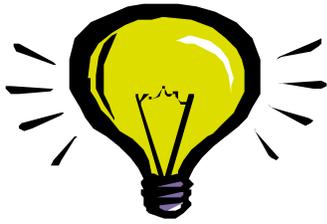
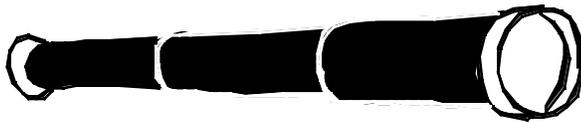


"Ideas & Discoveries" Teacher's Guide



This Teacher's Guide is designed to help you, the teacher, better prepare your class for their upcoming visit to Northern Stars Planetarium when it visits your school in the near future. "*Ideas and Discoveries*" is a planetarium show that is designed to be modular, so that over time parts of the presentation will change as new discoveries are made or new ideas are discussed in the news. Designed to offer three or four modules at a time, depending on the time needed for each sub-topic, the show will present a couple of interesting aspects of modern astronomy that is currently in the news or up for debate.

One of the main goals of this presentation is to make your students understand that astronomy, like all of science, is not a set of facts, but a way of examining the universe; that science is more about questions and inquiry than answers and facts. We hope that will come across clearly to all students who see and participate in "*Ideas & Discoveries*."



Current Show Outline

I. "*Saving the Night*", a fifteen minute taped multimedia presentation about light pollution and why it's an important issue.

II. Extra-Solar Planets

- A. The methods of discovering planets around other stars..
 1. Direct imagery
 2. Astrometry-measuring the wobbles in the proper motion of a star through the heavens.
 3. Doppler Spectrum Shifts--measuring shifting redshifts and blue shifts of approaching and receding stars.
- B. Where there are some known Extra-Solar Planets

III. Is Pluto a Planet?

- A. Why is this a question?
- B. Discovery of the Kuiper Belt
- C. Historical Perspective
 1. The story about Ceres, the first asteroid discovered.
 2. The story about Pluto, the first Kuiper Belt object discovered.

Light Pollution

Light pollution is light that is generated by poorly designed streetlights, security lights, etc. that send large amounts of light into the sky. This greatly reduces the number of stars that can be seen by an observer in that area and it costs people in the United States nearly **two billion dollars a year!** That's two good reasons to reduce light pollution. Today the beauty of a truly dark starry sky is lost to millions of city dwellers, and the problem even affects those who live in small towns and the country where all night "security lights" shine outside all night.

The fact is light that shines into the sky is lost. It does not help us see, it does not deter crime, it merely cost us money (all artificial light cost money to create), and it steals the night sky from those who would otherwise enjoy it.

The solution: light fixtures that direct the light downward and lights that reduce glare. Bright lights at night can actually make it harder to see, due to glare. Look at the following two pictures and see how the light's glare obscures the view of the man near the fence. Block out the glare with your hand and the man is clear to see.



Glare obscures man



Blocked Glare

Los Angeles, California at night. How many stars do you think you could see from L.A.? How much do you suppose it cost Los Angeles to light up the sky in this way?



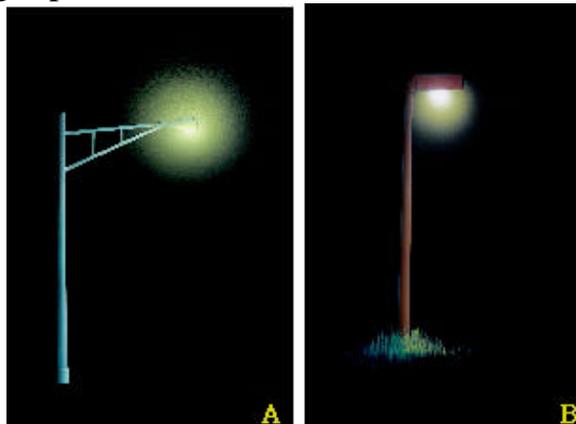
Los Angeles, California at night.

