Physics 102 - October 28, 2009

Project - groups formed
Webpage - update
Start digging a bit
Email questions
Meetings after Nov. 9

No lectures in HoyT next week (Nov. 2+4)
Monday, Nov. 2 → PDF + MP3 lecture
Wed., Nov. 4 → watch Parallel Universes
Inherent Nuclear Stability as Function of Nuclear Size

nucleons held more tightly

Nucleons held less tightly
The life cycle of Stars

Gas in the interstellar medium
1 atom per ~20 cubic centimeters

89% H
9% He
2% elements up Z>2

Light elements Mostly Big Bang nucleosynthesis with contribution from fusion in stars

Heavyish elements from stellar fusion + Novas + Supernovae

Much more on this later
Tenuous gas + dust in space collapses due to gravitation.

Heat pushes outward.
Mostly hydrogen

Initial reactions burn hydrogen to helium

Fusion

Must have $M > 0.8M_{\odot}$ for fusion

Finally gets hot enough at core of star to initiate fusion reactions
Mostly Hydrogen

Initial reactions
burn hydrogen to helium

Fusion

Must have > 0.8 M_{sun} for fusion

Finally gets hot enough at core of "star" to initiate fusion reactions
Stars - from dust to dust

Stars form from condensation of gas/dust due to gravitation mostly hydrogen gas

Star-Birth Clouds - M16
HST - WFPC2

The Pleiades
Young stars residual dust surrounding them
at birth

as cloud collapses - angular momentum is conserved - get material forming spinning disk

star forms at center

planets in outer part of disk
Primary Fusion Processes in the Sun

\[ p^+ + p^+ \rightarrow ^2H + e^+ + \nu_e \] 99.77%  
\[ p^+ + e^- + p^+ \rightarrow ^2H + \nu_e \] 0.23%  
\[ ^2H + p^+ \rightarrow ^3\text{He} + \gamma \] 10⁻⁵%  
\[ ^3\text{He} + p^+ \rightarrow ^4\text{He} + e^+ + \nu_e \] 15.08%  
\[ ^3\text{He} + ^4\text{He} \rightarrow ^7\text{Be} + \gamma \] 99.9%  
\[ ^7\text{Be} + e^- \rightarrow ^7\text{Li} + \nu_e \] 0.1%  
\[ ^7\text{Be} + p^+ \rightarrow ^8\text{B} + \gamma \] 84.92%  
\[ ^3\text{He} + ^3\text{He} \rightarrow ^4\text{He} + 2p^+ \] ppI  
\[ ^7\text{Li} + p^+ \rightarrow ^4\text{He} + ^4\text{He} \] ppII  
\[ ^8\text{B} \rightarrow ^8\text{Be}^* + e^+ + \nu_e \] ppIII  
\[ ^8\text{Be}^* \rightarrow ^4\text{He} + ^4\text{He} \]
late life massive star

fusion process into nuclei larger than $^{56}\text{Fe}$ takes energy rather than releasing energy
STAR went supernova in 1054—observed during day by Chinese and Arab astronomers.

Crab Nebula
Star went Supernova in 1054
Elements with Atomic Mass < that for iron can be made in stars via fusion

How do we get elements with $A > 57$?

And how do these materials get dispersed into space to become part of other stars + planets?

**Nova**

**Supernova**

→ as core of massive star cools down can have instability - core can collapse due to gravity and then slow or rebound as reach the point where "held up by particles". Shockwaves can propagate and ignite the outer layers of star

→ Massive Explosion

→ Produces heavy elements + disperses material in space
Death of a Star

White dwarf

$0.8 \, M_\odot < M_{\text{star}} < 1.4 \, M_\odot$

Star runs out of fusion fuel at temp reached
+ slowly cools

Gravity "wins" - held up by electron degeneracy pressure
Neutron Star

$1.4 M_\odot < M_{\text{star}} \lesssim 2.5 M_\odot$

held up by neutron degeneracy pressure

\[ \sim 10 \text{ km} \]
Black hole

\[ M_{\text{star}} \gtrsim 2.5 \, M_{\odot} \]

Gravitation so strong that even light cannot escape

Time appears to stop at event horizon (to outside observer)
Tidal effects ... not a trip you want to take

photo from http://orbitingfrog.com/blog/2008/07/10/can-light-orbit-a-black-hole/