Thursday, February 5, 2009

Review session this evening, 5 PM RLM 15.216B

First Exam NEXT WEEK, Thursday, Feb. 12
Review Session, Wednesday, February 11, RLM 15.216B, 5 PM
First sky watch extra credit due Tuesday, February 17

Astronomy in the News?

Methane on Mars

Comet Lulin may be visible to the naked eye by late February

New exoplanet may be only two Earth masses

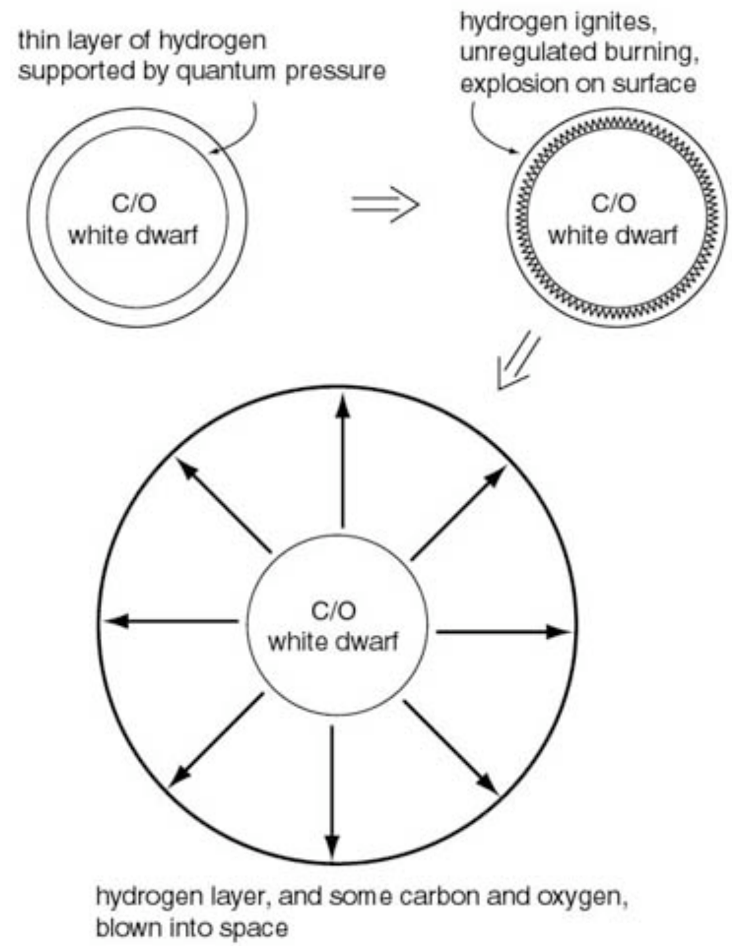
Pic of the Day - X-ray/optical image of star forming region in galaxy M33

Classical Nova

Hydrogen from transfer accumulates on surface of white dwarf composed (usually) of Carbon/Oxygen (burning He → C/O in core of red giant before envelope is ejected as a planetary nebula)

H is supported by ***Quantum Pressure***
H gets denser, hotter begins to burn (to make He)
Burning is ***unregulated*** - explode surface layer of H

C/O core essentially undisturbed, although a little mass is ripped from the surface of the core



Sky Watch

Classical Novae:

CP Pup, toward constellation Puppis in 1942

Pup 91, another toward Puppis in 1991 (not same place in our Galaxy, just accidently off in the same approximate direction)

QU Vul, toward constellation Vulpecula, white dwarf composed of Oxygen, Neon, and Magnesium rather than Carbon and Oxygen.

GK Per toward constellation Perseus - has had both a classical nova eruption in 1901 and dwarf nova eruptions.

Recurrent Nova

Mechanism uncertain

Probably variation of Classical Nova with mass of white dwarf especially near ***Chandrasekhar mass***

At ***Chandrasekhar mass***, may get a Supernova (will discuss specific mechanism later, Chapter 6)

U Sco in the constellation Scorpius is a Recurrent Nova,
It may be a candidate to explode as a supernova!

Might see Scorpius just before sunrise. Also has neutron stars and black holes.

T Pyx in constellation Pyxis.

One Minute Exam

In dwarf nova systems, the activity causing the outburst occurs

A In the mass transferring star

B In the accretion disk

C On the surface of the white dwarf

D At the inner Lagrangian point

§5.3 Origin of Cataclysmic Variables

Cataclysmic variables often have a ***main sequence companion transferring mass*** -- how can this be?

