Dynamics and Stability of Free Thin Films

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The flows of thin films have been a subject of intense investigation for many years. The reason for this interest is the wide variety of applications of such flows, both natural and industrial. Free liquid films are thin liquid layers bounded by two interfaces between liquid and gas or liquid and two other liquids. Examples of such a configuration are the layers between two bubbles in a liquid or between two drops of different liquids suspended in a third liquid. Other examples concern the free thin films attached to frames surrounded by an ambient gas. A similar configuration can be found at the solidification of a thin film pulled from melt.

The modeling of the free thin film drainage and stability is usually performed in the framework of a generalized lubrication approach, including inertial, viscous, capillary and intermolecular surface forces. For films with fully mobile surfaces, this approach leads to a system of nonlinear PDE for the film thickness and lateral velocities. In the present work the 1D variant of this system is studied numerically at different dynamic and static boundary conditions in the case of a laterally bounded free film. A linear and non-linear stability analysis is performed for a free film attached on a frame, with a prescribed wetting angle on the frame, that generalizes the linear stability results obtained for a periodic free film by other authors. The results show that when the van-der-Waals forces are not active, the steady film shapes are stable. However, when the van-der-Waals forces are active, steady shapes do not exist for each value of the wetting angle and Hamaker constant (characteristics of the van-der-Waals forces) and some of the existing steady shapes are stable, while others are unstable.

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