Friday, September 6, 2013

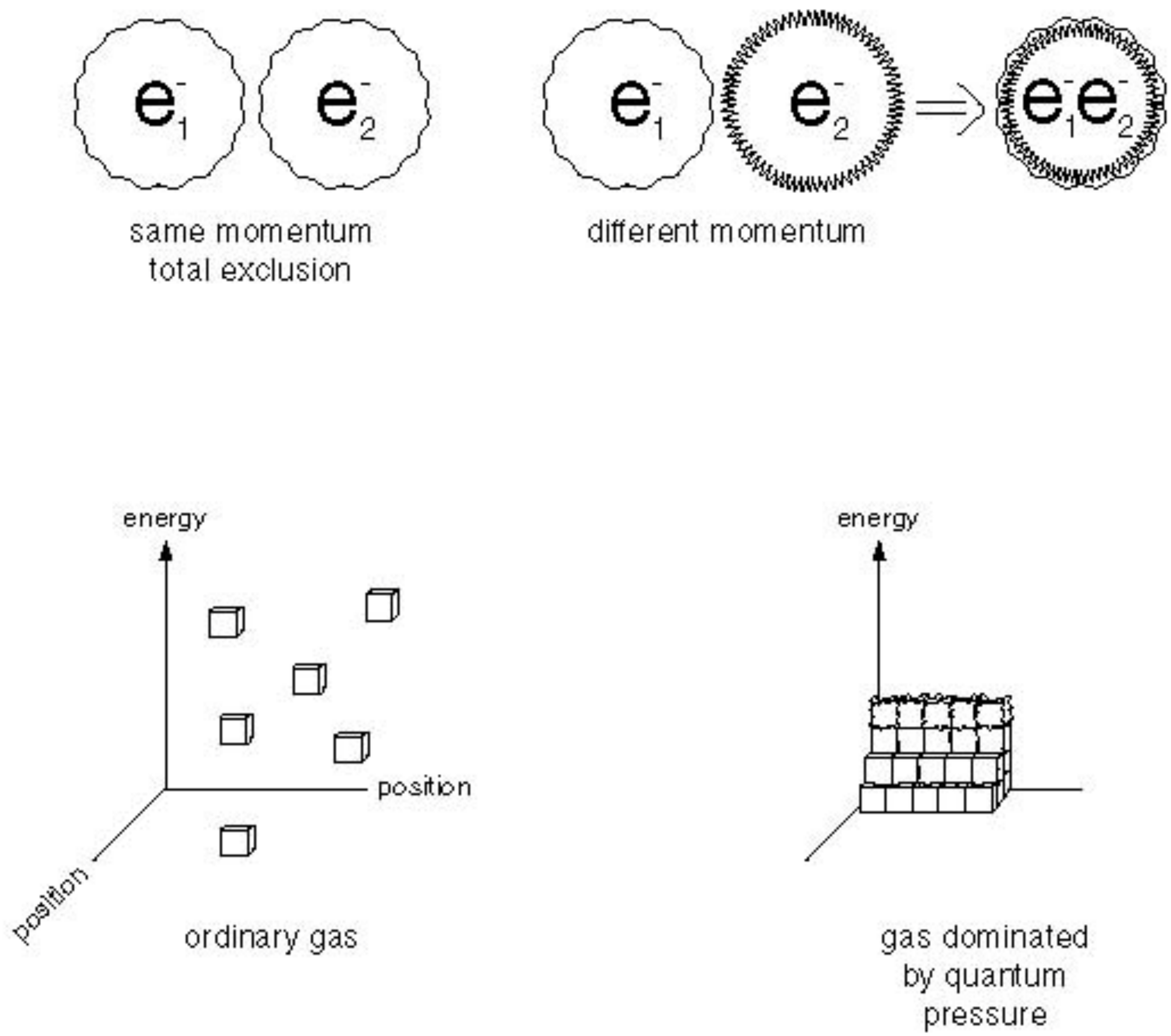
Astronomy in the news?

First exam a week from today.

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.

