DETROIT THE NEW Science CENTER

DASSAULT SYSTEMES PLANETARIUM

JOURNEY TO THE EDGE OF SPACE AND TIME

Teacher's Resource Kit

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Journey to The Edge of Space and Time
Teacher's Resource Kit

Introduction to the Dassault Systèmes Planetarium

Thank you for scheduling a field trip to the New Detroit Science Center and the Dassault Systèmes Planetarium. The Planetarium is a 50-foot wide theater, featuring 116 seats with room for 6 wheelchairs and assisted listening devices for the hearing-impaired. The Planetarium can transform into the interior of a spacecraft, taking you to witness the birth of a star, or explore the heavens above as you take a personal tour of the night sky.

Information about the Show

Come along on a fantastic voyage to the edge of all we know. This dynamic 30-minute show takes the audience on a journey to a black hole, galaxy clusters, and to the birth of the universe. With telescopes expanding our view, the pieces of a cosmic puzzle are falling into place, promising answers to once unanswerable questions: Find out more in Journey to the Edge of Space & Time.

This show appropriate for

Grade Level(s):	6-12
Program Length:	40 minutes

Michigan Curriculum Benchmarks

Journey To The Edge of Space and Time covers these benchmarks:

Elementary School
Motion of Objects III, 1-3
Matter & Energy IV. 2-7
Waves & Vibrations IV. 4-3-6
Solar System, Galaxy & Universe V. 4-1-3

Middle School
Motion of Objects III, 1-3
Matter & Energy IV. 2-7
Waves & Vibrations IV. 4-3-6
Solar System, Galaxy & Universe V. 4-1-3

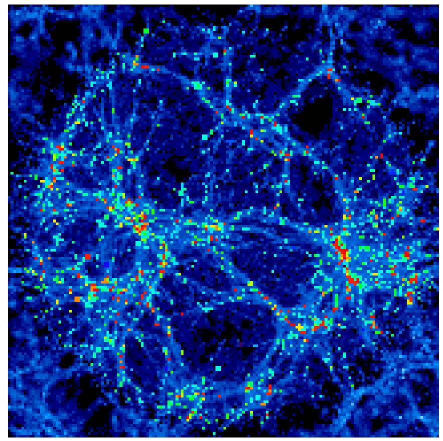
Michigan Curriculum Benchmarks (Continued)

High School
Motion of Objects III 1-2
Matter & Energy IV. 2-5
Waves & Vibrations IV. 4-4
Solar System, Galaxy & Universe V. 4-2,3

Program Objectives:

Upon completing this program, students will be able to:

1. Describe how the universe got started;
2. Explain how astronomers can look back in time with telescopes;
3. Explain how to use supernovae to measure distance;
4. Describe which stars can become black holes, and that process.



The New Detroit Science Center and the Dassault Systèmes Planetarium will assist you in building and utilizing curricula based on the above-mention standards and benchmarks.

We welcome any suggestions, comments, or tips on the activities and resources in this kit, so we can improve these resources for you and your students! Thanks for choosing the New Detroit Science Center & Dassault Systèmes Planetarium!

Todd Slisher - Extension 449
Director of Science Programs
tslisher@sciencedetroit.org

John Schroer - Extension 435
Planetarium Education Coordinator
jschroer@sciencedetroit.org

Pre-visit Activities: JEST Q & A

Questions to discuss before your visit.

Q: How old is the Universe?

A: According to many cosmologists, our universe appears to be approximately 13.7 billion years old. That makes our solar system a mere youngster, less than half as old as the universe.

Q: If the Universe is only 13.7 billion years old, then there was a beginning to the Universe?

A.: As far as we can tell with observations, the universe is getting bigger and bigger, with the space between galaxies growing larger. That means that at one time in the past the galaxies were closer together. So that leads astronomers and cosmologists to the conclusion that everything in the universe was one very small and hot spot, and something triggered the growth or expansion of the universe. This beginning is called the **Big Bang**. The name came from astronomers who did not agree about a possible beginning and end of the universe.

Q: How big is the Universe?

A: As far as we can tell, the universe is a very large place. It is so large that we cannot see it all from the earth. The part of the universe we can see is called the observable universe. Four hundred years ago, we could only see a very small part of our own galaxy – the Milky Way.

Before the invention of the telescope, humans were limited to exploring the heavens with their eyes. We could only see the bright planets and stars in the sky. As telescopes were built with larger lenses and mirrors, we could see further into space. Now with telescopes in space, we look deeper into space and expand our knowledge of the universe.

Q: How large is the Universe, and is it changing?

