The Magnetically Enhanced Electrolysis (MEE) Experiment

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Summary

Water electrolysis is a key technology for oxygen and hydrogen production in space, finding application in environmental control and life support systems, propulsion technologies, and high-density energy storage devices. However, the management of multiphase flows in microgravity is complicated due to the absence of buoyancy. Diamagnetic buoyancy can be induced by means of permanent magnets to remove and collect gas bubbles and simplify current oxygen generation architectures. Ultimately, this could lead to a new generation of electrolytic cells with minimum or no moving parts. The Magnetically Enhanced Electrolysis (MEE) experiment seeks to evaluate this approach by testing a technology demonstrator onboard Blue Origin's New Shepard suborbital rocket. Preliminary drop tower results exemplify the effectivity of this method.

Experimental Setup

The MEE setup, depicted in Fig. 1, is designed to study the (i) bubble life-cycle dynamics and (ii) magnetic electrolysis performance. Formatted as a 0.5 kg 2U structure, it is composed of magnetic and non-magnetic electrolytic cells, with the latter serving as a control unit. Two block magnets are used to induce the detachment, collection, and coalescence of hydrogen and oxygen bubbles. The system is monitored during the ~3 min New Shepard microgravity flight by a small camera and a potentiostat implemented in a Raspberry Pi.

Results & Discussion

Prior to the suborbital campaign, the magnetic cell was exposed to 4.7 s of microgravity conditions at ZARM's drop tower in Bremen, Germany. The recording, shown in Fig. 2, demonstrates that magnets can effectively detach and collect gas bubbles in microgravity. Bubble trajectories are driven by the diamagnetic and Lorentz forces, with the first producing well-defined trajectories and the second inducing an helicoidal motion. This observation determines the operational strategy of the experiment onboard Blue Origin's NS-23 flight.

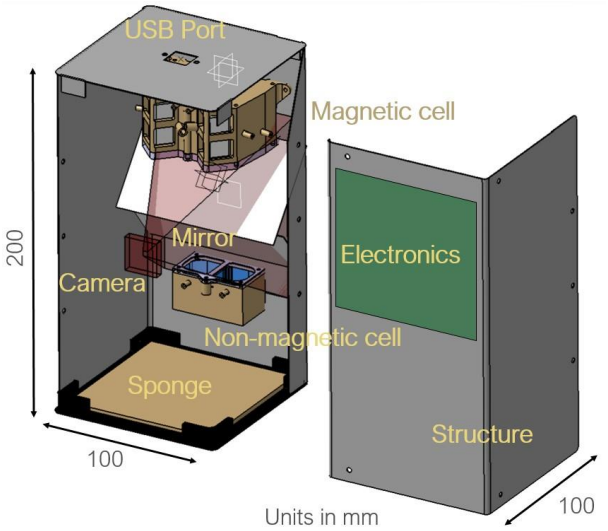

Figure 1: Experimental setup of the MEE experiment.

The NS-23 suffered a booster failure that prevented the collection of microgravity data. Luckily, the experiment operated as expected and survived the flight thanks to the capsule launch escape system. A future New Shepard mission will test the long-term performance of the MEE experiment and assess whether diamagnetic buoyancy can, as indicated by preliminary results, simplify microgravity electrolysis cell design.

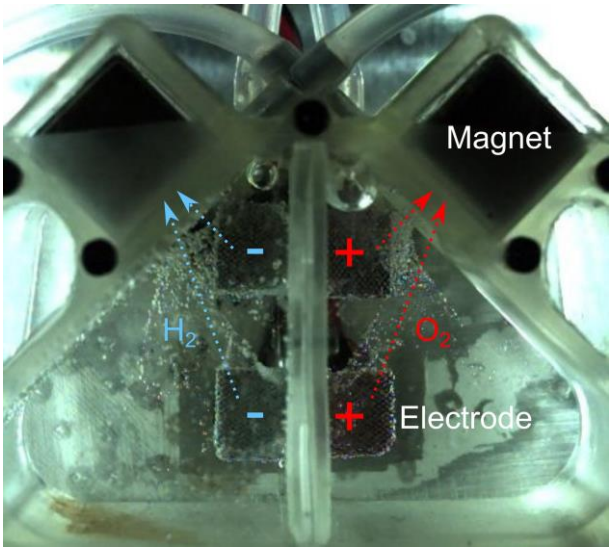

Figure 2: Gas bubble dynamics in microgravity.