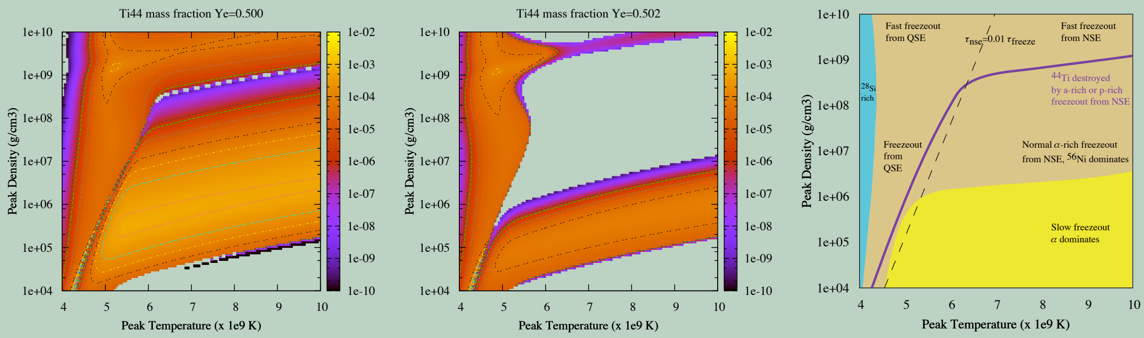
^{44}Ti and 56Ni from Core-Collapse Supernovae



Yields of 44Ti for different peak shock temperature and densities in symmetric matter are shown in the left plot. Note the chasm (in purple) due to material transitioning from fast cooling quasi-equilibrium states to slower cooling freeze-out states. The middle image shows the dramatic effect of the same shocj rtrajectories passining through slightly proton-rich material. The cartoon on the right delineates key regimes in the temperature-density plane, Movies and additional plots may be downloaded by clicking on this link.

Radioactive ^{44}Ti, an observable diagnostic of core-collapse supernovae, is an isotope of key significance. It is observable by gamma ray emission from young supernovae remnants such as Cassiopeia A. The mass of ^{44}Ti ejected by core-collapse supernovae probes the dynamics of material near the location where material is either ejected or becomes part of the proto-neutron star. In addition, the relatively large abundance of ^{44}Ca -- the second most abundant calcium isotope and the 44th most abundant species overall in solar system material -- is commonly believed to be due to its synthesis as ^{44}Ti.

This project is undertaking a comprehensive survey aimed at understanding the yields of 44Ti and 56Ni from material cooling along various thermodynamic trajectories. The figure shows a few examples for cooling along commonly modeled shock adiabatic paths. The neutron/proton ratio has a dramatic effect on the width of the the chasm where ^{44}Ti is severely depleted. The key reactions that control the nuclear flows in and around the chasm are being quantified. In addition, this project is using more realistic trajectories from multi-dimensional supernova models -- they can have much more complex thermodynamic behavior -- and comparing the results to the commonly imposed trajectories. In particular, the presence of explosion asymmetries in supernovae alters both the extent of the hydrodynamically mixed regions, as well as the conditions for burning within the supernova shock. This serves to change both the distribution and abundance of the ^{44}Ti and ^{56}Ni ejected.

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