A. The universe is so large that we cannot see all of it. Thanks to Edwin Hubble, we also know that the universe is expanding and getting bigger. The galaxies of stars that we see are not growing bigger, but the space between galaxies is. The big question is whether the universe has enough stuff to stop the expansion, or will it expand forever.

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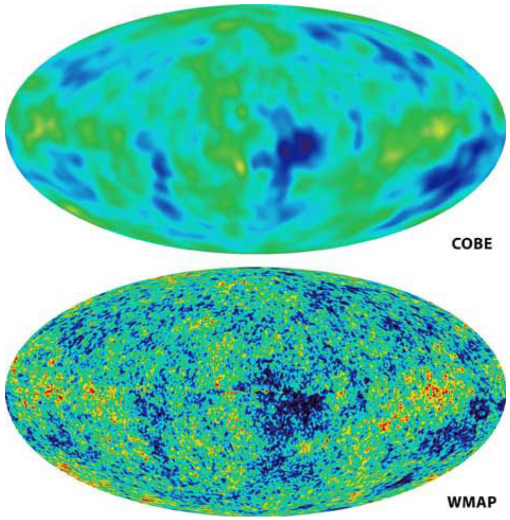
Q: How far back can we see into the past of the universe?

A: Two NASA satellites, the Cosmic Background Explorer (COBE) and the Wilkinson Microwave Anisotropy Probe (WMAP) measured the faint echo of the Big Bang by listening to radio signals from the Big Bang. Known as the Cosmic Microwave Background (CMB), these signals can be seen with a TV with a simple antenna. Connect the antenna, and tune to an empty TV channel. 1% of the static you see is the CMB. COBE was first to see differences in the CMB, while WMAP could see more details. These differences resulted in matter clumping into stars, galaxies then galaxy clusters.



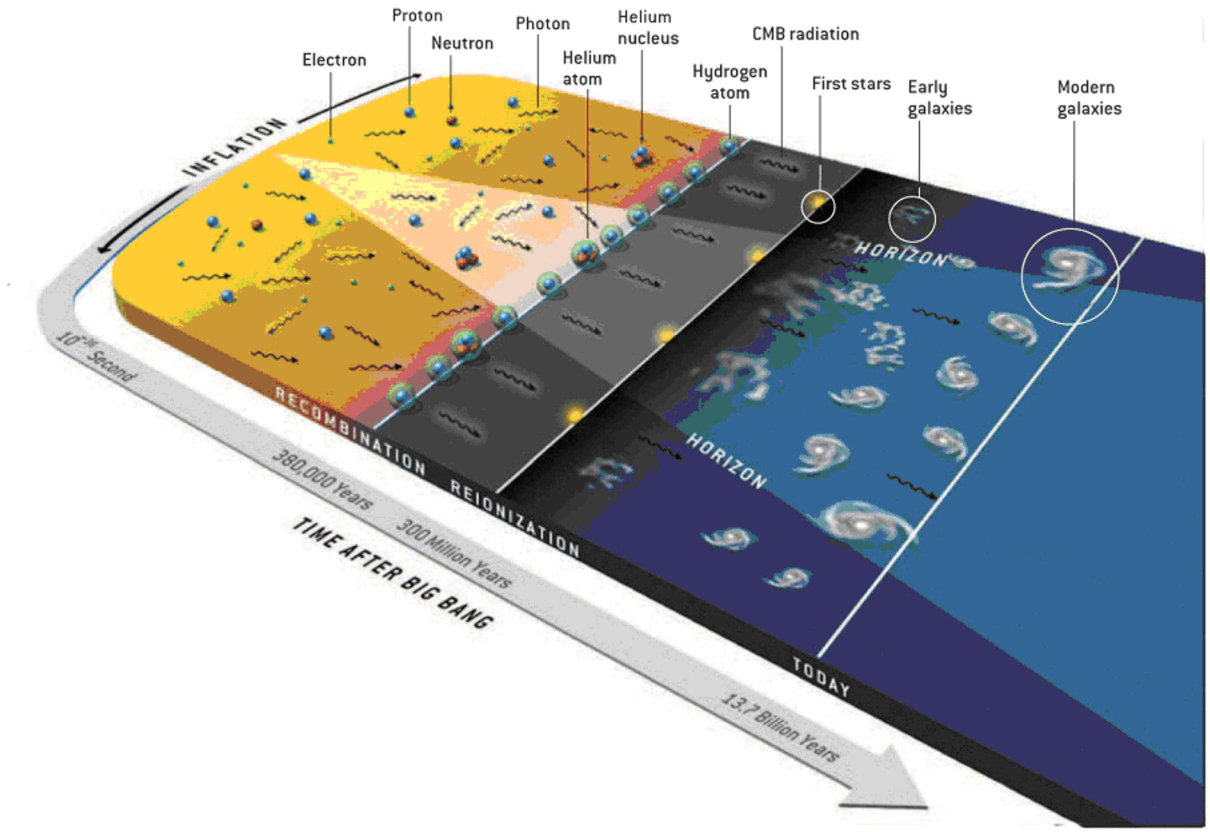


Figure 1 - A Brief History of the Universe - Dr. Wayne Hu - University of Chicago

Classroom Activity – Make A Galactic Mobile!

