AST 353 Astrophysics. 04-26-2016

In this lecture we discuss the deaths of the first stars.

Stellar Deaths and Remnants.

→ Death of the first stars

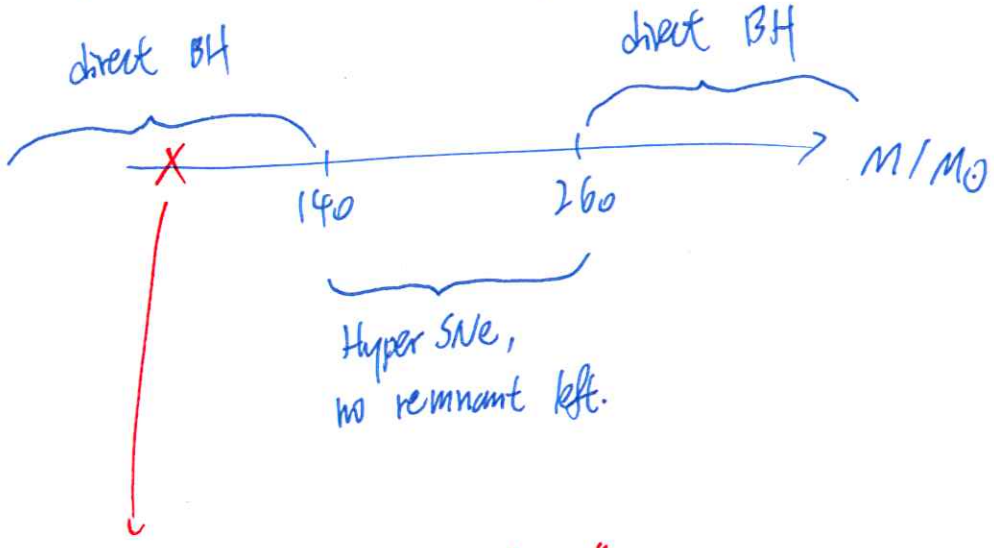
i.e. fate of massive ($M_* \sim 100 M_\odot$) stars.

Two possibilities:

(i) Hyperenergetic Supernovae (SNe)

(ii) Black holes (BHs)

depends on the mass of progenitor



$100 M_\odot$: "BH conundrum".

— If first stars all collapse directly into BHs, where did all the heavy elements come from?

Big Q: What is the governing physics of such dichotomy? 04-26-2016

→ fate of any star is determined by what happens in the center.

Note: more massive stars are hotter !!

