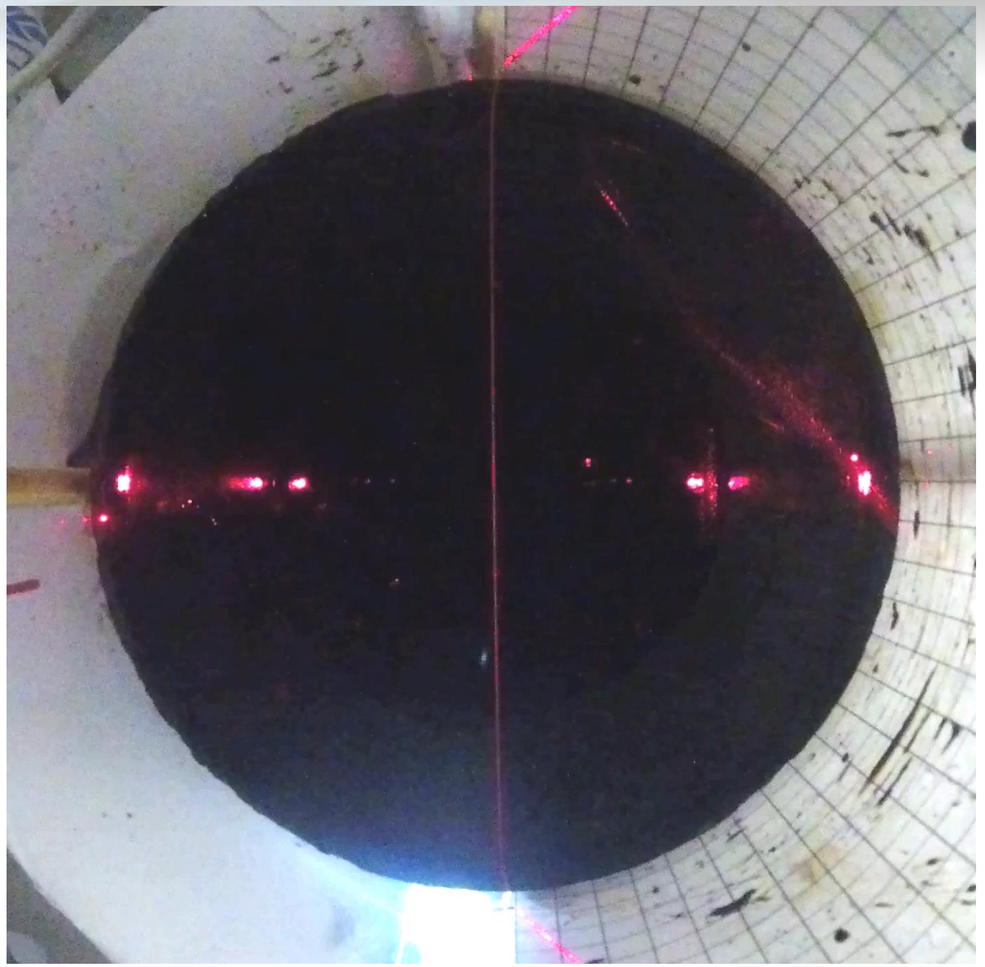
UNOOSA DropTES 2019: StELIUM



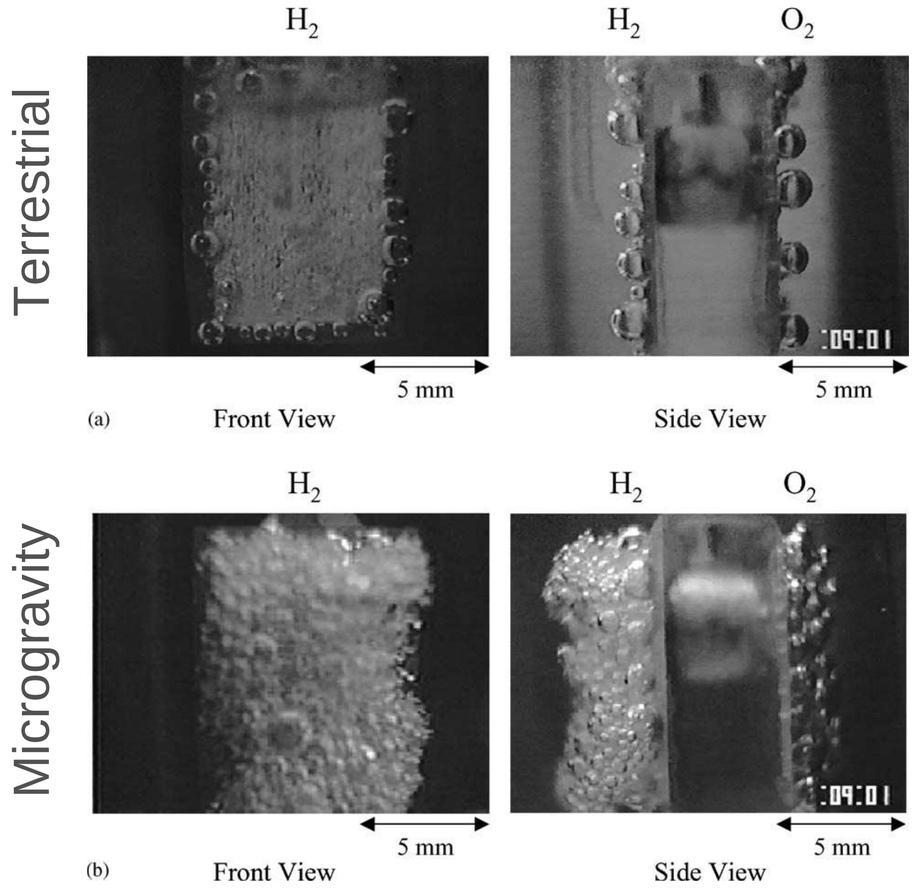


Á. Romero-Calvo et al., *"Free Surface Reconstruction of Opaque Liquids in Microgravity. Part 1: design and on-ground testing"*, 2020, *under review*

Research Project 2:
