# A SYMMETRY BREAKING EXPERIMENT ABOARD MIR AND THE STABILITY OF ROTATING LIQUID FILMS

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We discuss results for two parts of our study on the behavior of liquids under low-gravity conditions. The first concerns the Interface Configuration Experiment (ICE) aboard the Space Station Mir on the Mir-21/ NASA-2 mission. The experiment investigates fluid interfaces in certain "exotic" containers in a low-gravity environment. These containers are rotationally symmetric and have the property that for given contact angle and liquid volume, a continuum of distinct rotationally symmetric equilibrium configurations can appear, all of which have the same mechanical energy. These symmetric equilibrium configurations are however unstable, in that deformations that are not rotationally symmetric can be shown mathematically to yield configurations with lower energy. On an earlier Space Shuttle mission it was found experimentally, in confirmation of mathematical results, that the stable configuration that formed was not rotationally symmetric. In the Mir mission there formed as well a second, distinct locally stable non-rotationally-symmetric configuration, as predicted by numerical computations; the two configurations possessed different dynamic characteristics. This intriguing phenomenon of asymmetric local energy minimizers in a symmetric container can occur even if conditions for an exotic container are not completely satisfied.

The second investigation concerns the behavior of slowly rotating liquids in a low-gravity environment. For many liquids the classical Young-Laplace-Gauss formulation for equilibrium capillary free surfaces gives reliable information concerning the shape and stability of free-surface interfaces. Our investigation concerns the behavior of a case of a highly wetting liquid partly filling a container, for which straightforward application of the classical theory may not hold, as under certain conditions "super-wetting" liquid films can form covering the container's inner surface. A configuration of particular interest is that of a highly wetting liquid partly filling the annular region in a closed circular cylindrical container with concentric rod; the entire configuration is to be kept rotating at a uniform speed in such a manner as to maintain the center of mass on the axis of symmetry. This configuration has been proposed as a space-orbiting cryogenic cooling device for the STEP and Gravity Probe-B Relativity Mission studies. In a 1-$g$ experimental study, which attempted to minimize the relative effects of gravity (by using small physical dimensions and large rotation speeds), it was found that a liquid film that formed on the rod became unstable. Liquid was "pumped" continually into the film from the bulk of the liquid, with liquid departing from the film sporadically in blobs. Equilibrium never was achieved. A subsequent mathematical study, based on a classical formulation enhanced to include a van der Waals potential of adhesion, gave critical film thickness and length criteria for the model problem of a film of uniform thickness on a cylindrical rod. Numerical experiments based on the enhanced formulation were then carried out for the actual container geometry for low-gravity. It was found, over a broad range of parameters, that the liquid films that form on the central rod are always sufficiently thin so as to remain stable, never becoming thick enough to satisfy the mathematical criteria for instability. Thus, the experimentally observed instability must derive from other factors. It is not known presently if an experiment conducted in microgravity, free of the scaling and complications inherent in a 1-$g$ experiment simulation, would exhibit the instability.