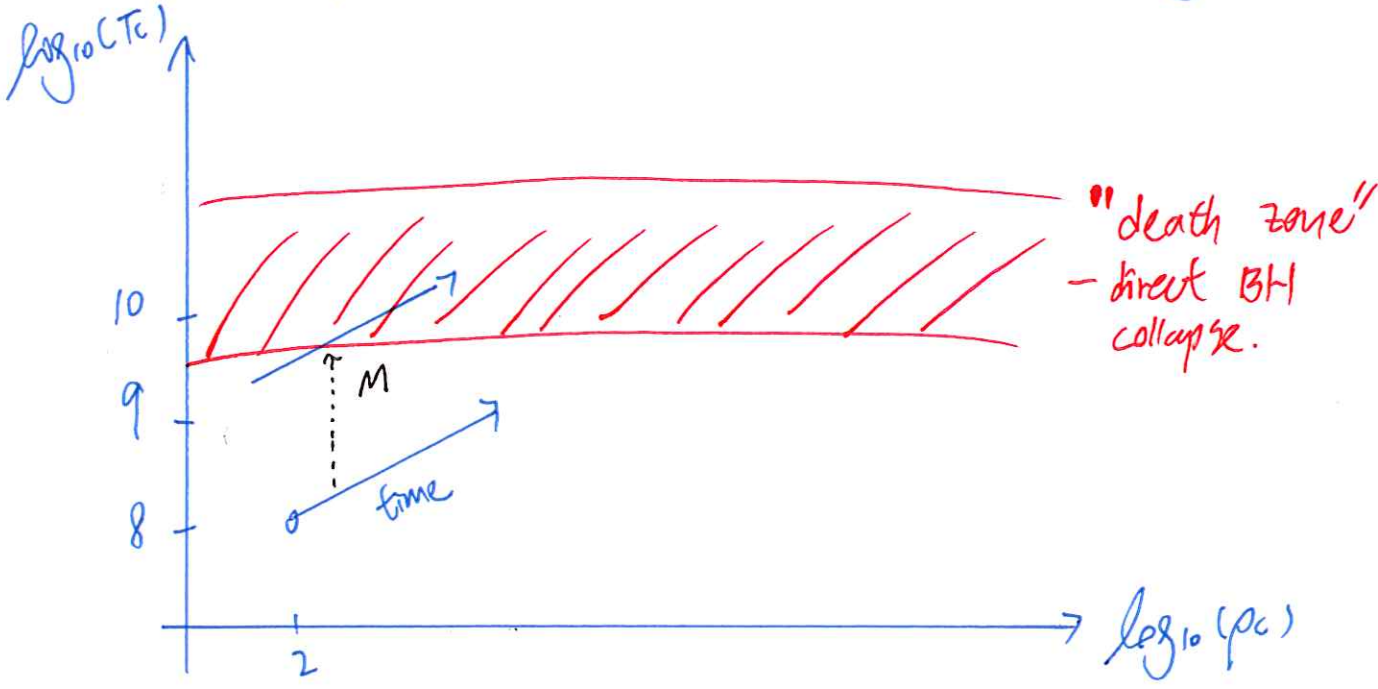
Recall Virial theorem

$$E_{kin} \approx |E_{pot}|$$

$$k_B \cdot T \cdot \frac{M}{m_H} \simeq \frac{GM^2}{R}$$

$$\Rightarrow T \propto M^{2/3} \cdot \rho^{\frac{1}{3}} \quad (\text{using } M \sim \rho R^3)$$

We can then show the evolution of stars on a phase diagram: of interior temperature (T_c) and density (ρ_c)



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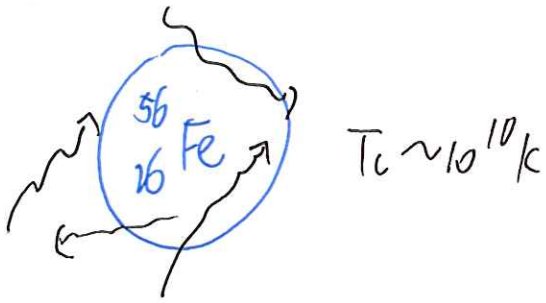
Stars evolve and move along a straight line on the diagram.

Recall : massive stars balance gravity by radiation pressure P_{rad}.

- when $T \gtrsim T_c \sim 10^{10} K$

At the end of stellar nuclear fuel cycle



Energetic photons destroy iron

—— photo-desintegration.

$$\gamma + {}^{56}_{26}Fe \rightarrow 13 \cdot {}^{4}_{2}He + 4n$$

→ this removes photon energy

⇒ Hydrostatic equilibrium broken

⇒ free-fall collapse into BHs.

Q: How can we ever get massive star to explode?

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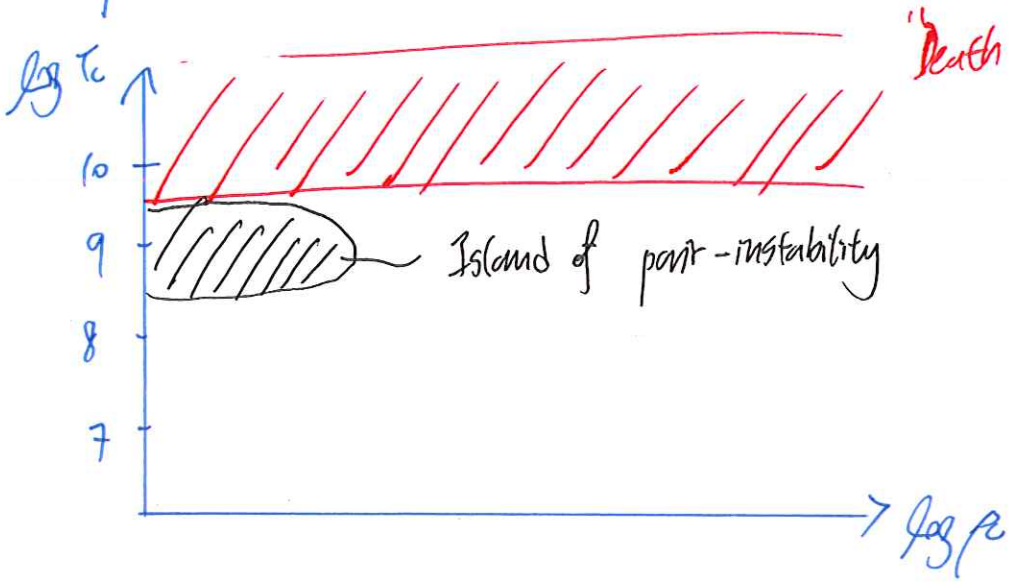

for star lying in the "Island of pair-instability", the following can occur:

$$\gamma + \gamma \rightarrow e^- + e^+$$

a electron-positron pair.

this process is called — "pair production"