Grade Level: 5th - 7th with adult supervision and assistance

Goal: Students will build a mobile made of different kinds of galaxies, and learn about how galaxies are bunched into groups of galaxies called clusters.

Objective: To merge science and art activities as your students build a model of a galaxy cluster!

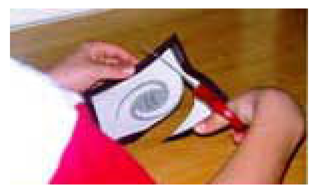
Materials

- - 12" or 7" round cardboard from pizza box or cut from a box.)
- - 4 large sheets (11" x 17") black construction paper
- - Glitter--gold, silver, red, orange, yellow, blue, purple
- - White glue
- - Paintbrush, about 1/4 to 1/2 inch wide
- - Scissors
- - Thread (black is best) or fine nylon fishing line
- - Small, 4-holed button
- - Large, sturdy sewing needle
- - 16 sequins or very small beads, black is best (optional)
- - Tape measure or yard (meter) stick
- - Galaxy forms (See Pages 10-11)

What To Do

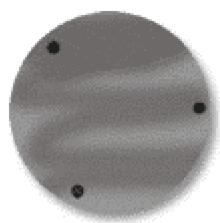
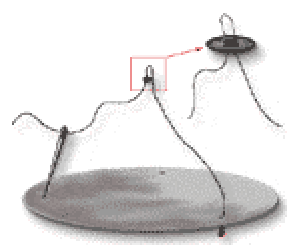
First, make the galaxies:

1. Print out the patterns for the galaxies.
2. Cut the galaxy patterns on the dotted lines.
3. Use the patterns to cut each galaxy out of construction paper. If you are making a 12" mobile, use all 12 galaxies. For a 7" mobile, use only 9 galaxies. Here's one way to cut out the galaxies: First cut out a small square of construction paper a little larger than the pattern paper. Tape the edges of the pattern to the construction paper so it doesn't slip when you cut. Now, cut out the galaxy, cutting through both the pattern and the construction paper.



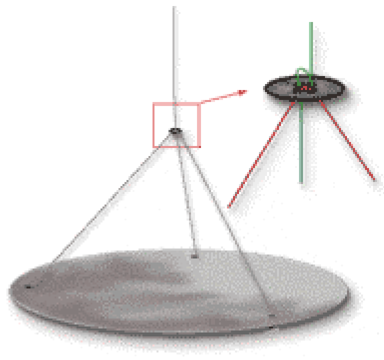
4. Now decorate the galaxies with glitter. Imagine each speck of glitter is a star! Use the brush to spread the glue on one side of one galaxy. Sprinkle one or two colors of glitter on each. Remember, galaxies are brighter in the center (where the stars are younger and hotter), becoming fainter at the edges or on the spiral arms.

Classroom Activity – Make A Galactic Mobile!

5. When you have decorated one side, set the galaxy on something it won't stick to when the glue is dry! (Like a cookie sheet, for example.)
6. When you have decorated one side of each galaxy, let the glue dry. Then turn them over and decorate the other side. Be sure to leave them laying flat until the glue is completely dry. Otherwise, the spiral arms will droop. (If they do, when they are dry you can set a heavy book on them for a while.)
   While you wait for the glue to dry . . .
   Make the frame for the mobile:
7. Use the round pizza cardboard as a pattern to draw a circle in the center of each of two pieces of construction paper. If the paper is big enough, cut the two paper circles a little larger than the cardboard.
8. Glue the paper circles to the top and bottom of the cardboard. If the paper circles are large enough, glue their edges together so the edge of the cardboard is also covered.
   
   Note: Instead of covering the cardboard with paper, if you wish, you can paint both sides of the cardboard with flat black spray paint.
9. Make three pencil marks equally spaced around the edge of the circle, about 1 inch in from the edge.
   
10. Cut a length of thread about 2 feet long. Thread the needle, and either tie a fat knot in the end or tie a sequin or small bead to the end (include only one strand of thread).
    
