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.

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.

(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.

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

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