Geophysical Research Abstracts
Vol. 13, EGU2011-1535, 2011
EGU General Assembly 2011

Mixing and diffusion in buoyancy driven self-similar flows

Jose M. Redondo (1), Otman Ben Mahjoub (1,2), Roberto Castilla (1), Margarita Diez (1,3), and Emil Sekula (1)
(1) Universitat Politecnica de Catalunya (UPC), Dept. Fisica Aplicada, Barcelona, Spain (redondo@fa.upc.edu, +34-(0)934016090), (2) Universia, I.P.D. Madrid, Spain, (3) Ports de la Generalitat, Vilanova i la Geltru, Spain

A Numerical and Experimental study of the local self-similar mixing structure in the evolution of turbulent fronts driven by both Rayleigh-Taylor and Richtmyer-Meshkov instabilities has shown that active mixing regions that show a local cascade process can be detected using multi-fractal analysis. The geometric and topological features of the interaction between the spectral and multi-fractal structure of the fronts driven by the acceleration induced instabilities RT and RM have been investigated following the Fractal box-counting algorithm for the different sets of marked value ranges, Grau(2005). Further analysis on Mixing RT experiments by Linden and Redondo(1991) and Linden et al.(1994) have been used to relate the multifractal and spectral measurements of the density field, the volume fraction and the mixing products detected with chemical tracers. The methodology that relates intermittency (Mahjoub et al 1998) and anomalous scaling while mixing is taking place can also be used to evaluate scalar and tracer diffusivity and it is applied both in the RT mixing fronts as well as in other complex flows (Fraunie et al (2008) and Diez et al (2008))

The regions of localized mixing, have a higher range of multifractal dimension values, and using box-counting and wavelet analysis, where the turbulent cascade reaches the Batchelor scales indicates the statistical structure of the instability driven mixing process. Digitalizations of the RT and RM experiments analysed with LIF, Shadowgraph, Reactive colour change and with other diagnostic techniques is seen have a very hetereogeneous mixing structure, with most mixing taking place in the sides of the of the blobs and spikes. The use of LES simulations of RT and RM fronts, as reported by Redondo and Garzon (2004), Redondo et al.(2006) agrees with the experiments and gives further insight on the different cascading processes that take place in the flow, mainly the tracer density spectra, the velocity, the vorticity and the helicity spectra.

Mixing efficiency is estimated locally, both in time and space relating the maximum fractal dimension of the velocity and volume fraction sets and comparing the LES and the experiments. Both overall mixing efficiency and the evolution of local mixing efficiency are compared for a set of low Atwood number experiments and LES simulations of the Rayleigh-Taylor instability. The differences between the continous acceleration of the RT fronts and the shock induced RM fronts are also discussed with astrophysical and geophysical applications in mind.

References

Grau J. (2005) PhD Thesis, U.P.C. Barcelona.
Linden P.F., Redondo, J.M. and Youngs D.L. (1994) Molecular Mixing in Rayleigh-Taylor Instability, J. Fluid Mech. 265, 97-124.

Linden P.F. and Redondo, J.M. (1991) Molecular mixing in RT instability, Part I, Global Mixing. Physics of Fluids,A 3, 1269-1277.

Redondo J.M. and Linden P.F.(1990) Mixing produced by Rayleigh-Taylor instabilities, Waves and Turbulence in stably stratified flows, IMA conference. 43 Ed. S.D. Mobbs. Oxford Univ.Press, Leeds

Redondo J.M., Rozanov V., and Garzon G. (2006), Velocity, Vortical and Helical self-similar structures in RT and RM driven turbulent flows, in Lectures in Environment Turbulence. Eds. Babiano A., Fraunie P, Redondo J.M. and Vassilicos.UPC CD, Barcelona.

Redondo J.M. and Garzon G. (2004) Multifractal structure and intermittent mixing in Rayleigh-Taylor driven fronts IWPCTM9.http//www.damtp.cam.ac.uk//proceedings/IWPCTM9/Papers/Redondo_Garzon/Talk.pdf

Mahjoub O., Redondo J.M. and Babiano A. (1998) Structure Functions in Complex Flows, Applied Scientific Research 59, 299-313.

Fraunie P., Berreba S. Chashechkin Y., Velasco D. and Redondo J.M. (2008)LES and laboratory experiments on the decay of grid wakes in strongly stratified flows. Il Nuovo Cimento C 31, 909-930.

Diez M., Bezerra M.O., Mosso C., Castilla R. and Redondo J.M. (2008) Experimental measurements and diffusion in harbor and coastal zones. Il Nuovo Cimento C 31, 843-859.