

But what happens when the density of the collapsing core exceeds 100 trillion times the density of water?

STRANGE THINGS HAPPEN-
YOU HAVE ENTERED

THE TWILIGHT ZONE



Light has no mass, but it follows the force of gravity!!!

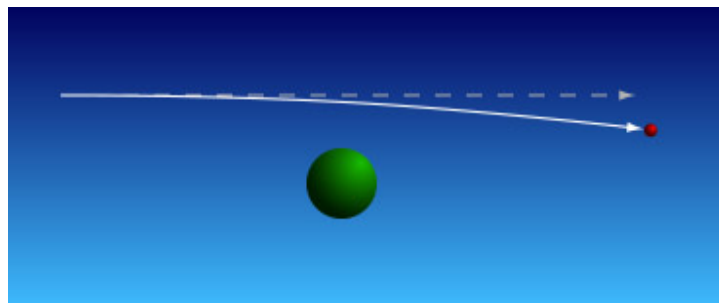
WHY?

Einstein's **THEORY OF GENERAL RELATIVITY**.

OI' Albert realized that **mass** places a stress on both **time** and **space**.

Thus, light is only following the local space time curvature...

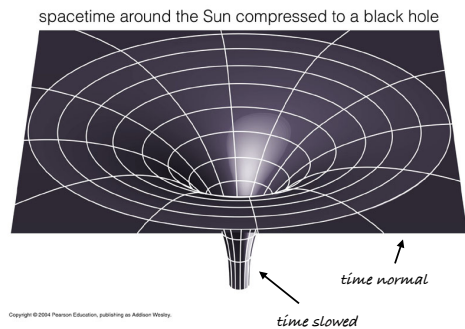
and this can cause *SOME... STRANGE... EFFECTS ...*



Mass really “warps” space and time.

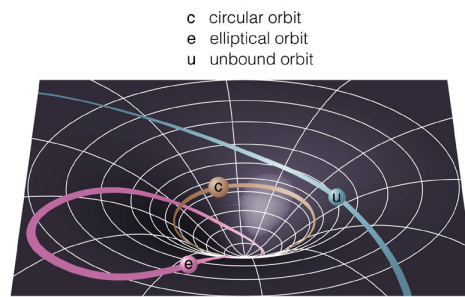
Think of space as a two dimensional sheet. A lot of mass in a small area forms a very deep and narrow funnel.

The more space is warped, the slower time flows. Deep in the funnel time passes slowly, away from the funnel it passes “normally”.



The motions of much smaller masses in the proximity of a massive object is governed by the shape of space.

It just so happens that Newton’s Law of Gravity describes these motions perfectly well, but only in regions that are not deep in the funnel. But note that Einstein says these motions are a consequence of space-time warps due to masses.

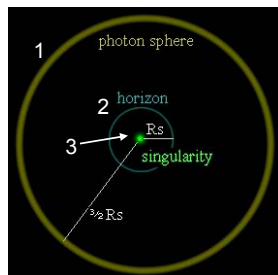


Black Hole

When the a large mass is confined to a small size, the funnel becomes infinitely deep!

The density is so high (greater than 100 trillion times water) that ...
no form of matter can support itself against the crush of its own space time warp!

$$R_s = \frac{2GM}{c^2} \quad \text{The “size” of a black hole!}$$



1. Photon Sphere: $1.5R_s$
distance where light can go into circular orbit!

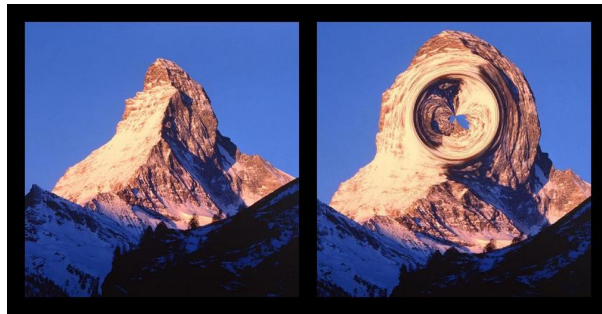
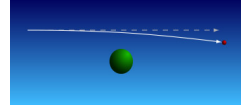
2. Event Horizon: R_s
distance where escape speed equals speed of light!

