Energy transport induced by Rayleigh-Taylor mixing

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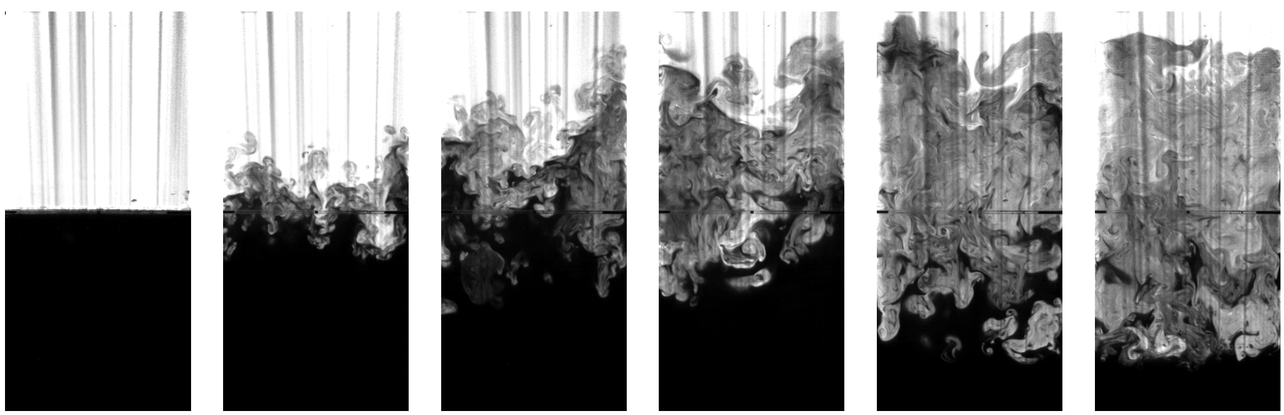
We seek to understand the net energy conversion (mixing efficiency) between quiescent initial and final states in a miscible Rayleigh-Taylor driven system. The configuration we examine is a Rayleigh-Taylor unstable interface sitting between linearly stably stratifed layers above and below. Our experiments in brine solution measure vertical profiles of density before and after the unstable interface is allowed to relax to a stable state. Our analysis suggests that exactly half the initially available energy is irreversibly released as heat due to viscous dissipation, while the other half irreversibly changes the p.d.f of the density field by scalar inter-diffusion and therefore remains as potential energy, but in a less useful form. While we observe this equipartition property in many Rayleigh-Taylor driven mixing flows, our new configuration admits energetically consistent end-state density profiles where less energy could be dissipated as heat and more could be re-absorbed into potential energy, or vice versa. We present experiments which show that the fluid maintains equipartition of energy, despite the flexibility to do otherwise, and compare these to high resolution simulations. We conclude that equipartition represents an upper bound to the fraction of the initially available energy that can lead to mixing, regardless of the configuration of the initial density field.



Experimental image sequence showing the Rayleigh-Taylor instability confined by linear stratification. The Atwood number is $A = 2 \times 10^{-3}$.