Pseudo-spectral Navier-Stokes simulations of compressible Rayleigh-Taylor instability

Benjamin Le Creurer & Serge Gauthier

CEA, Bruyères-le-Châtel, F
benjamin.le-creurer@cea.fr, serge.gauthier@cea.fr

Numerical simulation of transitional and turbulent flows requires highly accurate schemes. Such simulations are usually carried out with spectral methods. However flows with stiff and unsteady gradients - such as those occurring in Rayleigh-Taylor (RT) instability - require specific techniques: in these cases, one has to resort to transformation of coordinates. Guillard, Malé and Peyret (1992) introduced an adaptive procedure in which a coordinate transform was chosen to minimize the weighted second Sobolev norm of the solution. These results were generalized to the multidomain approach and we have shown that the criterion based on the minimum of the norm may also be used to determine the best location of the subdomain interfaces (Renaud & Gauthier, 1997). This adaption may be carried out dynamically to follow strong gradients.

A two (Fournier *et al.*, 2001) and then a three-dimensional pseudo-spectral numerical code has been developed along these guide-lines. It solves the full Navier-Stokes for a binary mixture with constant transport coefficients (viscosity, thermal conductivity and diffusion of species) by using a Fourier-Fourier-Chebyshev decomposition. This code has been parallelized with MPI with a two-level distribution of processors.

On the other hand, the linear stability analysis of the RT flow is performed within the normal mode framework in which the initial value problem is reduced to a boundary value problem. It is solved by diagonalizing the finite dimensional matrix corresponding to the linear Navier-Stokes operator. The numerical method also uses the multidomain decomposition. We obtain dispersion curves and eigenfunctions for various values of the dimensionless parameters of the model (Reynolds, Schmidt and Prandtl numbers) (Serre & Gauthier, 2002). It has been shown that the physical model described above exhibits a cut-off wavenumber beyond which the RT flow is stable.

Finally data analysis software has been developed which handles the results of the simulations. In particular, it provides 1D mean profiles versus time, spectra of any physical variables and Fourier decomposition of the quasi-interface.

Results and analyses of 3D numerical simulations will be detailed at the conference.

References

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