3. Singularity: ?
Mathematical point at center... we don’t know what it is, but it is where the point of the funnel comes to a head... if it does?

R_s = radius of event horizon is the “size of black hole.”
Depends upon mass and the speed of light.

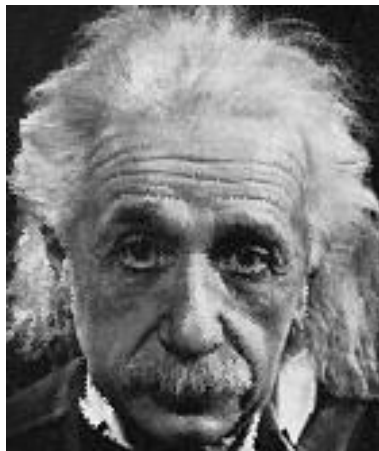
The shape of space around a black hole results in what we call the “bending” of light.

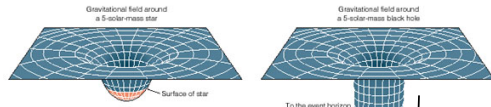
The bending of light can lead to some strange effects!!



If the Earth were squeezed to the size of a pea, it would collapse into a black hole!
If this pea sized, Earth mass black hole passed between you and a background object, the light paths would be bent and you would see some pretty bizarre features!

What would it look like if a Earth mass black hole passed in front of Albert?





The space time around a star is identical to the space time around a black hole, until you get close to the event horizon.

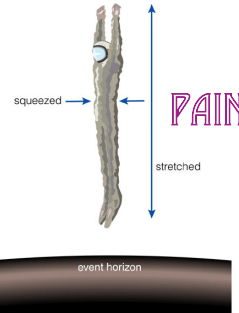
WHAT WE SEE WHEN YOU ARE FALLING IN

1. Redshifted (turn red) until redshifted to infinity (you disappear from view)
2. Time slows until it stops when you reach the event horizon

What you see is totally different than what we see

WHAT YOU SEE FALLING IN

1. Squeezed and stretched
2. Looking back out to the universe and all time passes by in an instant!

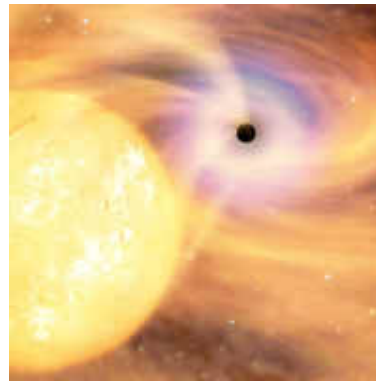
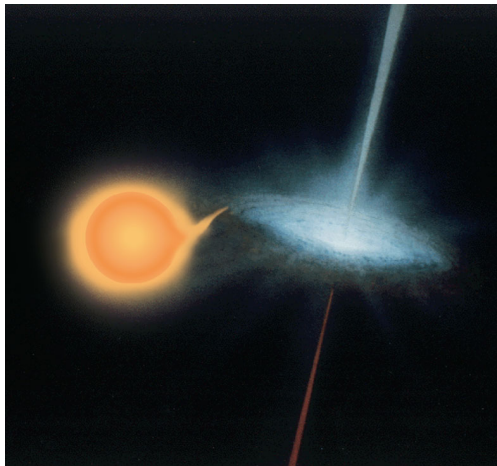