Diamagnetically Enhanced Electrolysis

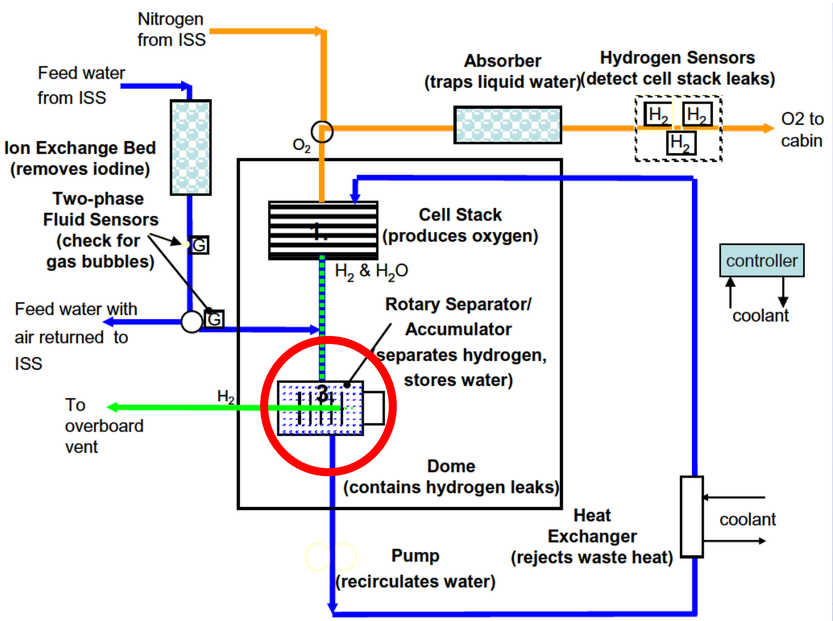
Phase separation in microgravity

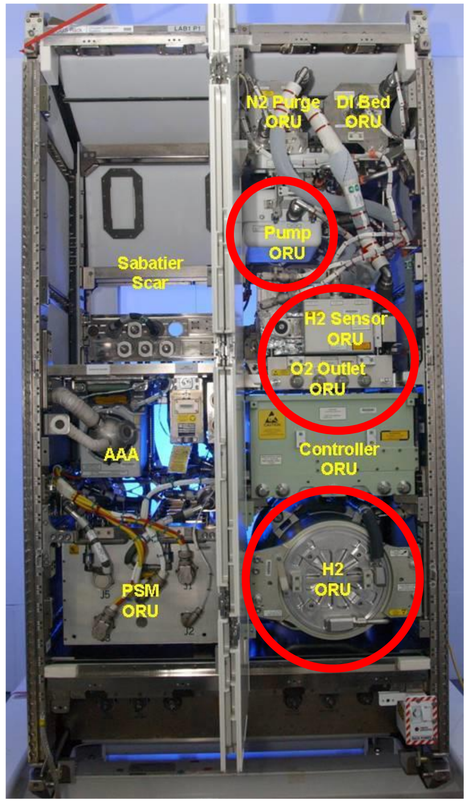
Electrodes



H. Matsushima et al., Water electrolysis under microgravity. Part 1. Experimental technique, Electrochimica Acta (48), 4119-4125, 2003

