A brief Description of SUNFLUIDH

SUNFLUIDH is a computational software developped by Yann Fraigneau at LIMSI in order to maintain the know-how of the lab in terms of numerical methods development and to be able to respond to the needs of the searchers in the domain of computational fluid dynamics. A brief description of the computational software is here presented. More details are provided in the documents that can be downloaded here .

Kind of simulations

SUNFLUIDH is developped for the simulation of 2D and 3D unsteady incompressible flows or flows under Low Mach number hypothesis. The code covers a large range of flows :

- forced, natural or mixed convection flows
- multi-component flows, reactive flows
- turbulent flows (by means of DNS or LES approaches)
- diphasic incompressible flows based on a level set method (in progress)

Geometries

The geometrical configurations mainly rely on a cartesian topology as the mesh is restricted to an orthogonal strutured form. It is however possible to define complex geometries by means of immersed bodies wich modelize solid parts. Cylindrical geometries are also available.

Numerical Methods

The Navier-Stokes equations are solved with a usual projection method. The spatial discretization of the governing equations are carried out on a staggered grid (MAC approach). Differents numerical schemes are available. Their accuracy is generally of 2nd order in time and space (a specific numerical scheme based on fourth order compact discretization is also available). The main numerical schemes are listed here :

- 2nd order centered scheme in space coupled with the following time discretization :
  - 2nd order Backward differentiation formula (semi-implicit scheme)
  - 2nd order Crank-nicolson method (semi-implicit scheme)
  - 2nd order multi-step operator splitting methods (explicit schemes for reactive flows)
- 4th order centered compact scheme in space coupled with the following time discretization :
  - 2nd order Crank-nicolson method (semi-implicit scheme)
  - 3rd order Runge-Kutta scheme (explicit scheme)

The projection method implies a Poisson's equation that can be solved with different methods :

- The partial diagonalisation of the laplacian operator (a direct method suitable for separate problems only)
- The Relaxed Gauss-Seidel method couled with a muti-grid approach in order to accelerate the convergence (an iterative method applicable for any problem)

This last method can be used for different formulations of the Poisson equation :
$\Delta \phi = S$ where S is proportional to the divergence of the momentum.
$\nabla \dot \frac{1}{\rho}\nabla \phi = S$ where S is proportional to the divergence of the velocity.