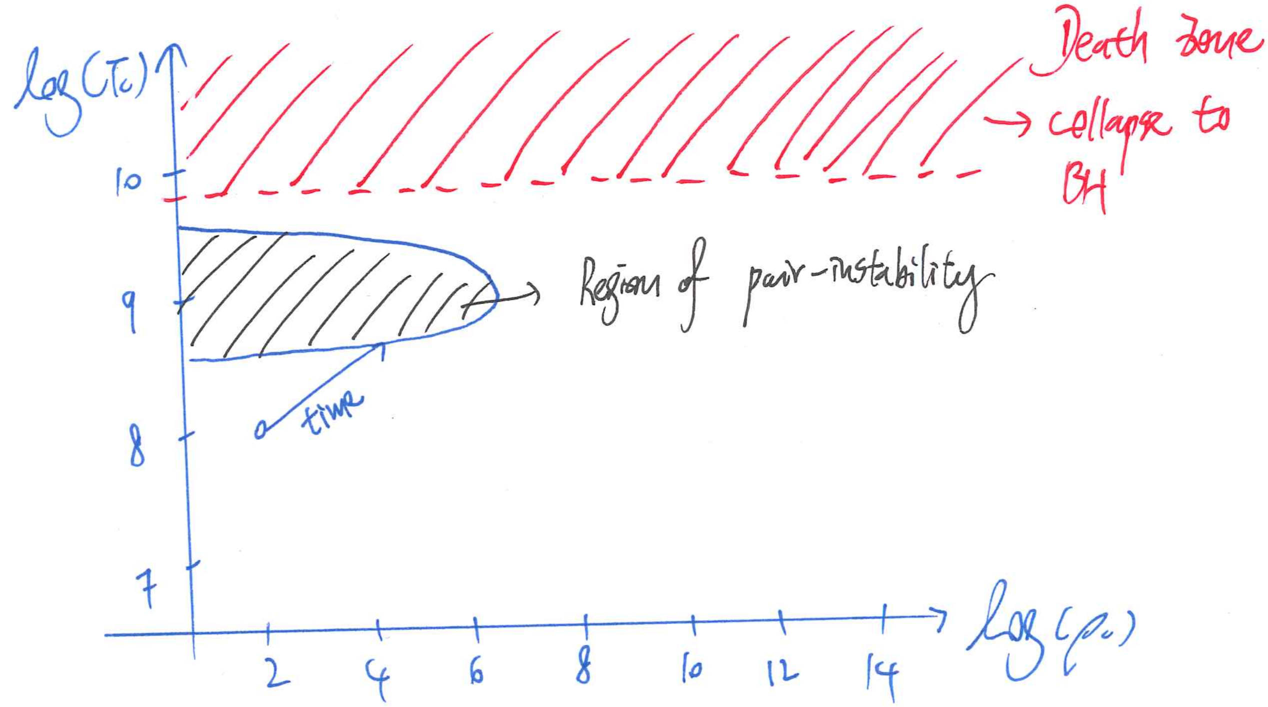
AST 353 Astrophysics. 04-28-2016

This lecture we continue the story about the death of massive stars. In particular, we will answer the question of how we can get massive stars to explode!

Stellar Death (continued).

Recall the phase diagram:



$$\gamma + \gamma \rightarrow \underbrace{e^+}_{\text{rest energy } m_e c^2 \sim 0.5\,\text{MeV}} + e^-$$

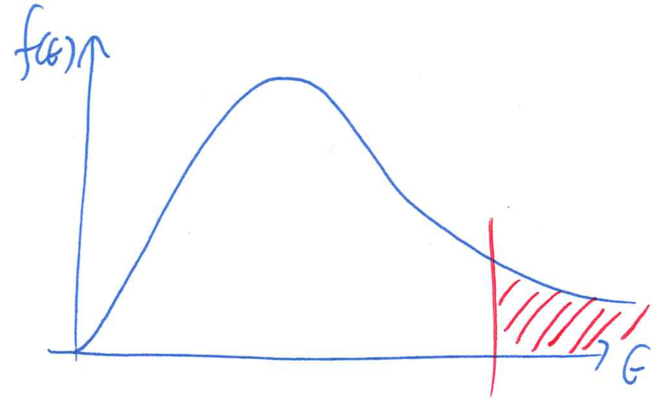
For blackbody photon, 04-28-2016

$$h\nu \simeq k_B T.$$

Energy budget

$$k_B T \gtrsim m_e c^2$$

Quiz 18 : $T \gtrsim 10^{10}$ K.