ISS Oxygen Generation Assembly





R.J. Erickson et al., International Space Station United States Orbital Segment Oxygen Generation System On-orbit Operational Experience, AE Int. J. Aerosp. 1(1):15-24, 2009

An interesting physical mechanism

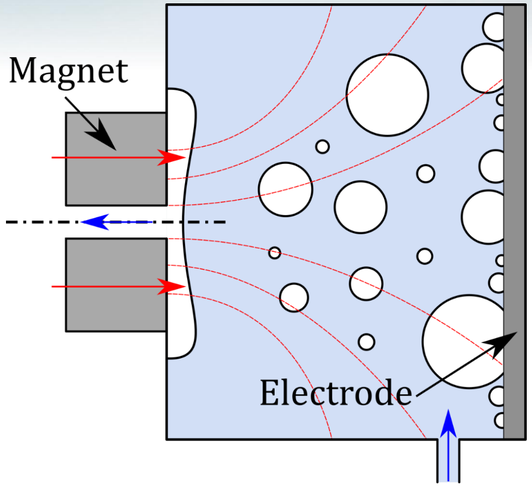
https://youtu.be/Gqr5qdDDRB8

Can frogs fly?

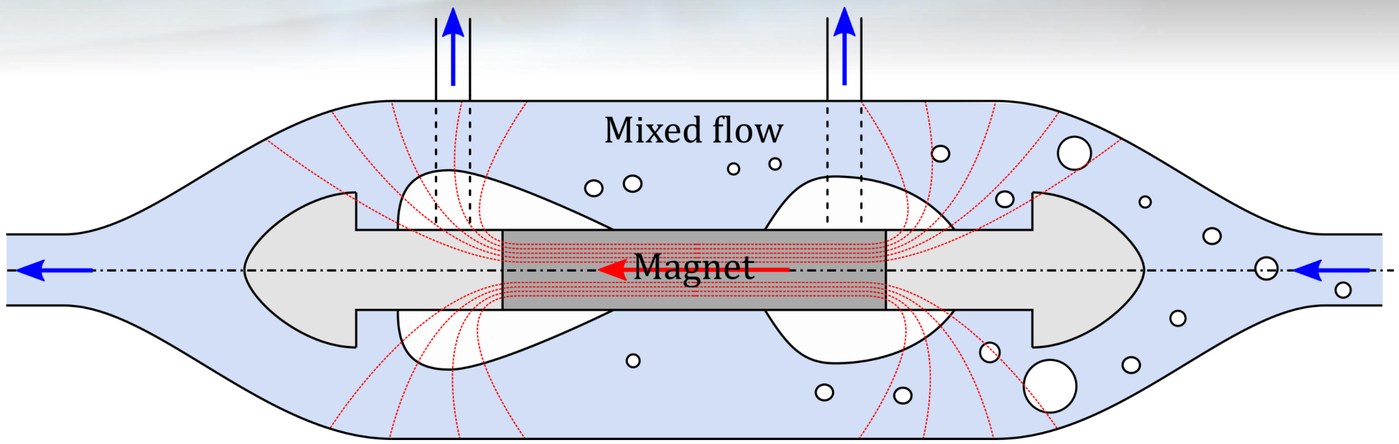
https://youtu.be/KlJsVqc0ywM

Diamagnetically enhanced electrolysis

