

Everything is in Motion, Everything is Connected, Everything is Relative


When you tune a radio to a spot between stations, the static you hear is, in part, radiation that was emitted a few hundred thousand years after the Big Bang, a remnant of the birth of the universe. You can use a laser pointer and a dab of glue to visualize the chaotic and incessant motion of molecules. You can make a measurement that affects the outcome of another measurement thousands of miles away, with no communication. The matter that we know and understand only makes up only 4% of the universe, and we aren't sure what the other 96% is.

In the past two courses I've offered we've looked at the physics of life and the physics of everyday life, dealing with topics most people have some familiarity with. This course is a bit different. We'll still do some tabletop experiments and share some interesting demonstrations. But we'll use what these teach us to illuminate some of the most fascinating topics in all of science, things you may never have thought about.

Brian Jones
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Week 1

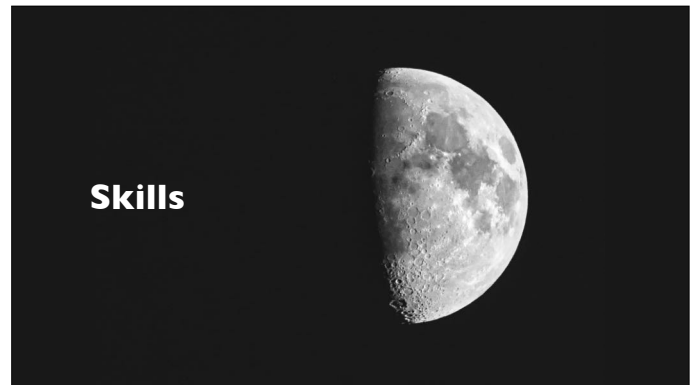
We Don't Know What the Universe is Made of:
The Strange Story of Dark Matter and Dark Energy



Theory of the Class

**Active
Social
Focused on
Wonder**

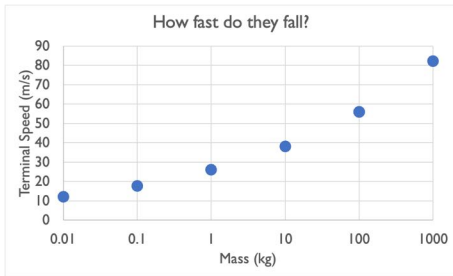
Ask questions when you have them
Let me know how its going
You may not understand the fine points, but you will understand the key points



Skills

Reasoning From Trends

How fast do they fall?



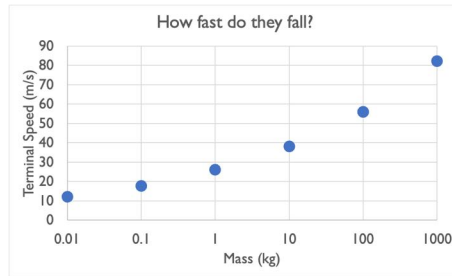
Mass (kg)	Terminal Speed (m/s)
0.01	10
0.1	18
1	28
10	40
100	55
1000	80

As a group, discuss and report:

What is a one sentence description of the trend the graph shows?

Reasoning From Trends

How fast do they fall?



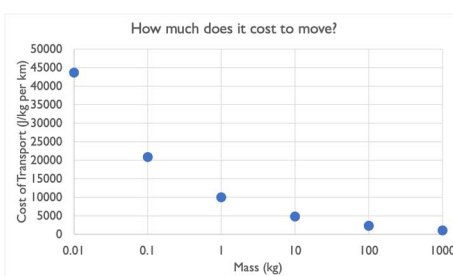
Mass (kg)	Terminal Speed (m/s)
0.01	10
0.1	18
1	28
10	40
100	55
1000	80

As a group, discuss and report:

Use this trend to explain something one might notice in the living world.

Reasoning From Trends

How much does it cost to move?



