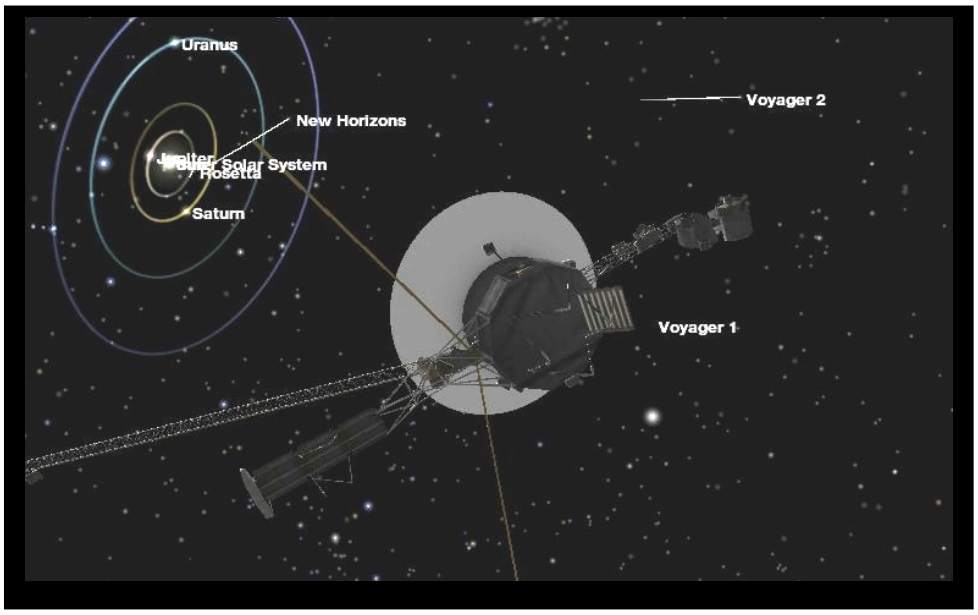
Eye Spy – Light Travel Time and the Expanding Universe



Get the Data

Visit EOSS **http://1.usa.gov/V23f5m** to recreate the scene above. Recommended operating system: MS Vista or later; Browser: MS Internet Explorer 8 or later.

Step 1 – Click on the 'Visual Controls' tab and make sure that the following items are selected with a 'white spot': spacecraft, planets, labels, orbit lines, trails and metric.

Step 2 - Activate the Distance Measuring tool and measure the distance between the Sun and the Voyager 1 spacecraft.

Current Voyager 1 status : http://voyager.jpl.nasa.gov/mission/weekly-reports/index.htm

Answering Questions

Problem 1 – The speed of light is 300,000 km/sec. How long does it take the light from the sun to reach the Voyager 1 spacecraft in hours.

Problem 2 – In January 2012, the distance from Voyager 1 to the Pioneer 10 spacecraft was 32.6 billion kilometers. How many days would it take a radio signal to travel this distance?

Problem 3 – The nearest star is 4.2 light years from the sun. How many times the Voyager-Pioneer distance is this?

Math Challenge

Challenge Problem: The universe is expanding, which means that the distances between galaxies is increasing as space-itself stretches. This stretching shows up as a speed increase between two objects. For galaxies this is 70 km/s for every million parsecs of distance. At the scale of the two spacecraft, the speed increase is 2.3×10^{-18} cm/sec per cm of distance. At the current separation of Pioneer 10 and Voyager 1, by how much does their separation speed increase due to cosmic expansion?

Answer Key

Problem 1 – The speed of light is 300,000 km/sec. How long does it take the light from the sun to reach the Voyager 1 spacecraft in hours?

Answer: On January 21, 2012 the distance was 18.4 billion km. 18.4 billion km / (300000 km/s) = 61,333 seconds = **17.0 hours**.

Problem 2 – The distance from Voyager 1 to the Pioneer 10 spacecraft is 32.6 billion kilometers. How many days would it take a radio signal to travel this distance?

Answer: **T = 1.25 days**.

Problem 3 – The nearest star is 4.2 light years from the sun. How many times the Voyager-Pioneer distance is this?

Answer: (4.2 years x 365 days/year) / 1.25 days = **1226 times**.

Challenge Problem: The universe is expanding, which means that the distances between galaxies is increasing as space-itself stretches. This stretching shows up as a speed increase between two objects. For galaxies this is 70 km/s for every million parsecs of distance. At the scale of the two spacecraft, the speed increase is 2.3×10^{-18} cm/sec per cm of distance. At the current separation of Pioneer 10 and Voyager 1, by how much are their separation speeds increasing due to cosmic expansion?

Answer: The separation is 32.6 billion kilometers or 3.26×10^{14} centimeters. Speed of separation is

2.3×10^{-18} cm/sec/cm x 3.26×10^{14} cm = 7.5×10^{-4} cm/sec.

Note: We can convert this speed to km/hour to get 7.5×10^{-4} cm/sec x 3600 sec/1hr = **2.7 cm/hour**. Because it takes light 1.25 days to travel the distance between the spacecraft, the speed you would be able to measure is 2.7 cm/hr x 1.25 days x 24 hours/day = 81 centimeters.