11. Poke the needle through one of the pencil marks on the edge of the cardboard circle. Pull the thread through to the knot, sequin, or bead.
12. 
    Take the 4-holed button and poke the needle up through one hole in the button and down through another.
13. Now poke the needle back down through another pencil mark on the circle (since the mark will be on the wrong side of the circle, you'll have to poke the needle up the other way first just to mark the hole).
14. Unthread the needle and tie a fat knot, sequin, or bead in the end of the thread.

Classroom Activity – Make A Galactic Mobile!

15. Now, cut a length of thread about 3 feet long and rethread the needle. Again, tie a fat knot, sequin, or bead in the end. Poke the needle up through the remaining pencil mark on the circle. (Knots, sequins, or beads should all be on the same side.)

16. 

Poke the needle up through one of the remaining holes in the button and then down through the last hole. Unthread the needle and tie a loop in the end of the thread for hanging the mobile from the ceiling. **Hang the galaxies from the mobile frame:**

17. 

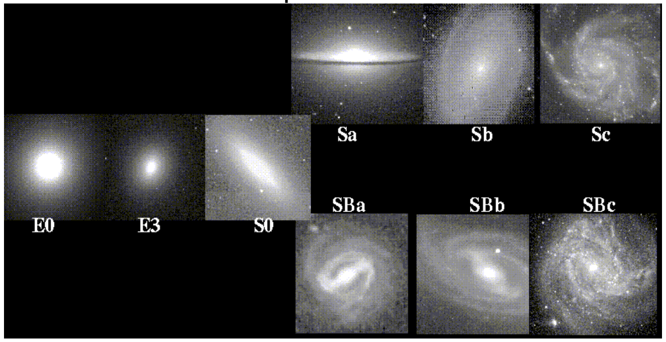
Make pencil marks on the bottom of the cardboard circle where you will be attaching each galaxy. For a 12-inch mobile, you could put eight evenly spaced around the edges and four evenly spaced in the center area. For a smaller mobile, you could put six around the edges and three in the center.

18. For each galaxy: Cut a length of thread and thread the needle. Tie a knot, sequin, or bead to the end. Draw the needle through the center of the galaxy. Now poke the needle through one of the marks on the circle. Adjust the length of the thread so the galaxy hangs nicely, then cut the thread and tie a knot, sequin, or bead in the end.

19. Make the galaxies hang at different levels, so they can turn freely without hitting each other.

20. Hang your Galactic Mobile from the ceiling. Notice that you can adjust the thread going through the button to make the circle hang level.

21. Galaxies are classified or organized by their shape. The two on the left in the image below are elliptical or oval shaped without any structure. Other galaxies have no shape or structures are listed as irregular. The six galaxies on the right of the image are spiral or pinwheel, and are divided into spirals with or without a central bar.



Classroom Activity- Escape Velocity – Escape from a Gravity Well

Grade Level: Grades 4th and up

Goal: Students will build a device to demonstrate how much velocity is needed to leave a gravity well. Gravity Wells vary in size, based on the amount of matter at the center of the well. This device will assist students in explaining how matter is pulled into gravity wells such as planets, larger ones around stars, and monstrous gravity wells that we call black holes.

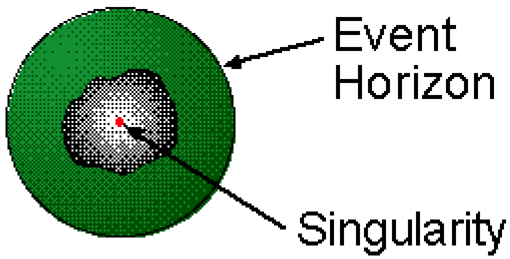
Objective: To understand that the size and strength of a particular gravity well is proportional to the amount of mass an object in space, such as a planet, star or black hole.

Background

Normal objects in space, such as planets or stars, distort or change the area of space around them. Astronauts such as your students have to be aware of this effect, or risk falling down the gravity well. The largest gravity wells are made by black holes, formed from the collapse of a giant star under its own gravity. All of its mass is squeezed into a single point, known as a singularity. At this point, both space and time stop. It's very hard for us to imagine a place where mass has no volume and time does not pass, but that's what it is like at the center of a black hole.

Anatomy of a Black Hole

The point at the center of a black hole is called a *singularity*. Within a certain distance of the singularity, the gravitational pull is so strong that nothing--not even light--can escape. This boundary is called the *event horizon*. The event horizon is not a physical boundary, but the point-of-no-return for anything that crosses it. When people talk about the size of a black hole, they are referring to the size of the event horizon. The more mass the singularity has, the larger the event horizon. The structure of a black hole is something like this:



Many people think that nothing can escape the intense gravity of black holes. If that were true, the whole Universe would get sucked up. Only when something (including light) gets within a certain distance from the black hole, will it not be able to escape. But farther away, things do not get sucked in. Stars and planets at a safe distance will circle around the black hole, much like the motion of the planets around the Sun. The gravitational force on stars and planets orbiting a black hole is the same as when the black hole was a star because gravity depends on how much mass there is--the black hole has the same mass as the star, it's just compressed.

