**Blue Waters Petascale Semester Curriculum v1.0**

**Unit 11: Domain Science: Astrophysical Fluid Dynamics**

**Lesson 4: MPI Simulations and Visualization**

**Instructor Guide**

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## Code and Documentation

The Astrophysical Fluid Dynamics unit utilizes PLUTO version 4.3. PLUTO is a freely-distributed software for the numerical solution of mixed hyperbolic/parabolic systems of partial differential equations (conservation laws) targeting high Mach number flows in astrophysical fluid dynamics. The code is designed with a modular and flexible structure whereby different numerical algorithms can be separately combined to solve systems of conservation laws using the finite volume or finite difference approach based on Godunov-type schemes.

Equations are discretized and solved on a structured mesh that can be either static or adaptive. The AMR interface relies on the Chombo library for parallel calculations over block-structured, adaptively refined grids.

The code is written in the C programming language while the AMR interface also requires C++ and Fortran.

PLUTO is a highly portable software and can run from a single workstation up to several thousands processors using the Message Passing Interface (MPI) to achieve highly scalable parallel performance.

The software is developed at the Dipartimento di Fisica, Torino University in a joint collaboration with INAF, Osservatorio Astronomico di Torino and the SCAI Department of CINECA.

### Documentation links:

* PLUTO 4.3 User’s Guide: <http://plutocode.ph.unito.it/userguide.pdf>
* Method Paper, static grid version: Mignone et al. 2007: <https://arxiv.org/pdf/astro-ph/0701854.pdf>
* Method Paper, adaptive grid version: Mignone et al. 2012: <https://arxiv.org/pdf/1110.0740.pdf>
* VisIt: <https://wci.llnl.gov/simulation/computer-codes/visit/manuals>
* Chombo - Software for Adaptive Solutions of Partial Differential Equations: <https://commons.lbl.gov/display/chombo/Chombo+-+Software+for+Adaptive+Solutions+of+Partial+Differential+Equations>

### Code links:

1. Module 11.1:
   1. PLUTO 4.3: <http://plutocode.ph.unito.it/download.html>
   2. Rayleigh-Taylor Instability test code: <http://plutocode.ph.unito.it/Doxygen/Test_Problems/_m_h_d_2_rayleigh___taylor_2init_8c.html>
2. Module 11.2:
   1. VisIt 3.1: <https://wci.llnl.gov/simulation/computer-codes/visit/executables>
   2. HD Jet test code: <http://plutocode.ph.unito.it/Doxygen/Test_Problems/_h_d_2_jet_2init_8c.html>
3. Module 11.3:
   1. Sedov-Taylor blast wave test code: <http://plutocode.ph.unito.it/Doxygen/Test_Problems/_h_d_2_sedov_2init_8c.html>
4. Module 11.4:
   1. MHD Blast Wave test code: <http://plutocode.ph.unito.it/Doxygen/Test_Problems/_m_h_d_2_blast_2init_8c.html>
5. Module 11.5:
   1. Chombo library: download, install, remake PLUTO: <https://commons.lbl.gov/display/chombo/Chombo+Download+Page>
   2. 3D shock cloud test code: <http://plutocode.ph.unito.it/Doxygen/Test_Problems/_m_h_d_2_shock___cloud_2init_8c.html>