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Intermittency and Topology of Shock Induced Mixing

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The advance of a Rayleigh-Taylor front is described in Linden & Redondo (1991),[1-3] and may be shown to follow a quadratic law in time where the width of the growing region of instability depends on the local mixing efficiency of the different density fluids that accelerate against each other g is the acceleration and A is the Atwood number defined as the diference of densities divided by their sum.

This results show the independence of the large amplitude structures on the initial conditions the width of the mixing region depends also on the intermittency of the turbulence. Then dimensional analysis may also depend on the relevant reduced acceleration driven time and the molecular reactive time akin to Damkholer number and the fractal structure of the contact zone [2,4].

Detailed experiments and simulations on RT and RM shock induced fronts analized with respect to structure functions are able to determine which mechanisms are most effective in local mixing which increase the effective fractal dimension, as well as the effect of higher order geometrical parameters, such as the structure functions, in non-homogeneous fluids (Mahjoub et al 1998)[5].

The structure of a Mixing blob shows a relatively sharp head with most of the mixing taking place at the sides due to what seems to be shear instability very similar to the Kelvin-Helmholtz instabilities, but with sideways accelerations. The formation of the blobs and spikes with their secondary instabilities produces a turbulent cascade, evident just after about 1 non-dimensional time unit, from a virtual time origin that takes into account the linear growth phase, as can be seen by the growth of the fractal dimension for different volume fractions.

Two-dimensional cuts of the 3D flow also show that vortex flows have closed or spiral streamlines around their core. Examples of such flows can be also seen in the laboratory, for example at the interface of atwo-layer stratified fluid in a tank in which case streamlines are more regular. Mixing in turbulent flows remains less well understood, and in spite research some basic problems are still virtually unexplored.
Th
e indications suggest that mixing in non-decaying and accelerating turbulent flows are different from those in vortical and steady flows. Fluid element pairs separate, neither linearly nor exponentially but according to a generalized intermittent Richardson's law. Fractal analysis in the laboratory shows that fluid element pairs travel close to each other for a long time until they separate quite suddenly suggest that straining regions around hyperbolic points play an important role in the violent turbulent stirring and in the mechanisms by which turbulence causes fluid element pairs to move apart [6,7]. So the eddies that are most effective in separating fluid elements are those that have a size comparable to the instantaneous separation between the two fluid elements. This is seen in both RT and RM instabilities.

For a constant acceleration, the RT instability is found to grow self -similarly according to mixing coefficients which when measured over a comprehensive range of density ratio (Atwood nubers)show that the results are found applicable to supernova exlposions.For an impulsive acceleration (RM), there are two components. The RM impulse from a shock is greatly reduced at high Mach number due to compressive effects in reasonable agreement with linear theory. The ensuing motion is essentially incompressible and described by a power law However, the exponents obtained from the compressible RM experiments are larger than those obtained from incompressible RT experiments. The discrepancy is not well understood but intermittency differences could explain the role of compressibility in fractal media.

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