# Week 2 and 3 discussion questions

2 types of supernovae (1, 2) #3

## Type 2:

→ core collapse
- onion structure
- iron core
- implode / explode
- production of neutrinos

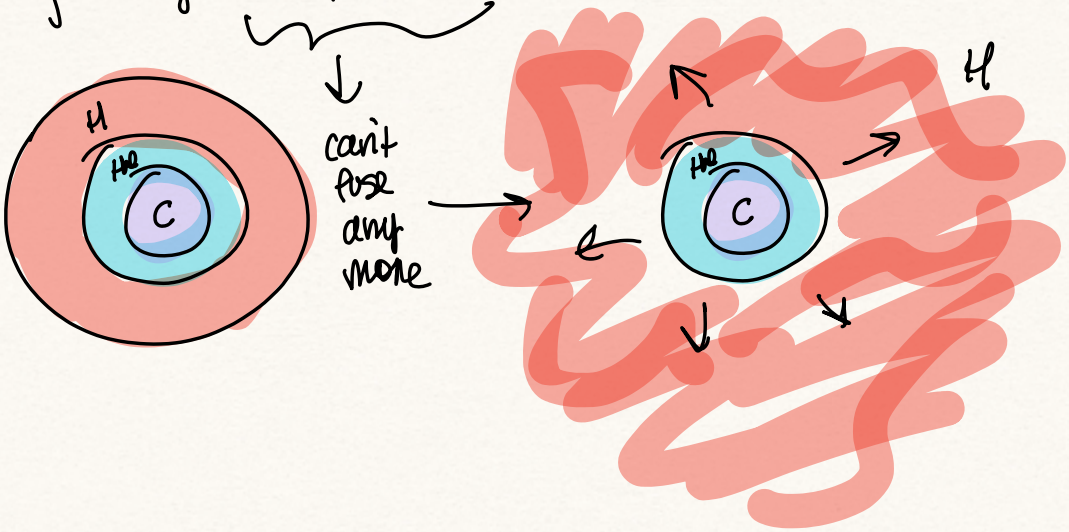
## Type 1: (most common)

→ Binary star systems
- white dwarf strips energy of other star
- one star >> other, burns fuel faster
- can produce nebula or supernova

## Planetary Nebula? #6

→ less massive star (no supernova)
- goes through life span

- after no fuel, No fusion
- becomes red giant?
- gravity compresses star, temp/pressure ↑.



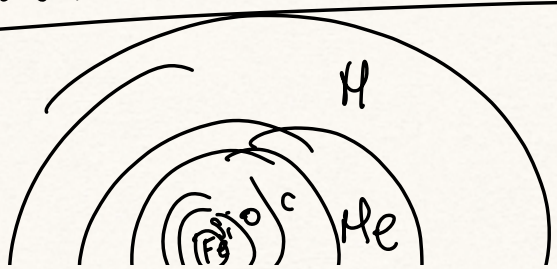

## Why we detect neutrinos first. #2

- Neutrino cross section < photon cross section
  - ↳ interacts w/ less during supernova process

$\sigma_{em} \sim 10^{-27} cm^2$ ← photons interaction area

$\sigma_{weak} \sim 10^{-44} cm^2$ ← neutrinos

## How neutrinos formed in supernova #1




↙ core massive star

↓

heavier elements to center

→ When Fe is ~1.4 $M_\odot$, star implodes (Fusion)

Typical atom:

nucleus

empty space

electrons

Hyper compressed Fe

All layers proceed in

everything is too close

zoom in.

p+e → n+ν

(compressed within seconds)

