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Late mass loss

BBH-merger EM counterpart $\Rightarrow$ mass loss needs to be close to 2nd core-collapse

Observational evidence

- Flash spectroscopy of SNe
  - e.g., Khazov et al. 2016

- narrow-lined SNe (Ibn & IIn)
  - e.g., Filippenko 1997,
  - Smith 2016

- CSM-powered SLSNe
  - e.g., Chevalier & Fransson 1994,
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- SN-impostors
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Theoretical ideas

- Wave driven mass loss
  - e.g., Shiode & Quataert 2014, Fuller \textit{et al.} 2017

- Pulsational pair instability + Core collapse
  - e.g., Barkat \textit{et al.} 1967, Chatzopoulos & Wheeler 2012, Woosley 2017

- ...

-...
Different behaviors with $M_{\text{ZAMS}}$ and/or $M_{\text{He}}$

\[\text{IMF}(M) \propto M^{-2.3}\]

- $M_{\text{He}}$ governs the fate, determines $M_{\text{BH}}$

- cf. Woosley 2017
Evolution during (P)PISN
Radiation dominated:

\[ P_{\text{tot}} \sim P_{\text{rad}} \]

\[ M_{\text{He}} \gtrsim 32 \, M_{\odot} \]

(Woosley 2017)
1. Pair production
\( \gamma\gamma \rightarrow e^+e^- \)

**Preliminary calculations with MESA**

- \( M_{\text{He}} = 46 \, M_\odot, \, Z = 0.001 \)
- \( \Gamma_1 < 4/3 \)
- \( \langle E_\gamma \rangle > E_{\text{Fermi}}^{\pm} \)
- \( \langle E_\gamma \rangle < 2m_e c^2 \)
- \( \rho \, [\text{g cm}^{-3}] \)
- \( T \, [\text{K}] \)
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\[ \gamma \gamma \rightarrow e^+ e^- \]

2. Softening of EOS triggers collapse
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4a. Pulse with mass ejection

4b. PISN: complete disruption
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4a. Pulse with mass ejection

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5. \( \nu \)-cooling and contraction

6. Entropy loss and fuel depletion stabilize the core

7. BH
Example: $M_{\text{He}} = 46 \, M_\odot$, $Z = 0.001$, no envelope
## Discussion

### Can PPISN provide the mass around the BBH?

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Cons

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- ...

Bonus:

- Naturally produces BHs of $\sim 30 M_\odot$
- Can modify the BH mass function (2nd mass gap)

Correlation between $M_{\text{BH}}$ and EM signal?