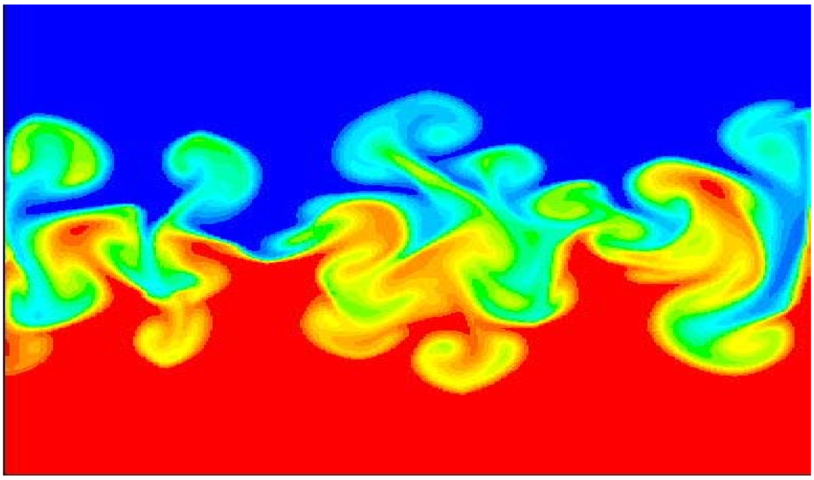
INTERNATIONAL SUMMERSCHOOL ON VARIABLE DENSITY TURBULENT FLOWS

UPC, Vilanova i la Geltrú
Barcelona, Spain
September 1-5, 2003



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Universitat Politécnica de Catalunya (UPC)

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PROGRAM

Valid for days 1, 2, 3 and 4	Monday 1 Sept.	Tuesday 2 Sept.	Wednesday 3 Sept.	Thursday 4 Sept.	Friday 5 Sept.	**Valid for day 5 only**
10 h 00 – 11 h 30	**P. Chassaing** 3D Turbulence (with / without density variation)	**F. Godeferd** 2D Turbulence (stratified flows with / without rotation)	**L. Joly** Baroclinic instability	**J.M. Redondo** Rayleigh – Taylor instabilities	**J. Borée** Experimental methods	10 h 00 – 12 h 00
11 h 30 – 12 h 00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break	12 h 00 – 12 h 15
12 h 00 – 13 h 30	**P. Chassaing** (cont'd)	**F. Godeferd** (end)	**L. Joly** (end)	**J.M. Redondo** (end)	Seminars (students) Final discussion / synthesis animated by all the lecturers	12 h 15 – 13 h 15 13 h 15 – 14 h 15
13 h 45	Lunch	Lunch	Lunch	Lunch	Lunch	14 h 30
17 h 00 – 19 h 00	**P. Fraunié** Applications in oceanography or for the upper atmosphere	**P. Chassaing** 3D Turbulence (end)	**R.A. Antonia** Similarity of decaying isotropic turbulence with and without a passive scalar	**D. Souffland** Hydrodynamic instabilities and inertial confinement fusion targets	Visit of the Dept. of Applied Physics at UPC / Barcelona (http://dfa.upc.es)	Afternoon

Turbulence in flows without and with density variations : basic concepts and modelling issues

Patrick CHASSAING

ENSICA – INP, Toulouse, France

- First glance at turbulence
- Dynamics of isovolume fluid motions
- Instability and transition
- Isovolume turbulence : statistical concepts and second-order analysis
- Physical insight of variable density fluid motions
- One-point statistical analysis of variable density fluid turbulence
- Turbulence modelling : (i) incompressible flows
- Turbulence modelling : (ii) variable density flows

Stratified turbulent flows in Ocean and Atmosphere : Processes, observations and CFD

Philippe FRAUNIE

LSEET, Université de Toulon et du Var, France

In environmental fluid mechanics, variable density effects are due to lead to either vertical convection or horizontal stable stratification. First basic mechanism occuring at any scale is concerned with vorticity in the vertical plane (e.g. sea breeze) and the so called baroclinic instability. The density gradients are due to either temperature or concentration variations (humidity in atmosphere, salinity in the ocean) and sometimes both (e.g. double diffusion mechanism in the ocean). Most of the processes can be accurately described using the Boussinesq approximation, without involving equation for energy because of slow thermodynamic exchanges compared to convection characteristic time. Apart from strong convection or stratification effects, frontogenesis is an important field of interest and it is noticeable that, in environmental modelling (CFD), TVD (Total Variation Diminishing) numerical schemes previously developed for shock waves capturing for transonic and supersonic flows are commonly used for capturing the fronts in ocean and atmosphere.

Very specific events occur in stable stratified flows due to buoyancy effect (thanks to Archimedes) characterised by the Brünt Vaïsälä frequency N_{BV}. Indeed, the stratified medium is possibly ready to oscillate in the vertical at any occasion, involving wavy motions in inviscid flow. In an initially sheared flow $U_0(z)$, the vertical motion of a particle away from its equilibrium location follows :

$$\frac{\partial^2 w(z)}{\partial z^2} + \left\{ \frac{\frac{\partial^2 U_0}{\partial z^2} k}{(C - U_0(z))} + \frac{\left(N_{BV} \frac{m}{k}\right)^2}{(C - U_0(z))^2} - m^2 \right\} w(z) = 0$$

Dealing with environmental shear flows and description of 3D turbulence, two basic mechanisms competitate : the Kelvin Helmholtz instability leading to vortices and internal waves. The main parameter to consider is the Richardson number (also related to the Froude number more commonly used in convection). The value $R_i = 1/4$ is considered as critical from this point of view :

$$Ri = \frac{N_{BV}^2}{s^2} = \frac{N_{BV}^2}{\left(\frac{\partial u_h}{\partial z}\right)^2} = \frac{\frac{g}{\rho_0}\frac{\partial \rho}{\partial z}}{\left(\frac{\partial u_h}{\partial z}\right)^2}$$

It is important to notice these two basic processes are very different as vortex generation at any scale locally generates cascading turbulence with strong energy transfer when internal waves occuring for given time and space scales involve conservative motions advecting energy far away up to breaking into turbulence. One of the most amazing process is the so called "fossil turbulence" introduced by Gibson. Some more complex mechanisms can occur in some specific situations as the transient Holmboe instability.