The United States at Night!

Light Pollution isn't generated just in the big cities. Can you find any towns near where you live? This is an actual photograph made from a series of night shots taken from space. How many cities can you identify?



Streetlights. Not all streetlights are created equal. Which light (A or B) do you think is more efficient? Which one pollutes the skies more? Look around your town and take notice of the different styles of streetlights. Are most of your town's streetlights light polluters or not?



Extra Solar Planets

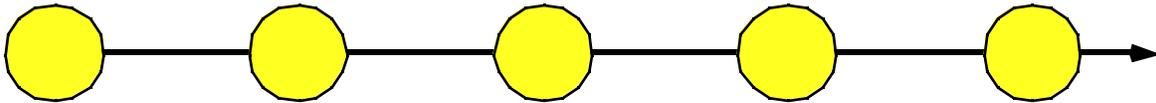
Probabilities:

If there are 100 billion stars in the average galaxy (our Milky Way has nearly 200 billion!), and there are an estimated billion galaxies (some estimates go as high as 50 billion galaxies!), then there are at least 5,000,000,000,000--that's 5 trillion stars in the universe. Wouldn't it be odd if the Sun were the only star to have planets?

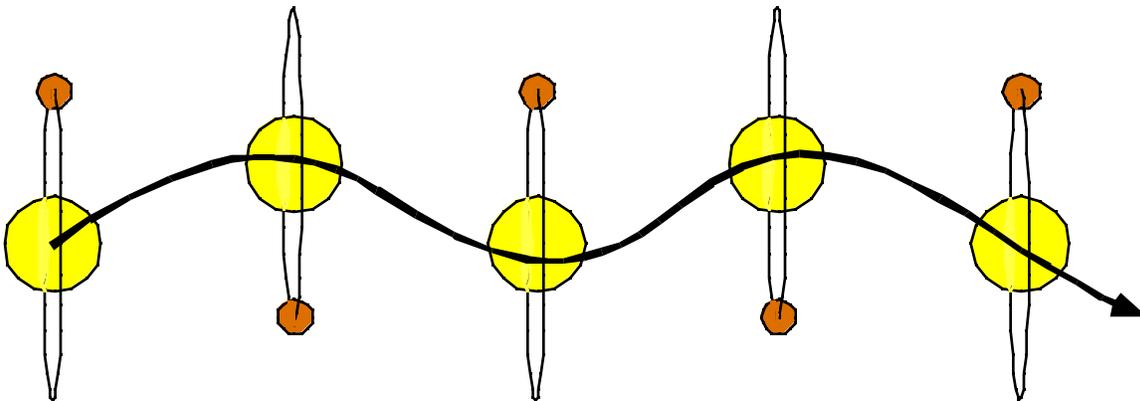
Scientists believe that planets are very common. The problem with finding them is that compared to big, very bright stars, they are small and dim, and a long way away. That makes them difficult to detect. Currently scientists have already found planets going around numerous other stars, but they have not directly seen any of them. To detect them they watch for stars to wobble as the planet's gravity tugs on the star as it orbits, this is called *Astrometry*. Another way to detect planets is to see shifts in the star's spectrum generated by the stars motion toward us or away from us, this is called it's *Doppler Shift*. If there is no planet the shift is constant, but if there is a planet orbiting that star then the shift will fluctuate.

Astrometry--The study of the proper motion of stars through the galaxy.

