PRESOLAR SILICON CARBIDE X GRAINS, EXPLOSIVE HYDROGEN BURNING, AND THE EVOLUTION OF MASSIVE STARS.

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Introduction: The nitrogen-15 abundance in presolar silicon carbide (SiC) X grains remains a puzzle. These grains presumably formed in the outflows from exploding massive stars (supernovae). Detailed supernova yields [1] fail to explain the correlation between aluminum and nitrogen isotopic signatures in the presolar SiC X grains [2].

Nitrogen-15 production: To help understand the nitrogen isotopic abundances in presolar SiC X grains, we explore ^{15}N nucleosynthesis in massive stars. Nitrogen-15 is produced as the supernova shock passes through the helium-rich layers [3] and heats them up. Nitrogen-14 captures an alpha particle to make ^{18}F. The ^{18}F can then undergo a (n,α) reaction to produce ^{15}N. It can also be produced by explosive hydrogen burning when the shock first encounters the hydrogen-rich outer layers of the star. In these shock-heated layers, abundant ^{14}N captures a proton to become ^{15}O. After the shocked layers expand and cool, the ^{15}O decays to ^{15}N. The amount of ^{15}N produced depends on the post-shock temperature.

Presupernova stellar evolution: Most supernova models do not show evidence of strong explosive hydrogen burning; however, the 25 solar mass model of [1] does show a strong spike in the ^{15}N abundance due to this burning. The carbon and nitrogen signatures in presolar SiC X grains can be explained if material from the ^{15}N spike is included in mixing models to account for the grains' origins [2]. The 25 solar mass model in [1] shows an ^{15}N spike whereas, for example, the 15 solar mass models does not because the pre-shock temperature at the inner edge of the hydrogen shell in the 25 solar model is roughly 5 x 10^7 K while it is about 2 x 10^7 K for the 15 solar mass model. Since the post shock temperature is a multiple of the pre-shock temperature (about 2 for a Mach 2 shock and 4 for a Mach 3 shock), the 25 solar mass model can achieve a higher post-shock temperature than the 15 solar mass model for the same speed shock.

Our presupernova models of a 25 solar mass star show significant differences in the pre-shock temperature at the inner H-shell depending on the treatment of convection and mass loss [4]. If we include mass loss and use the Schwarzschild convection criterion, the temperature at the inner edge of the hydrogen shell is 2.5 x 10^7 K. If we include semi-convection using the Ledoux criterion, the inner-H shell temperature is ~3.5 x 10^7 K. If we use the Schwarzschild convection criterion and do not include mass loss, the temperature is ~2 x 10^7 K. These differences mean that, if indeed ^{15}N-spike material is needed to explain the nitrogen composition of SiC X grains, presolar SiC X grains may help constrain mixing and mass loss in presupernova stellar evolution.

References: [1] Rauscher T. et al. 2002. *Astrophys. J.* 576:323-348. [2] Lin Y. et al. 2010. *Astrophys. J* 709:1157-1173. [3] Meyer B. S. and Bojazi M. J. 2011. Abstract #2376. 42nd Lunar & Planetary Science Conference. [4] El Eid M. F. et al. 2009. *Space Sci. Rev.* 147:1-29.