From practical situations as accountered both in atmosphere and ocean, this lecture mainly deals with the layering effect in stable environmental fluid at small scale.

Anisotropic homogeneous turbulence - stably stratified flows with or without rotation

Fabien GODEFERD

L.M.F.A., Ecole Centrale de Lyon, Ecully, France

Baroclinic Instability

Laurent JOLY

ENSICA, Toulouse, France

- Introduction - Illustrative examples from experiments and simulations
- The baroclinic torque in high Froude number flows, its organization, scale and order of magnitude
- Stability of the inhomogeneous mixing-layer
- Transition of the inhomogeneous mixing-layer and the 2D secondary baroclinic instability
- The strain field of 2D light jets
- Transition to three-dimensionality in light jets and the question of side-jets
- Baroclinic instability of heavy vortices and some elements on vortex interaction in inhomogeneous 2D turbulence
- Perspectives

Similarity of decaying isotropic turbulence with and without a passive scalar

Robert A. ANTONIA

Discipline of Mechanical Engineering, University of Newcastle, Australia

Since the seminal paper by Karman & Howarth (1938), significant attention has been given to how homogeneous isotropic turbulence decays from an initially prescribed state. In spite of this, the question is not yet satisfactorily resolved. Although the recent equilibrium similarity proposal of George (1992) (G92) is attractive, it challenges the concept of statistical equilibrium, introduced by Kolmogorov (1941) (K41). This seems to be a good enough reason to revisit this question. The presentation will focus significantly – but not exclusively – on recent DNS data obtained in a periodic box for both the velocity and passive scalar fields. The similarity forms of E(k) and $E_\theta(k)$, the 3D energy and scalar spectra as well as the non-linear transfer functions T(k) and $T_\theta(k)$, which appear in the well known equation

$$\frac{\partial E(k,t)}{\partial t} = T(k,t) - 2\nu\ k^2 E(k,t)$$

$$\frac{\partial E_\theta(k,t)}{\partial t} = T_\theta(k,t) - 2\nu_\theta\ k^2 T_\theta(k,t)$$

are tested against the predictions of George but are also examined in the context of K41 and scaling based on Batchelor variables. The Schmidt number Sc ($\equiv \nu/\nu_\theta$) ranges from about 0.7 to 7.

The talk will be structured roughly as follows :

- Background information
- Classical approach vs G92
- Consistency of G92 with K41?
- DNS Results for E(k) and T(k)
- Experimental data in grid turbulence
- Extrapolation to high Reynolds numbers
- Decay characteristics of a passive scalar
- DNS results for different values of Sc
- Implications for turbulence modelling
- Conclusions & suggestions for future work

Rayleigh-Taylor instability, mixing, dispersion and other environmental topics

José M. REDONDO

Dept. of Applied Physics, Polytechnic University of Catalunya, Barcelona, Spain

1. Introduction
2. Review of basic instabilities and dimensional numbers
3. Sructure of Rayleigh-Taylor instability (expts and LES simulations)
4. Fractal analysis
5. Structure functions and ESS
6. Dispersion and mixing
7. KS-DNS Generalized Richardson's law
8. 2D-3D Turbulence
9. Stratified flows (expts), mixing efficiency
10. Rotating flows
11. Field/environmental applications

Hydrodynamic instabilities
and inertial confinement fusion targets

Denis SOUFFLAND

CEA/DAM/DIF/DCSA, Paris, France

The goal of inertial confinement fusion (ICF) is to obtain D+T reactions in small spherical targets imploded by laser beams. After a quick presentation of the LMJ (Laser Mega Joule) facility that will be build during the forthcoming years at the CEA-Cesta near Bordeaux, we introduce the different types of hydrodynamic instabilities that develop at the interfaces between fluids during the target implosion. They are the subject of numerous studies since the subsequent mixing can inhibit the ignition process.

Then, in the main part of this talk, we focus on the turbulent mixing induced by shock waves, as a result of Richtmyer-Meshkov instability (RMI), and on the turbulence production due to shock wave passage on a pre-existing turbulent mixing zone. We present, in particular, the features of a second order turbulence model devoted to these applications and the main results obtained with comparisons to experiments in shock tubes or wind tunnels.

Main topics:

1 – The LMJ facility. Target design for ignition achievement. Implosion and combustion. Hydrodynamic instabilities in ICF targets (ablation front instability, Richtmyer-Meshkov instability, …) Instabilities dedicated experiments around laser facilities.

2 – Available experiments: the Jacobs' experiment for incompressible RMI, the Linear Electric Motor, shock tubes, wind tunnels,…Linear and non-linear phases of the RMI. A model for the transition time. The limitation of two equation turbulence models. The two-time scale approach. Melt-2o: a second-order turbulence model: features and results. Further developments to improve mixing description.

Review of optical methods for the measurement of constant and variable density flows

Jacques BOREE*, Livier BEN+, Rudy BAZILE+

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