The turbulent magnetic Rayleigh–Taylor instability

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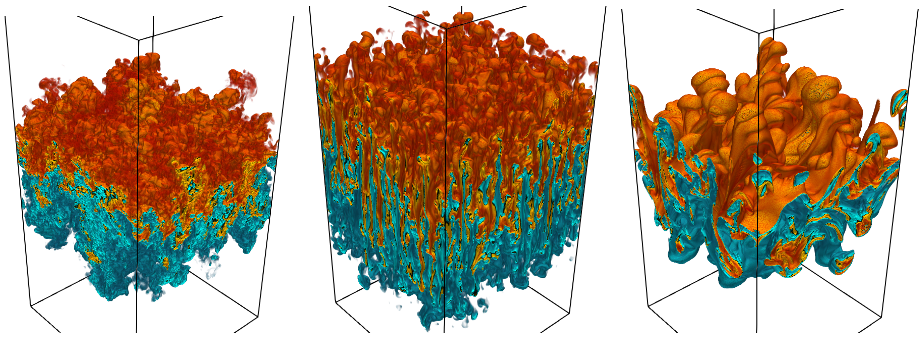
The late time miscible Rayleigh–Taylor instability (RTI) is characterized by a self-similar regime[1] whose growth rate α expresses the expansion of the turbulent mixing layer. It is known that α can be modified by coupling with other mechanisms, such as rotation, compressibility and magnetic fields[2].

This is on the latter that we focus in this work, and we wish to understand how the presence of a mean magnetic field B_0 can enhance or damp the growth of the mixing layer in the RTI. This is relevant for some astrophysical objects, such as solar prominences or expanding young supernova remnants, where elongated structures are attributed to the magnetic RTI[3].

In a recent paper[4], we developed a theory based on simplified equations for the large scales of the flow, successfully assessed by multiple high resolution DNS, that predicts that α is decreased by a mean magnetic field perpendicular to the interface. The story is quite different when B_0 is parallel, and we obtain that α is rather increased with respect to the hydrodynamic case. We present first results in which we compare the perpendicular and parallel mean magnetic field configurations, with energy budgets and considerations about transition to turbulence, small-scale mixing and anisotropy. Fig. 1 illustrates that structures are vertically stretched for B_0 perpendicular, and become very large for B_0 parallel, compared to the hydrodynamic reference case.



(a) (b) (c)

Figure 1: 3D density field (red is heavy, blue is light, pure fluids are transparent) at the same time for (a) $B_0 = 0$: $\alpha = 0.019$. (b) B_0 perpendicular: stretched structures, $\alpha = 0.013$ and (c) B_0 parallel: large-scale structures, $\alpha = 0.037$.

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