SUPERNOVA

--a supernova happens once somewhere in the universe every second

--there are two classifications of supernovas

- --Type I supernovas don't have hydrogen in their spectrum
- --Type II supernovas have hydrogen in their spectrum

--Type II supernovas are produced when the core of a large star collapses

- --we have already talked about this kind of supernova

--Type I supernovas can be produced in several ways

--Type Ib and Type Ic are core collapse supernovas just like the Type II we've already discussed except they are produced by large stars that have had much of their hydrogen removed from them by a companion white dwarf

--Type Ia produced by white dwarfs (remember, a white dwarf is really the core of a star that has lost it outer shell as a planetary nebulae)

--so how do Type Ia (white dwarf) supernovas work?

  --the key is in the fact that all of the accreted mass around a white dwarf in a binary star system does not blow when the dwarf novas

  --the consequence of this is that over time the dwarf's mass increases

--the lower bound for a supernova death is a star with a 1.4 solar mass core (the sun's core is considerably less than this)

--if a white dwarfs mass reaches 1.4 solar masses, the electron pressure holding the star from collapsing can no longer hold up, and the core implodes

--this increases core temperatures to the point where carbon fusion begins simultaneously throughout the core and the entire structure explodes

--(in other words, when this kind of supernova occurs, there's nothing left of the star when it's over)

--this is called a *carbon detonation supernova*

--final two point:

--first, the core collapse that generates a supernova happens in less than a second

--second, a large star that supernovas puts out as much energy as the entire visible universe does in one second

THE CORE OF A SUPERNOVA

--a star's after-death state is determined by the star's mass and takes one of three forms . . .

- --they can start out as a white dwarf and slowly devolve to a red dwarf on its way to cold oblivion (this is what our star will go)
- --they can become a neutron star
- --they can become a black hole

--a white dwarf death happens when a star's core mass is less than 1.4 solar masses, and when the star is not a part of a binary star system

--for stars whose core mass is between 1.4 and 1.8 solar masses (this corresponds to stars between 15 and 20 solar masses)

- --the core electrons fighting quantum intrusion will become so energetic that they become relativistic (i.e., the energies will exceed 1 MeV)

- --when these electrons meet protons, they will combine to make neutrons giving off a neutrino in the process

- --what stops the implosion is *neutrons* fighting quantum intrusion

- --by the time the implosion stops, the mass is around 10 km across

- --to simulate this kind of density on earth, you would have to take between 100,000,000 tons and 1,000,000,000 tons of stuff (remember the 1000 Nimitz-size aircraft carriers) and compress it down to the size of a marble

--A body moving in a straight line will have inertia (this is a tendency to resist changes of its motion). A rotating body will have *rotational inertia* (the tendency to resist changes in its *angular* motion).

--A measure of a body's inertia is called mass (big mass means the body will resist changes of its motion mightily). It is numerically quantified with the symbol "m."

--A measure of a body's rotational inertia is called *moment of inertia* (big *moment of inertia* means the body will resist changes of its rotational motion mightily). It is numerically quantified with the symbol "I."

-- Although they both quantify resistance to some kind of motion, moment of inertia is more complicated than mere mass. How so? Mass is related to the amount of “stuff” there is in a body. Moment of inertia is not only related to the amount of “stuff” there is in the rotating body, it is also related to how that mass is *distributed*.

> --It is harder to change the motion of a rotating body whose mass is distributed out away from its axis of rotation than it is for a rotating mass whose mass is close in to the axis of rotation. In the former case, the moment of inertia is large; in the latter case, the moment of inertia is small.

--Angular momentum is defined as a rotating body' s rotational inertia “I” times its angular speed “ω ,” or $I\omega$ “. (This, just as regular momentum is defined as the body' s mass “m” times velocity “v,” or “mv.”)

--Under the right conditions, a body' s angular momentum “L” can stay the same even though the body changes it' s mass distribution and, hence, it' s rotational inertia. (When this happens, the angular momentum is said to be “conserved.”)

--An example of this is an ice skater who does into a spin.

--At the beginning of the spin, the skater has some angular speed and has her arms outstretched. This distributes her mass out away from her axis of rotation giving her large rotational inertia (i.e., a big moment of inertia “I”). To start with, then, her angular momentum is:

$$\mathbf{I}\,\omega$$

--That is, big moment of inertia "I" and mediocre angular speed "ω."

$I\omega$

--This is one of those instances when angular momentum is conserved, so when she pulls her arms in and her rotational inertia goes down, her angular speed must increase so the product of the two stays the same. In other words, the conservation of momentum equation becomes:

$${\Huge I}\omega = I{\Huge \omega}$$

Stars spin, so when a star between supernovas and its core goes from the diameter of the sun to 15 miles across, its moment of inertia drops to almost nothing and its angular speed sky rockets. In other words, we get:

$$I \quad \omega = I \quad \omega$$

If this was all that was happening, it would be a nice theoretical novelty with no proof. Interestingly, though, neutron stars give off synchronous radiation--electromagnetic radiation in the radio frequency range that is very directional.

If the earth happened to be in the path of this honed synchronous radiation, our radio telescopes will pick up the radio transmission every time the neutron star rotates once.

When this was first observed, astronomers thought they were being hailed by life from another planet and they called the objects that produced the signals "pulsars."

After closer scrutiny, it was observed that the pulsar signals were all coming from the center of supernova remnants, which is to say from neutron stars.

What is truly remarkable is that these super dense, relatively large (15 miles across) structures have been found to be rotating at frequencies over 700 rotations per second. (Think about how fast you can snap your fingers, then try to imagine an object 15 miles across rotating over 700 times every second!)

In short, pulsars are really fast spinning neutron stars.

--everything that happens in the making of a neutron star happens for a star whose core mass is greater than 1.8 solar masses:

- --the difference is that stars in this category have cores that are so massive, *nothing can stop the implosion*

- --called *black holes*, we will talk about these later