

Ole Rømer and the finite speed of light

Abstract

The first to observe that the propagation of light was not instantaneous was the astronomer Giovanni Domenico Cassini (1625-1712); the first to estimate its speed, in 1676, was the Danish astronomer Ole Christensen Rømer (1644-1710), both based their observations on the solar system.

One way to estimate the longitude of terrestrial locations, or rather the difference in longitude, is based on the analysis of the differences in times (or delays) between events observed from different locations. These events can be the culmination of the Sun at midday, but also eclipses or the occultation of one celestial body by another. In particular, occultations of the easily observable moon Io by Jupiter were considered at the time. Cassini observed the sky from Paris, Rømer from Uraniborg, the observatory built on the island of Hven between Denmark and Sweden by Tycho Brahe (1546–1601). The main purpose was to calculate the longitude of the two locations.

Discrepancies in his own measurements over the course of a year led Cassini to believe that light must have a finite speed; his estimates of the time taken were about 10–11 minutes to traverse half the diameter of Earth's orbit (now called astronomical unit, AU). Rømer's estimate was 22 minutes per 2 AU, comparable to the actual values of 16 minutes and 40 seconds, but lacking a reliable estimate for Earth's orbit measure, he did not go beyond rough estimates.

Figure 1 shows a very very simplified diagram of the path difference of the observed light signals, with all the orbits projected onto the ecliptic plane and made circular and without any respect for the proportions of the real measures. Not to mention that Jupiter's position also changes over time. And more it is clear that the measurements cannot be made with the Sun in the middle; actual observations were made throughout the year with the differences of the occultation times progressively increasing from the position E_1 to the position E_2 , until Jupiter was observable. Perhaps the assessments made after three months and after a quarter of the Earth's revolution path were the most useful, given Jupiter's smaller displacement and the estimated distance difference of about one AU.

Therefore from the sketch we can trivially simplify as:

$$\Delta t = t(\overline{IE_2}) - t(\overline{IE_1}) \Rightarrow \tilde{c} = \frac{2U}{\Delta t}$$

Others calculated the speed from Rømer's data, including Christiaan Huygens (1629–1695), who deduced that light traveled at 16.6 Earth diameters per second, about 200,000 km per second. An acceptable order of magnitude for such a complex measurement based on knowledge from the end of the 17th century.

Anyway, Ole Rømer is remembered as the first to measure the finite speed of light.

Figure 1