Because of high-energy tail,

$$T \gtrsim 10^9 \text{ K}.$$

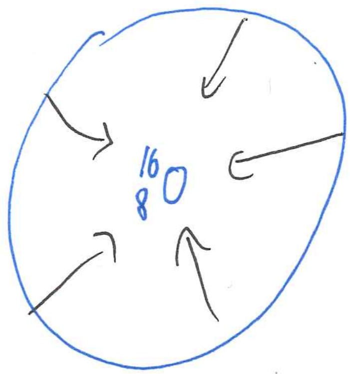
- Basic burning stages in stars' life

		T_{min}
"Hydrogen burning"	$4H \to He$	10^7 K
"Helium burning"	$3He \to C$	10^8 K
"Carbon burning"	$C + He \to O$	5×10^8 K
"Oxygen burning"	$^{16}O + ^{16}O \to \cdots \to$ $\to \cdots \to Fe$	10^9.

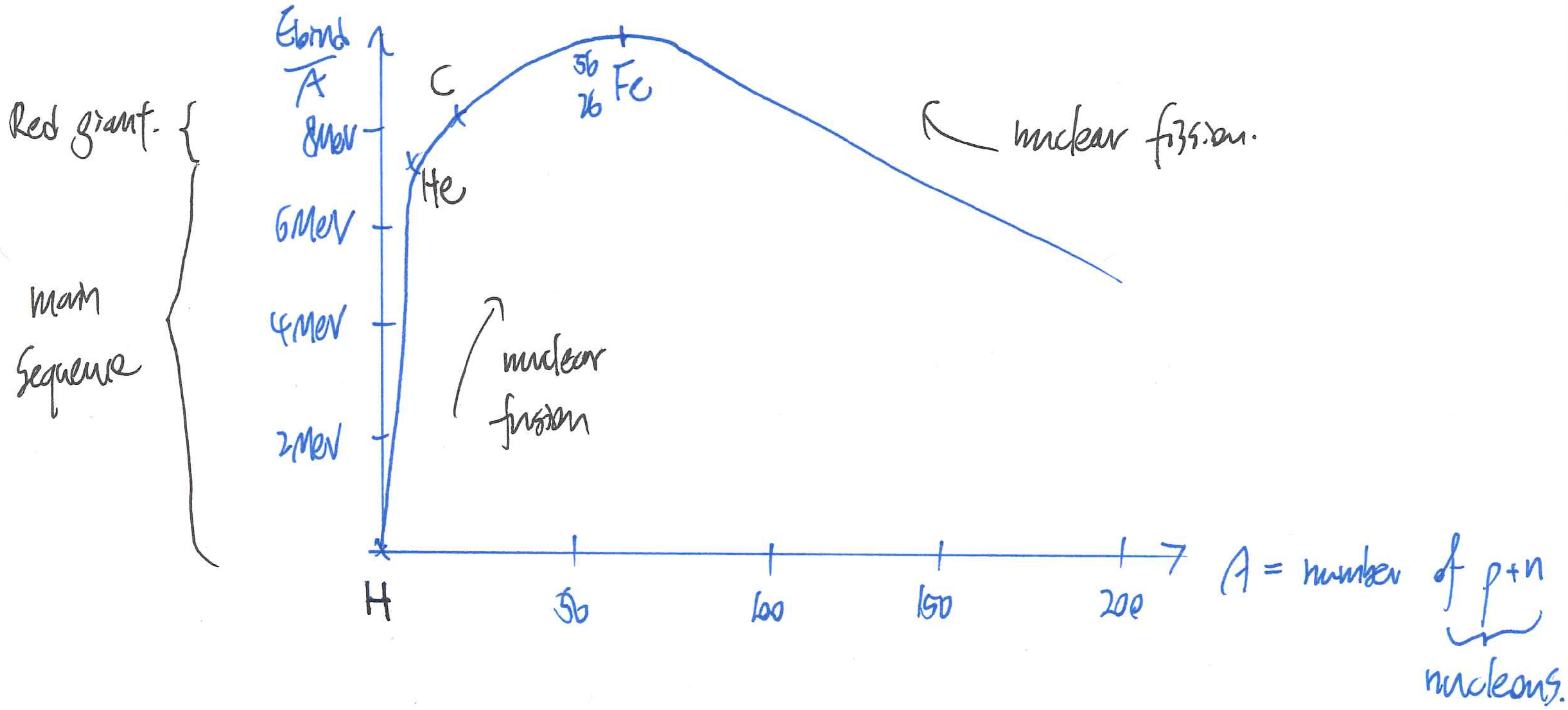
At Oxygen ignition, star enters region of pair-instability

