



THE SOLAR SYSTEM AND BEYOND – THE METER STICK MODEL

Standard IV: Students will understand the scale of size, distance between objects, movement, and apparent motion (due to Earth's rotation) of objects in the universe and how cultures have understood, related to and used these objects in the night sky.

Objective 1: Compare the size and distance of objects within systems in the universe.

c. Compare the size of the Solar System to the size of the Milky Way galaxy.

Background:

Distances between planets are very large but they are insignificant compared with distances between stars. Because units that are commonly used to measure distances on Earth such as miles or kilometers are too small for use in astronomy, other units of distance are needed. Within the solar system, the astronomical unit or AU is used. An AU is the average distance between the Sun and Earth which is about 149,000,000 kilometers (93,000,000 miles). For distances beyond the solar system, the light-year is one of the units of distance that is used. Although it is sometimes confused with a unit of time, a light-year is the *distance* light travels in one year. Light (in a vacuum) travels 299,792.458 kilometers (186,282 miles) in one second. This is fast enough to travel around Earth about 7 ½ times in one second. One light-year is about 9,460,000,000,000 kilometers or 5,880,000,000,000 miles.

Invitation to learn:

Materials: A one-inch piece of string for each student

When astronomers measure distances in space, units such as feet, meters, miles, and kilometers are too small to be practical. For example, the sun is nearly 25,000,000,000,000 miles away from its nearest neighbor, Proxima Centauri. Numbers this large aren't easy to work with and are hard to comprehend. Astronomers have a more practical way of expressing distances in space: light-years. In one year, light travels about 6 trillion miles. This distance is one light-year. So, the distance between the sun and Proxima Centauri can be expressed as 4.2 light-years—which is a much more manageable number than the one listed previously. This activity will help students understand why astronomers use light years instead of feet, meters, miles, or kilometers.

Directions:

1. Provide each student with a one-inch piece of string.
2. Divide the group into pairs and take them to a large area (inside or outside).
3. Have each pair use the string to measure some large distance, e.g. the length of the parking lot, hallway, building, or auditorium, in inches.
4. When everyone is finished bring the students together for a class discussion. How many inches did they come up with? Do they think inches are the best way to express the distance they measured? Why or why not? What would have been a better unit of measurement?

(Feet or meters would have been more practical. For longer distances, miles or kilometers would have been a better unit of measurement.)

5. Ask the students to predict how long it would take to run or walk 63,360 inches.
6. Explain that since an inch is so small compared to the total distance being measured, it is hard to imagine how far 63,360 inches is. For this reason, it is difficult to predict how long it would take to run that distance because the number is too great to visualize how far it actually is (63,360 inches is 1 mile).
7. Discuss that the same analogy is true in space. Astronomers use light-years instead of miles, because light-years are much easier to work with for vast distances. For example, the distance to Proxima Centauri is about 25 trillion miles. That is a hard number to visualize. However, if you say it is 4.2 light-years away, it is easier to comprehend and to compare this distance to other distances in the universe.

Activity

Materials:

Meter stick
Local map
Map of Utah
Map of US

SOLAR SYSTEM

If the size of the Solar System is reduced about six trillion times, Pluto (on average) would be about one meter from the Sun. On this scale, the Sun itself will be about 0.2 millimeters (1/100 inch) in diameter. This is about the size of the POINT on a pin.

Place a mark on a meter stick at the distance of each planet. (Place the mark for Pluto at the end of the stick).

<u>PLANET</u>	<u>Distance (inches)</u>
Mercury	$\frac{3}{8}$
Venus	$\frac{3}{4}$
Earth	1
Mars	$1\frac{1}{2}$
Jupiter	$5\frac{3}{16}$
Saturn	$9\frac{9}{16}$
Uranus	$19\frac{1}{4}$
Neptune	$30\frac{1}{8}$
Pluto	$39\frac{1}{2}$

BEYOND

How far away are the stars on this scale? It would be difficult to measure in inches. We need a new measuring unit.

The average distance between the Earth and Sun is called an Astronomical Unit or AU. In the meter stick model, one AU is one inch. There are about 63,240 AU in one light-year. There are 63,360 inches in one mile.

Because these are almost the same, we can extend our meter stick model solar system to model distances to the stars. In this model, one light-year is one mile. The nearest star to the sun is 4.2 light-years away. So, in the meter stick model, the nearest star is OVER FOUR MILES AWAY!

The following is a list of all of the stars that are within 10 light-years of the Sun. The distance to each star in light-years is the distance to each star in miles on the meter stick model. Have the students identify landmarks or places that are at these distances from the school. Remind students that Pluto is 39.5 inches from the Sun on this scale.

