Cosmology Demonstrations

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INTRODUCTION:
This lab is broken up into several short demonstrations to help you understand a variety of concepts associated with cosmology. Each demonstration has its own question(s) to consider.

MATERIALS & EQUIPMENT:

- ❑ Plastic cup
- ❑ Dry powdered milk
- ❑ Spoon
- ❑ Balloon
- ❑ Sharpie pen
- ❑ 60cm length of string
- ❑ Ruler
- ❑ Photo of star field

PROCEDURE:

Part A – Galactic Rotation

In 1924 Edwin Hubble discovered that the Milky Way was just one of many galaxies in the Universe. Each galaxy contains billions of starts that rotate around a mass at or near the center of the galaxy. He categorized these galaxies according to their shape.

1. Fill the cup halfway with cold water.
2. Rotate the cup slowly to get the water flowing in a circular motion.
3. Sprinkle about ½ tsp. of powdered milk into the center of the cup.
4. Stop rotating the cup.
5. Observe what happens.
6. DRAW you results.
7. Repeat the steps above conducting 5 more trials, changing the speed of rotation each time (faster or slower).

Part A – Question to Consider

How do your drawings compare with the Hubble Classification galaxy shapes that you studied earlier in this unit?

Based on the observations I took in my lab when we added the dry milk to the water and spun the water around I would categorize the type of spirals as something resembling a E3 elliptical spiral. Which has a deeper nucleus and is more compact. A lot of E7 elliptical spirals, which just consist of a wider nucleus and overall wider surface area.

My observations also included a SBc barred spiral, as well as a SBb barred spiral. Both of which develop arms, and are different in that the SBc barred spiral has two arms not compactly curved and the SBb barred spiral has more compact curved arms. Any other spiral we got resembling a galaxy would probably be categorized as an irregular.

How does altering the speed of rotation affect the galaxy shape?

Based on the observations I took in my lab, I found that the faster the galaxy was spinning the more arms it developed. The speed also governed the form the arms were in, for instance I found that a faster spinning galaxy had more curved arms and resembled a SBb barred spiral. The slower spinning galaxies were often more compact, and did not develop arms that were easily visible.

Part B – The Expanding Universe

In the 1920s Edwin Hubble observed the light coming from different galaxies and was able to determine that the farther something was from Earth, the faster it seemed to be moving away. This relationship, known as Hubble's Law, pointed to the fact that the universe must be expanding.

1. Inflate your balloon to roughly 10cm in diameter. Do not tie the end.

2. Make six dots on the surface of the balloon in widely scattered locations.
3. Label one dot "Home" and the others A-E. Home represents the Milky Way, the other dots represent other galaxies formed in the early Universe.
4. Use the string & ruler to measure the distance from Home to each galaxy and record these under the heading "Time 1".
5. Inflate the balloon so that the diameter in roughly 15cm. Do not tie the end.
6. Measure and record the distances once more under the heading "Time 2".
7. Repeat the steps above at least 3 more times.

Part B – Questions to Consider

Which galaxies appeared to move the greatest distance?

The galaxies that appeared to move the greatest distance from the home galaxy was B, C, & D. This is because they were located closer to the top of the balloon as opposed to the home galaxy which was near the bottom. And if you've ever seen a balloon inflate you may have noticed that it is not a perfect sphere. More often than not the top of the balloon will extend farther and faster than the outsides, and one the top has reached it's limit the sides will begin to grow bigger. If you can imagine the points B, C, & D on the top of the balloon they would move farther away from home sooner and faster than any other point that is not near the top of the balloon.

Explain how this model relates to the Big Bang?

The theory of the big bang is that time, space, energy, and matter all came into existence 13.7 billion years ago. In tit's first moments, the universe was infinitely dense, unimaginable got, and contained pure energy. But within a tiny fraction of a second, vast numbers of fundamental particles had appeared, created out of energy as the universe cooled. Within a few hundred thousand years these particles had combined to form the first atoms. This relates to our experiment in that when the balloon was expanding the universe was getting bigger and bigger and the space between all of the objects got bigger or smaller.

How might you use this model to explain the The Big Rip, The Big Crunch and The Big Bounce?

I personally know these terms by different names being: The open, closed, and flat universe. They are all theories on the fate of the universe. If the density of the universe is exactly a critical value it is “flat.” In a flat universe parallel lines never meet. The 2-D analogy is a plane. The universe is thought to be flat or nearly flat.

If the universe is denser than a critical value, it is positively curved or “closed” and is finite in mass and extent. In such a universe parallel lines converge. The 2-D analogy is a spherical surface. If the universe is less dense than a critical value, it is negatively curved or “open” and infinite. The 2-D analogy of such a universe is a saddle-shaped surface on which parallel lines diverge.

Part C – Ranking the Stars

About 2100 years ago, the Greek Astronomers Hipparchus & Ptolemy observed that the stars in the night sky varied significantly in their brightness, so he devised a system that ranked them into one of six different categories. Stars in category 1 are the brightest and category 6 stars are the dimmest. Stars in category 1 are 100 times brighter that the stars in category 6.

