Nonlinear instabilities in viscous multilayer flows

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"Immiscible viscous liquids, flowing under the action of gravity on inclined plates (open flows), or due to pressure gradients in channels (closed flows), can exhibit interfacial instabilities even at small Reynolds numbers. This talk will be mostly concerned with closed flows. If there are more than two layers present, e.g. three layers with the fluids separated by two interfaces, then instabilities can arise even at zero Reynolds numbers. This is due to a resonance between the interfaces and one part of this talk will describe the mathematics behind such instabilities by deriving coupled systems of PDEs governing the dynamics. A particularly interesting aspect of these interfacial phenomena, is that the flows can become unstable nonlinearly even in the absence of linearly unstable modes. This is due to transitions from hyperbolic to elliptic behaviour in the underlying structure of the mathematical models. Such inertialess transitional instabilities will be studied in detail computationally and analytically (where possible), and transition criteria will be described for second order dissipation (due to stable density stratification) as well as fourth order dissipation (due to surface tension)."