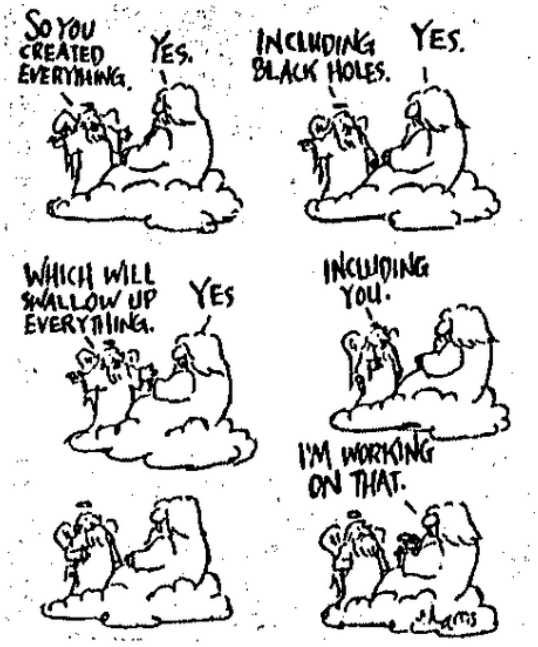
White Dwarfs

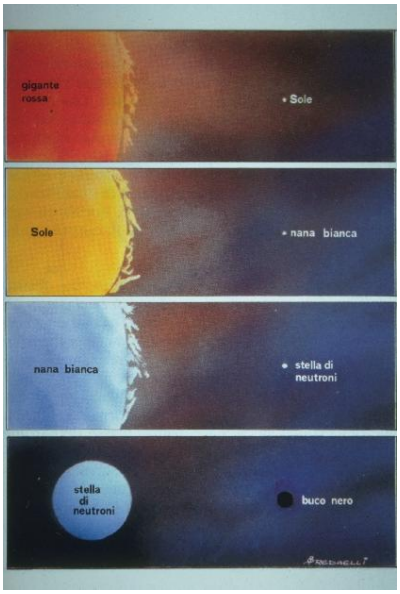
Neutron Stars

and

Black Holes



Solar Mass Star: Comparative Sizes



Red Giant vs Sun

Red Giants can be as big as the Earth's orbit around the Sun

Sun vs White Dwarf

White Dwarfs are about the size of Earth

White Dwarf vs Neutron Star

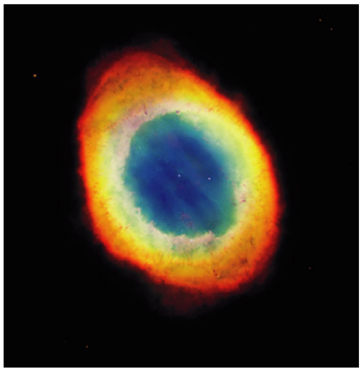
Neutron Stars are about the size of a small city, like Las Cruces

Neutron Star vs Black Hole

Solar mass Black Holes are about the size of a university campus, like NMSU

White Dwarfs

WDs are the hot core remnants of dying low mass (<8 Msun) stars. When they first form the outer layers of the star can be seen in a planetary nebula

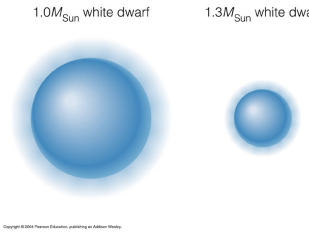


The WD is made of oxygen and carbon locked into a degenerate gas. The density is about 10^6 g (million times that of water).

A young unknown student in India named Chadrashekar realized that WDs with larger masses were smaller.

But, his calculations showed that at 1.4 times Msun, the locked together oxygen and carbon could no longer support the star! It had to collapse.