Figure 1.4


e₁⁻ e₂⁻
same momentum
total exclusion
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**

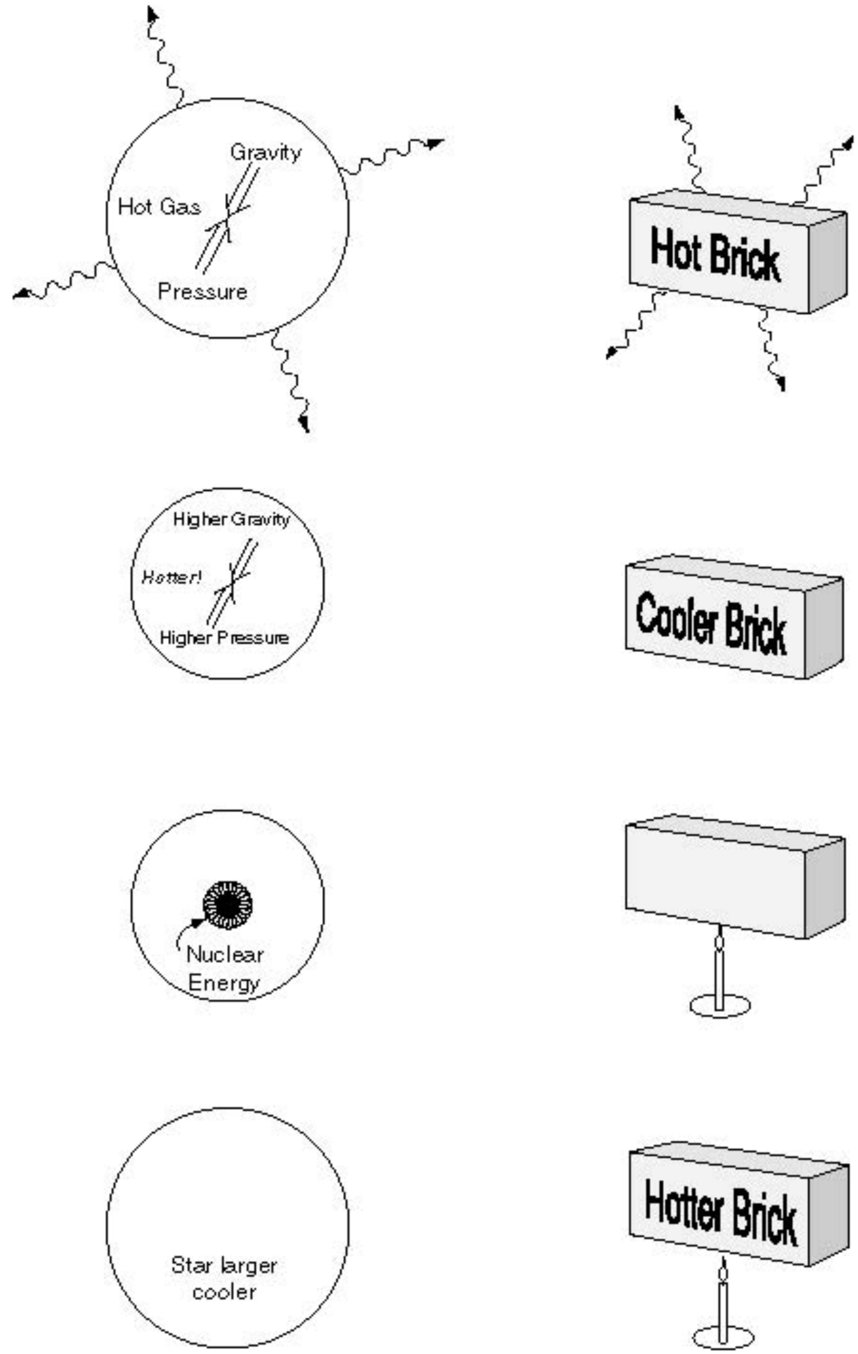
Opposite behavior	Normal Star - *Regulated*	put in energy, star expands, cools
	White Dwarf - *Unregulated*	put in energy, hotter, more nuclear burning -- explosion!

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.



A normal star supported by thermal pressure regulates its temperature. If excess energy is lost, the star contracts and heats. If excess energy is gained, the star expands and cools. Feedback loop, akin to the furnace, thermostat in your house.

