MAESTRO, CASTRO, and SEDONA - Petascale Codes for Astrophysical Applications

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Performing high-resolution, high-fidelity, three-dimensional simulations of Type Ia supernovae (SNe Ia), the largest thermonuclear explosions in the universe, requires not only algorithms that accurately represent the correct physics, but also codes that effectively harness the resources of the most powerful supercomputers. We are developing a suite of codes that provide the capability to perform end-to-end simulations of SNe Ia from the early convective phase leading up to ignition, using the low Mach number AMR code MAESTRO, to the explosion phase in which deflagration/detonation waves explode the star, using the compressible AMR code CASTRO, to the computation of the light curves resulting from the explosion, using the Monte Carlo radiative transfer code SEDONA. In this paper we discuss the scaling behavior of these codes with an emphasis on the techniques needed to scale the hydrodynamics codes to petascale architectures, demonstrating that each scales to 100K cores or more. We also discuss the issues regarding transitioning from a low Mach number model into a fully compressible code.