Transition from shear-dominated to Rayleigh-Taylor turbulence

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In natural flows, a mean shear often co-exists with an unstable buoyancy gradient. If taken independently, these forcing mechanisms generate shear-dominated and Rayleigh-Taylor (RT) turbulence, respectively. In this contribution, we analyze the turbulent mixing layer arising by the simultaneous effect of a mean shear and an unstable buoyancy gradient. To do so, we develop a phenomenological theory that allows to identify two distinct turbulent regimes: an early regime, dominated by mean shear, and a later regime dominated by RT turbulence[1]. The main theoretical result consists of the identification of a cross-over timescale t_c that distinguishes between the shear- and the buoyancy-dominated turbulence, which depends only on the buoyancy and the velocity difference between the two streams. We validate our theory against direct numerical simulations (DNSs) of a temporal turbulent mixing layer compounded with an unstable stratification (figure 1.a,b). Our empirical data confirm that the cross-over time predicts the transition from shear- to buoyancy-driven turbulence, as evidenced by the evolution of turbulent kinetic energy production, mixing layer thickness (figure 1.c) and entrainment rate.

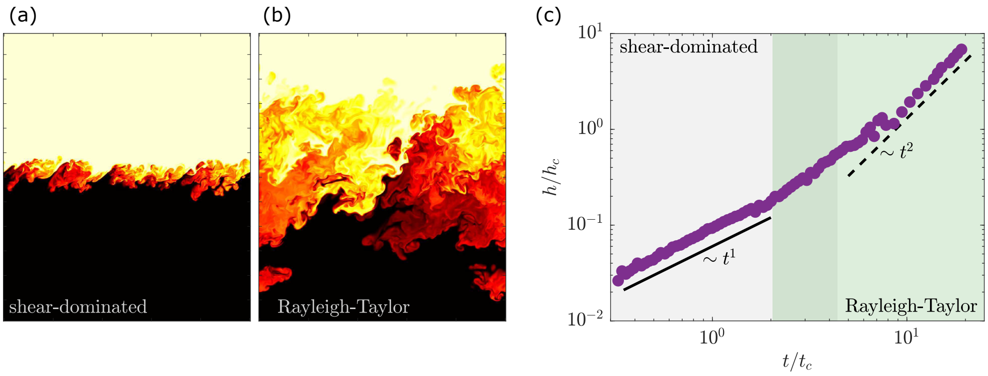

Figure 1: Panel a and b: vertical slice from a snapshot of temperature from a DNS of compound shear and RT turbulence; at early time the shear dominates (a), while at later times RT turbulence prevails (b). Panel c shows the temporal evolution of the mixing thickness h normalized with its value h_c at the crossover time t_c.

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[1] Brizzolara, S., Mollicone, J., Van Reeuwijk, M., Mazzino, A., Holzner, M., *J. Fluid Mech.* (2021)