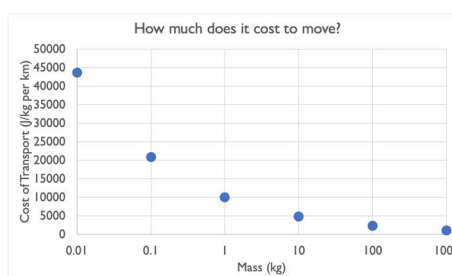
Mass (kg)	Cost of Transport (\$/kg per km)
0.01	45000
0.1	20000
1	10000
10	5000
100	3000
1000	2000

As a group, discuss and report:

What is a one sentence description of the trend the graph shows?

Reasoning From Trends

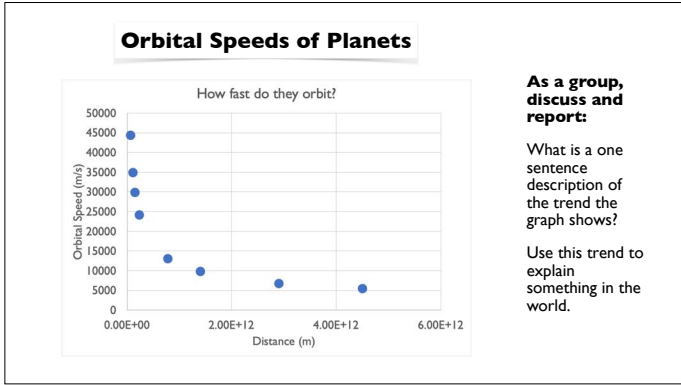
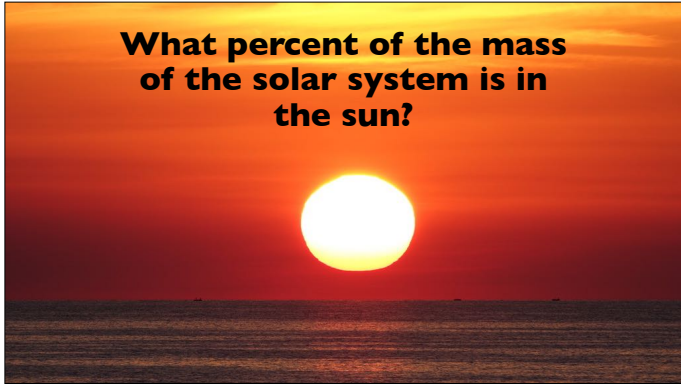
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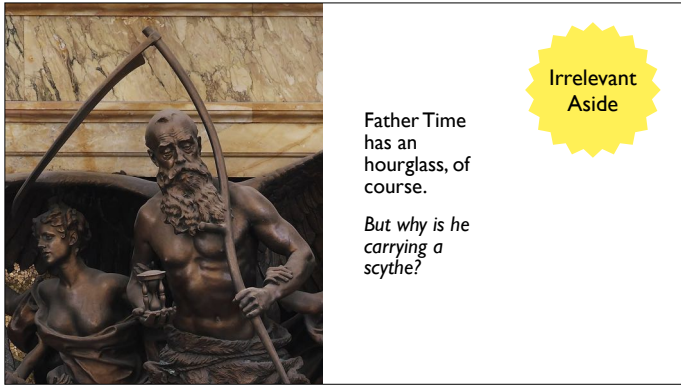
As a group, discuss and report:

Use this trend to explain something one might notice in the living world.

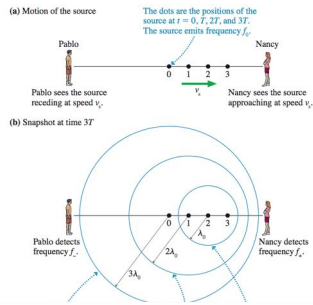


Saturday	Saturn	Samedi
Sunday	Sun	Dimanche
Monday	Moon	Lundi
Tuesday	Tyr / Mars	Mardi
Wednesday	Woden / Mercury	Mercredi
Thursday	Thor / Jupiter	Jeudi
Friday	Freya / Venus	Vendredi

Irrelevant Aside



The Doppler effect



If the source of sound is moving toward you, the wavelength shifts shorter.
 If the source of sound is moving away from you, the wavelength shifts longer.