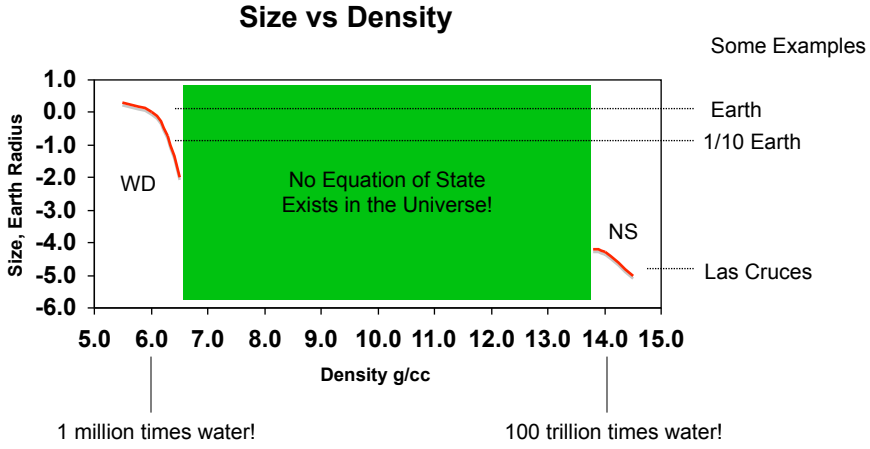
He was laughed at, but he was right.



(bigger mass -> smaller size)

Equation of State--- relationship between size and density

There is a vast region of density of matter where matter is unstable. There exists no physics nor form of matter to support itself from gravity.

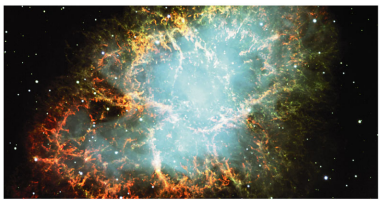


Thus, no objects exist with densities between a few million and 10 trillion times that of water (1g/cc).

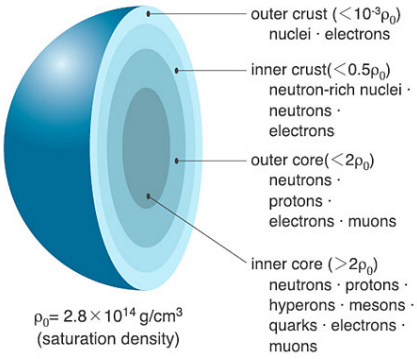
A Neutron Star is Born

So What Happens?

During SN explosion, if the core mass is greater than 1.4 Msun, then the core must totally collapse. All the atomic nuclei in all the atoms mash together into one big nucleus, made of neutrons and electrons and other forms of exotic matter.



CRAB NEBULA: a supernova that blew 950 yrs ago. It has a NS in its center.



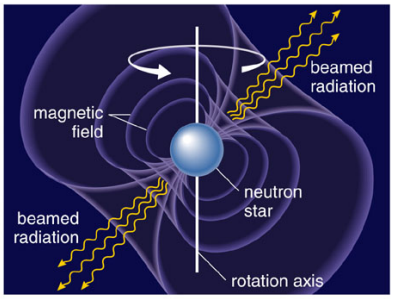
$\rho_0 = 2.8 \times 10^{14}$ g/cm^3 (saturation density)

How do we know?

Neutron stars are the lighthouses of the Universe.

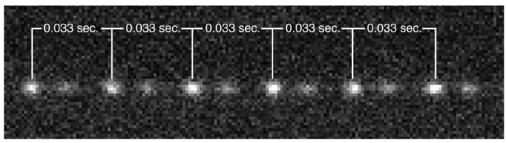
The *magnetic fields* of the stars also collapse and become very very concentrated.

The star is now **spinning very very fast** (between *30 up to 1 million times per second*!).



With all that energy and spinning, surface electrons get stripped out and *beam* gamma-ray, X-ray, UV, and optical radiation along the star' s poles.

Crab Nebula Pulsar pulses every 0.033 seconds



Neutron Star!

Called a **PULSAR**