



NASA's Voyager 1 spacecraft officially is the first human-made object to venture into interstellar space. The 36-year-old probe is about 12 billion miles (19 billion kilometers) from our sun.

Voyager 1 does not have a working plasma sensor, so scientists needed a different way to measure the spacecraft's plasma environment to make a definitive determination of its location. A coronal mass ejection, or a massive burst of solar wind and magnetic fields, that erupted from the sun in March 2012 provided scientists the data they needed. When this unexpected gift from the sun eventually arrived at Voyager 1's location 13 months later, in April 2013, the plasma around the spacecraft began to vibrate like a violin string.

On April 9, Voyager 1's plasma wave instrument detected the movement. The pitch of the oscillations helped scientists determine the density of the plasma. The particular oscillations meant the spacecraft was bathed in plasma more than 40 times denser than what they had encountered in the outer layer of the heliosphere. Density of this sort is to be expected in interstellar space. The plasma wave science team reviewed its data and found an earlier, fainter set of oscillations in October and November 2012. Through extrapolation of measured plasma densities from both events, the team determined Voyager 1 first entered interstellar space in August 2012.

**Problem 1** – The solar coronal mass ejection left the sun in March 2012 and was first detected by Voyager 1 in April 2013 at a distance of about 19 billion kilometers from the sun. What was the average speed of the CME in: A) kilometers/day? B) kilometers/sec? C) miles/hour? (1 mile = 1.6 km)

**Problem 2** – The speed of light is 300,000 km/s. How long does it take a radio message to travel from Voyager 1 to Earth in hours?

**Problem 3** - Measurements taken between April 9 and May 22 of 2013 show that Voyager 1 was, at that time, located in an area with a density of about 0.08 hydrogen atoms per cubic centimeter which is similar to the expected density of interstellar space. To two significant figures, how many hydrogen atoms would you expect to find in a container as large as your bedroom if your bedroom measured exactly 10-feet x 9-feet x 12-feet? (1 foot = 30.5 cm)

NASA Spacecraft Embarks on Historic Journey Into Interstellar Space  
[http://www.nasa.gov/mission\\_pages/voyager/voyager20130912.html](http://www.nasa.gov/mission_pages/voyager/voyager20130912.html)  
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**Problem 1** – The solar coronal mass ejection left the sun in March 2012 and was first detected by Voyager 1 in April 2013 at a distance of about 19 billion kilometers from the sun. What was the average speed of the CME in: A) kilometers/day? B) kilometers/sec? C) miles/hour? (1 mile = 1.6 km)

Answer: The difference in time between the two dates is April 2013 – March 2012 = 365+30 = 395 days.

A) The distance traveled is 19 billion km, so the speed was 19 billion km/395 days = **48 million km/day.**

B) 1 day = 24 x 3600 = 86400 seconds so the speed is 48 million km/86400 sec = **555 km/sec.**

C) 555 km/sec x (1 mile/1.6 km) x (3600 sec/1 hour) = **1.2 million miles/hour.**

**Problem 2** – The speed of light is 300,000 km/s. How long does it take a radio message to travel from Voyager 1 to Earth in hours?

Answer: Time = distance/speed = 19 billion km / 300000 km/s = 63,333 seconds.  
 Time = 63333 seconds x (1 hour/3600 seconds) = **17.6 hours.**

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Answer: The room measures exactly 10 feet x (30.5 cm/1 foot) = 305 cm. 9-feet = 274 cm and 12 feet = 366 cm so the measurements are valid to three significant figures and so the volume is 305 x 274 x 366 = 30,600,000 cm<sup>3</sup>. The density is 0.08 hydrogen atoms/cm<sup>3</sup>, so the total number of hydrogen atoms in this volume would be N = 30,600,000 x 0.08 = **2.4 million atoms!**