The Doppler Effect Works For Light Waves

Long Wavelengths

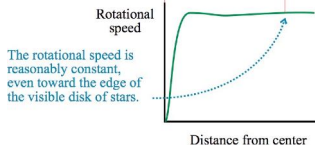
Short Wavelengths



You Can Use the Doppler Effect to Measure How Fast Things Are Moving

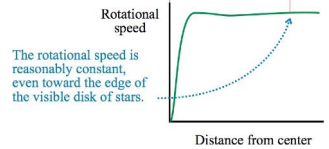
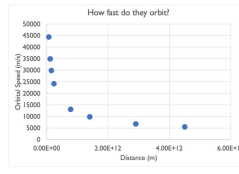


Galactic rotation curves



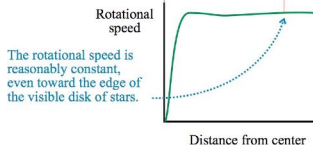
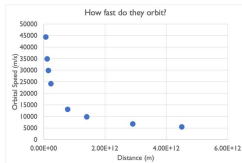
So, Things Are Orbiting Faster Than They Should.

Galaxy NGC3198

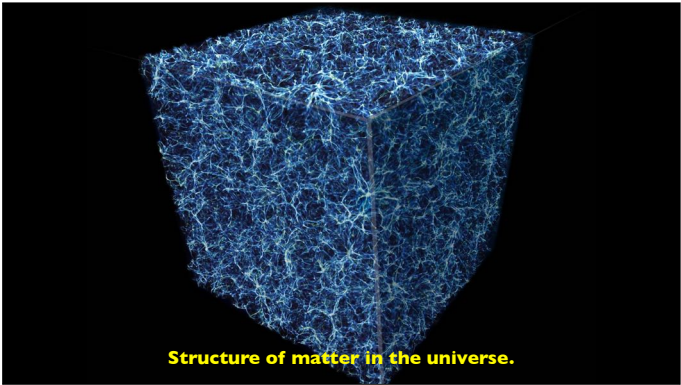
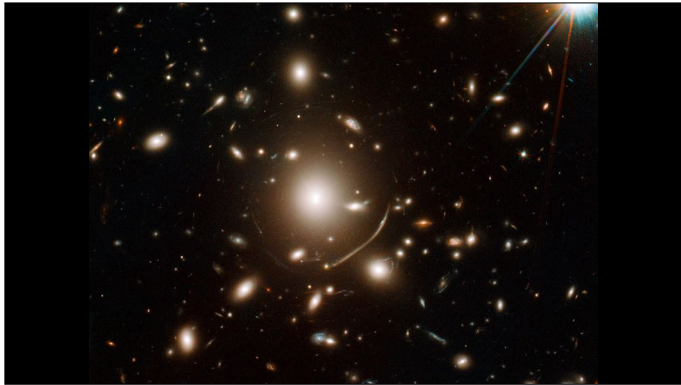
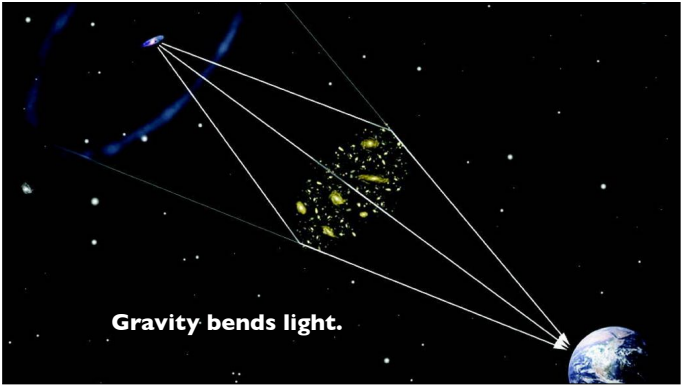
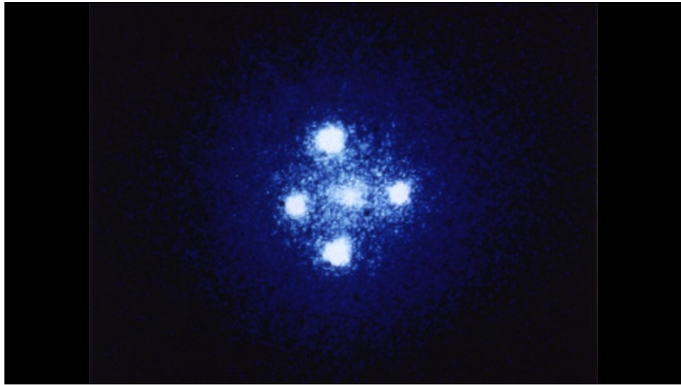
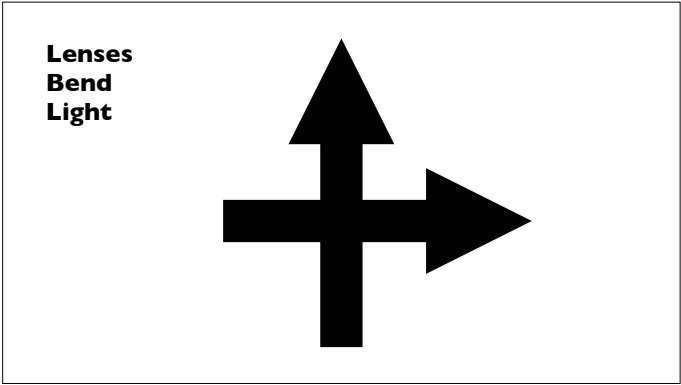
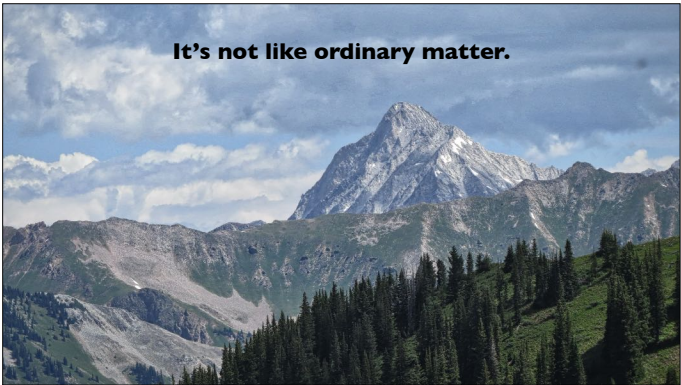
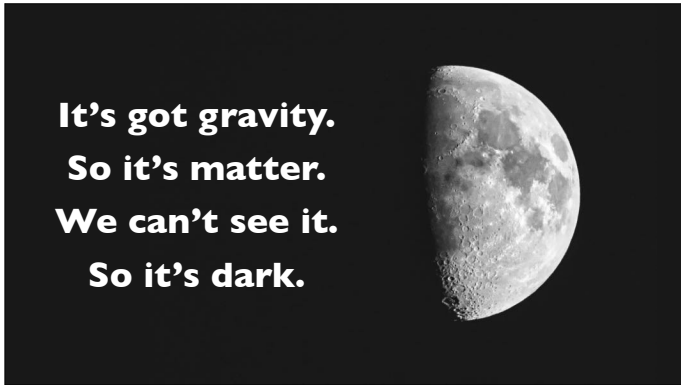


