RESEARCH MASTER INTERNSHIP

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INTERNSHIP DESCRIPTION

Domain : Computational Fluid Dynamics (CFD), Instabilities and Turbulence

Title : **TWO-DIMENSIONAL NUMERICAL SIMULATION OF RICHTMYER-MESHKOV INSTABILITY**

Hydrodynamic phenomena such as Rayleigh-Taylor or Richtmyer-Meshkov instabilities are of primary importance when studying inertial confinement fusion (cf. Mégajoule Project of the french Atomic Energy Commission : CEA) since they may reduce the efficiency of the reaction. A fundamental knowledge of these instabilities is thus necessary to improve the design of such prospective experiences. The Richtmyer-Meshkov instability is a fundamental fluid instability that develops when perturbations on an interface separating gases with different densities grow following the passage of a shock wave. It is a baroclinic instability since the vorticity production observed after the passage of the shock is due to the misalignment of $\nabla\rho$ and ∇p which produces a non-negligible baroclinic term $[(\nabla\rho\times\nabla p)/\rho^2]$. This instability is typically studied in shock tube experiments (cf. Haas [3], Collins and Jacobs [1]). A collaboration is currently arising between CEA and ISAE on this subject. The shock tube activity of CEA will indeed be transfered to ISAE before the end of 2008 and will be operated by ISAE from now on. In this context, we would like to develop a numerical activity on this issue that would be completing the experimental aspect of the thematic.
A new numerical tool allowing direct simulations of turbulent flows has been developed in the frame of a PhD thesis. This code is based on up-to-date numerical schemes well suited for investigating several configurations such as shock/turbulence interaction (WENO [*Weighted Essentially Non Oscillatory*] schemes: cf. Pirozzoli [6], Ponziani *et al.* [7]), but it does not allow to cope with mixtures of gases. The present work aims at introducing the relevant modifications into the code in order to conduct 2D simulations of Richtmyer-Meshkov instability (3D cases would be beyond the possibilities of the computational facilities of the laboratory). This will mainly consist in adding a concentration equation in the resolution procedure. Validation of the introduced modifications will be completed through comparisons between Linear Interaction Analysis (LIA) results (cf. Griffond [2]) and recent bidimensional numerical studies in the litterature (cf. Latini *et al.* [5]).
Another aspect of the work will be to study the reshock phenomenon that occurs in shock tubes. When the incident shock wave has crossed the interface (and hence generated the instability), the transmitted shock reflects from the shock tube end wall and travels back to interact once again with the evolving interface during what is called the ``reshock" phenomenon. This results in the appearance of complex shock-turbulence interaction. This part of the work will be analysed with regard to the previous studies conducted at the laboratory on this topic (cf. Jamme *et al.* [4]).
All results will be compared to what is known from experiments.
A Ph.D work on this topic funded by CEA will begin in October 2009. The Ph.D student will participate in the operation of the shock tube and to the development of PIV (Particle Image Velocimetry) on this apparatus. This work will also comprise a numerical part close to what will be done in the present research master. The applicant selected for this research master will have priority for the Ph.D work.

Methods: CFD : numerical code in C++, Matlab post-processing.

References:

[1] B.D. Collins and J.W. Jacobs. PLIF flow visualization and measurements of the Richtmyer-Meshkov instability of an air/SF6 interface. J. Fluid Mech., 464: 113-136, 2002.
[2] J. Griffond. Linear interaction analysis applied to a mixture of two perfect gases. Phys. Fluids, vol. 17(8), 2005.
[3] J.-F. Haas. Measurements of turbulent mixing within an air/SF6 shocked and reshocked interface. 10th

International Workshop on the Physics of Compressible Turbulent Mixing, Paris, 2006.
[4] S. Jamme, J.-B. Cazalbou, F. Torrès and P. Chassaing. Direct numerical simulation of the interaction of a shock wave and various types of isotropic turbulence. Flow, Turbulence and Combustion, 68:227-268, 2002.
[5] M. Latini, O. Schilling and W.S. Don. Effects of WENO flux reconstruction order and spatial resolution on reshocked two-dimensional Richtmyer-Meshkov instability. J. Comp. Phys., 221: 805-836, 2007.
[6] S. Pirozzoli. Conservative hybrid compact-WENO schemes for shock-turbulence interaction. J. Comp. Phys., 178: 81-117, 2002.
[7] D. Ponziani, S. Pirozzoli and F. Grasso. Development of Optimized Weighted-ENO schemes for multiscale compressible flows. Int. J. Numer. Meth. in Fluids, 42: 953-977, 2003.

80 % Theoretical Research	20 % Applied Research	0 % Experimental Research

Possibility to go on a Ph.D.: ☒ Yes o No

APPLICANT PROFILE

Knowledge and required level:

Fluid Mechanics, CFD, turbulence

Langages/Systèmes : Linux, Object-Oriented Programming, C++, Matlab

Applications should be sent by e-mail to the supervisor.