Naturwissenschaften

Floating Liquid Zones

I. Da Riva and I. Martínez
Universidad Politécnica de Madrid, Spain

The aim of our experiment on the Spacelab D1 Mission was to study the stability of long liquid columns under microgravity. Nominal configuration was a cylindrical liquid bridge anchored at the edges of two equal solid discs, 35 mm in diameter. Mechanical stimuli were applied through the discs and the liquid outer shape recorded for analysis.

Nominal experiment procedures [1] were similar to those proposed for Spacelab-1 (1983), where by wetting problems allowed only partial success [2]. The same Fluid Physics Module, but with corrected end discs and a manually operated syringe for liquid injection, was used.

Experiment

Payload specialist Dr. Furrer was in charge of the experiment in flight, assisted by Dr. Martínez on ground when voice and video link was available. Start time was Mission Elapsed Time 5/23:35:00 and the experiment proceeded as expected, with the following deviations:

It was soon realized that g-jitter (Fig. 1) was much higher from Spacelab-1 and Texus-12 experience [3]. Long columns were continuously trembling. This noisy ambient stressed the operator, who on the first trial followed a slightly scarce filling law that caused the first disruption of the column (Fig. 2) soon after the nominal working length $L=$ 95 mm was reached.

Experiment reinitiation was achieved thanks to the skillful operator (and not once, but five times),

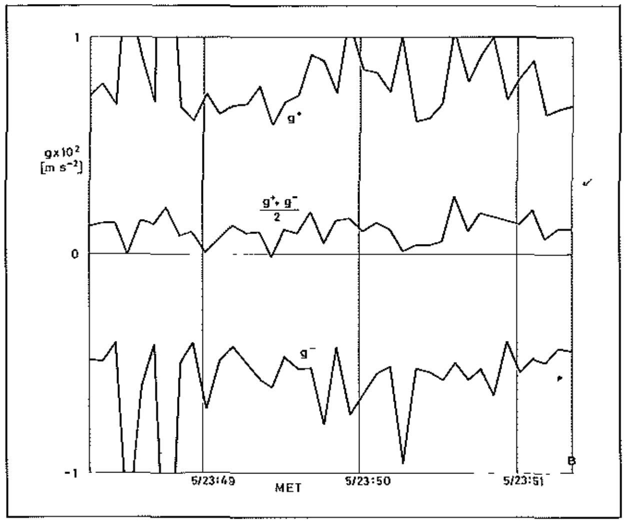


Fig. 1. Accelerometer data in the column axial direction prior to the first column breaking, at Mission Elapsed Time B. g^+ and g^- are the readouts of the Werkstofflabor accelerometers (maximal value sampled at 1-s interval)

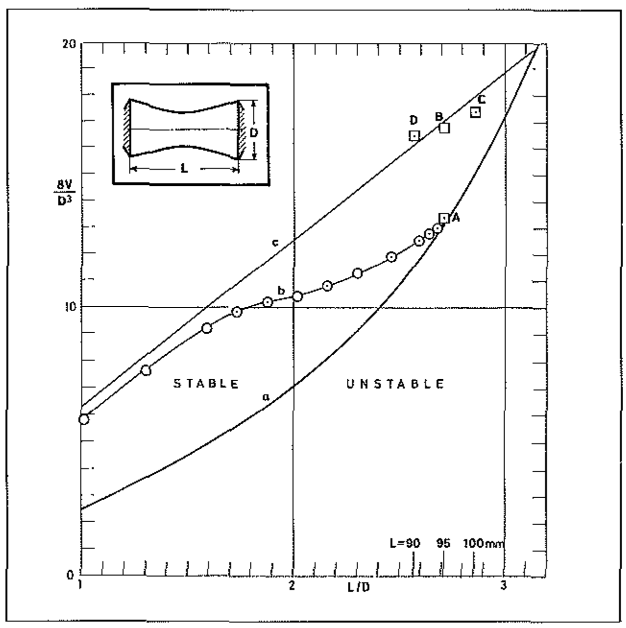


Fig. 2. Liquid bridge stability diagram. a) Minimal stable volume; b) filling law manually followed in the first trial; c) nominal cylindrical column evolution. A, B, C and D show where column breaking occurred; B, C and D breakings were due to isorotation at 12, 10 and 13 rpm in sequential order