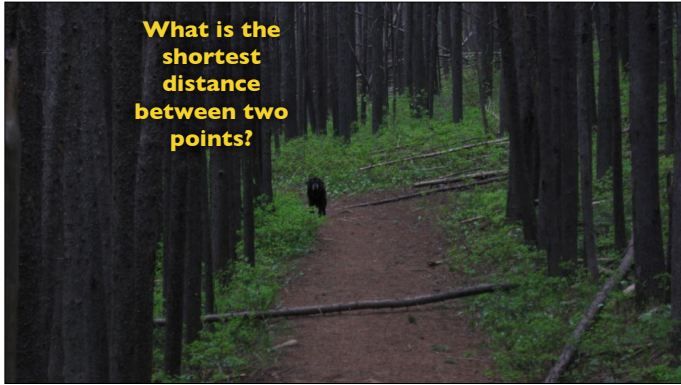
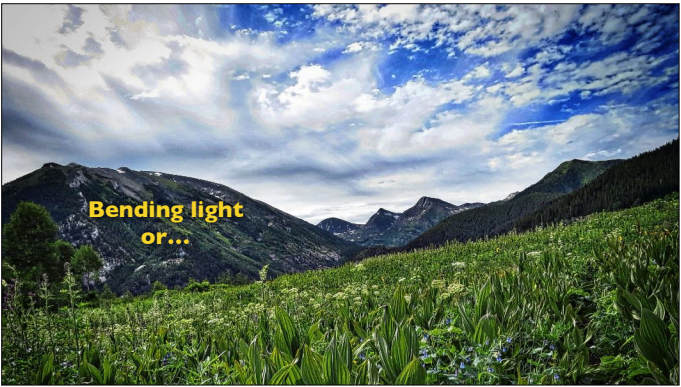
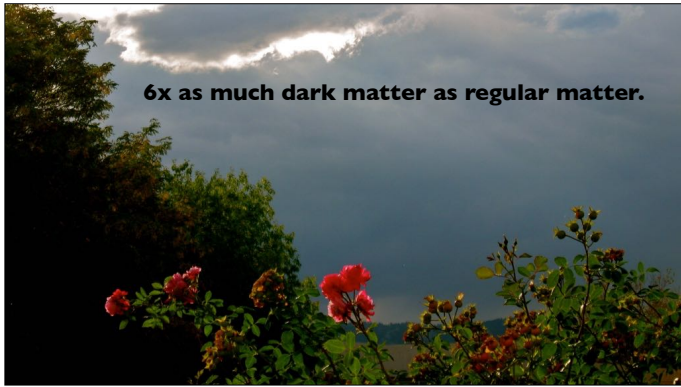
What Can We Conclude From This?

