HPC Software for Multiphase Flows and Applications

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FronTier is a multi-physics software package based on front tracking. The Lagrangian front tracking method is an adaptive computational method employing a lower dimensional grid that follows discontinuous interfaces in multiphase flows and resolves their topological changes. The library is coupled with various PDE solvers, including hyperbolic Euler equations for compressible fluid, Navier-Stokes equations for incompressible fluid, magnetohydrodynamic equations, parabolic diffusion equations, and other mixed PDE systems. An alternative method uses smooth particle hydrodynamics for free surface and multiphase flows. The code has been optimized for large parallel supercomputers and used for scientific, engineering, and industrial applications.

Turbulent Fluid Mixing

We have achieved fundamental advances in simulations by combining front tracking with turbulence subgrid scale models and sharply resolved numerical gradients (capturing methods). Convergence under the mesh refinement (verification) and excellent agreement with experiments has been achieved.

Tokamak (ITER) Fueling by the Pellet Injection

The injection of frozen pellets of deuterium and tritium is considered the major mechanism for fueling of tokamaks. This problem is significantly important for ITER and US fusion facilities. The goal of this study is to develop and validate accurate computational models for the pellet ablation in tokamaks, including ITER.

Hybrid Methods in Nuclear Fusion

In the plasma jet induced magnetoh-inertial fusion concept, a plasma liner, formed by the merger of a large number of radial, highly supersonic plasma jets, implodes on a plasma target and compresses it to conditions for fusion ignition. The goal of this project is to evaluate the feasibility of achieving high fusion energy gains by using refined physics models, high fidelity numerical algorithms, and large scale computing.

Atomization of High Speed Liquid Jets

Simulation of breakup, cavitation, and atomization of fuel jet.

Oblique shock waves induced by jet merger. Isosurfaces (top) and cross section (bottom) of pressure field in the liner.

Liquid Mercury Targets for Future Accelerators

The Muon Accelerator Program (MAP) develops concepts and technologies required for Muon Colliders and Neutrino Factories. These muon based facilities have the potential to discover and explore new exciting fundamental physics.

FronTier simulation of muon collider mercury target evolution after interaction with a 24 GeV, 10 teraproton beam.