SN 2007bi
Identification of SN 2007bi on 2007 April 6.5 UT

Main-sequence star
H-burning
He-burning, C-burning, Ne-burning
O-burning, Si-burning

Observational features of SN 2007bi (Yoon et al. 2009)

- Peak R-band absolute magnitude

- $M_\text{He} = 2.31 \text{ mag}$

- $^{56}\text{Ni}$ amount evaluated from spectral analyses

- $M(\text{He}) = 3.7 - 7.4 M_\odot$

- Metallicity of the host galaxy (Yoon et al. 2010)

- $Z = 0.004 - 0.008 (0.2 - 0.4 Z_\odot)$

- Observations and theory of SNe

- Relation among the amount of $^{56}\text{Ni}$, $M(\text{He})$, the mass of CO core, $M_{\text{CO}}$, and SN type

- Theory of stellar evolution

- Relation among the main sequence mass, $M_{\text{MS}}$, the mass of CO core, $M_{\text{CO}}$, and surface abundance of He

- Purpose: Investigation of the evolution of very massive stars to constrain the explosion mechanism of SN 2007bi

Model of Very Massive Stars
Model of very massive stars (plotted by Salo et al., 1998, Yamas & Nomoto 2000)

- $100 \text{ M}_\odot \leq M \leq 500 \text{ M}_\odot$, $Z = 0.004$

- From the main-sequence (MS) stage to C-burning

- Chemical compositions and energy generation

- Nuclear reaction network; $\mu$, H,$\mu$-He (282 nuclei)

- Mass loss rate → 3 cases including uncertainties

- Case A: standard mass loss

- Case B: large mass loss

- Case C: small mass loss


- Final Mass & CO Core Mass of Very Massive Stars

- Relation among the MS mass, $M_{\text{MS}}$, the final mass, $M_f$, and the mass of CO core, $M_{\text{CO}}$

- Pair-instability SN

- Core-collapse SN

Surface He Amount
Type Ic SNe → weak or absent He spectra

Criteria recognized as Type Ic have not been theoretically established.

Conditions of the He abundance discussed in the present study

- Total He mass, $M(\text{He})$

- Mass fraction of He at the surface, $Y_s$

- Mass ratio of He to intermediate layers, $M(\text{He}) / M_{\text{MS}}$ (Woosley & Lattimer 1997)

Concluding Remarks

- The range of the MS mass consistent with the explosion of SN 2007bi

- Considering $^{56}\text{Ni}$ yield and He abundance at the surface

- PISN/CCSN population ratio $r_{\text{PCC}}$, derived using Salpeter IMF

- $r_{\text{PCC}} = 0.024 - 0.19$ (The cases where the explosion of PISN is possible)

- The probability of SN 2007bi exploding as a CC SN is larger.

- Condition of He abundance for SN 2007bi to explode as a Type Ic SN

- The probability of Type Ic PISNe is strongly sensitive to the condition.

- It is important to evaluate definite criteria to classify into SN Ic.

- Possibility of direct collapse without bright SNe

- It is necessary to evaluate theoretically or observationally the probability of direct collapse without bright SNe in CCSNe.