Black holes are truly black. Light rays that get too close bend into, and are trapped by the intense gravity of the black hole. Trapped light rays will never escape. Since black holes do not shine, they are difficult to detect.

Classroom Activity- Escape Velocity – Escape from a Gravity Well

Materials

1. A Large round garbage can
2. A square yard of swimsuit or other stretchable cloth
3. 2 – 3 Foot long Bungee cords
4. A bag of large (quarter-sized) marbles

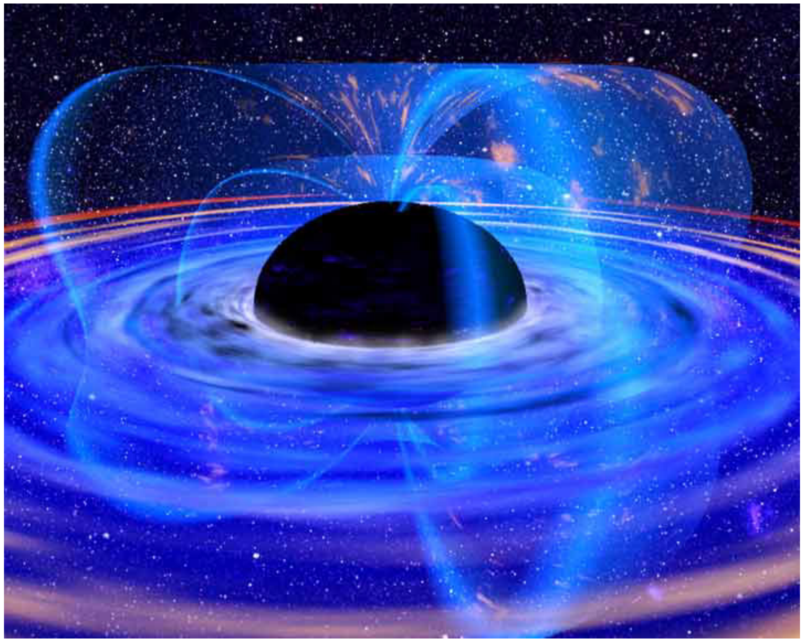
What to do:

First, start by putting a marble in the middle of the stretchable material, and tie the bungee cord in a knot around the marble. Then put a hole in the bottom of the can, and feed the bungee cord through the hole. Now put the cloth over the open end of the garbage can, and secure it to the garbage can with the other bungee cord. You should have a flat surface covering the garbage can, with a small dent in the middle of the cloth.

This will represent a gravity well created by the mass of a moon or planet. Now shoot some marbles around the gravity well. What happens to the marble after it orbits the planet's gravity well for 30 seconds or longer?

Now experiment with a stronger gravity well. Pull on the cord attached to the center of the cloth until you have a larger depression in the center of the material. This represents the gravity well around a star such as the Sun. Shoot some marbles in orbit around the star's gravity well. Compare the results with the planet's gravity well. What is the difference?

Now pull on the cord until you have a very deep depression. This represents the gravity well around a giant star or a small black hole. Again, shoot the other marbles around on the cloth. Try to get them to orbit around the depression. As they move closer to the well, what happens to the marbles?



Classroom Activity-How Far/How Faint

Grade Level: Grades 4^{th} and up

Goal: Students will experiment with light sources to measure distance. Described in the Inverse Square Law for Light, it is used by astronomers to measure the distance of far away galaxies.

Objective: To understand how the brightness of a light source diminishes with distance, then measure the brightness of near and far light sources to determine the distance of these light sources.

Background

To begin, lets make some generalizations. There is a certain amount of sunlight reaching Earth at any given moment. Overall, the Sun is remarkably constant in its behavior.

We can describe the amount of the Sun's energy reaching Earth as 1 solar constant. The average distance from the Sun to Earth is 149,600,000 kilometers (93,000,000 miles), which we simplify to 1 Astronomical Unit or 1 AU. So Earth is 1 AU from the Sun and receives 1 solar constant. This will help keep the math easy. The relationship can be expressed most simply as: $1/d^2$ (one over the distance squared) where d = distance as compared to Earth's distance from the Sun (for our first examples).