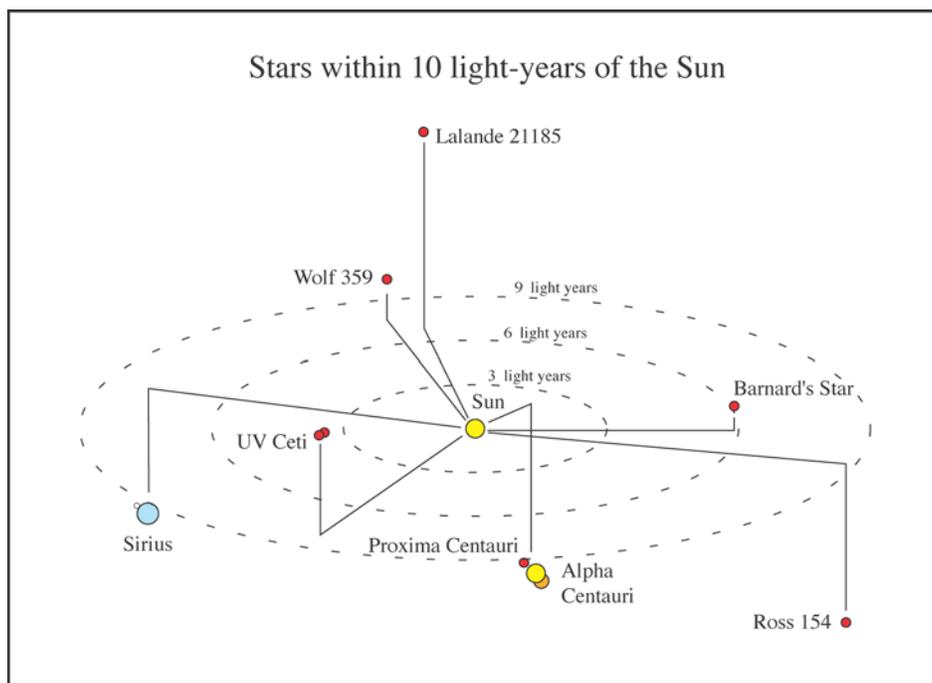
THE SUN'S NEIGHBORHOOD

ALL STARS WITHIN 10 LIGHT-YEARS OF THE SUN

Star Name	Constellation	Distance (light-years)
Proxima Centauri	CENTAURUS	4.2
Rigel Kentaurus (Alpha Centauri)*	CENTAURUS	4.4
Barnard's Star	OPHIUCHUS	5.9
Wolf 359	LEO	7.8
Lalande 21185	URSA MAJOR	8.3
Sirius*	CANIS MAJOR	8.6
UV Ceti*	CETUS	8.7
Ross 154	SAGITTARIUS	9.7

*Double Star

With the exception of the stars in the Alpha Centauri and Sirius star systems, stars within 10 light-years of the Sun are red dwarf stars.



THE BRIGHTEST STARS

Below is a list of the 17 brightest stars* (*as seen from Earth*) that are visible from Utah. They are listed in order of brightness. The list also gives the distances to these stars in light-years. These are also the distances to these stars in MILES in the meter stick model.

Using maps of the State of Utah or the United States, find cities or other landmarks at the approximate distance of each star listed.

Star Name (In order of brightness)	Constellation	Distance (light-years)
Sirius	CANIS MAJOR	8.6
Arcturus	BOOTES	37
Vega	LYRA	25.3
Capella	AURIGA	42
Rigel	ORION	773
Procyon	CANIS MINOR	11.4
Betelgeuse	ORION	522
Altair	AQUILA	16.8
Aldebaran	TAURUS	65
Spica	VIRGO	262
Antares	SCORPIUS	604
Pollux	GEMINI	34
Fomalhaut	PISCIS AUSTRINUS	25.1
Deneb	CYGNUS	1467
Regulus	LEO	78
Adhara	CANIS MAJOR	431
Castor	GEMINI	52

Given each star's distance, which star is most likely to be the brightest? Why?

THE GALAXY

The Milky Way galaxy is about 100,000 light years in diameter. In the meter stick model, this would be a little over four times the distance around Earth's equator or about $\frac{2}{5}$ of the distance between Earth and the moon.

*How to find these stars in the night sky:

All but two of the stars in the list above are identified on Uncle Al's Sky Wheels (<http://www.lhs.berkeley.edu/starclock/skywheel.html>). The two not identified are Fomalhaut and Adhara. Adhara is the bottom star (marking the "foot" of the dog) in the constellation Canis Major. Fomalhaut is the brightest star in the unnamed constellation just below Aquarius. The name of this constellation is Pisces Austrinus.