EXPLORING THE NATURE OF EXPLODING MASSIVE STARS WITH HIGH RESOLUTION

Research Challenge
- Pre-collapse progenitors come in a wide variety, driven largely by variations in the initial mass, rotation, and composition
- During the explosion heating comes from neutrinos emitted from the neutron star forming at the center of the collapse, which requires energy resolved neutrino transport
- After the explosion begins the evolution of the nuclear isotopes in the ejecta requires a nuclear reaction network

Methods & Codes
- Chimera code
- Hydrodynamics, gravity, active nuclear reactions (burning)
- Dimensionally split piecewise parabolic finite volume scheme for hydrodynamics
- Global multipole expansion of Poisson equation for gravity
- 14 or 160 species in nuclear reaction network

Why Blue Waters
- Core-collapse supernova simulations are large, lengthy, and expensive, requiring 1000+ coupled nodes. Even a single 3D simulation can overwhelm the available allocations for a single project at other large sites, but with Blue Waters the team can perform about three simulations per year.

Results & Impacts
- Measured the development of the cascade of turbulent energy to small scales
- Results indicate that the 1° models of our full-geometry 3D Blue Waters models should be sufficiently resolved and allay concerns that future gains in available capability must be thrown primarily into achieving better resolution
- Second set of simulations follows the collapse and explosion of a lower-mass star (9.6 solar masses) as a site for production of calcium-48 using an in-situ nuclear reaction network

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Slice in entropy through the 90° wedge models of various angular resolutions (2° to 1/4°) in the pre-supernova convective phase. As resolution increases, the number of fine structures increases, but the character of the models with regions of lower entropy inflow (green) and upwelling heated material (orange) remains.