Abstract Submitted
for the DFD09 Meeting of
The American Physical Society

Interfacial instability of turbulent two-phase stratified flow with non-Newtonian rheology LENNON O'NARAIGH, PETER SPELT, Imperial College London — We study the stability of a stratified flow configuration where the bottom layer exhibits non-Newtonian rheology, and where the top layer is Newtonian, fully developed, and turbulent. We first derive a base-state model to describe the equilibrium flow in the flat-interface state, which takes into account the yield stress and power-law nature of the bottom fluid, while a closure model is used to constitute the Reynolds stresses in the upper fluid. Next, we develop a linear-stability analysis to predict when the base state is unstable, and pay particular attention to characterizing the influence of the non-Newtonian rheology on the instability. Increasing the yield stress (up to the point where unyielded regions form in the bottom layer) is destabilizing; increasing the flow index, while bringing a broader spectrum of modes into play, is stabilizing. In addition, a second mode of instability is found, which depends on conditions in the bottom layer. For shear-thinning fluids, this second mode becomes more unstable, and yet more bottom-layer modes can become unstable for a suitable reduction in the flow index. One further difference between the Newtonian and non-Newtonian cases is the development of unyielded regions in the bottom layer, as the linear wave on the interface grows in time. These unyielded regions form in the trough of the wave, and can be observed in the linear analysis for a suitable parameter choice.

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Date submitted: 06 Aug 2009 Electronic form version 1.4