pbs video explaining c

Speed of Light
Background Reading

The time delay between seeing a flash of lightning and hearing the rumble of thunder is an excellent demonstration of the finite speed of sound. The loud explosive noise we call thunder is produced as a result of a bolt of lightning heating the surrounding air extremely quickly. While the flash of light and the booming sound is produced at essentially the same time, you often see the lightning before you hear the thunder. This delay occurs because sound travels about a million times more slowly than light does.

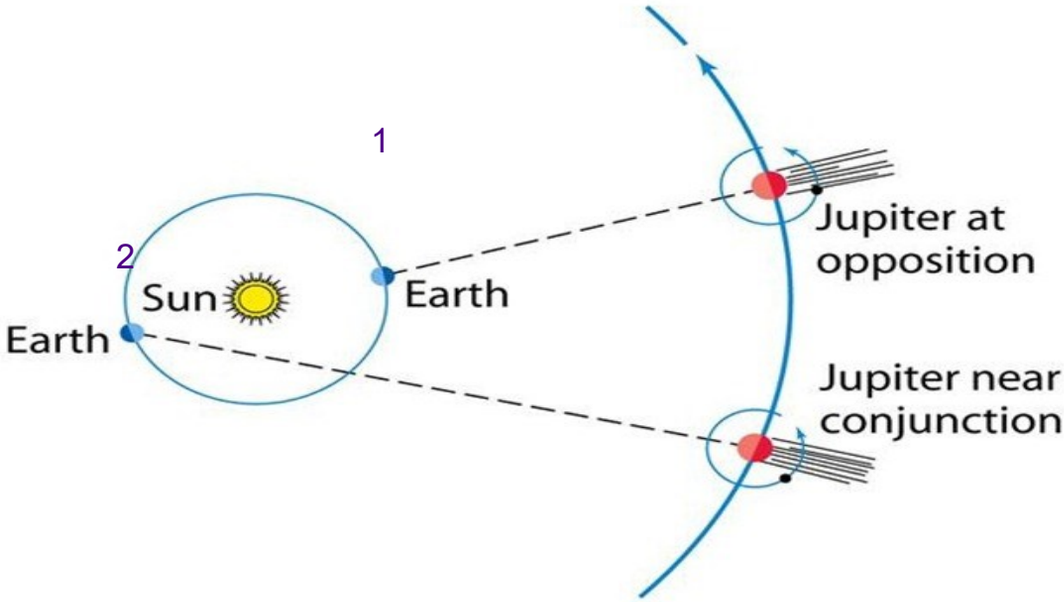
Nowadays, we know that both sound and light travel at finite speeds. However, it wasn't always known that light has a measurable speed. Light travels so fast that, at the short distances we are used to in everyday life, it appears to travel instantaneously. From the time of Aristotle until the seventeenth century, it was generally believed that light traveled at an infinite speed.

However, in the 1600s, Italian astronomer Galileo became convinced that light, like sound, had a measurable speed. He tried to measure this speed by clocking how long it took for flashing lantern signals to travel back and forth between two hilltops. Unfortunately, because light travels so fast and human reaction time over such a short distance is unreliable, this method failed.

Not long after Galileo's experiment, Danish astronomer Ole Roemer studied the time it took for one of Jupiter's moons, Io, to complete its orbit. He observed that the amount of time it took Io to reappear from behind Jupiter—that is, for the light reflected from Io's surface to be seen by Roemer—varied, depending on the distance between Earth and Jupiter. If the speed of light was infinite, there should have been no such delay. Using the diameter of Earth's orbit and this time lag, Roemer calculated the speed of light as 227,000 kilometers per second (140,000 miles per second)—about one-quarter below the modern value of 300,000 km/s (186,000 mi/s). Inaccurate though it was, this was the first physical evidence that light had a finite speed.

So how fast is 300,000 km/s? Consider that it would take you about nine years to walk the distance between the Earth and the Moon. Sound would take approximately two weeks to travel that same distance. Light would only take about 1.3 seconds to make the trip!

Roemer's calculation of the speed of light



Roemer knew that Io had a period of 1.80 days as it orbits Jupiter. So, every 43.2 hours, observers on earth will see Io emerge from Jupiter's shadow. After observing this pattern for several years, he noticed that the emergence of Io was late by about 22 minutes when Earth was farther away from Jupiter (point 2) compared to when Earth was closer to Jupiter (point 1). He proposed that light travels at a finite speed; therefore, light coming from Io takes longer to reach point 2 than point 1. At that time, the diameter of earth's orbit was estimated to be 2.9×10^{11} meters. Based on this information, what did Roemer calculate as the speed of light?