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Instability of Gravity-Driven Flow Over Uneven Surfaces

Discussed in this talk is the gravity-driven two-dimensional laminar flow of a thin layer of fluid down an uneven incline. In particular, the effect of bottom topography and surface tension on the stability of the flow was investigated. The equations of motion are non-hydrostatic approximations to the Navier–Stokes equations which exploit the assumed relative shallowness of the fluid layer. The explicit dependence on the cross-stream coordinate is eliminated from the equations of motion by means of a weighted residual approach. The resulting mathematical formulation constitutes an extension of the modified integral-boundary-layer equations first proposed by Ruyer–Quil and Manneville (see Eur. Phys. J. B **15**(2000), pp. 357–369) for flows over even surfaces to flows over variable topography. A linear stability analysis of the steady flow is carried out using Floquet–Bloch theory. Results from the linear analysis are used to initiate a weakly nonlinear analysis based on asymptotic theory. A numerical solution procedure is also used to solve the nonlinear governing equations and to calculate the evolution of the perturbed equilibrium flow. The numerical simulations serve to confirm the analytical predictions and to investigate the interfacial wave structure. The bottom topography considered in this study corresponds to a sinusoidal profile characterized by a wavelength and amplitude. Conclusions are drawn on the combined effect of bottom topography and surface tension.