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Linear stability analysis of thin films in wall bounded shear flow

AHMED KAFFEL, AMIR RIAZ, University of Maryland — In this study we examine the stability of core annular flow of two fluids with large density and viscosity ratios to investigate the physical mechanisms associated to thin liquid films flow in microgap channels. Emphasis will be placed on predicting and controlling the growth of interfacial instabilities which can lead to the rupture of the thin liquid films encountered in annular flows. A multi-domain Chebyshev collocation spectral method along with QZ eigenvalue solver are used to solve the Orr-Sommerfeld stability equations in both layers. The algorithm is computationally efficient and accurate in reproducing the whole spectrum of the eigenvalues and associated eigenfunctions. The derivation of the asymptotics of these modes shows that the numerical eigenvalues are in agreement with the analytic formula obtained previously by Yih (1967), Orszag (1971), Higgins et al (1988), Dongarra (1996) and Sahu et al (2007). The numerical simulations and experiments are carried out to quantify unstable wave patterns with respect to the underlying fluid dynamic mechanism for various flows rates. We consider the case of isothermal, non-adiabatic, parallel flow of liquid and vapor phases. A parametric study is analyzed and the numerical stability results are presented and will be used later as a tool to validate the direct numerical solver and to identify the physical mechanisms in two-phase liquid vapor flows.

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