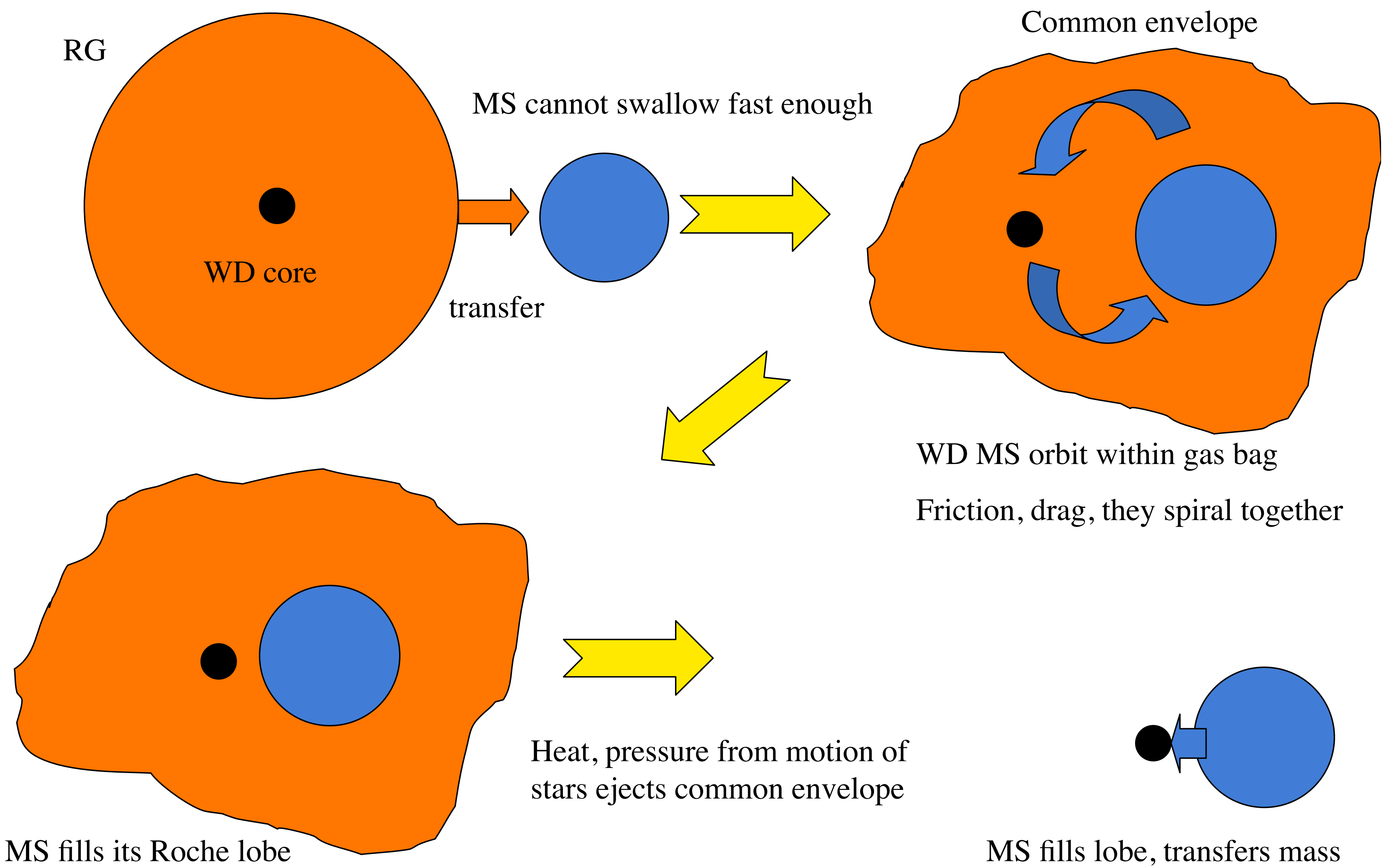
The two stars must once have been far apart to allow the originally more massive star to make a red giant with a white dwarf core.

Need room!!

The stars are observed now to be close together with the main sequence star filling its Roche lobe.

The main sequence star has not expanded to become a red giant, how come it is filling its Roche lobe?