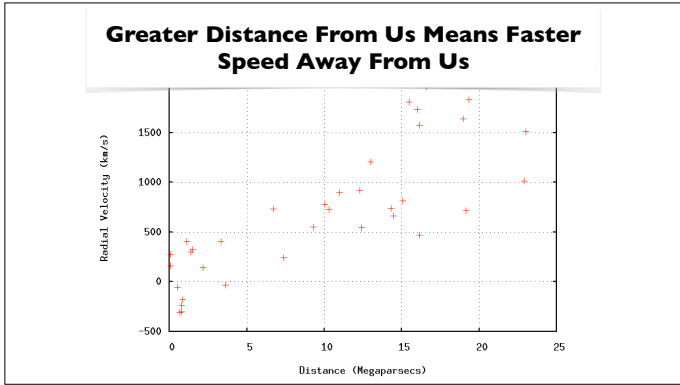
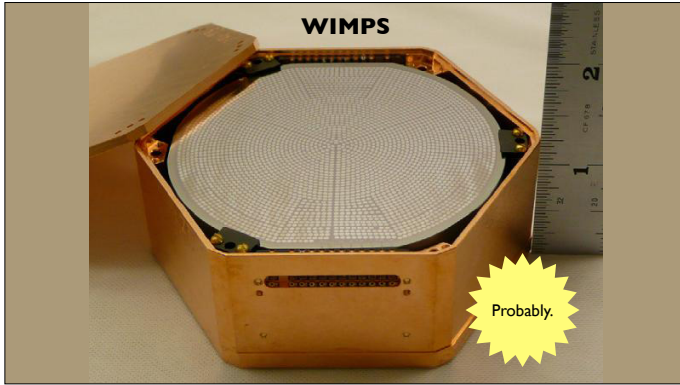
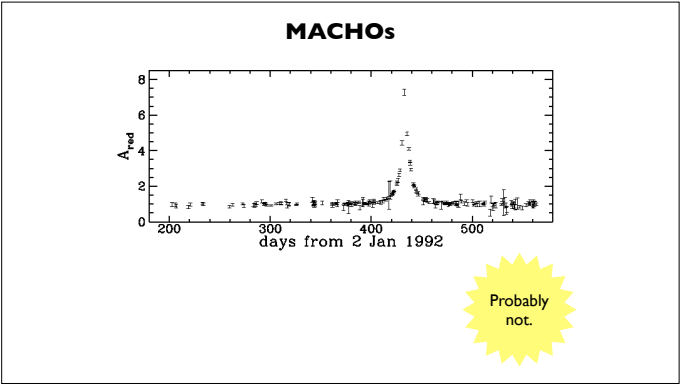
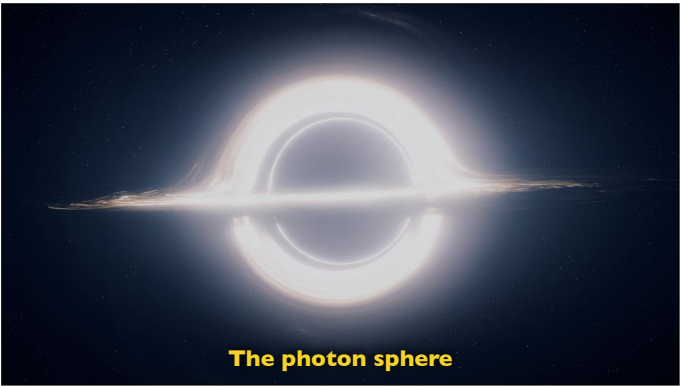
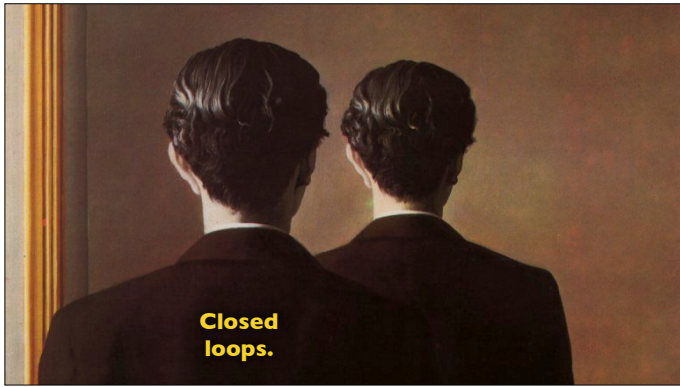
Galaxy NGC3198