too close

*cannot put 2 electrons within orbital*

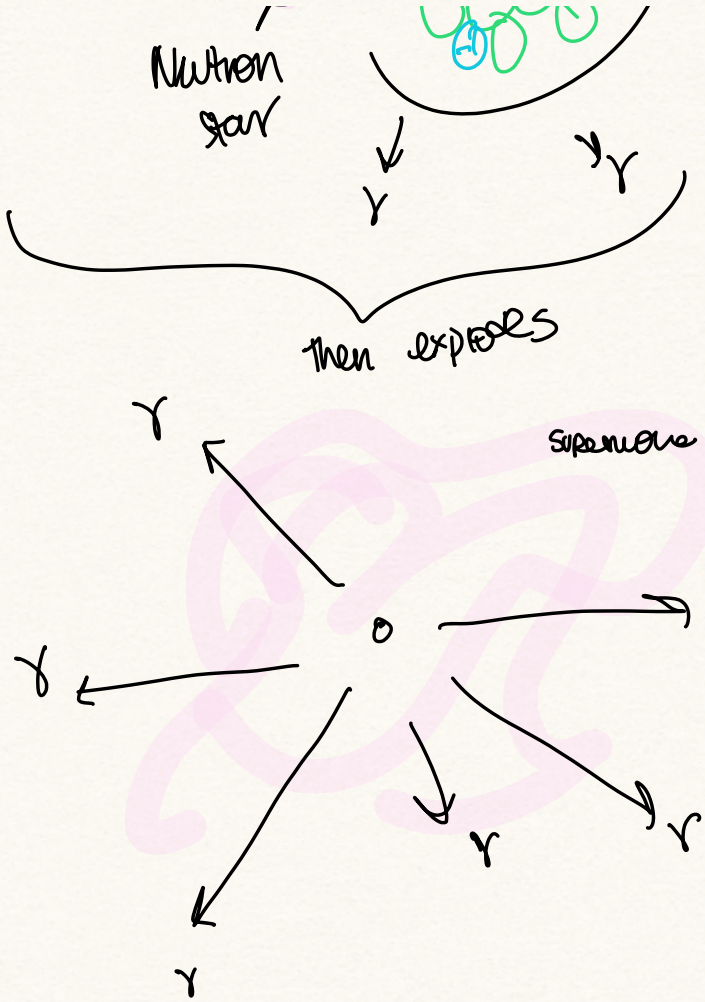
→ electrons NEED space, cannot be near.

*Detect neutrino: ν+p → n+e*

then:

everything else

→ ν




## How can neutrinos explain things #8

- # of neutrinos, time
- comparing to models to know how supernovae form
- Messengers for high energy processes
  - → neutron star mergers
  - → gamma ray bursts

- only react via weak force
  extremely low mass
- have mass
  → C, experience no time
  → ν do oscillate
  ν flavors → change over time
  → must have mass

What makes up supernova remanent. #5

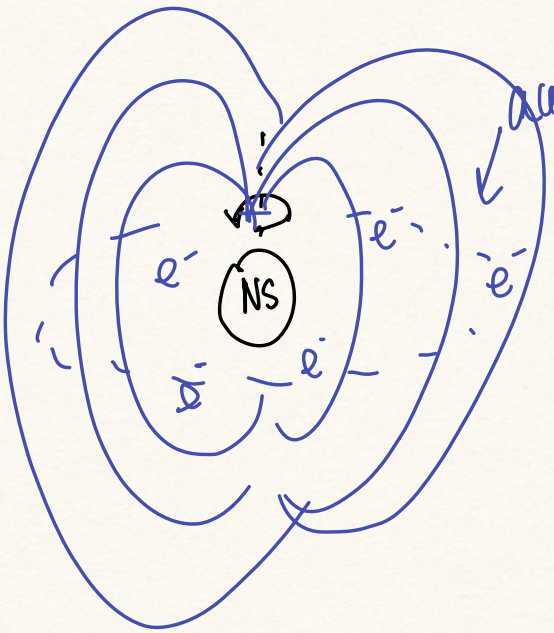
- Hydrogen, helium, other elements
  → heavy elements in fusion that runs around explosion

→ Temperature
  ~ $10^4$ K, hotter than surface of sun
  → Temp cools down because of getting density dispersed into the universe

→ Energy goes to neutrinos/light and due to entropy transfers to the gas in the universe.

Blue glow → neutron star

→ Synchrotron




Density of Neutron Star: $\rho_{NS} = \frac{M_{NS}}{V_{NS}} = \frac{1.5 M_\odot}{\frac{4}{3}\pi R_{NS}^3}$

$R_{NS} \sim 10 km$ $\rho_{NS} = 7 \times 10^{14}\ g\ cm^{-3}$ #7

$\rho_{center\ of\ \odot} \sim 100\ g\ cm^{-3}$ → $10^{12}$ x denser (trillion)

$\rho_\odot \sim 5.5\ g\ m^{-3}$

Earth will only react w/ $\frac{1}{10^{61}}$ neutrinos

#7

$6.6 \times 10^{10} \frac{cm^3}{s}$ ~ Google

$60 \times 10^9 \frac{1}{cm^2 s}$