

On the role of a pre-existing turbulent field in the development of a mixing region in the presence of an acceleration field

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The Rayleigh-Taylor (RT) instability may occur in high-energy-density environments, where interfaces are accelerated by shocks or blast waves. Initial perturbations at a RT unstable interface grow due to the instability, and may evolve to a turbulent mixing region. The mixing region growth is of particular interest in inertial confinement fusion as penetration of the cold outer-layer of the fuel to the hot spot region at the center of the capsule due to hydrodynamic instabilities is one of the main engineering challenges in achieving an efficient fusion. In this work, we are interested in investigating the role of a pre-existing turbulent field in the development of a mixing region between two fluids of different densities, subject to an acceleration field. We consider three different configurations: RT stable, RT unstable configurations and zero acceleration. A high-order accurate minimally dissipative kinetic-energy preserving is used to perform current direct numerical simulations. Our results show that initially the acceleration field has negligible effect on the growth, which is governed by turbulent diffusion. After this initial period, the growth is arrested in the RT stable set-up due to buoyancy. In the absence of an acceleration field, the mixing region becomes self-similar, and the growth rate decreases as turbulence decays. Different arguments are proposed to describe the observed growth. In the RT unstable set-up, baroclinic vorticity is generated, which provides energy for the initially decaying field. The largest growth is achieved for the RT unstable case as expected, but a quadratic growth, expected for the classical RT set-up, is not achieved. In addition to the mixing region growth analysis, we studied flow isotropy at different scales and small-scale intermittency. Our results confirm that an acceleration field leads to anisotropy at the Taylor microscale. In the absence of such an acceleration field, a high density ratio is required to observe anisotropy at the Taylor microscale in the mixing region. It is shown that an acceleration field results in higher small-scale intermittency particularly in the direction of the acceleration. The mass fraction field is found more intermittent than the velocity field.