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The Oldest Stars as Tracers of Heavy Element Formation at Early Epochs

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Abstract. Elemental abundance patterns in very metal-poor halo field stars and globular cluster stars play a crucial role both in guiding theoretical models of nucleosynthesis and in providing constraints upon the early star formation and concomitant nucleosynthesis history of our Galaxy. The abundance patterns characterizing the oldest and most metal deficient stars ([Fe/H] ≤ -3) are entirely consistent with their being products of metal-poor massive stars of lifetimes $\tau \leq 10^8$ years. This includes both the elevated abundances of the *alpha*-elements (O, Mg, Si, S, Ca, and Ti) relative to iron-peak elements and the dominance of **r**-process elements over s-process elements. The nucleosynthetic contributions of lower mass AGB stars of longer lifetimes ($\tau \approx 10^9$ years) begin to appear at metallicities [Fe/H] ≈ -2.5, while clear evidence for iron-peak nuclei produced in supernovae Ia ($\tau \geq$ 1-2x10^9 years?) does not appear until metallicities approaching [Fe/H] ~ -1. Similar trends are also suggested by abundances determined for gas clouds at high redshifts. We review the manner in which a knowledge of the abundances of the stellar and gas components of early populations, as a function of [Fe/H], time, and/or redshift, can be used to set constraints on their star formation and nucleosynthesis histories.

Discussion

Charley Lineweaver: At the end of your talk you mentioned some interesting behavior of the isotopic ratios at the lowest metallilcities. You suggested that recent models of 50 to 100 $M_\odot$ type II supernovae may be able to explain the elemental ratios. Could you comment on this in more detail?

Jim Truran: I was referring specifically to studies of the evolution of 50–100 $M_\odot$ oxygen (helium) cores to supernovae via the pair instability. These are *not* the standard supernovae of type II. Detailed nucleosynthesis calculations for such massive stars, soon to be published (Heger & Woosley 2000; Waldman, Liune, Glasner, & Barkat 2000), can indicate whether such stars may have contributed to elemental abundances at the lowest metallicities [Fe/H]≤ -3.

Leonid Ozernoy: I am puzzled by the flat shape of your SN Type II occurrence rate as a function of time. Beginning with Fowler, many people have argued that the current rate $\sim 10^{-2}$ SNe/yr combined with the iron yield $0.1 - 0.2\,M_\odot$ per supernova would produce a current iron abundance 10 times lower than the observed one. I understand that simplistic order-of-magnitude estimates could explain the difference, but detailed calculations would be highly desirable to justify your approach.