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Multifractal structure and intermittent mixing in Rayleigh-Taylor driven fronts

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The advance of a Rayleigh-Taylor mixing front such as that described in Linden & Redondo (1991), may be shown to follow a dependence with time such that the average mixing region is described as $h = 2cgAt^2$ where h is the width of the growing region of instability, g is the gravitational acceleration and A is the Atwood number. The detailled structure of the front will afect the overall mixing as well as the transport properties between the fluids of different densities subject to gravitational acceleration. A Large Eddy Simulation numerical model using FLUENT as well as a dedicated code is used to predict some of the features of the experiments, (Figure 1) different models on the interaction of the bubble generated buoyancy flux and on the boundary conditions are compared with the experiments. The aspect ratios of the bubble induced convective cells are seen to depend on the boundary conditions applied to the enclosure. In the context of determining the influence of structure on mixing ability, multifractal analysis is used to determine the regions of the front which contribute most to molecular mixing and relating intermittency to the structure functions and to the maximum local fractal dimension.

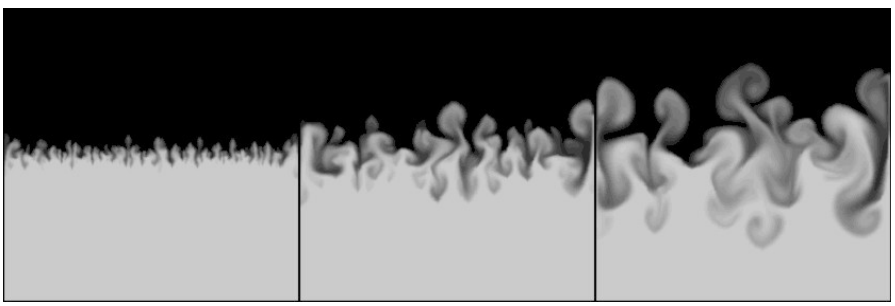

Figure 1. Structure of the RT front at times t/T=1,2 and 3.

Figure 2, shows the evolution of the multifractal dimension (calculated performing the box-counting algorithm) for each level of velocity modulus (a) and volume fraction (b). Much more relevant information can be extracted from these evolutions than from the maximum value presented by Linden et al.(1994), furthermore it is of great interest to study independently the fractal properties of velocity, volume fraction and vorticity fields for the different regions and thus determine the relative local mixing efficiencies during the transient mixing process.

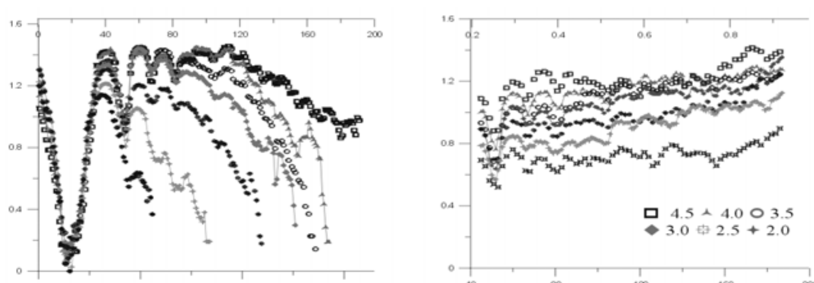

Figure 2. Evolution of the multifractal dimension RT fronts for the velocity and for the volume fraction at non dimensional times t/T=0.5, 1, 1.5, 2, 2.5, 3 and 3.5 for every level of intensity (normalized 0/1)

References

Linden P.F. & Redondo J.M. (1991) "Molecular mixing in Rayleigh-Taylor instability. Part 1. Global mixing". Phys. Fluids. 5 (A), 1267-1274.

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Linden P.F., Redondo J.M. and Youngs D. (1994) "Molecular mixing in Rayleigh-Taylor Instability" Jour. Fluid Mech. 265, 97-124.