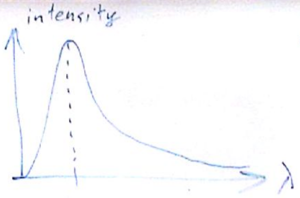
Compared to cooler stars, hotter stars emit photons at ______ peak-intensity wavelengths.

A) longer

B) shorter ✓

C) the same

$$E_{photon} = \frac{hc}{\lambda} \qquad \lambda_{photon} = \frac{hc}{E}$$



$$\lambda_{peak} = \lambda_p$$

A red stellar surface is cooler than a yellow one

$$\lambda_p = \frac{2.90 \times 10^{-3} m \cdot {}^\circ K}{T}$$

for "blackbody radiation"

applies to stars

protons repel
each other electrically.

Only at $\sim 10^{-15}$ m distances
does the strong nuclear
force attract them together
in spite of electrical repulsion

large $U_E = \frac{k q_1 q_2}{r}$ when r small

Needs high K.E. to bring protons together
↳ hence, high temperature to bring many proton pairs together

4-2= 2 neu

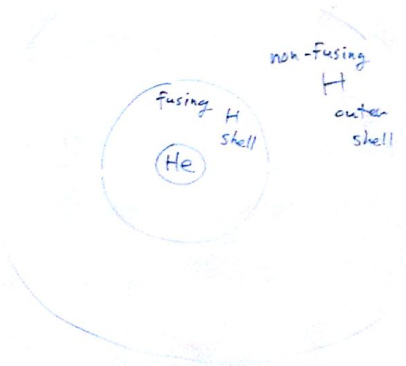
$$4p \rightarrow {}^{4}_{2}\text{He} + 2e^{+} + 2\nu + 2\gamma$$

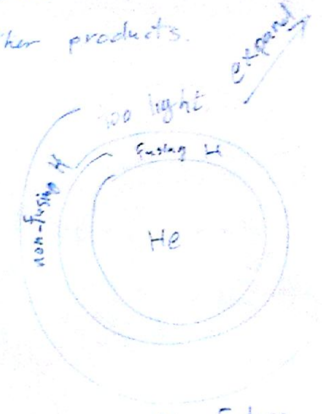
2 protons

p = proton = ${}^{1}_{1}\text{H}$

Converts 24.7 MeV of strong-force
potential energy into energy $\left(E = \frac{hc}{\lambda}\right)$
of the 2 photons & additional K.E.
in the other products.

Our sun now





red giant future
in $\sim 4.5 \times 10^{9}$ yrs

$$\lambda_p = 580\,\text{nm} \Rightarrow T = \frac{2.90\times10^{-3}\,\text{m}\cdot{}^\circ\text{K}}{580\times10^{-9}\,\text{m}} = 5000\text{K}$$ stellar surface temperature

core stellar tempature at least $\sim 10^7$ K

White dwarf core is hot enough to fuse He into C:

$$3\ {}^4_2\text{He} \longrightarrow {}^{12}_{6}\text{C} + \text{photons}$$

Releases 7.3 MeV

Can't get beyond He → C without $\geq 1.4\, M_{sun}$

For larger, hotter stars (blue giants),

Fusion of heavier elements occurs,

profitably up through ${}^{56}_{26}\text{Fe}$ & ${}^{56}_{28}\text{Ni}$,

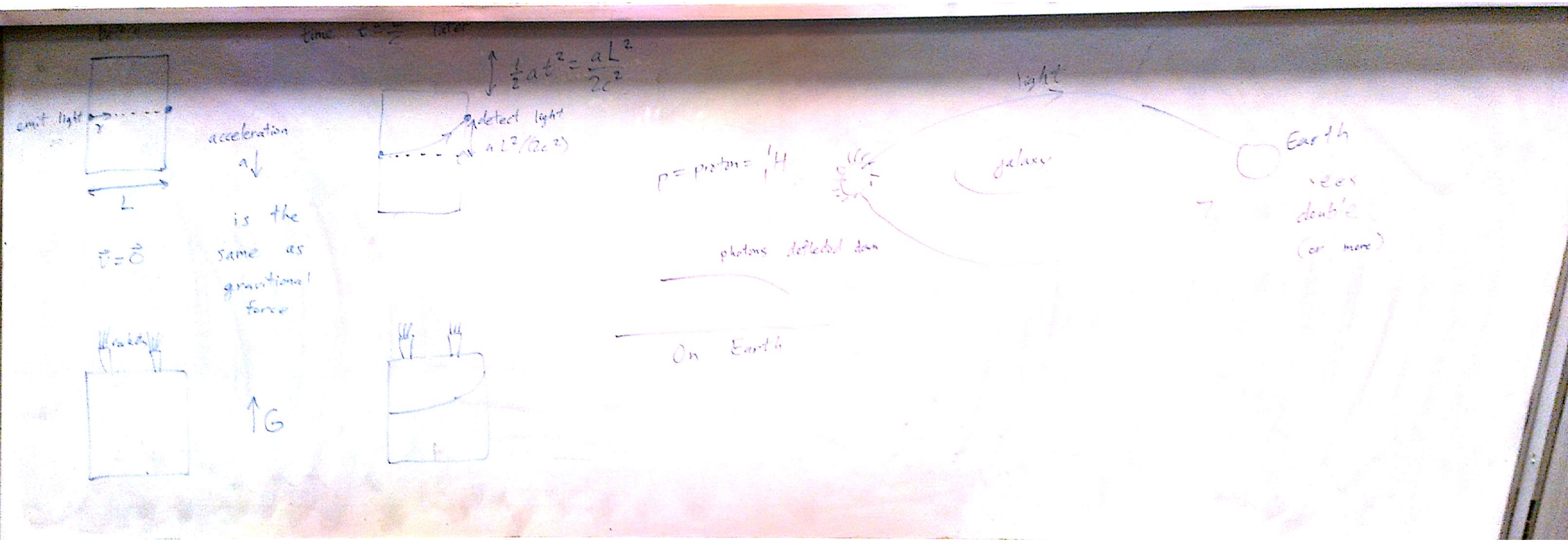
unprofitably for heavier nuclei.

Special relativity:

- moving clocks appear to run slow
- speed of light is always c

General relativity

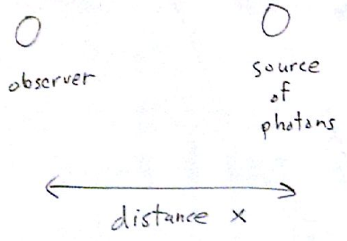
- higher(U_G) clocks appear to run fast
- light curves around massive objects



time $t = \frac{L}{c}$ later
emit light
γ
L
$\vec{v} = \vec{0}$
acceleration
a
is the same as gravitational force
G
$\frac{1}{2}at^2 = \frac{aL^2}{2c^2}$
detect light
$aL^2/(2c^2)$
$p = \text{proton} = {}^1_1H$
photons deflected down
On Earth
light
galaxy
Earth
sees double (or more)

Special Relativity

- Red shift : $\lambda_{obs} = \lambda_{emit}\sqrt{\frac{1+v/c}{1-v/c}} = \lambda_{emit}\sqrt{\frac{1+\beta}{1-\beta}} > \lambda_{emit}$ $\beta = \frac{v}{c}$



$\frac{dx}{dt} = v > 0$

red shift factor $z = \frac{\lambda_{obs} - \lambda_{emit}}{\lambda_{emit}} = \underbrace{\sqrt{\frac{1+\beta}{1-\beta}}}_{1+\beta+\ldots} - 1 \approx \beta$ for $\beta \ll 1$

$H = \frac{22 \text{ km/s}}{10^6 \text{ light-years}}$

$v = Hd$

Hubble's law
for distant galaxies

Everything is moving away from everything else since . . .

$t = \frac{d}{v} = \frac{d}{Hd} = \frac{1}{H} \approx 14$ billion years

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$\gamma + \gamma \longrightarrow e^+ + e^-$

before after

$E = 2hc/\lambda = 2\gamma m_e c^2$ $\gamma = \frac{1}{\sqrt{1-\beta^2}}$