A white dwarf, supported by the quantum pressure, cannot regulate its temperature. If excess energy is lost (the case for the vast majority of white dwarfs), they just get cooler. If Excess energy is gained, they heat up and can explode.

Behavior of white dwarf, Quantum Pressure, worked out by S. Chandrasekhar in the 1930's

Limit to mass the Quantum Pressure of electrons can support

Chandrasekhar mass limit ~ 1.4 $M_\odot$

density ~ billion grams/cc ~ 1000 tons/cubic centimeter

Maximum mass of white dwarf.

If more mass is added, the white dwarf must collapse or explode!

One Minute Exam

If nuclear reactions start burning in an ordinary star like the Sun, what happens to the temperature?

➡ The temperature goes up

⬅ The temperature remains constant

⬆ The temperature goes down

⬇ Insufficient information to answer the question

One Minute Exam

If nuclear reactions start burning in a white dwarf, what happens to the temperature?

- The temperature goes up
- The temperature remains constant
- The temperature goes down
- Insufficient information to answer the question

SUPERNOVAE

Catastrophic explosions that end the lives of stars,

Provide the heavy elements on which planets and life as we know it depends,

Energize the interstellar gas to form new stars,

Produce exotic compact objects, neutron stars and black holes,

Provide yardsticks to measure the history and fate of the Universe.

Reading:

Chapter 6 Supernovae

Also § 2.1, 2.2, 2.4 & 2.5 for background

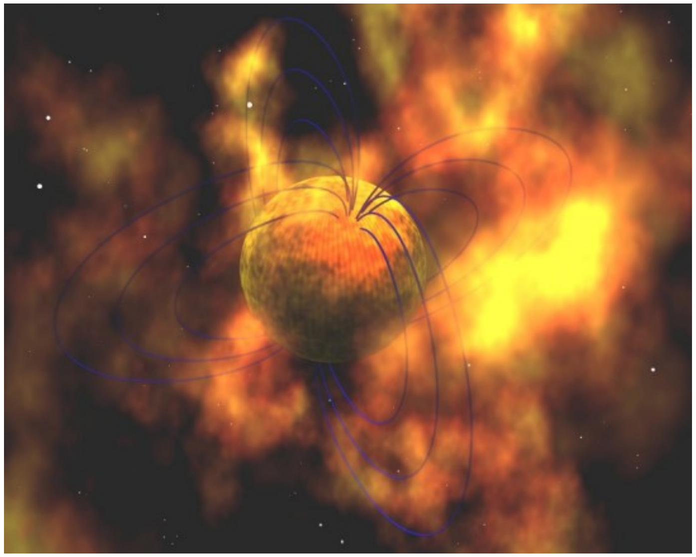
Issues to look for in background:

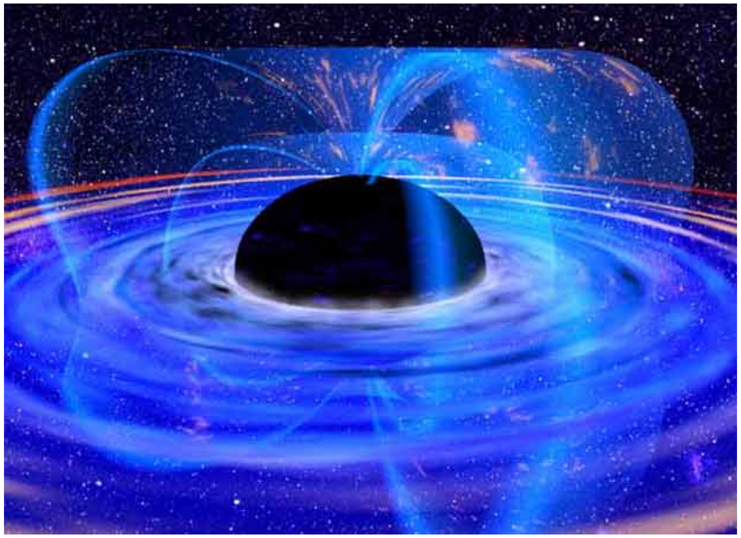
Why is it necessary for a thermonuclear fuel to get hot to burn? - charge repulsion § 2.1 & 2.2