04-28-2016

⇒ Hydrostatic equilibrium broken

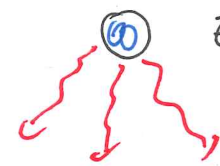


→ nuclear astrophysics basic Plot



Before | After | 04-28-2016

$E_{tot} = 0$ | $E_{tot} = E_{bind} + E_{heat}$



$E_{bind} = -E$

$E_{heat} = +E$

Q: How much energy can Pop III star release when catastrophically burning all remaining ^{16}O fuel?

$$E_{SN} = 10^{53} \text{ erg!}$$

→ Pair-instability Supernova (PISN)

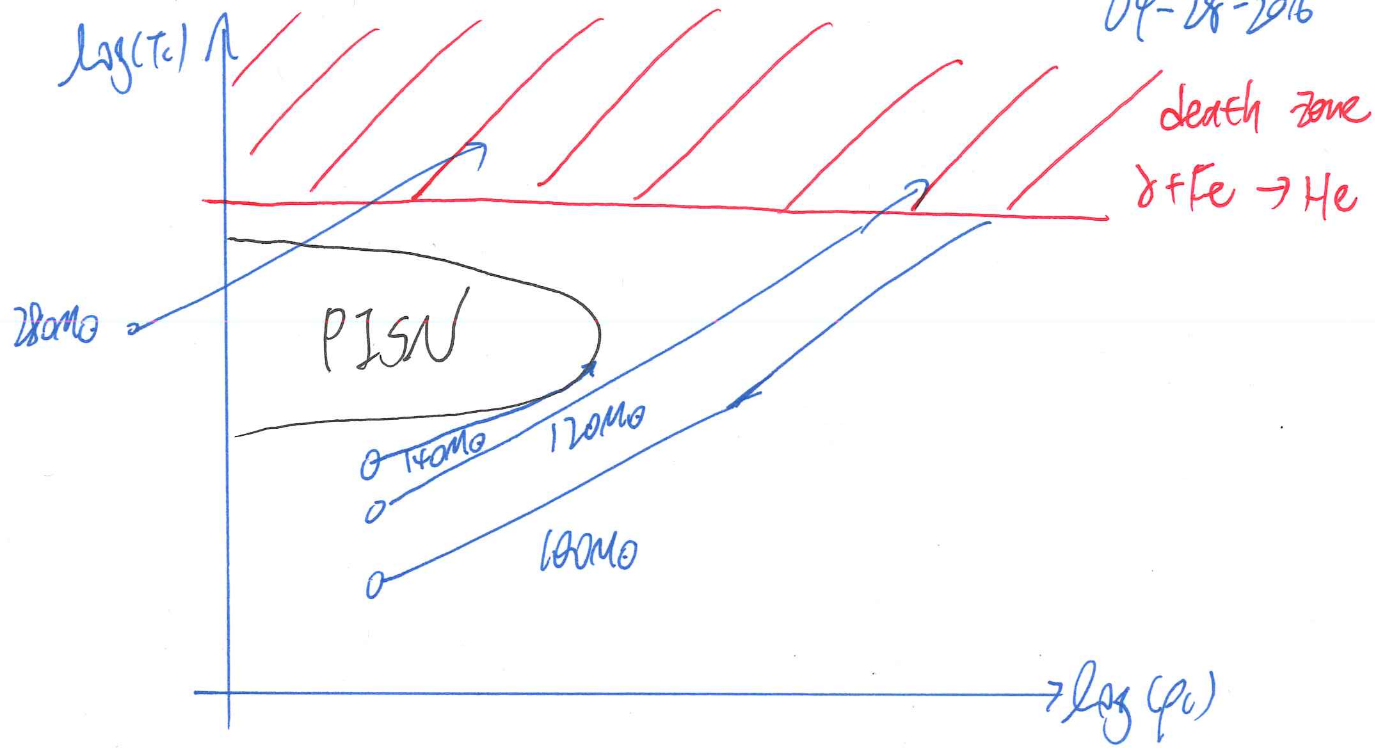
[compare to "standard" SNe $E_{SN} \sim 10^{51}$ erg].

→ Hyper-energetic explosion

→ No compact remnant left!

	Normal SN (core collapse)	PISN
energy power source	gravitational potential energy	nuclear thermonuclear

04-28-2016



For higher mass (than 260 M⊙), gravity takes over and no SN is possible.