Answer: § 3.9 Common Envelope Evolution



One Minute Exam

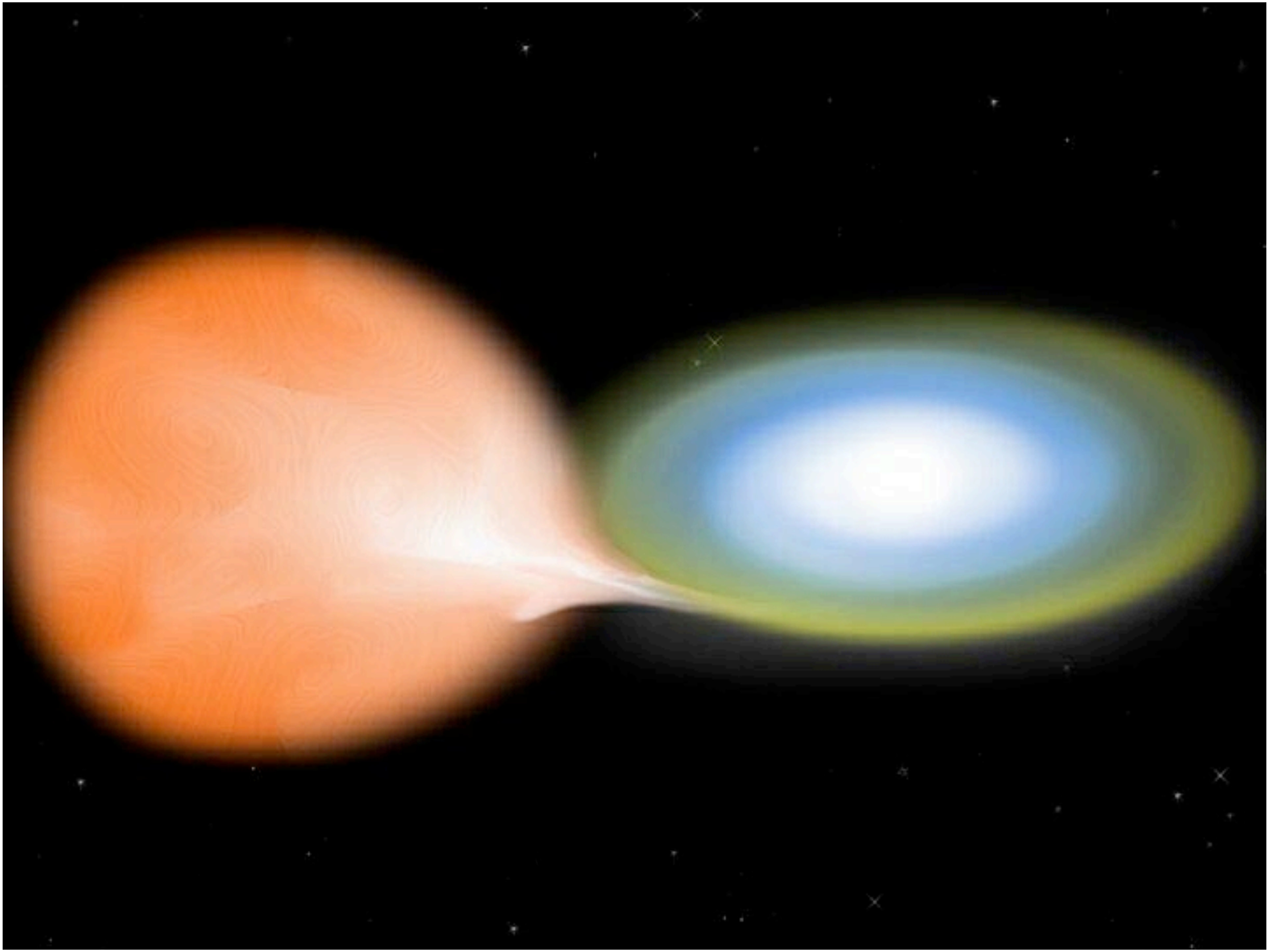
In most dwarf nova systems, the star transferring mass is a main sequence star. This means:

A The main sequence star was once a red giant, but lost mass

B The main sequence star used to be further away from the white dwarf

C The main sequence star and the star that made the white dwarf were born close together.

D The main sequence star has more mass than the white dwarf



§ 5.4 Final Evolution of Cataclysmic Variables

Some CVs have managed to reach large masses
$M_{wd} \sim M_{ch}$ Chandrasekhar mass, 1.4 solar masses, like U Sco

If get close enough to M_{ch}, attain high density,
ignite carbon in center
Quantum Deregulated → violent explosion
Supernova (Chapter 6)

What CVs have white dwarfs that reach M_{ch}?

Not classical novae

explosion of surface H shell also rips off a bit of the white dwarf mass - we see excess carbon & oxygen in ejected matter

white dwarf shrinks in mass rather than grows.