A star with no planet moves like this:

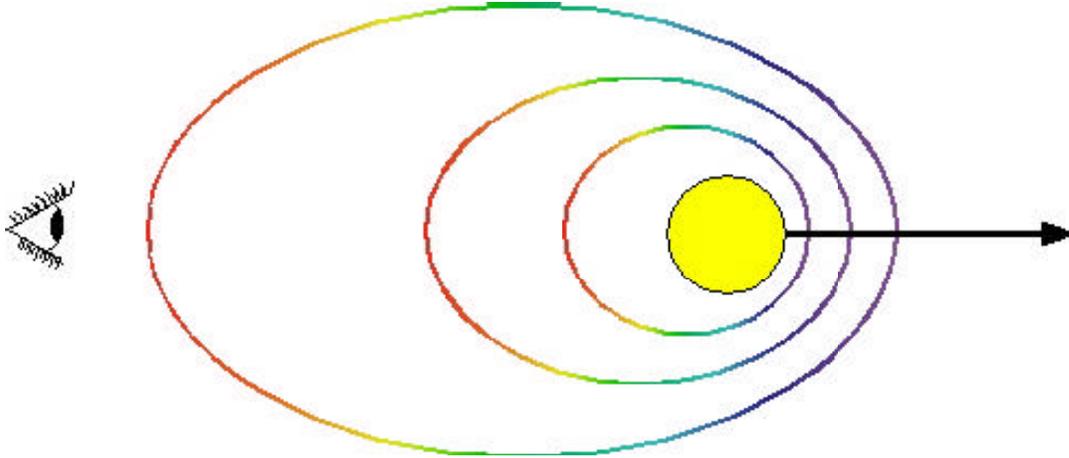


A star with a planet wobbles like this:

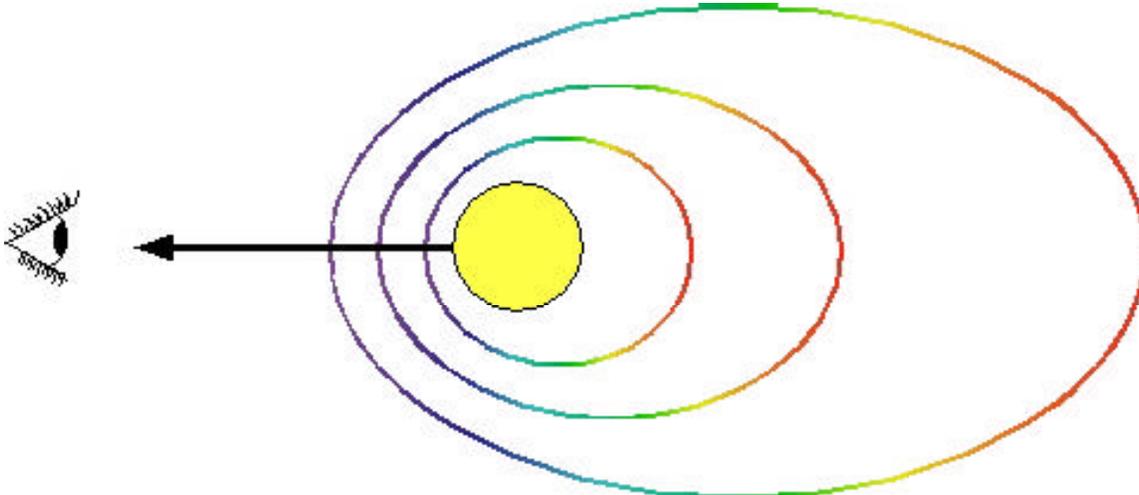


Doppler Shift--The shortening or lengthening of wavelengths as a star moves. If the star moves toward us the wavelengths shorten toward the blue, thus called blue shifted. If the star moves away from us, the wavelengths length toward the longer red waves, thus this is referred to as red shifted.

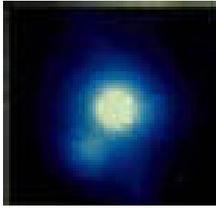
A star's light is **Red Shifted** when it is moving away from us, like this:



A star's light is **Blue Shifted** when it is moving toward us, like this:



When there is a planet revolving around a star moving like this it causes the amount of redshift or blueshift to vary. It varies with a regular period of time relative to its orbit around the star. Most of the extra solar planets discovered so far have been detected by finding these subtle changes in a star's redshifts and blueshifts.



