

FOAMS, FILMS AND SURFACES IN MICROGRAVITY

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Summary Beginning with a broad view of the role of surface tension and gravity in free liquid surfaces, thin films and foams, we identify the motivation for the microgravity research conducted in these systems over the last quarter century. In the case of foams, experiments have been quite limited in scope, and the intention to study *wet* foams has yet to be fully realized, except perhaps in the case of two-dimensional samples. New experiments are planned for MAXUS rockets and possibly the International Space Station (ISS).

Foams, films and liquid surfaces present three inter-related fields of research in which the force of surface tension may play a primary role. Unless the length scale (bubble size for example) is much smaller than the capillary length, gravity is also important. Hence there has been from the outset (the book of Plateau in 1873 [1]) a desire to somehow suppress gravity and study surface tension effects alone. In particular, this would enable us to study wet foams. There are several ways of doing this, but the microgravity environment of space offers the most straightforward and general method.

In addition, there are obvious practical reasons to be concerned about the behaviour of liquids in containers in space.

Such motivations have stimulated a variety of experiments over many years, ranging from drop-tower observations to sounding rocket experiments, and there are plans for future ISS facilities. An entertaining example is the observation of non-coalescence of droplets in the experiments of Monti *et al.* [2].

Despite many years of foam experiments, there has remained some uncertainty about reliable methods of foam production to generate samples, since gravity often plays a role in familiar terrestrial methods. There is also a difficulty in observing wet foams since light is diffusely scattered by them. Hence three-dimensional experiments have been quite rudimentary up to this point (despite complex technical elaboration). Experiments on two-dimensional samples by Noever [3] and recently by Caps *et al.* [4] have offered more readily interpreted data.

In tandem with this experimental work, theoretical advances have been made, often with the aid of simulations. One such simulation tool is Brakke's Surface Evolver [5], which models surfaces governed by the forces of surface tension and gravity, among others, subject to given constraints. In our own work we have used it to successfully predict the occurrence of surface-tension dominated instabilities in foams [6]. Such work proceeds alongside models of, for example, liquid flow through foams under a range of micro- and zero-gravity conditions [7].

Foams (and analogous emulsions) are ubiquitous in occurrence and in application in the terrestrial environment, and should be so in the man-made space environment as well, where they will behave quite differently. The next generation of experiments should indicate where the important differences will lie. The planned experiments involve both the familiar aqueous foams of the bathroom and kitchen but also the production of metallic foam materials that are of current industrial interest – see figure 1.

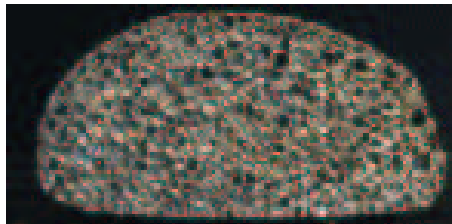


Figure 1. An example of a metallic foam. These materials have excellent properties, such as high strength-to-weight ratio, making them ideal for many industrial applications. In this case the foamed metal is zinc. Image courtesy of J. Banhart, HMI Berlin.

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References

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