Properties of the lowest mass Fe-core collapse supernovae

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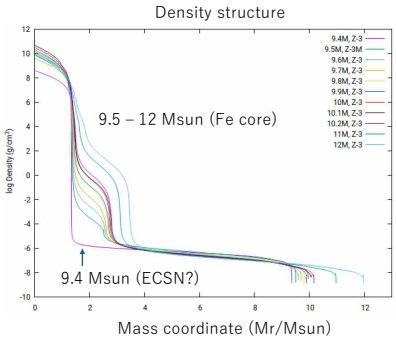
We calculate progenitors for Fe-core collapse SNe in a fine grid to investigate properties of low mass CCSNe. Treating the explosion energy as a free parameter, we attempt to constrain both the explosion energy and the ejected ^{56}Ni mass using observational constraints on neutron star mass and on chemical abundances in metal-poor stars.

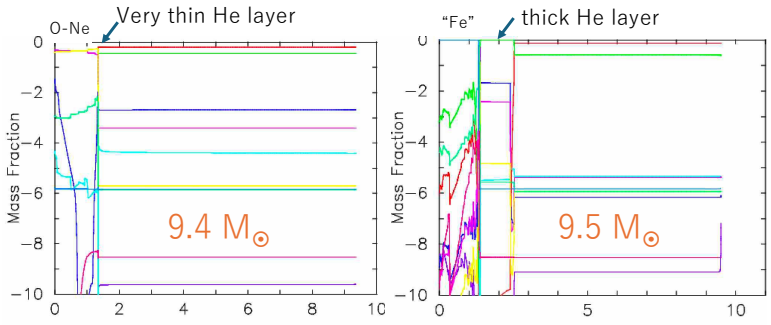
Our progenitor models

We consider 10^{-3} $Z_\odot$ models because we would like to compare with a metal poor star J1010+2358.
The lowest mass for Fe-core collapse : $9.5M_\odot$ ($9.4M_\odot$ forms an ONeMg core)

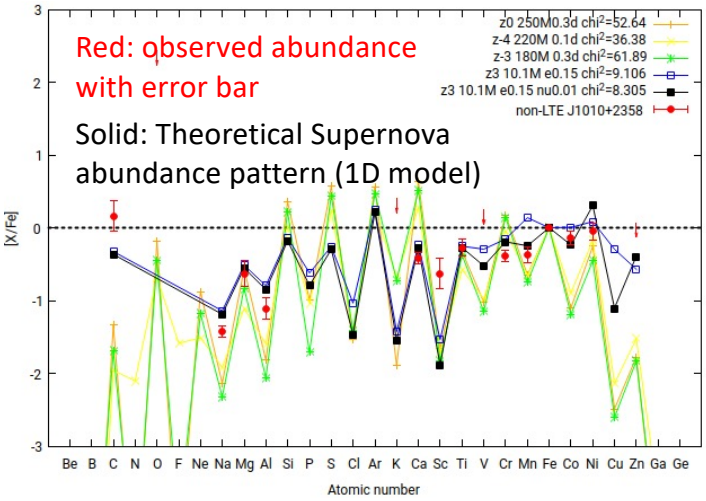
c.f., $Z_\odot$ model : $9.6M_\odot$ (lowest)
($9.5M_\odot$ forms an ONeMg core)



Our progenitor models (Internal abundance)



Abundance pattern of a metal poor star J1010+2358



Upper limit of Explosion energy

$Z_\odot$ model (mass)	Upper E_{ex} (B)
9.7	0.115
10.0	0.62
12.0	0.43
13.0	0.69
15.0	0.77
18.0	--- (>1.04)

This energy seems to be smaller than conventional wisdom

~E_{ex} of typical SN II should be around 1B

■ Best fit to a VMP star J1010+2358 is obtained for a metal poor CCSN model with initial mass $10.1M_\odot$, E_{exp}=0.15B, M(^{56}Ni)=$0.048M_\odot$, and weak neutrino process.

■ Low mass CCSNe have small E_{exp} and ^{56}Ni ejection.

■ ~9.5-10.0$M_\odot$ can be dark SNe II with small E_{exp} <0.1B without ^{56}Ni ejection.

■ It will be interesting to study these models further (nucleosynthesis and light curves) with detailed 2D & 3D simulations.