In the early 1900s, Annie Jump Cannon devised a classification system for stars based on their color. She found that their color and temperature were closely related.

Class	Temperature	Color
O	30,000 - 60,000 K	Blue
B	10,000 - 30,000 K	Blue-white
A	7,500 - 10,000 K	White
F	6,000 - 7,500 K	Yellow-white
G	5,000 - 6,000 K	Yellow
K	3,500 - 5,000K	Yellow-orange
M	< 3,500 K	Red stars

1. Look at the photo of the star field provided by your teacher
2. Pick 10 stars and label them 1-10
3. Classify each of them according to color and brightness
4. Record your data

Part C – Question to Consider

What are the limitations of the brightness scale developed by Hipparchus and Ptolemy?

What I think is the most serious limitation of having a brightness scale developed by Hipparchus and Ptolemy is that it is certainly not specific enough. There are certainly more than 7 varieties of stars colors. Another major flaw is that they could not see the entire sky when they were creating the table, therefore they could not see all the different varieties of stars their were.

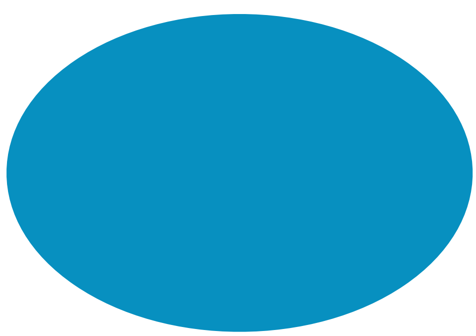
How has the brightness (or Magnitude) scale evolved since they first developed it?

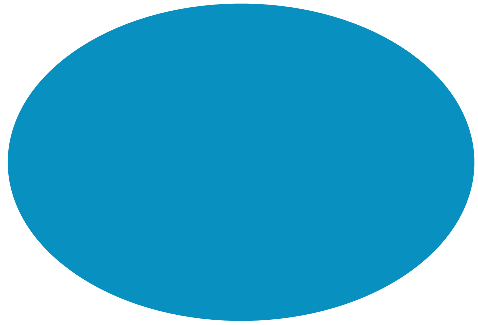
What I think the major difference that we have been able to offer the brightness scale is specificity. We have been able to attribute many more levels of brightness or magnitude to the scale. We have also been able to see more stars at one time and overall throughout the years allowing us to get a better idea of what the magnitude of each star is and how they vary.

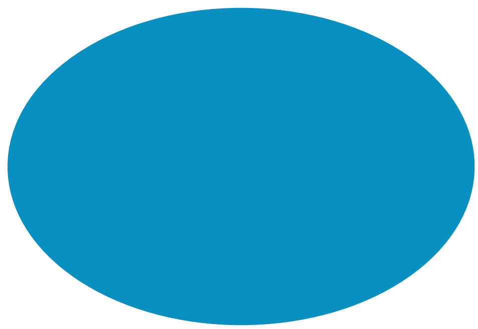
How is our Sun classified?

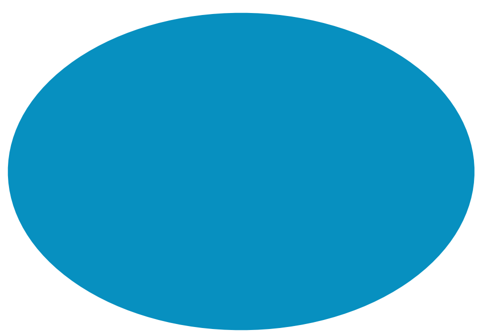
The Sun is classified as G2, which is probably the best known. It is just a slight variation of G on the chart we got in our assignment.

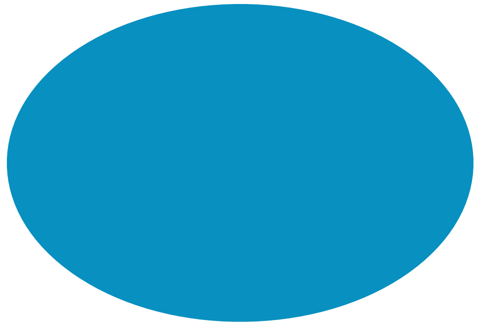
Data Tables:

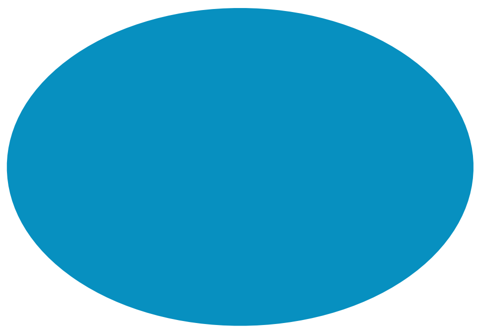
Speed	Notes	Visual Observations
The Speed of this test was a 4 out of 10 with 10 being the fastest	This trail had a very concentrated center and very few arms branching off of the center, and the arms disappear as it gets slower	

Speed	Notes	Visual Observations
The Speed of this test was a 9 out of 10 with 10 being the fastest	This trail did not have a very concentrated center but had many arms and had hardly any depth, and it was just spread out around the cup	

