Quick Quiz

Which of the following are not characteristics of Jovian planets?
  a) rocky
  b) giant
  c) has rings
  d) farther from the sun

The History of a Star

Chapter 33

Birth

- All stars start out as a gas and dust cloud. Gravity pulls it all together.
- A group or cluster of protostars form.
Protostar Collapse

- A rising temperature inside each protostar causes the gas to push back against gravity. The collapse slows.
- A slow collapse continues for ~10,000,000 years. The protostar shines by gravitation energy conversion to thermal and light energy.

Stellar Birth

- All stars are a condensation of gas that is balancing gravitational collapse against thermal explosion. The life history of a star is determined by which force is dominating.
- When a star finally begins to fuse H to He for its energy, it is a regular star and the collapse ends.

Eagle nebula

![Image of the Eagle nebula]
H-R Diagram

- Star colors and brightnesses are determined by their masses. Can use this to determine distances.

Normal, Average, Generic Stars.

- After stars emerge, they burn \( \text{H} \rightarrow \text{He} \) and settle into a stable life
  - Massive stars shine brighter but have shorter lives
  - Low mass stars shine fainter but have longer lives.
  - The sun is a low-mass star that is 5,000,000,000 years old and will live as is for another 5,000,000,000 years!
  - All stars, when they age become red giants.

Sun-like Stars (Low Mass)

- As the hydrogen is consumed in the core, the sun will expand into a huge red star, cooking the earth!
Planetary Nebula

- Eventually the outer layers drift off into space forming planetary nebulae.

The end of a small star

- White dwarf - carbon core, helium fusion layer, outer hydrogen layer
- Black dwarf - carbon cinder in the sky
- Note: a brown dwarf is not a star.
Massive Stars

- Massive stars are those that fuse all the light elements up to iron. They become red giants like low mass stars in the process. But they will not form planetary nebulae.
- Instead, as the core gets heavier, atomic protons are pushed into electrons creating neutrons and the entire core collapses!

Supernovae

- In the process of collapsing, the star violently blows the outer layers away, creating a supernova.

SN 1987a

- In 1987 a supernova exploded in a nearby satellite galaxy.
Neutron Stars

- The collapsed core is a neutron star, a giant atomic nucleus (!) that spins like mad, beaming light out like an airport beacon.

Supermassive Stars

- Supermassive stars evolve just like the massive ones with one exception. They have so much gravity in the core that we know of no force that can prevent their collapse to a point! (?) We call the resulting entity a black hole.
- To understand this we have to take a peek at General Relativity.

A Crude Representation
Black Holes

- When the curvature is infinite, it is a black hole.
- Even light, traveling along this infinite curve, cannot find a path out!
- There is a remarkably large amount of evidence supporting the reality of black holes.

Accretion Disk and Jets

- Oddly enough, black holes should manifest themselves by ejecting material from accreting disks surrounding them.

Core of M87 (a nearby galaxy)