Core Collapse § 2.4 & 2.5

One type of supernova is powered by the ***collapse*** of the core of a massive star to produce

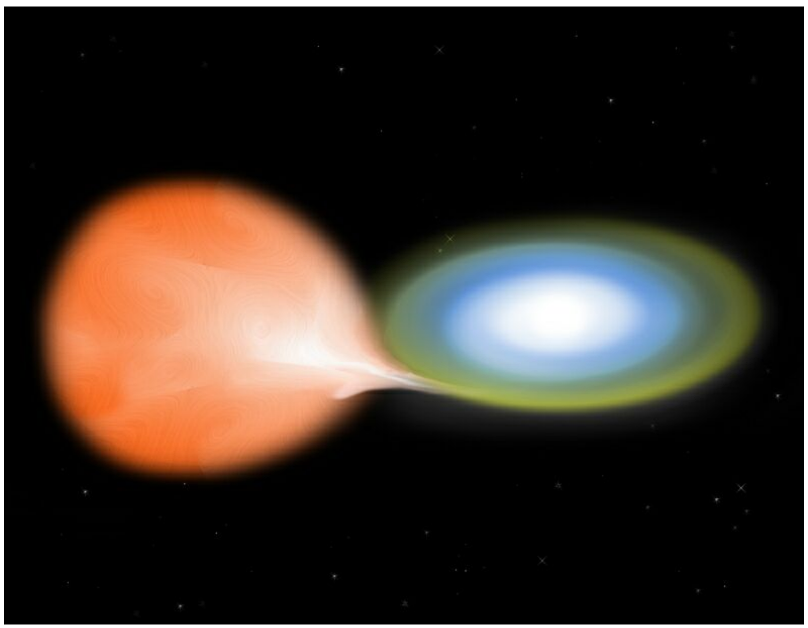
a ***neutron star***, or perhaps a ***black hole***



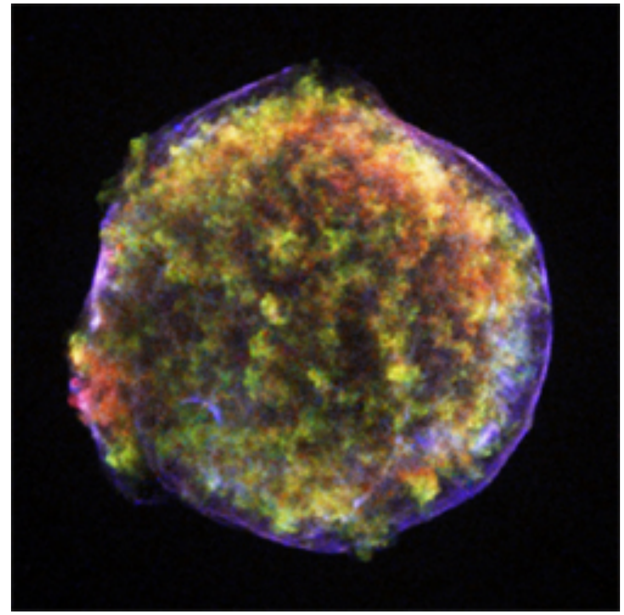


The mechanism of the explosion is still a mystery.

The other type of supernovae (Type Ia) is thought to come from a white dwarf that grows to an explosive condition in a binary system.



Chandra X-ray Observatory image
Of Tycho's supernova of 1572



These explode completely, like a stick of dynamite, and leave no compact object (neutron star or black hole) behind.

Goal:

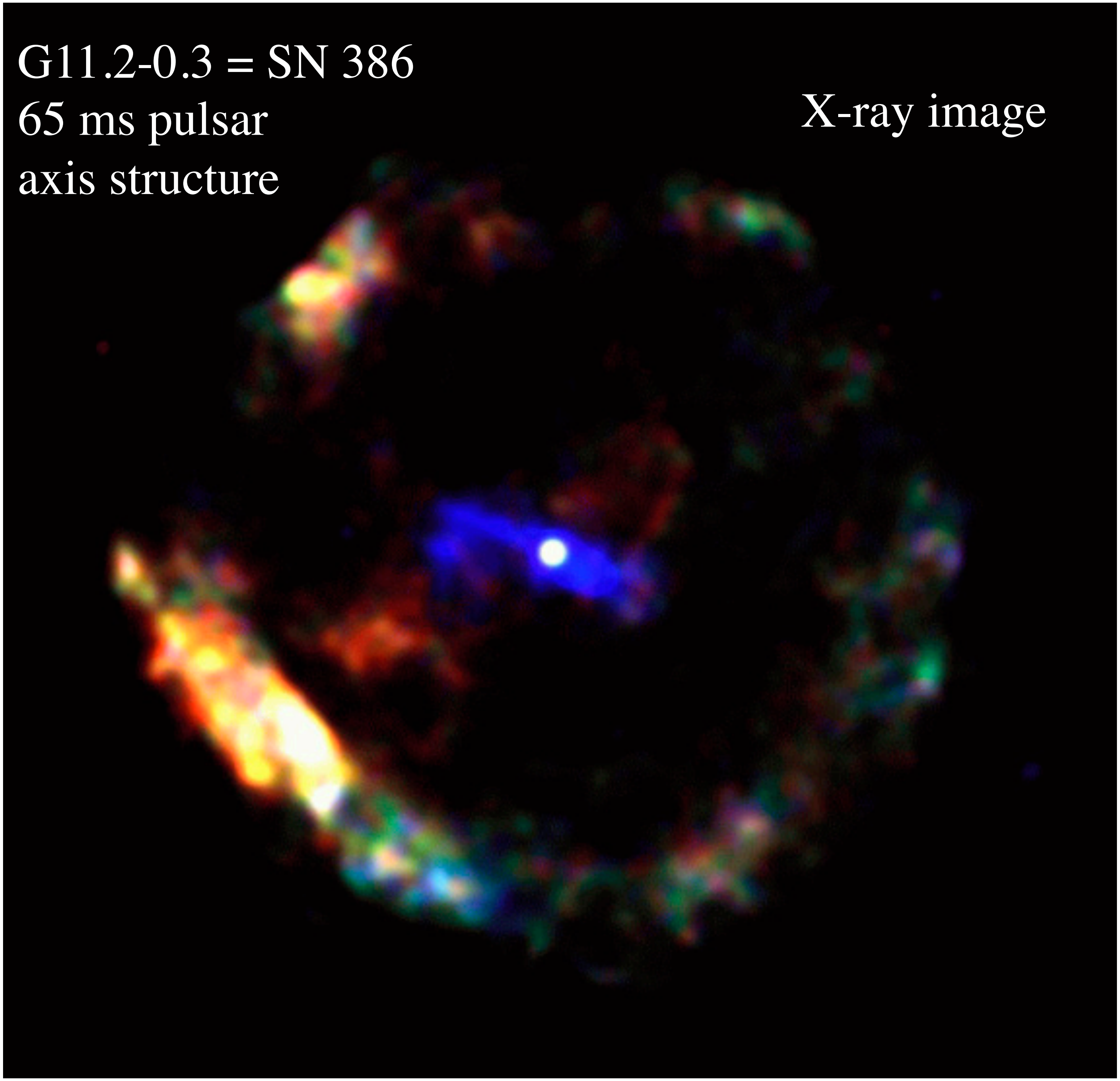
To understand what we have learned from the study of old supernova explosions in our Milky Way Galaxy.

Chapter 6 Supernovae

Historical Supernovae - ***in our Milky Way Galaxy*** observed with naked eye over 2000 years especially by Chinese (preserved records), but also Japanese, Koreans, Arabs, Native Americans, finally Europeans.

SN 185	earliest record	No NS
SN 386		NS, jet?
SN 1006	brightest	No NS
SN 1054	Crab Nebula	NS, jets
SN 1181	(Radio Source 3C58)	NS, jets
SN 1572	Tycho	No NS
SN 1604	Kepler	No NS
~1680	Cas A	NS? Jets
SN 1987A	nearby galaxy	NS? jets


Chandra Observatory X-ray image, Spitzer, WISE infrared image
SN 185 = RCW 86
No evidence for neutron star


G11.2-0.3 = SN 386
65 ms pulsar
axis structure
X-ray image