Inertial instability of viscosity-stratified flows in microchannels

XIAOYI HU, THOMAS CUBAUD, Stony Brook University — The hydrodynamic stability of stratifications made between miscible fluids having large differences in viscosity is experimentally investigated in square microchannels. Parallel fluid layers with a fast central stream and a slow sheath flow are produced by focusing a low-viscosity fluid into a high-viscosity fluid in a straight microchannel. Although such fluid arrangements are typically governed with the flow rate ratio and the viscosity contrast at low Reynolds numbers \( \text{Re} \), the formation of periodic wave trains at each fluid interface is observed for moderate \( \text{Re} \). Several functional relationships are developed for the propagating velocity, size, and frequency of the generated waves over a range of viscosities and flow rates. In particular, we demonstrate the wave phase locking for small central streams and show the production of high-viscosity fluid ligaments at the wave crests. In this regime, minute amount of high-viscosity fluid is entrained and blended into the low-viscosity fluid recirculating plumes formed by the traveling interfacial waves.

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