Neutron Stars

Neutron star - characteristics
- small (~20 km)
- dense (10^{14} gm/cc = 100 aircraft carriers/cc)
- mass = around 1.5 solar masses

Theory: A supernova produces a neutron star

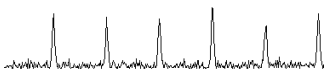
~~Can this theory be proven to be true~~?

Can this theory be supported?

1967 - Cambridge England

Radio telescope project

Jocelyn Bell



Pulsars!

What are they?

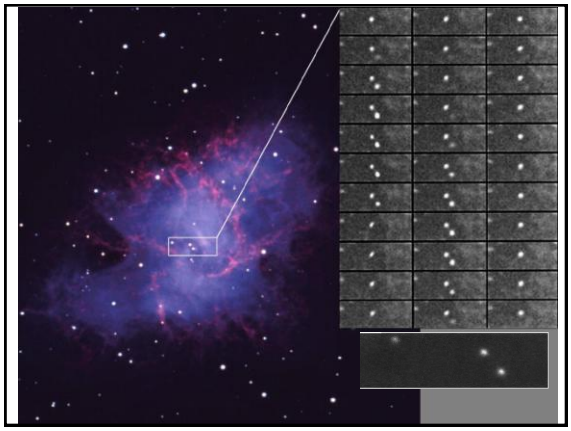
Rotating neutron stars?

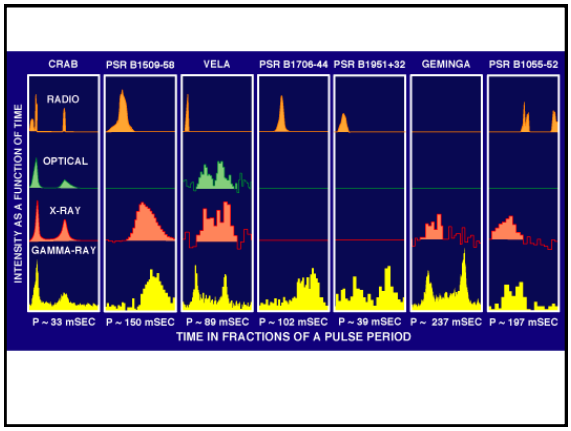
Crab Nebula - Supernova Remnant

Located inside is a pulsar!

Other remnants with pulsars!

Pulsar are Rotating Neutron Stars





A typical pulsar

The Crab pulsar

Very fast pulsar

Why so fast?

Conservation of Angular Momentum -

Rate of rotation ↔ Distribution of mass

What makes the radio pulse?

Compressed (STRONGER) Magnetic Field

So what does that do?

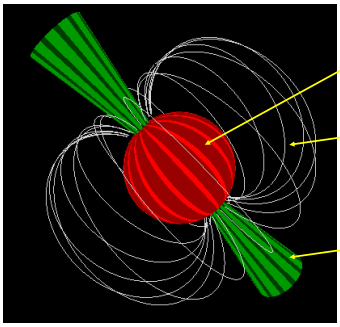
Electrons interact with the magnetic field

So what does that do?

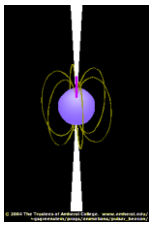
Electrons are accelerated by the magnetic field

SO WHAT DOES THAT DO?

Accelerated electrons give off **Synchrotron Radiation!**



Another movie



Black Holes

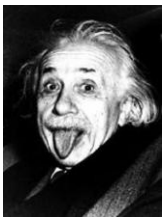
What if a core is too massive to be a neutron star?

It could become a black hole…..

What is a black hole?

What are its characteristics?

Need to take a detour into relativity



Special Theory of Relativity

Gives us $E=mc^2$

More importantly gives us the following rules -

1. The speed of light is constant (in space)
2. Nothing can go faster than the speed of light

So what? What's the big deal?

How fast will the ball be moving?

100 mph

How fast is the light moving?

V=c!!!!

Special Relativity - Limits the speed of objects, including light

Side effects as velocity get close to *c* (as seen by others)

- Lengths measure differently
- Colors (red-blue)
- Masses measure differently
- Time measured differently

Really?

Has been observed in many experiments!

General Theory of Relativity

The "difficult" theory

Basic premise -

1. Mass warps (distorts) space
2. Space influences how mass, or anything else in it, moves

Warped space?

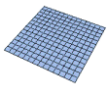
How is space warped?

Does this involve drugs? (no of course not)

3-dimensional space is warped into a 4th spatial dimension

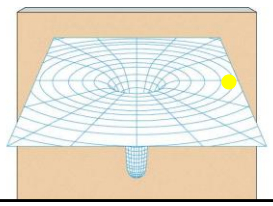
Huh?