Speed	Notes	Visual Observations
The Speed of this test was a 6 out of 10 with 10 being the fastest	This trail had a very concentrated center not very many arms that were easy to see and recognize	

Speed	Notes	Visual Observations
The Speed of this test was a 8 out of 10 with 10 being the fastest	This trail contained a lot of arms with a very dense center that was considerably smaller than the other trials did not have much depth	

Speed	Notes	Visual Observations
The Speed of this test was a 5 out of 10 with 10 being the fastest	This trail had all of the particles clumped at the center so the density was equally distributed about the mass of particles	

Speed	Notes	Visual Observations
The Speed of this test was a 1 out of 10 with 10 being the fastest	This trail had every single particle in the center of the cup very tightly packed together with now signs of arms or any spreading out	

Distance From Home	A	B	C	D	E
Time 1	8Cm	8Cm	6Cm	11Cm	13Cm
Time 2	12Cm	18Cm	16Cm	20 Cm	26Cm
Time 3	15Cm	22Cm	21Cm	21Cm	19Cm

Number	Classification
1	B

Number	Classification
2	K
3	G
4	D
5	B
6	M
7	M
8	O
9	K
10	M

Data Analysis:

The theory of the big bang is that time, space, energy, and matter all came into existence 13.7 billion years ago. In tit's first moments, the universe was infinitely dense, unimaginable got, and contained pure energy. But within a tiny fraction of a second, vast numbers of fundamental particles had appeared, created out of energy as the universe cooled. Within a few hundred thousand years these particles had combined to form the first atoms.

The big bang was not an explosion in space, but an expansion of space, which happened everywhere. Physicists do not know what happened in the first instant after the big bang, known as the Planek era,, but at the end of this period, they believe that gravity split from the other forces of nature followed by the strong nuclear force.

Many people believe tis event triggered "inflation" which is a short but rapid expansion. If inflation did occur, it helps to explain why the universe seems so smooth and flat. During inflation, a fantastic amount of mass-energy came into existence, in addition with an equal but negative amount of gravitational energy. Bu the end of inflation, matter had begun to appear.

The fate of the universe could come in any number of ways, there are three that have been the most commonly known. These are the open, closed, and flat universe. They are all theories on the fate of the universe. If the density of the universe is exactly a critical value it is "flat." In a flat universe parallel lines never meet. The 2-D analogy is a plane. The universe is thought to be flat or nearly flat.

If the universe is denser than a critical value, it is positively curved or "closed" and is finite in mass and extent. In such a universe parallel lines converge. The 2-D analogy is a spherical surface. If the universe is less dense than a critical value, it is negatively curved or "open" and infinite. The 2-D analogy of such a universe is a saddle-shaped surface on which parallel lines diverge.

I began this lab by filling a cup halfway with cold water, and rotating it in a circular motion. This was so that the water was moving in a spiraling motion when we added the milk powder to it. Adding the powdered milk to the water was supposed to make the characteristics of the water spinning stick out more. We preformed these steps 5 more times and twirling the water different speeds each time so that we could see how the speed of rotation affected the galaxy itself.

We found that the faster the galaxy rotates, the more arms it has. We also found though that these galaxies could vary from many categories. They were elliptical, normal, and barred and occasionally irregular. Usually the faster they were the more they leaned towards barred spirals. Another factor that came into play regarding speed was the size of the nucleus. If you look at the classification of galaxies the nucleus of the galaxies range from all different sizes. In my experiment I found that the faster the galaxy was spinning the wider the nucleus was. This is because usually when you spin anything it has the tendency to spread out as you could see in the galaxy.

In part B of the lab we drew a few points on a balloon and measured the distance from one of the points to all the others on the balloon. We then increased the size of the balloon so the distance from the points would get bigger. And we repeated that step twice. We found that the galaxies that appeared to move the greatest distance from the home galaxy was B, C, & D. This is because they were located closer to the top of the balloon as opposed to the home galaxy which was near the bottom. And if you've ever seen a balloon inflate you may have noticed that it is not a perfect sphere.

More often than not the top of the balloon will extend farther and faster than the outsides, and one the top has reached it's limit the sides will begin to grow bigger. If you can imagine the points B, C, & D on the top of the balloon they would move farther away from home sooner and faster than any other point that is not near the top of the balloon.

In part C of the lab we picked 10 stars from this picture:

and classified them using the chart that was provided. We found that there were a lot of red stars, which are the very lowest in temperature.

It is worth noting that we may have spun the water in the cup unevenly which could have changed some of our results. It is also worth noting that we may have also placed some of the dots on the balloon to close together which also could have altered our results.

Conclusion:

I did not have a hypothesis for this lab so I cannot state if it was correct or not. I learned how stars are created and what it takes to create them. I learned the life cycle of a star. I learned how galaxies differ based on their shape and size. And I learned how this lab can improve my understanding of the big bang.

WEB LINKS:

http://amazing-space.stsci.edu/resources/explorations/index.shtml
(Click on Star Light Star Bright)

http://cas.sdss.org/dr6/en/proj/basic/color/

http://mix.msfc.nasa.gov/IMAGES/HIGH/9809529.jpg