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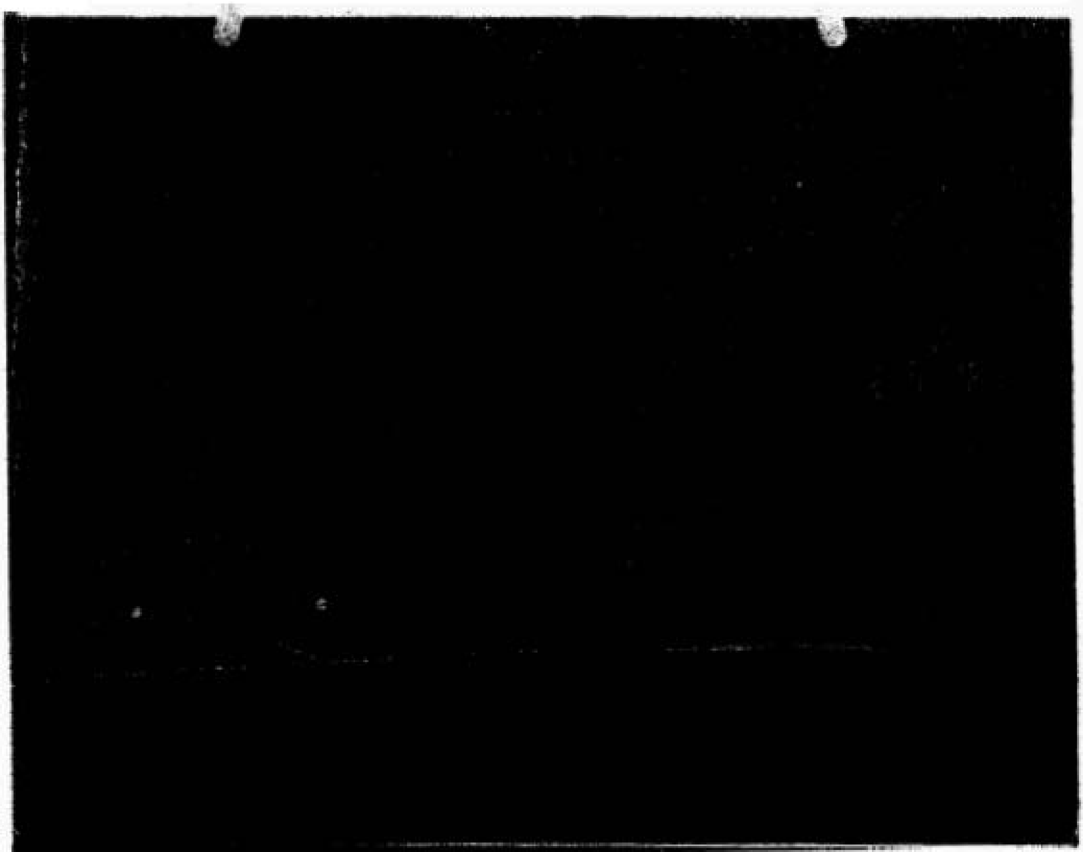

LONG WAVE INSTABILITIES OF HEATED FALLING FILMS: ROLE OF VAN DER WALLS ATTRACTION

Jameel, A.T[a]., Asrar, W[b]., Ismail, A.F[b]., and Yusuf, F[a].
[a]*Department of Biotechnology Engineering, Faculty of Engineering, International Islamic University Malaysia, P.O. Box 10, 50728 Kuala Lumpur, Malaysia*
[b]*Department of Mechanical Engineering, Faculty of Engineering, International Islamic University Malaysia, P.O. Box 10, 50728 Kuala Lumpur, Malaysia*

Thin layer of liquid flowing under gravity is susceptible to long-wavelength instabilities. For a liquid film on inclined plane, the liquid drains down due to gravity. If the layer thickness and the inclination angles are large enough to overcome the hydrostatic stabilization, it gives rise to surface wave propagation downstream. These instabilities occur for long waves, because short waves are suppressed by capillary forces. Nonisothermal thin films have been extensively studied for over past two decades [1-3]. The heating affects the film instability through the thermocapillary force acting at the free surface. Evaporative instabilities may also be present. Joo et al. [2] studied the dynamics of heated film on inclined plane by deriving a nonlinear evolution equation incorporating hydrodynamic, thermocapillary, and evaporative effects, without considering van der Waals attraction. Our previous work addressed the isothermal film on inclined plane under the influence of van der Waals force [3]. It was observed that with the thinning of film due to drainage, long range van der Waals force takes over the other forms of instabilities leading to eventual breakup and dry out. In case of heated film, as the local thickness of the film decreases, evaporation becomes important, and evaporative instability (owing to evaporation mass loss) causes the wave trough to thin, after which van der Waals attraction becomes increasingly significant rendering the film to rupture almost instantaneously.

Thus, the present work is an extension of our earlier study of isothermal film [3]. Here we attempt to study the influence of van der Waals attraction together with heat flux at the solid wall and evaporation at the free surface for gravity flow of liquid down an inclined support. We aim at investigating the nature of competitive instabilities, the spatio-temporal evolution of the film surface, conditions for film breakup and propensity of dry out. The sought after behavior of the heated layer on inclined plane is studied by a nonlinear formalism by deriving a nonlinear equation describing the evolution of various instabilities under complex nonlinear antagonistic effects of hydrodynamics, surface tension, thermocapillary, evaporation and van der Waals attraction. A linear stability analysis is performed. The nonlinear instability is characterized based upon the numerical simulation of the equation of evolution. The inclusion of the ubiquitous van der Waals force in our formalism of thin film is expected to delineate a more realistic picture of nonlinear instabilities in nonisothermal falling films.

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