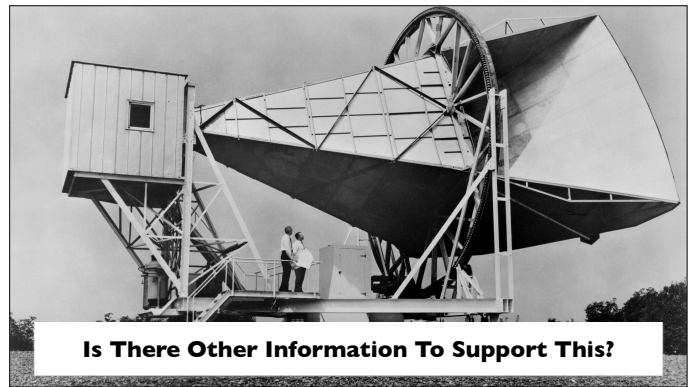
There is a whole bunch of stuff that we can't see. It forms a halo around and through our galaxy.





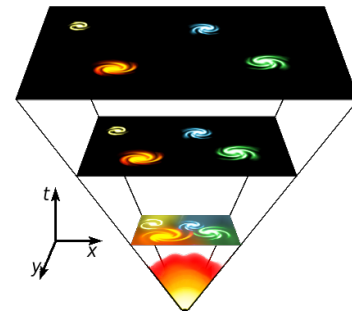
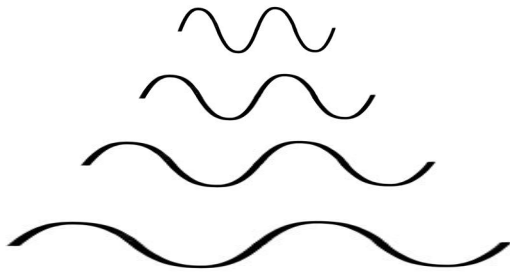


