Front tracking method is a structured and organized particle method. It is intrinsically a Lagrangian method in which a continuous geometrical manifold is represented and approximated by a discrete set of marker points. Interface propagation is performed through solving an ODE along the local characteristics of each marker point. This method solves for the position of the marker particle accurately. It can give resolution at subgrid level and maintain sharp corners with acute angles. It is suitable for simulations of hyperbolic conservation law with discontinuous interior structure and many other scientific problems.

New algorithms have been introduced to make the front tracking method more robust and efficient in topological bifurcation. Among them the most significant one is the locally grid based (LGB) method [1]. This method combines the accuracy of the generic grid free (GF) tracking [2] and the robustness of the grid based (GB) method in resolving the topological bifurcation, especially in three dimensions, see Figure 1.

A set of standardized functions have been constructed to serve as an user interface for application programs. This includes the start-up functions, initialization for front geometry and velocity functions, query functions to access interface entities such as vertices, simplexes and manifolds and functions for topological information. We have also built a set of function for interpolation and interaction between a moving front and the supporting rectangular mesh.

The propagation of front points can be divided into two categories. The first is the propagation independent of interface geometry. The CFL condition controlling the time step is hyperbolic. Figure 2 is an example of such problems. In the second type of propagation, front velocity depends on the geometry of the interface. A typical case is the velocity in normal direction of the interface and as a function of curvature. Since calculation of curvature involves second order of derivatives along the interface, the CFL condition controlling the time step is parabolic.

In this paper, we present several applications of the FronTier package.

**Turbulent Mixing** Turbulent mixing of acceleration driven fluids causes potential degradation of the performance of an ICF capsule. Acceleration by a steady driving force, known as the Rayleigh-Taylor mixing problem, is a specific and prototypical special case. Until recently, most simulation codes disagreed with experimental measurements for even the most basic diagnostic, the overall mixing rate, by a factor of two. Using FronTier code, we cured the excess numerical mass diffusion. We also address the insufficient physics models for physical mass diffusion and/or physical surface tension, see [3]. The result is in complete agreement or nearly so in the match of simulation to experiment for Rayleigh-Taylor mixing.

**Diesel Fuel Injection and Jet Atomization** We have studied the cavitation and atomization of high speed liquid jets in combustion applications. In the design of a fuel injector, the characteristics of the spray are crucial
variables to improve the engine performance and reduce the pollution. Direct numerical simulations are critical for improving spray predictions, understanding atomization mechanisms and providing input to spray combustion models for predictive modeling of diesel engine combustion. Front tracking has been used to simulate cavitation, jet breakup, and spray formation.

**Shock-Bubble Interaction** We report another distinguished property in the front tracking simulation of impulsive acceleration driven instability: the enhanced accuracy in the computation of the shock-contact interaction by enhanced vorticity generation. We show this by comparing the two dimensional enstrophy in the numerical solution of shock accelerated inhomogeneous flow in the study of shock-bubble interaction.

**References**

