January 26, 2011

Typo of class website url on handout:

http://www.as.utexas.edu/astronomy/education/spring11/wheeler/309n. html

Courageous question

Astronomy in the news? Last Space Shuttles coming up, future of NASA.

Pic of the day: M51, Whirlpool galaxy





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 energy, pressure tries to drop, star contracts and gets **hotter** (and higher pressure)
- White DwarfRadiate energy, temperature does not matter,
pressure, size, remain constant, star gets cooler

Opposite
behaviorNormal Star -
Regulatedput in energy, star expands, coolsUlticD6

White Dwarf -
Unregulatedput in energy, hotter, more nuclear
burning -- explosion!



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 limit ~ 1.4 M_☉ 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 $\S 2.1 \& 2.2$

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,



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.

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 386 SN 1006 SN 1054 SN 1054 SN 1181 SN 1572 SN 1604 ~1680 SN 1987A	earliest record brightest Crab Nebula (Radio Source 3C58) Tycho Kepler Cas A nearby galaxy	NS, jet? No NS NS, jets NS, jets No NS No NS NS? jets NS? jets
SN 1987A	nearby galaxy	NS? jets
Vela	10,000 years ago	NS, jets