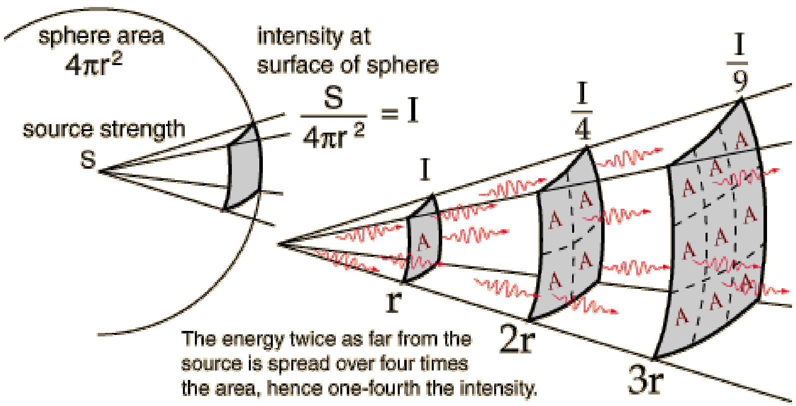
Let's start with sunlight. At 1 AU, Earth receives 1 unit of sunlight; such as we might see as a bright sunny day at noon. How much sunlight would a spacecraft receive if it were twice as far from the Sun as Earth? Your first guess might be that, since it is twice as far it will only receive half as much (not twice as much since it is farther away). The distance from the Sun to the spacecraft would be 2 AUs so... d = 2. If we plug that into the equation $1/d^2 = 1/2^2 = 1/4 = 25\%$ The spacecraft is getting only one quarter of the amount of sunlight that would reach it if it were near Earth. This is because the light is being radiated from the Sun in a sphere.

As the distance from the Sun increases the surface area of the sphere grows by the square of the distance. That means that there is only $1/d^2$ energy falling on any similar area on the expanding sphere.

Now lets try it for another real place. Mars is at a distance of 1.5 AUs from the Sun. $1/d^2 = 1/1.5^2 = 1/2.25 = 44\%$. There is less than half as much sunlight falling on the surface of Mars as on Earth! Jupiter is at 5.2 AUs so $1/d^2 = 1/5.2^2 = 1/27 = 3.7\%$. Neptune is at 30 AUs so $1/d^2 = 1/30^2 =$ 1/900 Å 0.1%! Noon on Neptune is like very deep twilight on Earth! What happens as we approach the Sun? Common sense tells us that the Sun will be brighter and the inverse square law tells us how much brighter. Mercury is at 0.387 AUs. $1/d^2 = 1/0.387^2 = 1/0.15 = 666.67\%$, almost seven times brighter! We can use this method to compare any spot in the Universe if we describe its distance as compared to Earth relative to the Sun.

Inverse Square Law, Light

As you can see with the image below, the light reaching the 2^{nd} object is spread over four time the area, so the light is four times less intense as the light at r.



Classroom Activity-How Far/How Faint

Materials
Overhead or Slide Projector
Rolling cart
Wall or projector screen

Step One - Set a slide or overhead projector either ten centimeters or one meter from a wall or board. Either of these distances will make the inverse square relationship readily apparent. (This distance can vary. This is a function of how much space you have and the size of your screen.) Note the distance between the board and the projector.

Step Two - Project light onto the board and outline the lighted square. Use a three-column table to keep track of the distance from the board, the length of the lighted square's edge, and the area of the lighted square.

Step Three - Have students predict what will happen to the lighted square when you move the projector further from the board. (It increases in size.) Ask them how the light intensity changes when you move the projector further from the board. (It decreases in intensity.)

Step Four - Move the projector twice the original distance from the board, explaining to your students exactly what you are doing. Outline the lighted square. The edge of this lighted square should be twice as long as the edge of Step 2's lighted square, and its area should be four times the area of Step 2's square. Ask students how the light intensity has changed, now that the same amount of light has to cover four times the area. They should say that the light intensity within the square is one fourth of the original light intensity.

Step Five - Ask students to predict what the intensity will be if you move the projector three times the original distance from the wall. When you move the projector this distance, the edge of this lighted square should be three times as long as the edge of Step 2's lighted square, and its area should be nine times the area of Step 2's square. Consequently, the amount of light hitting each unit area in Step 5 is about one ninth of the amount hitting each unit area in Step 2.

Step Six - Have students create a graph comparing the projector's distance from the board with the area of the lighted square. Then, introduce your students to the math of the Inverse Square Law. Refer to the distance, length, and area data from the table you created:

Epilogue - Type Ia Supernovae
A Type Ia Supernova is the explosion of a white dwarf star. This is a pinnacle that only a few stars like our sun are able to achieve. We think they are related to white dwarf stars, which are near another star in a binary system. These white dwarfs pull matter from their partner star, and material builds up onto the white dwarf. The star does not explore until the forces of electrons repelling electrons, which keep the star from collapsing against the force of gravity, lose their battle. At this point, the white dwarf begins to collapse. White dwarf stars are composed of carbon and oxygen atoms, and there is a still substantial amount of nuclear energy left in their atoms. As the white dwarf begins to collapse against the weight of gravity, this material is ignited, and rather than collapsing further, this nuclear blast wave consumes the star in a second, creating an explosion 10 to 100 times brighter than a Red giant star explosion, known as a Type II supernova.

