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Thin liquid film stability in the presence of bottom topography and surfactant

We consider the stability of gravity-driven fluid flow down a wavy inclined surface in the presence of surfactant. The periodicity of the bottom topography allows us to leverage Floquet theory to determine the correct form for the solution to the linearized governing partial differential equations. The result is that perturbations from steady state are wavelike, and a dispersion relation is identified which relates the wavenumber of an initial perturbation, κ, to its complex frequency, ω. The real part of ω ultimately determines the stability of the flow. We observe that the addition of surfactant generally has a stabilizing effect on the flow, but has a destabilizing effect for small wavenumbers. These results are compared and validated against nonlinear results, which are obtained by numerically solving the governing equations directly. The linear and nonlinear analyses show good agreement, except at small wavenumbers, where the linear results could not be replicated.