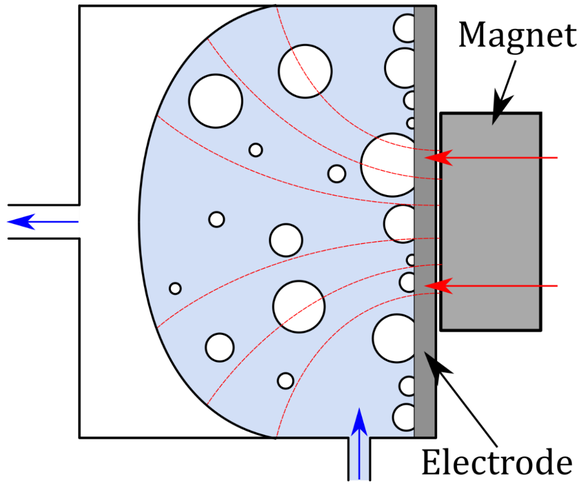
Diamagnetic electrolysis



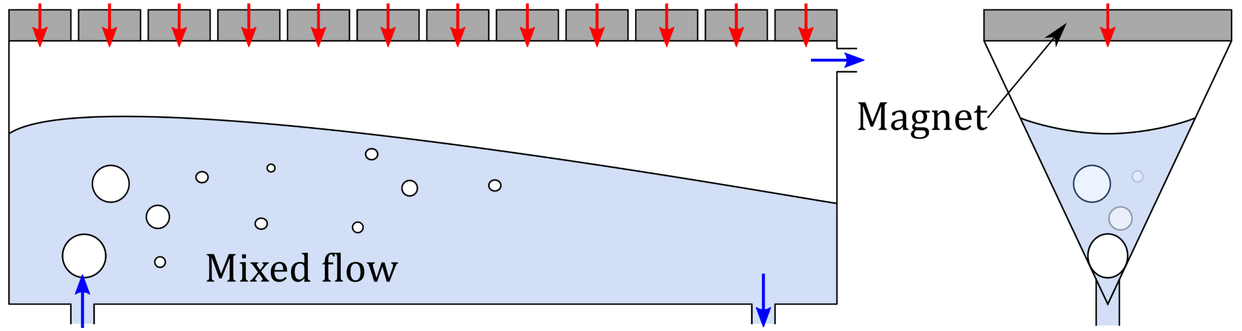
Magnetic phase separation



Para/ferromagnetic electrolysis



Combined phase separation



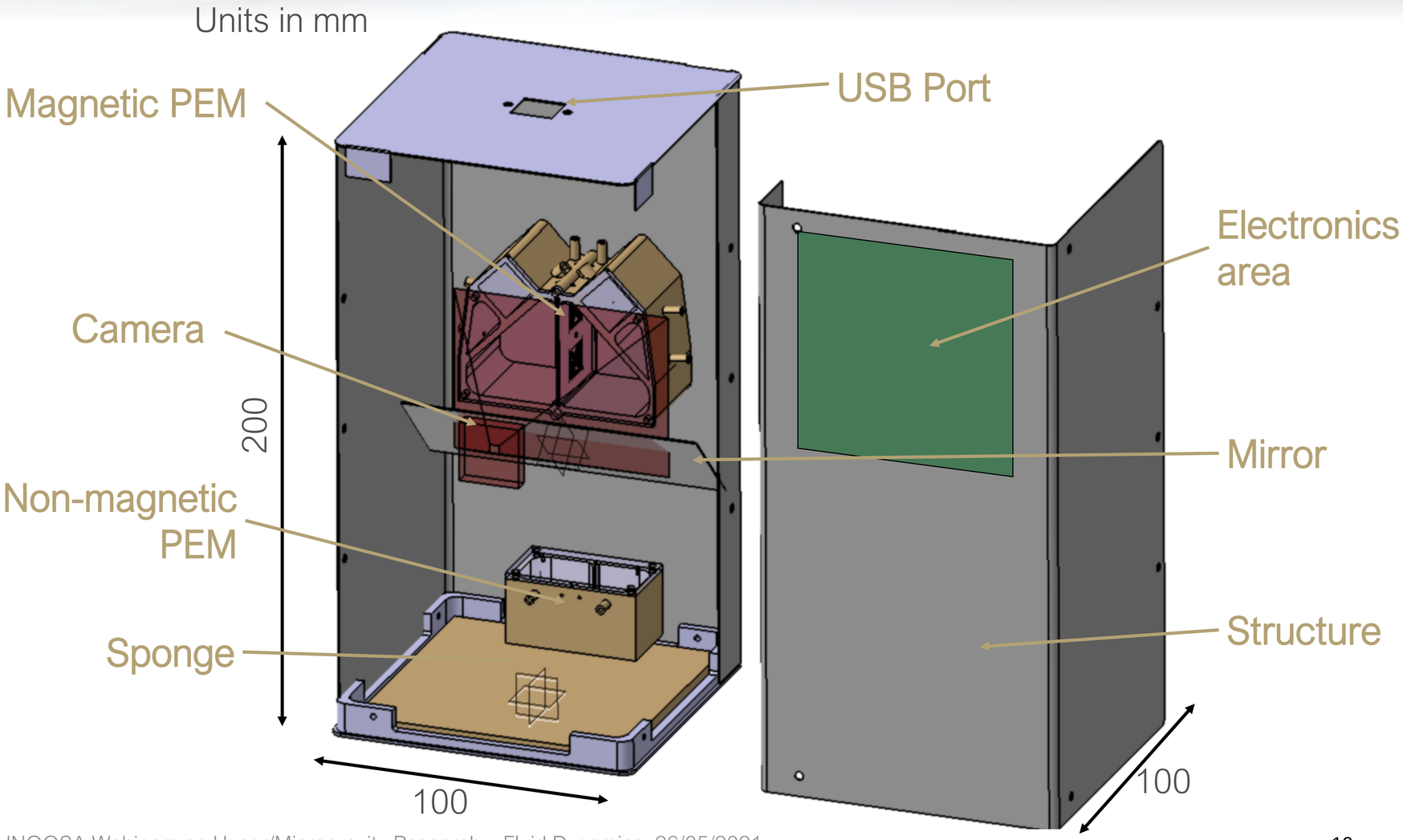
Á. Romero-Calvo et al., "Magnetic buoyancy-based water electrolysis in zero-gravity", 71st International Astronautical Congress (IAC), The Cyber-Space Edition, 2020