Is Pluto a Planet?

Pluto was discovered in 1930 by Clyde Tombaugh. In 1978 Pluto's moon Charon was discovered. In 1992 the first Kuiper Belt object, QB-1, was discovered. Now we know of dozens more Kuiper Belt objects. The Kuiper Belt is a region of the solar system, similar to the asteroid belt, only it is in the region of Pluto's orbit about the Sun, and is composed of icy objects. Is Pluto simply the largest Kuiper Belt object, the way that Ceres is the largest asteroid belt object? That is the question. If it is a planet, then shouldn't Ceres also be a planet?

1. How is Pluto different from all the other planets? Pluto is smaller and further away than all the other known planets. It has the most elliptical (oval) orbit of any planet. Its orbit is tilted more than any other planet. And it's the only planet made primarily of ices.

2. What would happen if you could move icy Pluto next to the Sun? Because Pluto is made primarily of different ices, the Sun's heat would melt and sublime some of the ice into liquids and gases. This would create a large halo of gases around the planet, similar to the coma that surrounds a comet. Then the solar wind would slowly push the halo of gases away from the Sun, thus forming a tail. In other words, Pluto would become a very large comet!

3. How cold is it on Pluto? Approximately -400°F , and when it gets to the most distant point in its orbit, the temperature will drop lower still, perhaps so low that Pluto's meager atmosphere would freeze solid and fall to the ground!

4. When was Pluto Discovered? Pluto was discovered on February 18, 1930 by Clyde Tombaugh at the Lowell Observatory in Flagstaff, Arizona.

5. Is Pluto really the farthest planet from the Sun? Yes and no. Pluto's orbit is very elliptical (oval shaped), and part of the orbit passes inside the orbit of Neptune. It takes Pluto 148 years to orbit the Sun once, and of those 148 years, 20 years of each orbit is spent closer to the Sun than Neptune!

6. Why do some astronomers refer to Pluto as a "Double Planet"? Pluto is often referred to as a double planet because of its moon Charon. Pluto is 1430 miles in diameter, while Charon is 745 miles in diameter. Pluto and Charon are closer in size to each other than any other planet/moon system. They are only 12,000 miles apart. Rather than Charon orbiting Pluto, Pluto and Charon really orbit each other, spinning about each other like two dancers!

7. Was Pluto named after Mickey Mouse's dog? No. Clyde Tombaugh, Pluto's discoverer, only referred to it as "Planet X". The name was suggested by a little girl in England who had been reading mythology. Pluto was the Roman god of the underworld, which was supposedly a place dark and distant, much like Pluto.



Visit us at: www.northern-stars.com

Some Great Web Sites:

Northern Stars Planetarium: <http://www.northern-stars.com>

The Space Place: <http://www.spaceplace.nasa.gov>

Extra Solar Planets: <http://www.public.asu.edu/~sciref/exoplnt.htm>

Extrasolar Planets Encyclopedia: <http://www.obspm.fr/encycl/encycl.html>

Solar System Exploration: <http://solarsystem.nasa.gov/>

Nine Planets: <http://seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets.html>

The International Dark-Sky Association: <http://www.darksky.org/~ida/index.html>

Space Telescope Science Institute: <http://www.stsci.edu/top.html>

Sky & Telescope: <http://www.skypub.com>

Astronomy: <http://www.kalmbach.com/Astro/Astronomy.html>

What's New at the Space Telescope SI: <http://www.stsci.edu/whats-new.html>

Jet Propulsion Laboratory: <http://www.jpl.nasa.gov/>

NASA: <http://www.nasa.gov/>



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Universe in the Classroom, Astronomical Society of the Pacific, Teacher's Newsletter, Dept. N. 390 Ashton Ave., San Francisco, CA 94112 (free to all teachers, request on school letterhead.)

