Monday, January 27, 2014

Wacky start to the term!

First Exam and Skywatch extra credit, Friday February 7. Get a head start on the skywatch on clear nights.

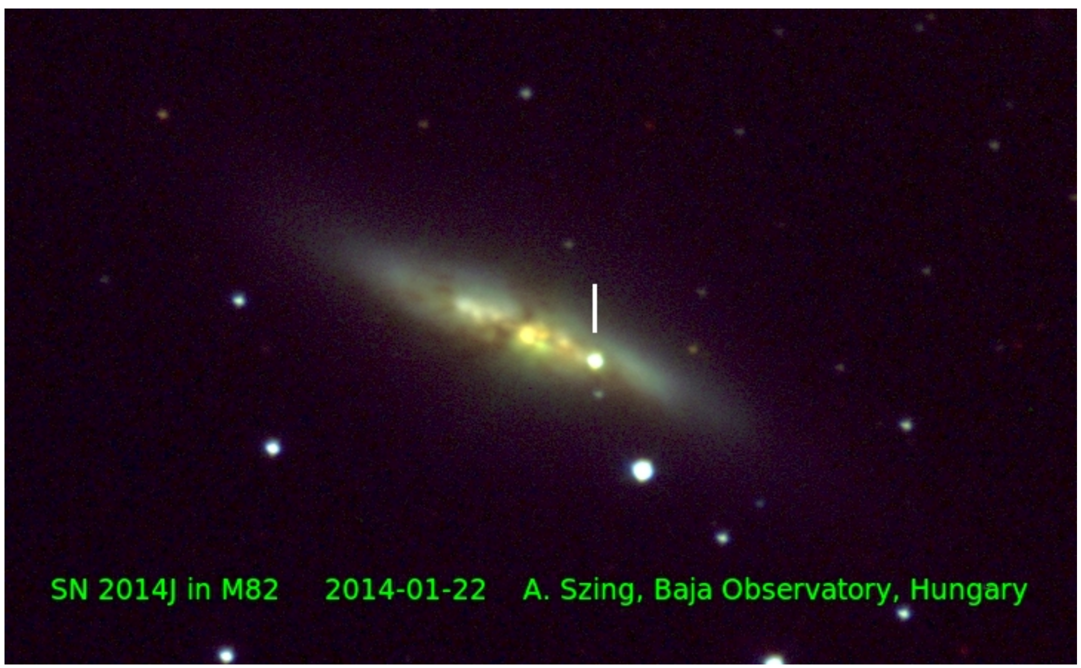
Astronomy in the news?

PBS special on Stephen Hawking, A Brief History of Mine, Wednesday 9 pm.

Update on new "nearby" supernova in M82

Now officially designated as SN 2014J, 10^{th} officially designated of the year (many others discovered, but not officially released, named). Observed with many telescopes around the world, including McDonald Observatory, and in space, Hubble Telescope, in optical, infrared, radio, X-ray. Peak light at the end of this week, then long, slow fade.

Image sent by my Hungarian colleague, Jozsef Vinko.



Discussion Points:

White dwarfs have about the same mass as the Sun and about the same radius as the Earth.

How does the gravity of a white dwarf compare to the Sun and the Earth, and why?

What do we know about white dwarfs?

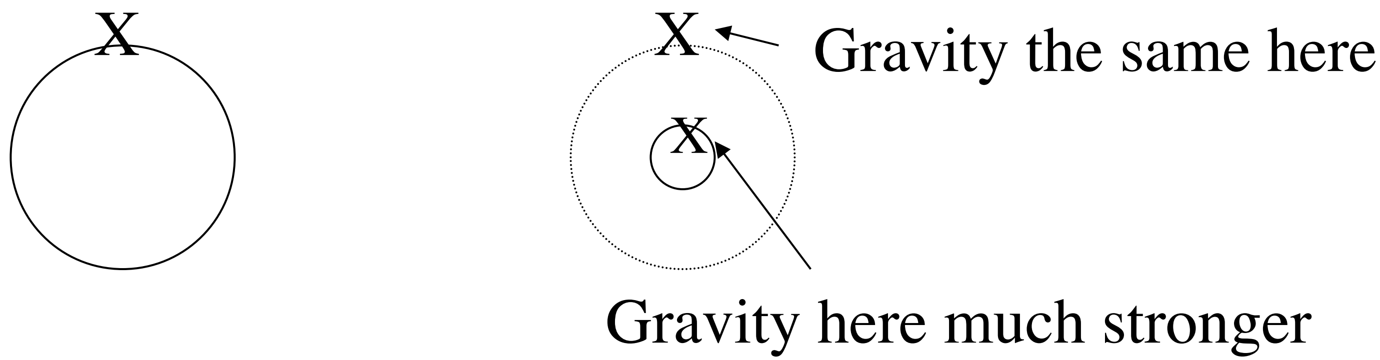
Mass ~ Sun
Most are single, 0.6 $M_\odot$ (solar masses)
Some in binary systems have higher mass

Size ~ Earth ~1% radius of Sun

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \rightarrow \frac{10^6 \text{ grams}}{\text{c. c.}} \sim \frac{\text{tons}}{\text{cubic centimeter}}$$

OR MORE!

HUGE GRAVITY!



Same mass, smaller size, gravity on *surface* is larger because you are closer to the *center*.