Likely outcome in this case - 2nd star finally burns out H, tries to form red giant, likely makes a 2nd common envelope => ***Two WDs!***

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, temperature/pressure try to drop, star compresses, gets **hotter** (and higher pressure)

White Dwarf Radiate energy, *temperature does not matter*, pressure remains 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!

Hydrogen transfers from a main sequence star to a white dwarf in a binary system.

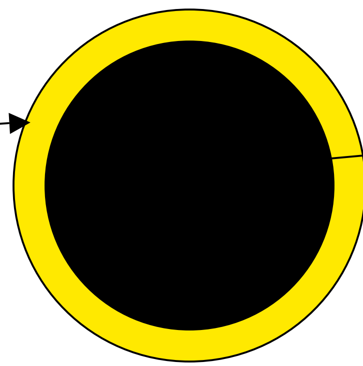
Modest rate of transfer, hydrogen has a chance to radiate and cool as it is added to the surface of the white dwarf, ends up cool but dense, supported by the ***quantum pressure***. If the hydrogen begins to burn the result is:

Unregulated hydrogen burning, an explosion --> ***Classical Nova***

White dwarf loses mass, cannot grow to Chandrasekhar mass

Second star eventually makes its own white dwarf --> 2 WD

Cool hydrogen layer, supported by quantum pressure, explodes!



C/O white dwarf loses a little mass

Clearly some systems like recurrent nova U Sco with nearly 1.4 solar mass white dwarf escape this fate - How?

Recent work suggests that transfer of mass at just the right fast rate allows the H layer to stay hot, supported by ***thermal pressure, regulated***

H burns to He, He to C and 0 that are added to white dwarf

M_{wd} grows in C/0 mass

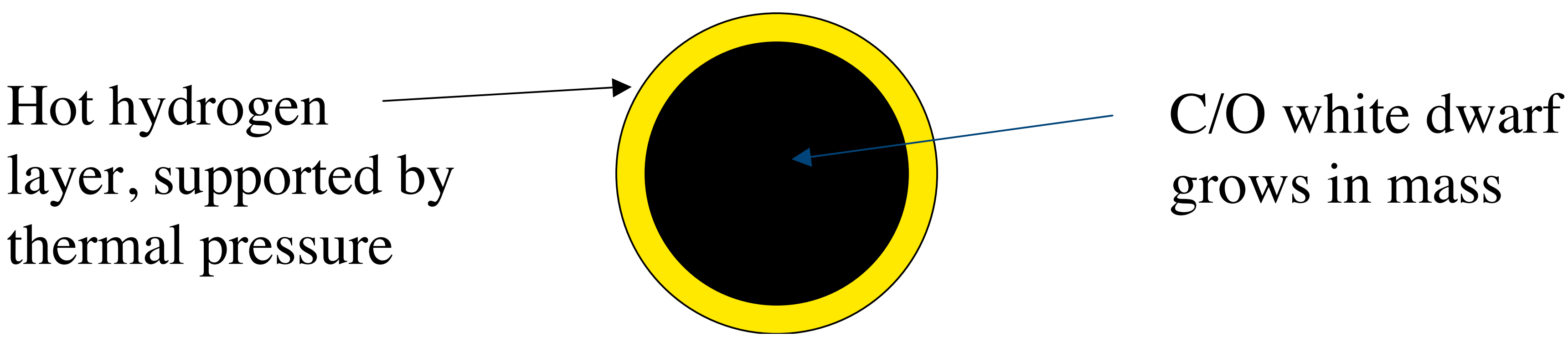
Hydrogen transfers from a main sequence star to a white dwarf in a binary system.

Higher rate of transfer, hydrogen does ***not*** have a chance to radiate and cool as it is added to the surface of the white dwarf, it stays hot and is supported by the ***thermal pressure***. If the hydrogen begins to burn the result is:

Regulated burning, bright flash, but no hydrogen explosion --> ***Recurrent Nova***

White dwarf gains mass, can grow to near Chandrasekhar mass

Eventually may ignite carbon in the center, quantum deregulated, explode whole star as a ***supernova***



A binary system could be a classical nova for some time
then accrete faster, convert to recurrent nova, grow WD to M_{ch}

Some white dwarfs may be born with larger mass.

Some white dwarfs grow to near the Chandrasekhar mass and explode, some don't.

We still don't fully understand why…

One Minute Exam

We expect classical nova systems to end up making two white dwarfs orbiting one another because:

A The first white dwarf loses mass and hence cannot grow and explode

B The first white dwarf will accrete mass until it reaches the Chandrasekhar limit

C The main sequence star transferring mass must eventually make a white dwarf

D The hydrogen layer is supported by thermal pressure