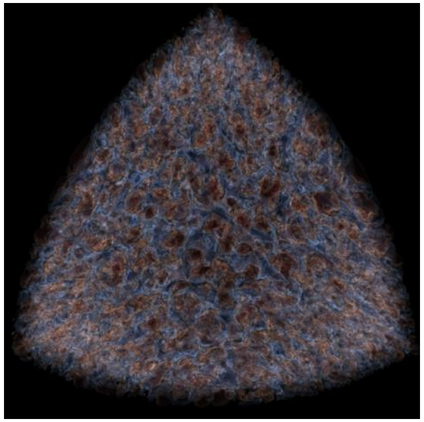
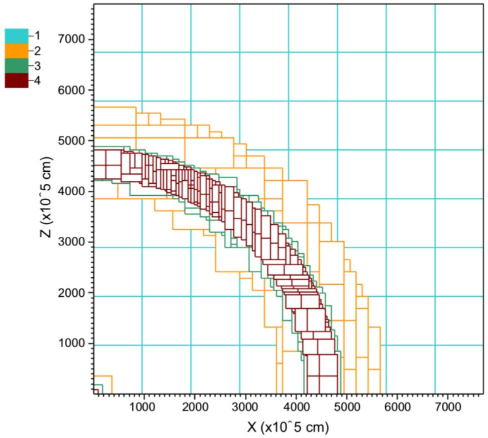
Low Mach Number Simulation of Astrophysical Phenomena

Objectives

Many astrophysical phenomena, such as Type I X-ray bursts on neutron stars and convection in massive stars, are characterized by subsonic flow in a stratified atmosphere. We have migrated the existing MAESTRO code to use the exascale-ready software framework AMReX in order to enable detailed high-resolution simulations on high-performance architectures.





(Left) Convective plumes driven by nuclear burning in a helium layer on the surface of a sub-Chandra white dwarf. (Right) Using AMR we are able to focus computational resources in regions of interest.

Impact

By combining low Mach number modeling techniques with adaptive mesh refinement (AMR), researchers can efficiently integrate long-time dynamics that are too expensive for compressible solvers.

Accomplishments

Using the AMReX software framework, researchers are now able to study low Mach number stratified astrophysical phenomena using state-of-the art linear solvers, grid hierarchy management, load balancing and intra-node optimization. AMReX uses a hybrid approach to parallelism.

Current algorithmic developments including improved hydrostatic mapping, rotating stars, and efficient coupling to a compressible code framework for post-ignition studies.

Citation: Zingale, Almgren, et al., Proceedings of AstroNUM 2017

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