Gravity on surface acts *as if* all mass beneath were concentrated at a point in the center -- Newton/Calculus

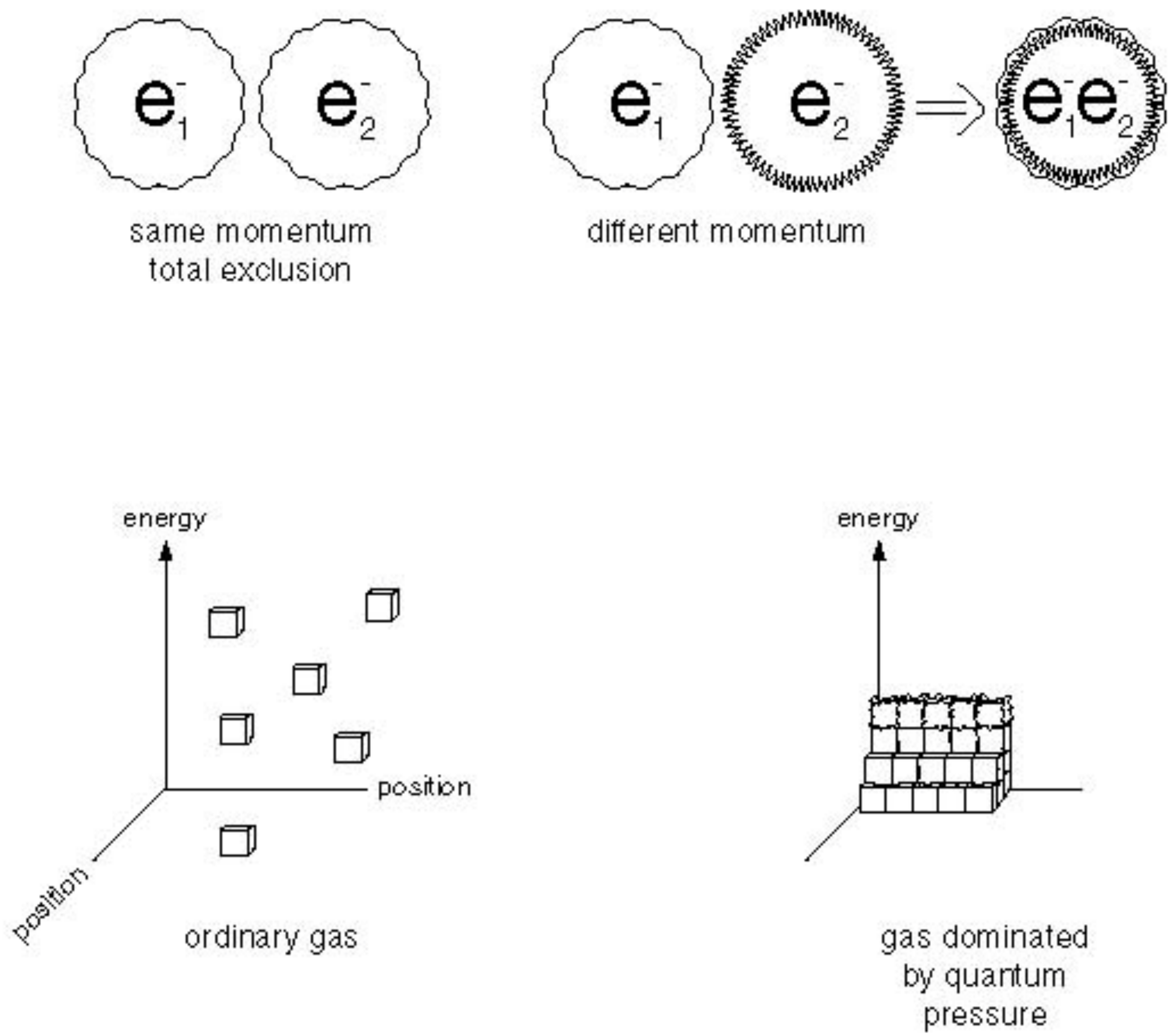
Goal:

To understand how pressure is created in stars, how thermal pressure controls the evolution of normal stars, and why quantum pressure makes white dwarfs liable to explode in some circumstances.

Huge gravity compresses a white dwarf --
requires special pressure to support it
(Section 1.2.4, Section 2.3)

- ***Normal pressure*** -- thermal pressure
  - Motion of hot particles -- ***Pressure depends on Temperature***
- ***Quantum Pressure*** -- Quantum Theory, particles as waves
  - Uncertainty Principle -- Can't specify position of any particle exactly. If you squeeze and "locate" a particle more precisely, its energy gets more uncertain, and larger on average.
  - Exclusion Principle -- No two identical particles (electrons, protons, neutrons) can occupy same place with same energy, but they can if one has more "uncertainty" energy.
  - ***Pressure depends only on density, not on temperature***

Figure 1.4



e_1^-
e_2^-
same momentum
total exclusion
e_1^-
e_2^-
$e_1^- e_2^-$
different momentum
energy
position
position
ordinary gas
energy
gas dominated
by quantum
pressure

Demonstration thermal pressure, quantum pressure - need volunteers.

Same mass in all three cases

One Minute Exam: Where is gravity strongest?

A.

B.

C.

Insufficient information

Discussion point:

How does the different form of the pressure, thermal or quantum, affect the behavior of stars?

What happens if the star puts in excess nuclear energy?

What happens if the star loses excess energy to space?

Quantum Pressure -- just depends on squeezing particles, electrons for white dwarf, to very high density

-- depends on density only

-- *does not* depend on temperature

Important Implication:

Normal ☆ Radiate excess energy, pressure tries to drop, star contracts under gravity, and gets **hotter** (and higher pressure)

White Dwarf Radiate energy, *temperature does not matter*, pressure, size, remain constant, star gets **cooler**

Opposite behavior	Normal Star - *Regulated*	put in energy, star expands, cools
	White Dwarf - *Unregulated*	put in energy, hotter, more nuclear burning -- explosion!

Figure 1.3

A normal star can and will radiate away thermal energy and hence structural energy.

A brick cannot radiate its structural energy,

A white dwarf cannot radiate away its quantum energy.