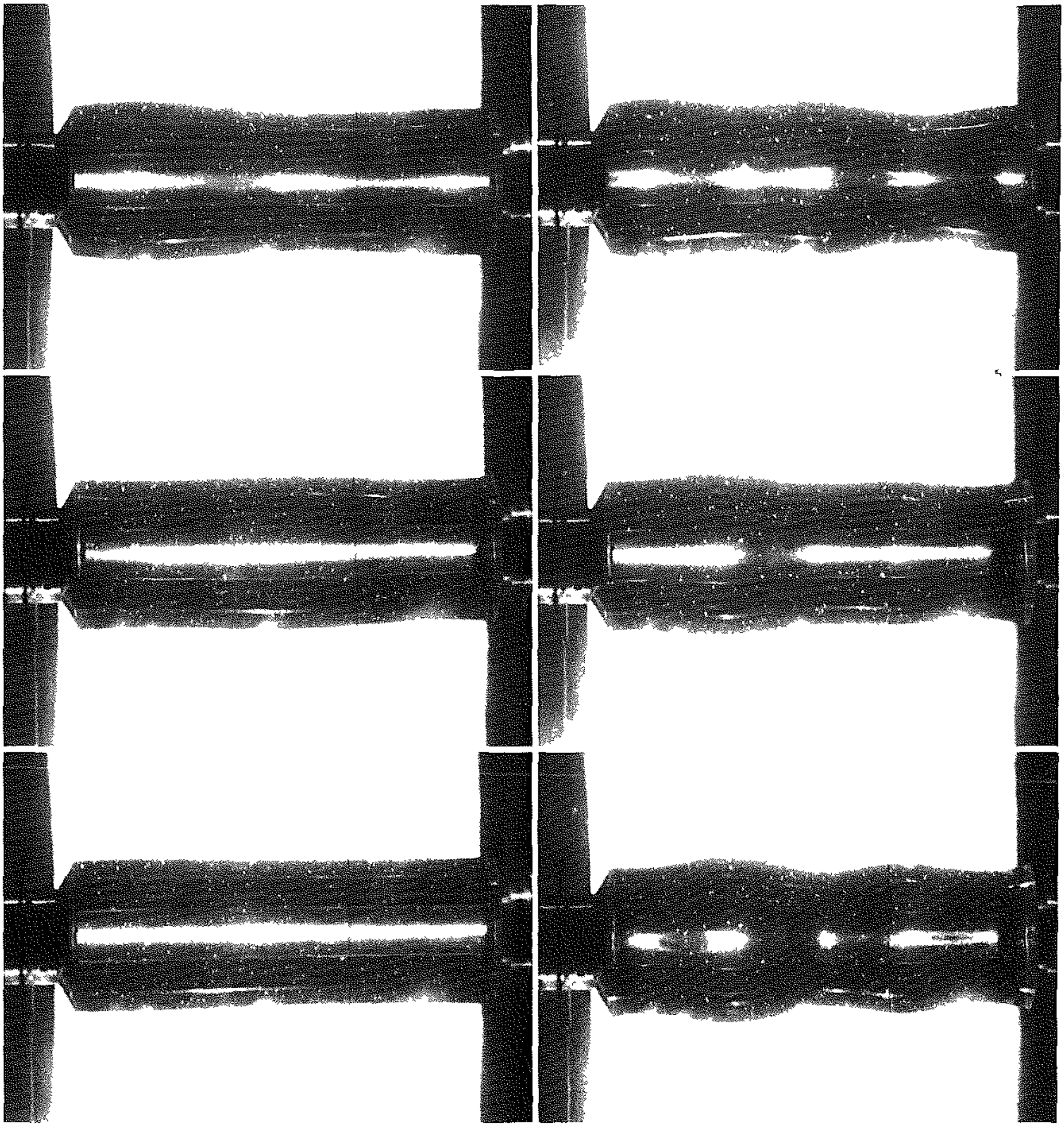
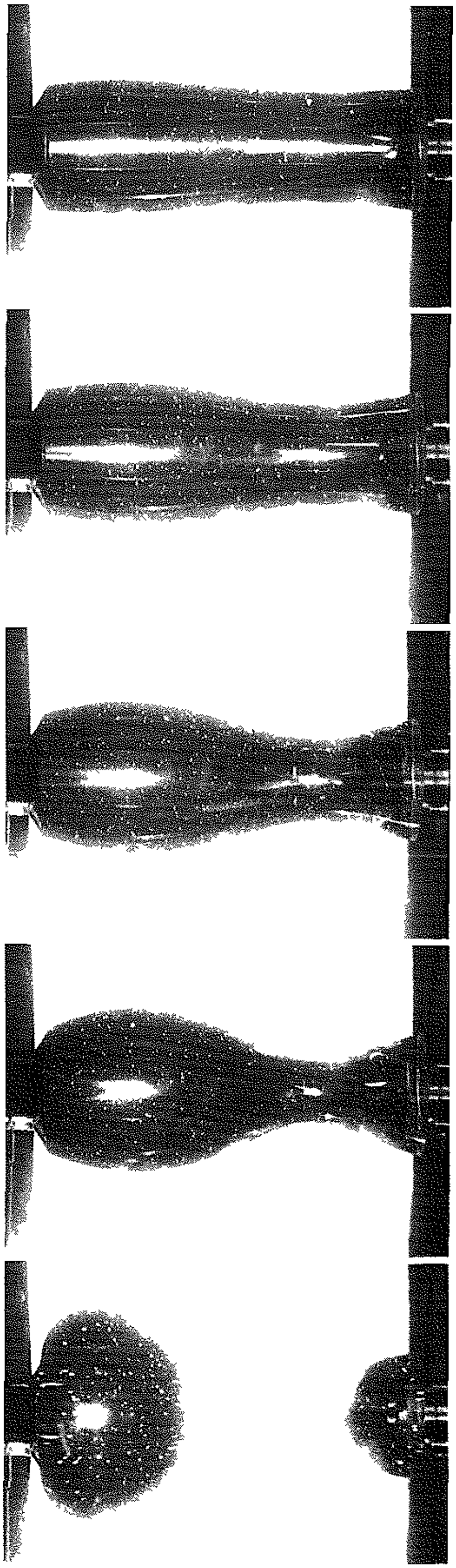


