Overview of TriForce: Projects, Progress, and Plans


The TriForce Center for Multiphysics Modeling, a collaboration between the Departments of Mechanical Engineering, Physics, Computer Science, and the Laboratory for Laser Energetics at the University of Rochester

- TriForce is a modular C++ framework for parallel GPU-accelerated particle-based hybrid fluid-kinetic 3D simulations.
- The code evolves results from both relativistic magnetohydrodynamic and fully kinetic codes in these asymptotic limits, and will operate in between where both descriptions may co-exist and interact.
- The hybrid method enables capabilities beyond either of the individual modeling methods alone, and is being used to investigate a range of topics such as controlled nuclear fusion, astrophysics, high-energy-density physics, and high-intensity lasers.
- The goal is to provide better predictive capability and access to advanced models for the benefit of the academic community.
- Student involvement: high school, undergraduate, and graduate:
  - High-intensity lasers
  - Field-reversed configuration (FRC)
  - Magnetized laser plasma physics
  - Pulsed power science

Why particles?

- Scientific motivation
  - Direct and indirect inertial confinement fusion (ICF)
  - Magnetic-inertial fusion (MIF)
  - Field-reversed configuration (FRC)
  - Pulsed power science

Material constructive models

- Equation of state
- opacity and +<
- Compressibility (thermodynamics, <+>>>, viscosity, density, sound speed, surface tension, stress-strain and material strength (elastic-plastic, shock-tube/locations)

Other models

- Explicit or implicit PIC particles
- Explicit or implicit EM fields
- Adaptive particles and mesh
- Charged particles (ions, electrons, ions, neutrals)
- Nonlinear thermal conduction
- Nuclear fusion and fission transport
- Neutron transport
- Photon transport
- Circuit model
- Gravity

Other models

- Nonlinear gradients (ionization, recombination, energy transport, ionization)
- Thomson and Compton scattering
- 3D Traps

Field-reversed configuration (FRC) from odd-parity rotating magnetic fields

- Closed field lines form for the plasma
- High magnetic field
- Current sheath in plasma

Magnetized laser plasma physics

- Plasma flow in pulsed power transmission lines
- Magneticized laser inertial fusion (MagIF)
- Magneticized plasma jet and gas puff p-particles

Low-noise “quiet” methods

- Ray-tracing example: Smooth bundles (uses interpolation)
- Options: “quiet direct simulation” (QDS)
  - and lab-scale simulation using GPU methods

Available models:

- Bragg mod.
- Doppler-Beams
- X-Field-Devices
- “QD-Beams” goal
- Compare MHD and ANSIE to implicate EAM/PIC

Acknowledgments

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- OMEGA laser (60 beams)
- 1 MJ in target
- J = 9 MA

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