The Universe Is Expanding

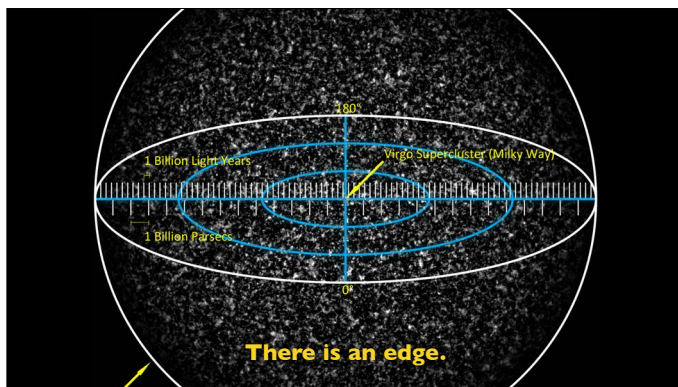


Is There Other Information To Support This?

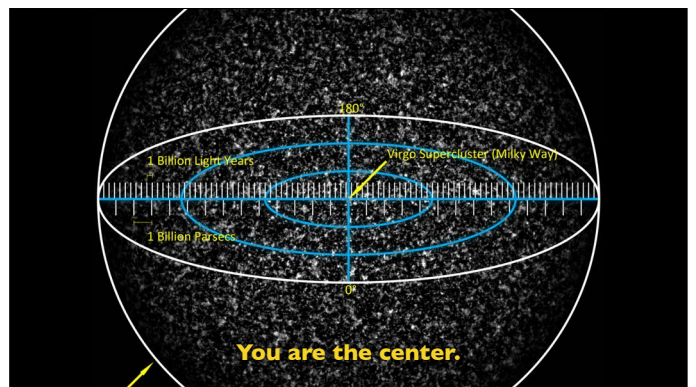
The Static Is Light.



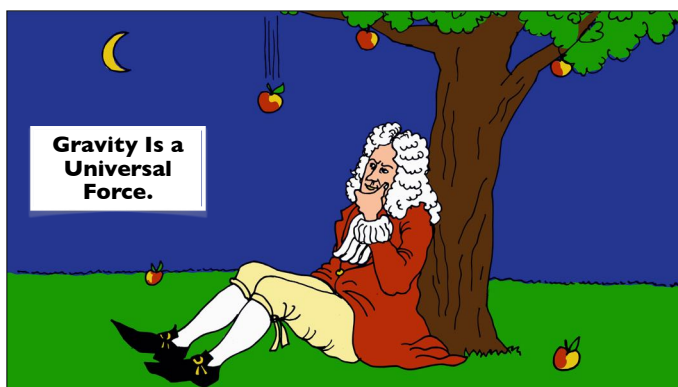
Big Bang Cosmology



There is an edge.



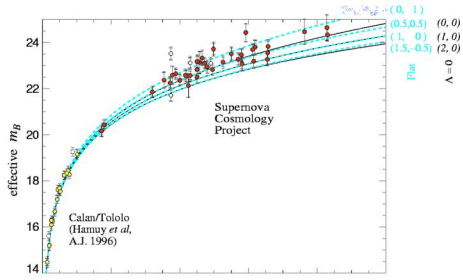
You are the center.



Gravity Is a Universal Force.



Should the Expansion Be Speeding Up, or Slowing Down?



The rate of expansion is increasing...

What is pushing out?



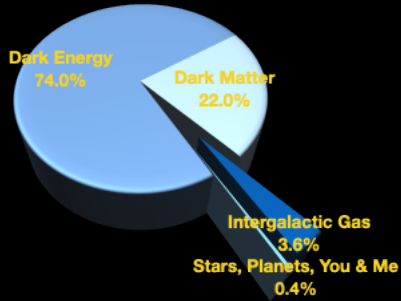
It's not matter.
So it must be energy.
We can't see it.
So it's dark.



Dark Energy.



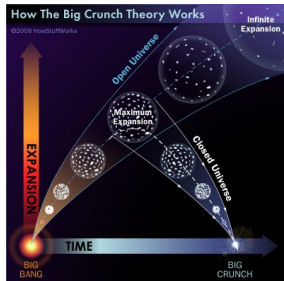
The Universe As It Is.



0.4 % of the universe.



The Shape Determines the Future.



If there is a contraction, what happens to time?

