Freeze-out Yields of Radioactivities in Core-collapse Supernovae

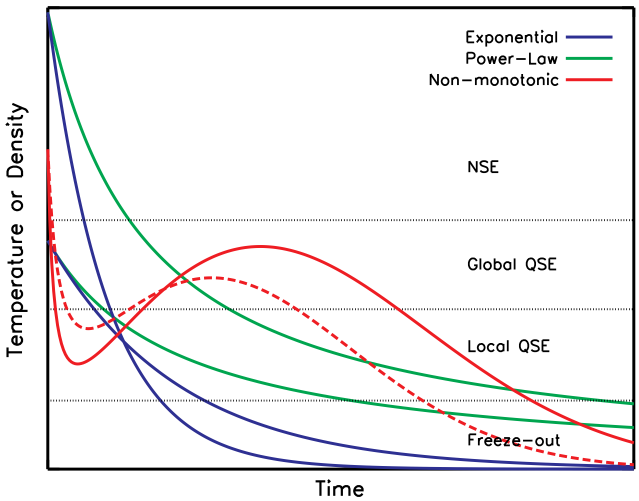

Fig 1 (above)- Schematic temperature or density evolution for the exponential, power-law, and non-monotonic profiles. Passages through different burning regimes for various peak conditions are indicated. The dashed red curve illustrates the impact of variations to the values of the local extremum points for the same peak conditions.

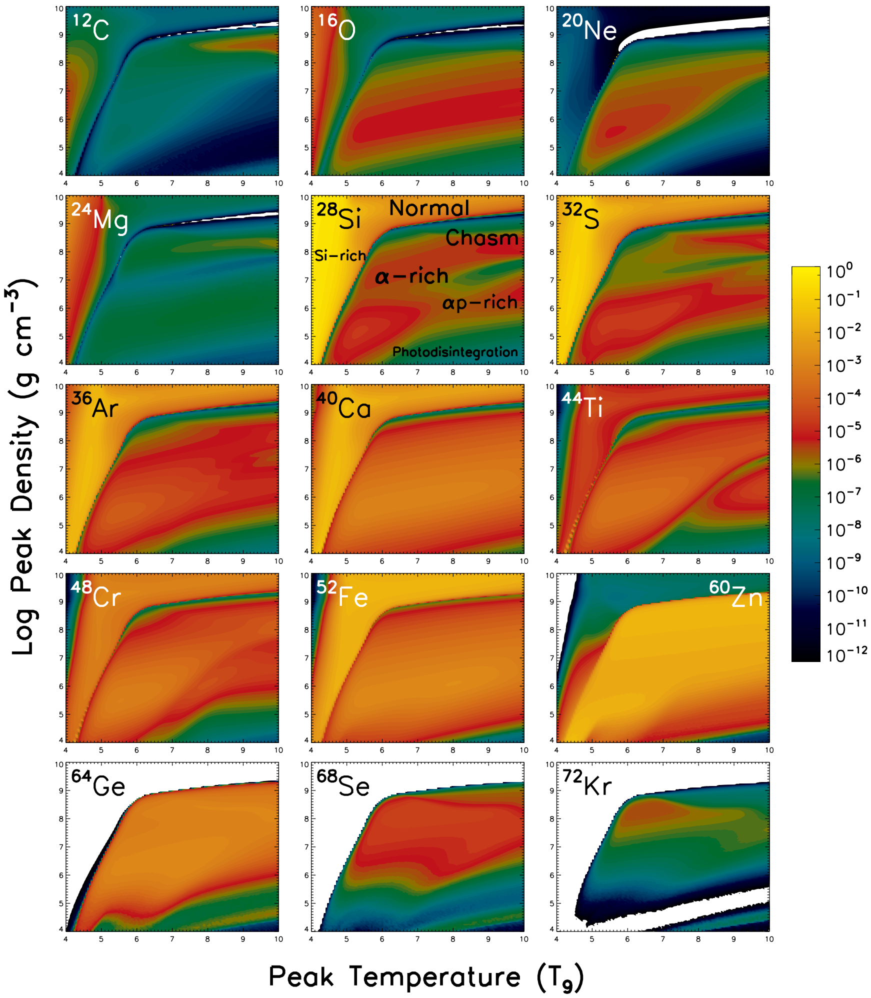

Fig. 2 (right) - Final mass fractions of the α-chain isotopes in the peak temperature–density plane for the exponential profile at Ye = 0.5. White colored space corresponds to values below the color scale shown.

We explore the nucleosynthesis trends from two mechanisms during freeze-out expansions in core-collapse supernovae. The first mechanism is related to the convection and instabilities within homogeneous stellar progenitor matter that is accreted through the supernova shock. The second mechanism is related to the impact of the supersonic wind termination shock (reverse shock) within the tumultuous inner regions of the ejecta above the proto-neutron star. Our results suggest that isotopes in the mass range 12 ≤ A ≤ 122 that are produced during the freeze-out expansions may be classified in two families. The isotopes of the first family manifest a common mass fraction evolutionary profile, whose specific shape per isotope depends on the characteristic transition between two equilibrium states (equilibrium state transition) during each type of freeze-out expansion. The second family is limited to magic nuclei and isotopes in their locality, which do not sustain any transition, become nuclear flow hubs, and dominate the final composition. Non-monotonic freeze-out profiles involve longer non-equilibrium nucleosynthesis intervals compared with the exponential and power-law profiles, resulting in mass fraction trends and yield distributions that may not be achieved by the monotonic freeze-out profiles.

Contact:
Georgios Magkotsios,
Notre Dame,
gmagkots@nd.edu

Researchers:
Georgios Magkotsios (ND)
Frank Timmes (ASU)
Michael Wiescher (ND)

Published: Raskin et al., Astrophysical Journal, 741, 48, 2011