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Temporal interfacial instability in vertical gas-liquid flows

PATRICK SCHMIDT, The University of Edinburgh, LENNON Ó NÁRAIGH, University College Dublin, MATHIEU LUCQUIAUD, PRASHANT VALLURI, The University of Edinburgh — We consider onset and dynamics of interfacial instability in gas-liquid flows, using two-dimensional channel flow of a thin falling film sheared by counter-current gas as a model. Our methodology consists of linear stability theory together with DNS of the two-phase flow in the case of nonlinear disturbances. We study the influence of three main flow parameters (density contrast between liquid and gas, film thickness, pressure drop applied to drive the gas stream) on the interfacial dynamics. Energy budget analyses based on Orr-Sommerfeld theory reveal coexisting unstable modes (interfacial, shear, internal) in the case of high density contrast, resulting in mode coalescence and mode competition, but only one dynamically relevant unstable interfacial mode for low density contrast. DNS of this scenario shows that linear theory holds up remarkably well upon the onset of large-amplitude waves as well as the existence of weakly nonlinear waves. In comparison, although linear stability theory successfully determines the most-dominant features in the interfacial wave dynamics at early-to-intermediate times in a high-density-contrast case, short waves selected by linear theory undergo secondary instability and the wave train is no longer regular but rather exhibits chaotic.

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