Evolution and Nucleosynthesis in Massive Pop III Supernovae: Abundances of Very Metal-Poor Halo Stars

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We calculate evolution and nucleosynthesis in massive Pop III stars with $M = 13 \sim 270 M_\odot$, and compare the results with abundances of very metal-poor halo stars to constrain the properties of Pop III supernovae (Umeda & Nomoto 2002 ApJ 565, astro-ph/0103241). Observed abundance of those stars can be explained by the energetic core-collapse supernovae with $M \lesssim 100 M_\odot$ ("hypernovae") but not by pair-instabillity supernovae (PISNe) with $M \sim 150 - 270 M_\odot$. This result constrain the IMF for the Pop III and very metal-poor Pop II stars.

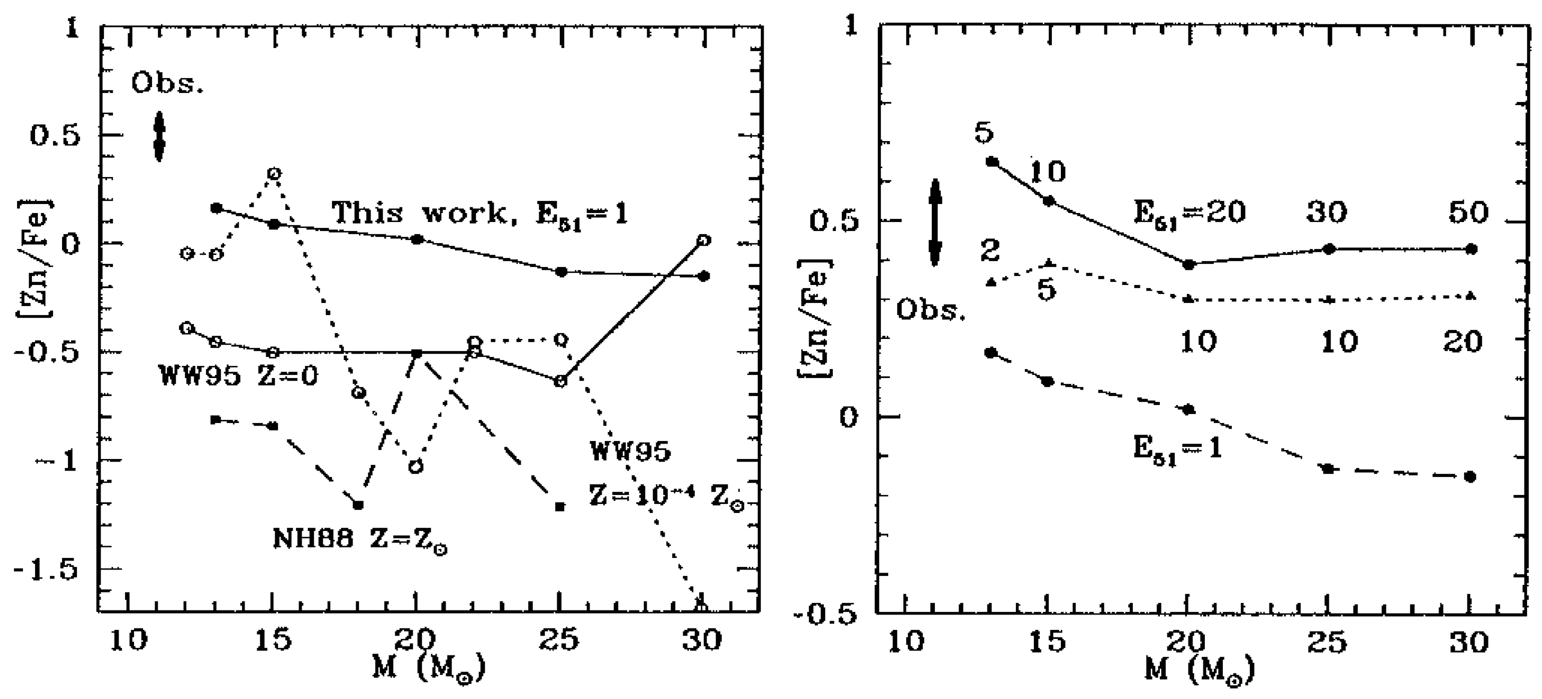

