Studying the Coarsening of Wet Foams in microgravity at International Space Station

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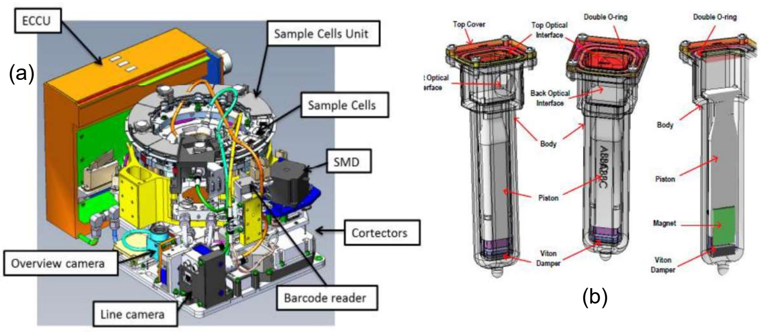
Overview

- ✓ Foams are collections of gas bubbles in a continuous fluid (or a solid). On Earth foam evolves through three ageing mechanisms: gravitational drainage, coarsening and coalescence.
- ✓ Coarsening arises from gas transfer from smaller bubbles to larger ones because of pressure differences, whereas coalescence arises from the rupture of the film between two bubbles. The study of “wet” foams (liquid fraction above 10%) is particularly difficult on Earth because of fast gravitational drainage.
- ✓ The foam coarsening (FOAM-C) project carried out with the European Space Agency (ESA) is focused on the study of wet foams and bubbly liquids (liquid fractions between 15% and 50%)

Experiments on ISS



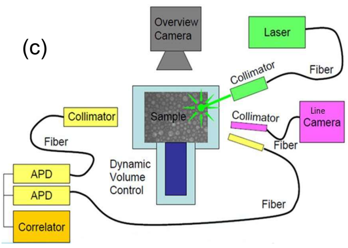


Figure 1: (a) ISS module with carousel containing 20 cells and optical diagnostics designed by Airbus, (b) foam sample cell showing the location of the piston to produce foam, (c) Schematic overview of the FOAM-C experimental setup.

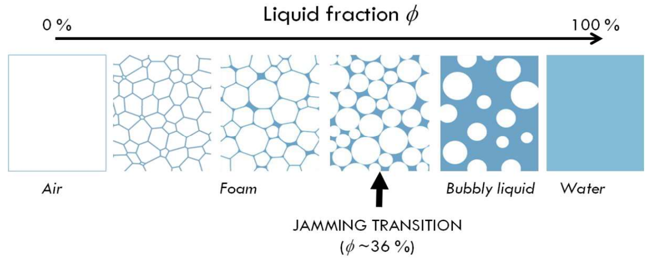
- ✓ An overview camera takes images of the foam surface, from which bubble size and bubble size distribution close to the cell wall are determined. Analysis of images of foam surface is performed by three different methods to identify pitfalls: manual analysis, automatic analysis with customized Python script and machine learning analysis.
- ✓ Diffuse Transmission Spectroscopy (DTS), allows measuring the bubble size in bulk.

Work Done so Far as a Postdoc

- ✓ The third round of ISS measurements (FOAM-C3) only started by mid-august. Meanwhile, I worked on imaging bubbles and determining the role of surface mobility (viscosity, elasticity) on their motion.
- ✓ I interacted with the B.USOC and Airbus teams, coordinating with them at the end of august during the commissioning and determining the best scan stage position and foaming parameters.
- ✓ Downloading incoming images, making movies for the completed long and short runs and checking for any anomalies in the current FOAM C3 experiments.
- ✓ Participating in the project management through weekly meetings one with the science team and the other with B.USOC/Airbus teams.

Objective

- ✓ Study the transition in coarsening regimes at the jamming transition, between wet foams and bubbly liquids.



Radius R ~ time $t^{1/2}$ **R ~ $t^{1/3}$**

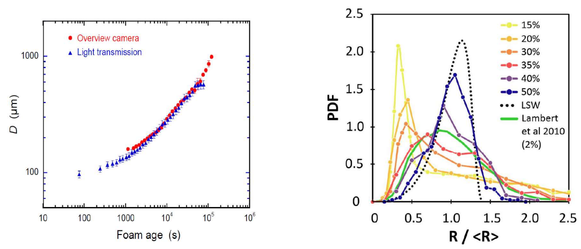


Figure 2: (a) Time variation of the average bubble diameter D = 2R: red points: from image analysis; blue points: from diffuse transmission spectroscopy; TTAB foam, liquid fraction Φ = 32.5%. (b) Size distribution for the different liquid fractions. TTAB foams

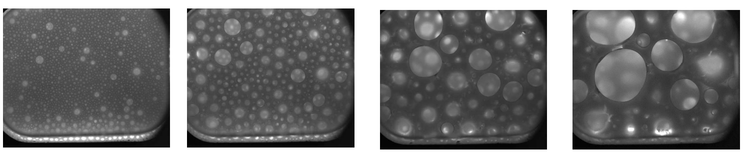


Figure 3: (a) Sketch of foam structure as a function of liquid fraction Φ. (b) Photograph of evolution of foam in ISS with a liquid fraction of 25% is shown. The scale bar is 20 mm.

- ✓ Understanding the role of the physico-chemical parameters (bulk and surface viscosity, surfactant concentration, nature of surfactant, presence of oil drops (foamed emulsions) in the coarsening process

Future Research Plan

- ✓ Participate to FOAM-C3 data analysis, once the experiments are completed (~ end of 2022)
- ✓ Participate to FOAM-C4 in 2023. The aim is to study the role of adhesion between bubbles, seen to shift the jamming transition and increase the coarsening rates. We plan to use a surfactant leading to a greater adhesion than TTAB. This will help to understand how adhesion changes foam behavior
- ✓ Finishing the analysis of the role of surface mobility in bubble motion through ground experiments

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