The effect of channel width and Kapitsa number on the primary instability and the wave characteristics of inclined film flow

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It is well-known that film flows at all inclinations, θ, beyond a few tenths of a degree are first destabilized by an interfacial mode, whose streamwise scale is significantly larger than the mean film thickness. A long-wave expansion leads to the classical result $Re_c=5/6\cot\theta$. However, it was recently observed[1] that the finite width of experimental channels may have a significant stabilizing effect. This is counter-intuitive, given that the observation refers to widths several orders of magnitude larger than the liquid film thickness.

It is presently shown that the intensity of the above stabilizing effect depends on Kapitsa number, $Ka=\sigma/(\varrho g^{1/3}\nu^{4/3})$, which represents the ratio of capillary to viscous stresses (Fig.1). More specifically, measurements tend to the theoretical prediction for small Ka (Ka<100), but deviate progressively as Ka increases and eventually reach a plateau 100% higher than the theoretical prediction in the limit of high Ka (Ka>2000). The above behavior is linked to the observation that the crestlines of traveling waves always develop a transverse curvature (Fig.2), which introduces an additional capillary stabilizing force.

Motivated by the aforementioned results, we document the characteristics of high Ka traveling waves emanating from the primary instability. Stationary, solitary waves exhibit a parabolic crestline, with apex curvature varying inversely with Re and channel width. Their height diminishes towards the side walls and their phase velocity decreases in narrow channels. Thus, a unified treatment of experimental 2-D and 3-D (or lamda[2]) solitary waves appears possible, with main differentiating parameter their transverse scale.

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[1] Vlachogiannis et al., *Phys. Fluids* **22**, 012106 (2010).
[2] Demekhin et al., *Phys. Fluids* **19**, 114103 (2007).