Type Ia supernovae, such as the one in the lower left in this image, are observed to all have a similar brightness, and this makes them very powerful objects for measuring distances. In addition, because they are so bright, they can be seen at great distances, and these two things make them currently unique objects for measuring the vast distances of the Universe.

Astronomy and Cosmology Web Sites

KICP Kavli Institute for Cosmological Physics AT THE UNIVERSITY OF CHICAGO

http://cfcp.uchicago.edu/
Kavli Institute of Cosmological Physics - the University of Chicago. Lots of information about cosmology and exploring the beginning of the universe – The Big Bang!

http://www.pbs.org/wnet/hawking/html/home.html
Stephen Hawking's Universe – a PBS TV series on cosmology.

http://imagine.gsfc.nasa.gov/docs/science/mysteries_l1/origin_destiny.html
NASA's Origin and Fate of the Universe web site

http://imagine.gsfc.nasa.gov/docs/science/mysteries_l1/structures.htm
NASA's Web Site on the Evolution of Structure in the Universe

Sloan Digital Sky Survey

http://www.sdss.org/
Web Site for the large-scale structure in the universe survey.

GALEX Galaxy Evolution Explorer

http://www.galex.caltech.edu/
Mapping the evolution of stars in the universe

Curious About Astronomy? ASK AN ASTRONOMER

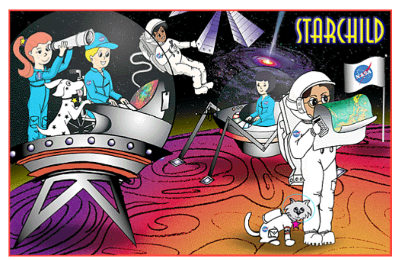
http://curious.astro.cornell.edu/cosmology.php
Cosmology is the study of the universe as a whole. What happened in its past and what will happen in the future?

Wilkinson Microwave Anisotropy Probe

http://map.gsfc.nasa.gov/
Web Site to the WMAP satellite, exploring the Cosmic Microwave Background (CMB), the echo of the Big Bang.

teach SPACE

http://www.space.com/teachspace/index.html
TeachSpace delivers easy-to-teach space science lessons to upper elementary and middle schoolteachers.

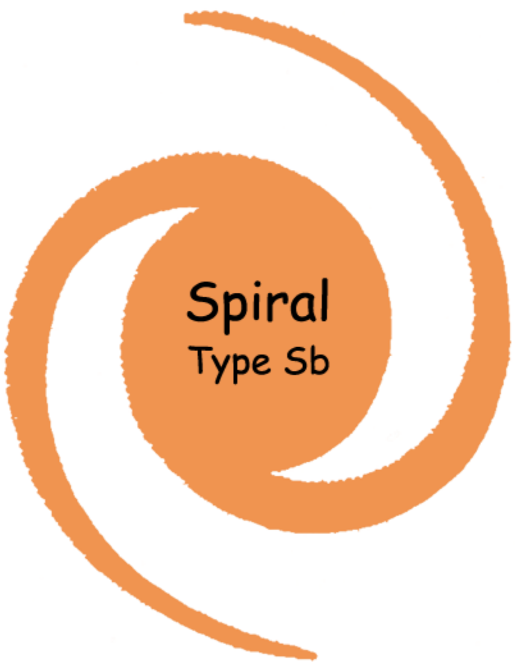


http://starchild.gsfc.nasa.gov/docs/StarChild/StarChild.html
Starchild is a learning center for Elementary age astronomers.