What we expect…

https://youtu.be/BxyfiBGCwhQ

- 1.25 cm radius sphere rotating at ~3.5 rad/s → Maximum buyoyancy accelerations of $\sim 5 \cdot 10^{-4}\ \mathrm{m}/s^2$ (increases with r^2)
- Magnetic acceleration of $10^{-3} - 10^{-2}\ \mathrm{m}/s^2$
- Should work! (hopefully)

ASGSR Ken Souza Award, Blue Origin's New Shepard



Interested? Let's talk!

Who are you? Where do you want to go?

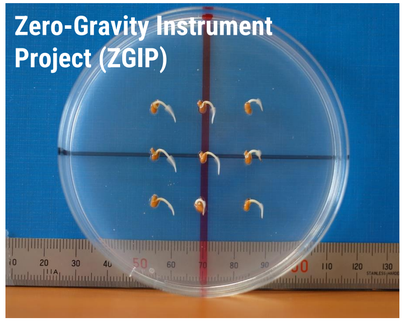
Make a plan & learn from a global community

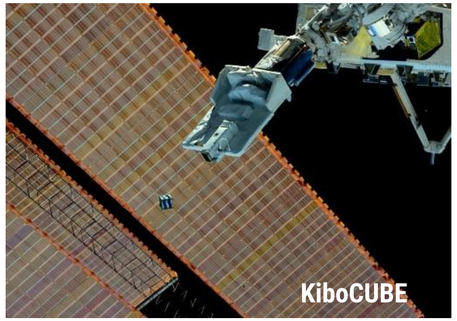
Apply to hands-on opportunities

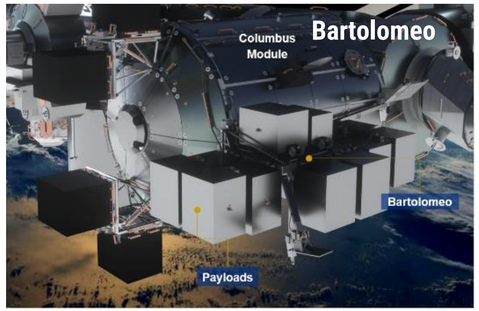
UNOOSA

UNOOSA Access to Space for All Initiative

*To answer to the increasing demand for **hands-on capacity-building**, the United Nations Office for Outer Space Affairs (UNOOSA) started to provide hands on opportunities in collaboration with various partners back in 2012 and, in 2018, launched the Access to Space for All Initiative which organizes all the hands-on opportunities offered by UNOOSA in three different tracks of increasing complexity, aiming at **developing capacity** in different space-related areas from A to Z.*







(Almost) no nationality restrictions!

Team up & have fun!

Questions?

alvaro.romerocalvo@colorado.edu

https://www.linkedin.com/in/alvaroromerocalvo/

www.researchgate.net/profile/Alvaro_Romero-Calvo

More information available at hanspeterschaub.info