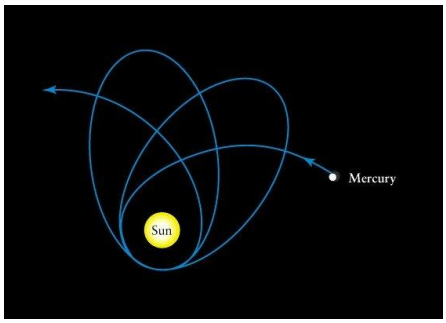
Use 2-dimensional analogies

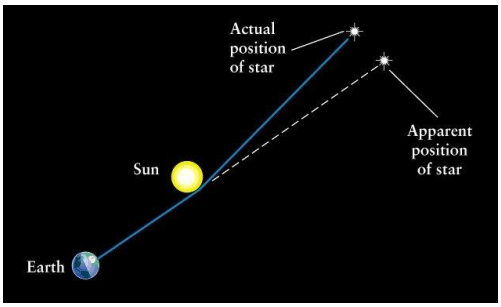


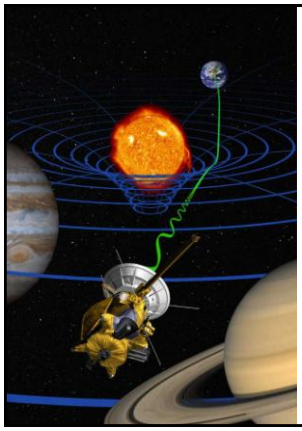
- Flat uncurved space
- Curved space

Objects must follow the shape of the space









Spacecraft heading for Saturn tested Einstein's theory of General Relativity

Test results matched prediction

Black Hole Characteristics

It has mass

Size =0

Huh?

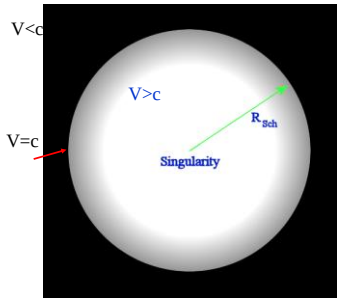
Size not defined - point = **singularity**

What else?

How close can you get to the singularity and still escape?

Schwarzschild Radius - "size" of a Black Hole

R_{sch} depends on the mass (1 solar mass = 3 km)



Journey into a Black Hole

Far from the black hole - everything's normal

Closer to the black hole, effects of relativity become obvious

How?

Let's send someone into the black hole!

Volunteers?


Far from the black hole - all normal

Astronaut - has a flashlight to signal us

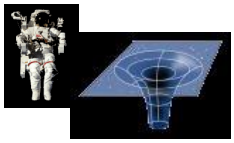
Bravely heads towards the Black hole



Closer to black hole, things get weird.....

We see
- astronaut moving slower
- light getting redder

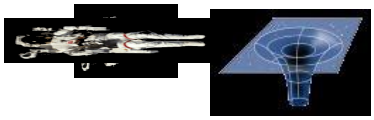
Astronaut sees
- us (the rest of the universe) moving faster
- more of the universe - wider view

Even closer to black hole, things get weird.....

We see
- astronaut moving really slow
- light getting redder (not visible eventually)

Word of warning - always go into a black hole sideways....



Why sideways?

Ouch!

Will we see the astronaut ever go into the black hole?

What will the astronaut see?

Do black holes really exist?

Black holes are black (they don't give off any light)

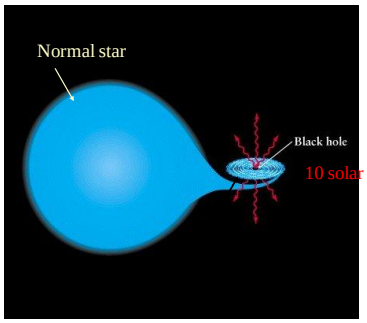
Space is black

How do you find one?

Look for its influence on its surroundings

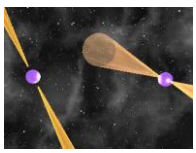
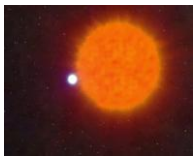
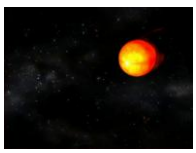
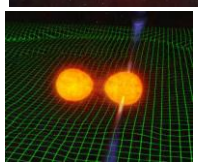
How?

By finding it in a binary star system



movie

Other Strange Binaries

SGR 1806-20 – magnetar gamma ray burst
December 2004