Fig 3 Two vibration examples of a 95-mm-long cylindrical liquid column (at 0 3 and 1 1 Hz) with an amplitude of 0 5 mm Consecutive frames at 2-s intervals

demonstrating the importance of a well-trained payload specialist on board. During a video link it was agreed to switch on background illumination in order to follow the free surface oscillations better (at the expense of a poorer tracer visualization by meridian plane lighting).
The small rotation of the discs at 3 rqm, intended for overall viewing, was switched off to diminish ambient noise (work had to be stopped several times due to the uncontrolled vibrations).
Axial oscillation of one disc at several frequencies was exercised and liquid response was as foreseen (Fig. 3) though departures from the cylinder were larger near the filling discs due to a residual accel-



eration (Fig. 1). A second, yet unexplained breaking took place just after the axial oscillation exercise, perhaps due to some Shuttle maneuver.
Further breakings occurred at $L=95$ mm with $\Omega=12$ rpm, 100 mm with 10 rpm (Fig. 4) and 90 mm with 13 rpm, all in an amphora-like mode. The last breaking showed an initial C-mode deformation (like a skipping rope), but ambient noise may have changed the final breaking mode.
The last C-mode rotation trial, at $L=75$ mm with $\Omega=16$ rpm, though much less sensitive to ambient noise, was not performed due to lack of time, in spite of the generous time extensions granted to this experiment.

Perspectives

A detailed analysis of the 16-mm-film images, shot at 2-s intervals, is underway, while awaiting the on-board video recording.
The overall result was excellent and a follow-up proposal for Spacelab-D2 (1988) has already been submitted to ESA for further work on the C-mode and unequal disc stability analysis.

This project is being financed by the Spanish Commission on Space Research (CONIE).

1. Da Riva, I., Martínez, I., in: Scientific Goals of the German D1 Mission, WPF, 1985
2. Martínez, I.: Materials Science under Microgravity, ESA SP-222 (1984)
3. Martínez, I., Sanz, A.: ESA J. 9 (1985)

Fig. 4. Breaking sequence of a 100-mm-long cylindrical liquid column. Observe the middle satellite drop in the last picture. Times are, relative to the last, 0, −2, −4, −10, −50 s