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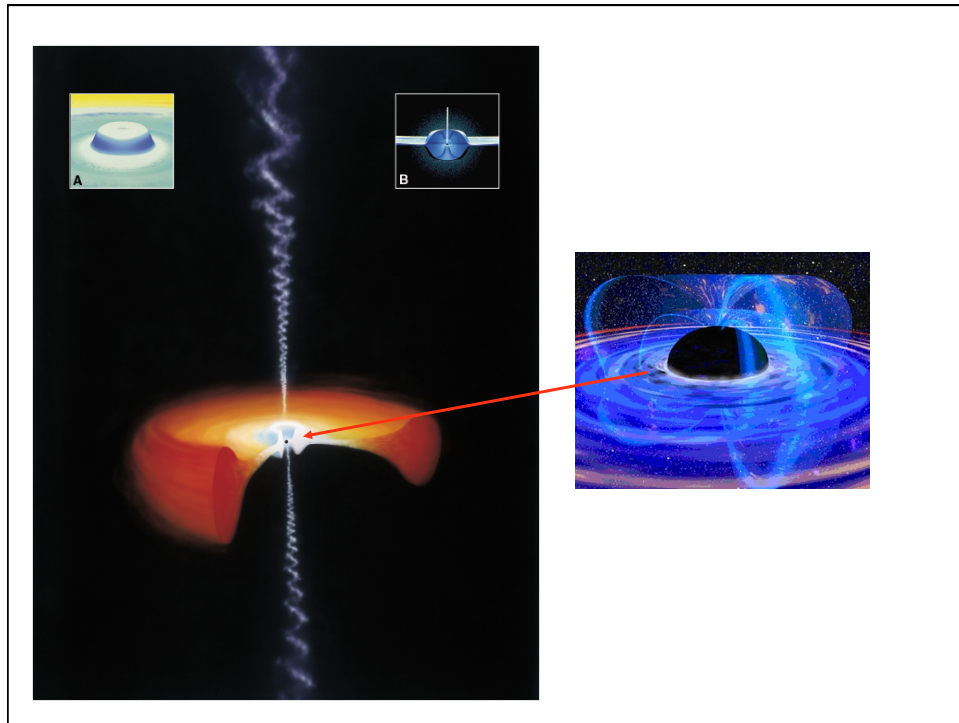
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Most black holes are found because they are eating their companion stars!

Like Neutron Stars, there are intense magnetic fields that channels some of the matter into jets.

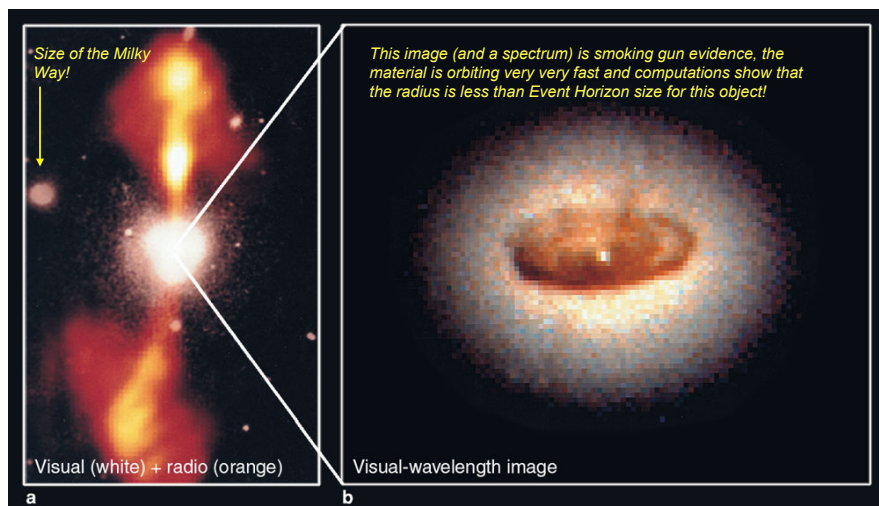


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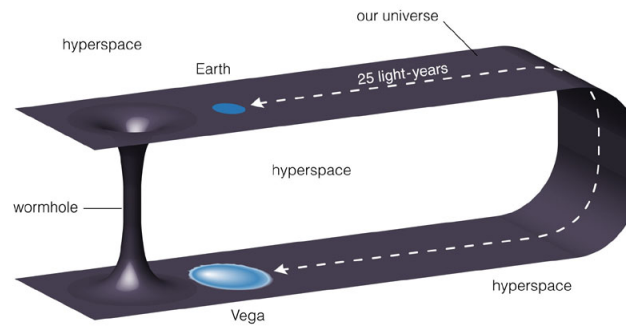
In some galaxies, black holes lurk in their centers. These BHs have devoured so much matter, **which makes them grow!** Some BHs have masses of several million M_{sun}

And the jets these babies make.... Astronomical Maniacs!!!! More later.



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Cheating Space... travel through a black hole and wormhole to Vega!



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