Figure 1: Observed range of [Zn/Fe] ($\equiv \log_{10}(X(\mathrm{Zn})/X(\mathrm{Fe})) - \log_{10}(X(\mathrm{Zn})/X(\mathrm{Fe}))_\odot$) for the very metal-poor stars ([Fe/H] $\lesssim -3$) compared with the yields of theoretical models with low explosion energy $E_{51} = E_{exp}/10^{51}$ erg $=1$ (left) and with high energies $E_{51} = 2 \sim 50$ (right panel). The observed large [Zn/Fe] value and also other unexpected trends in [Co, Mn, Cr/Fe] can be explained with this high energy ("Hypernova") models.

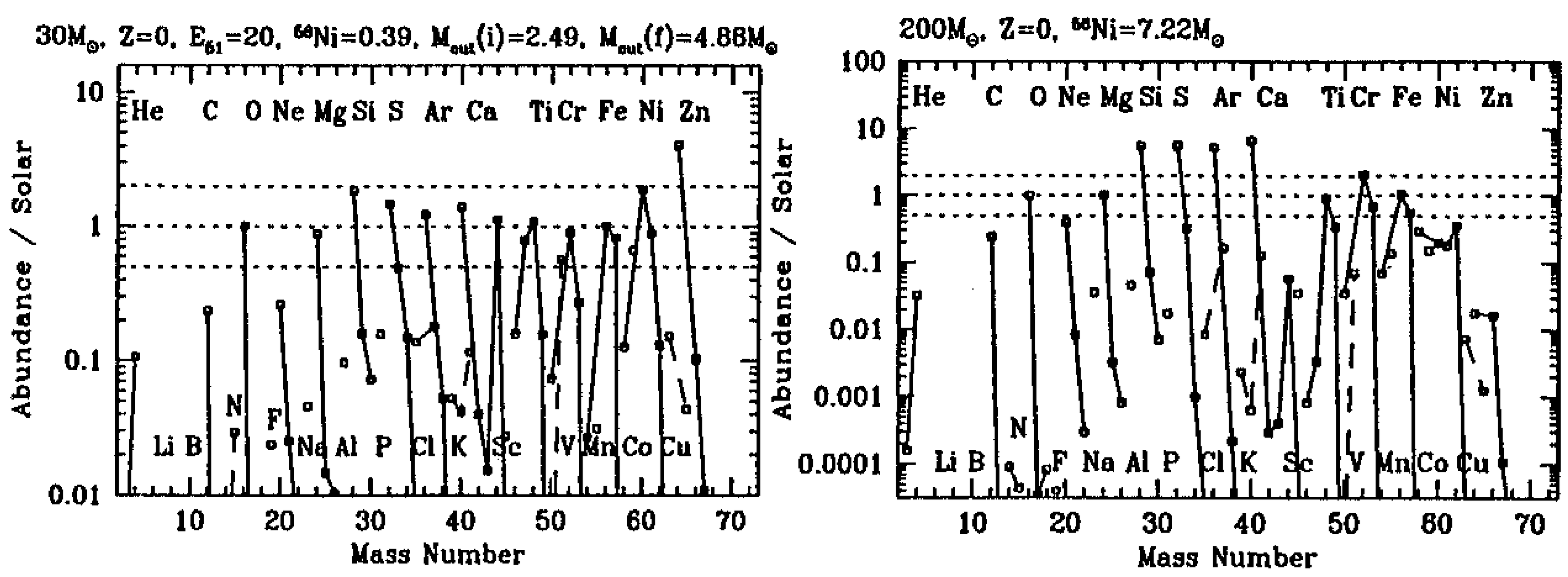

Figure 2: The abundance pattern of a hypernova (left) and a PISN model (right panel), normalize to the solar abundance. For PISNe with initial masses $M \simeq 130 - 300 M_\odot$ [Zn/Fe] is small, so that the abundance features of very metal-poor halo stars cannot be explained by these SNe.