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Long-wave analysis and control of the viscous Rayleigh-Taylor instability with electric fields RADU CIMPEANU, Imperial College London, THOMAS ANDERSON, California Institute of Technology, PETER PETROPOULOS, New Jersey Institute of Technology, DEMETRIOS PAPAGEORGIOU, Imperial College London — We investigate the electrostatic stabilization of a viscous thin film wetting the underside of a solid surface in the presence of a horizontally acting electric field. The competition between gravity, surface tension and the nonlocal effect of the applied electric field is captured analytically in the form of a nonlinear evolution equation. A semi-spectral solution strategy is employed to resolve the dynamics of the resulting partial differential equation. Furthermore, we conduct direct numerical simulations (DNS) of the Navier-Stokes equations and assess the accuracy of the obtained solutions when varying the electric field strength from zero up to the point when complete stabilization at the target finite wavelengths occurs. We employ DNS to examine the limitations of the asymptotically derived behavior in the context of increasing liquid film heights, with agreement found to be excellent even beyond the target lengthscales. Regimes in which the thin film assumption is no longer valid and droplet pinch-off occurs are then analyzed. Finally, the asymptotic and computational approaches are used in conjunction to identify efficient active control mechanisms allowing the manipulation of the fluid interface in light of engineering applications at small scales, such as mixing.

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