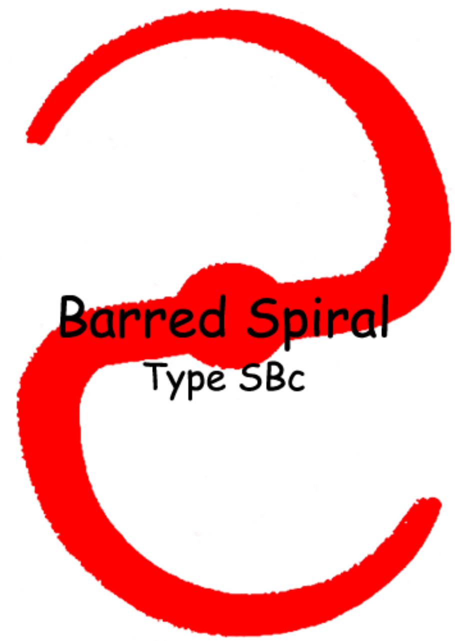

Spiral
Type Sa


Spiral
Type Sc

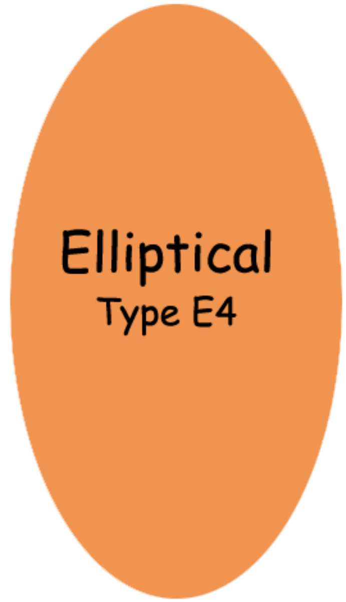

Barred Spiral
Type SBb


Spiral
Type Sb


Barred Spiral
Type SBb(s)


Barred Spiral
Type SBc


Elliptical
Type E0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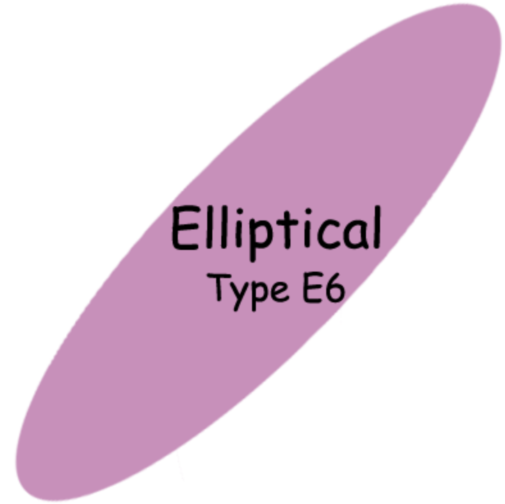
Type E4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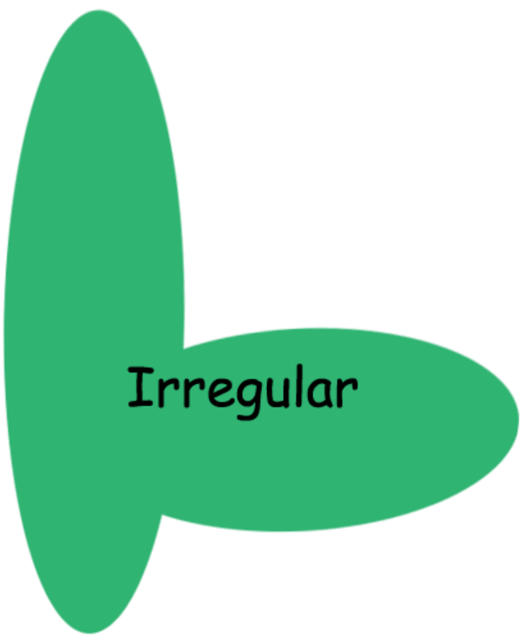
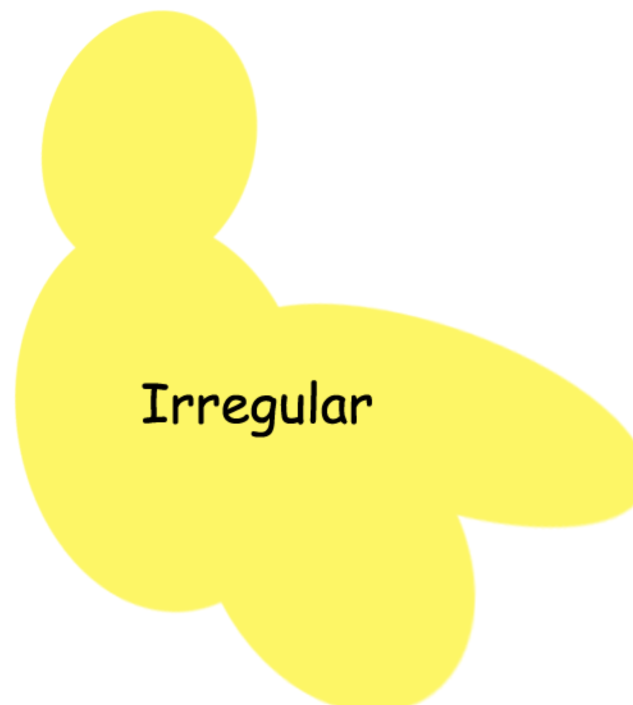

Irregular


Irregular


Irregular