A Presentation Concerning the Propagation of Light Determined by Monsieur Rømer of the Royal Academy of Sciences

Ole Rømer

December 7, 1676

Abstract: This is a translation of the paper, where the Danish astronomer Ole Rømer presents his original method for measuring the velocity of light. Rømer was the first person to determine a finite velocity for the propagation of light, and determined the velocity with an appropriate precision. This paper was originally published in French: Demonstration touchant le mouvement de la lumiere trouvé par monsieur Römer de l'Academie Royale des Sciences. *Journal des Sçavans*, du lundy, 7 Decembre 1676, pages 233–236. Herein the original Danish transcription of the name of the author is used instead the French, Römer, printed in *Journal des Sçavans*. In this paper an anonymous reporter of *Journal des Sçavans*, who actually wrote the text from Rømer's words, referred Rømer in the third person, according to the academic tone and traditions usual in the 17th century. Translated into English in 2008 by Dmitri Rabounski.

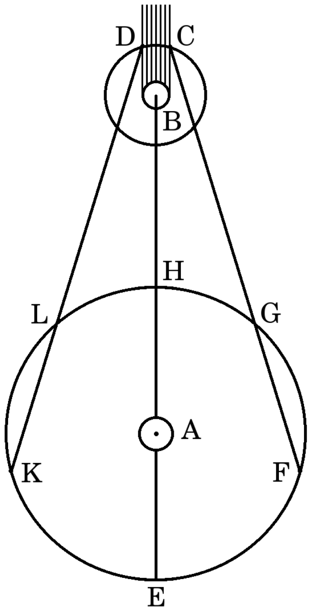
For a long time philosophers were troubled to find an experiment resolving the following problem: is the action of light transferred in an instant at any distance, or does it require some time? Monsieur Rømer of the Royal Academy of Science* found such a method, based on observations of the first satellite of Jupiter. Using this method, he showed that light travels a distance of about 3,000 leagues†, i.e. approximately the diameter of the Earth, in less than one second.

Let A be the Sun, B — Jupiter, C — the first satellite, which moves into the shadow of Jupiter, then appears again from the shadow at the point D, while E, F, G, H, L, K denote the locations of the Earth at different distances from Jupiter (see Figure).

Suppose someone of the Earth, which is located at the point L (near the second quadrature of Jupiter), observes the first satellite of Jupiter at the moment when it appears from the shadow at the point D. Then,

*This is *l'Academie Royale des Sciences*, established in 1666 in Paris by Jean-Baptiste Colbert. The Academy was closed due to the French Revolution of 1789, as well were all the Royal institutions in France. — Editor's comment. D.R.

†Rømer means *la lieue de Paris* (3,898 m) known also as *la nouvelle lieue*. It was introduced in 1674 instead of *l'ancienne lieue* (3,248 m), and remained a standard for distances until 1793. — Editor's comment. D.R.



approximately $42\frac{1}{2}$ hours later, after one full orbital revolution of the satellite, the Earth arrives at the point K, he observes the satellite coming back at the point D. Obviously, if light travels along the path LK during a finite time, the satellite should be observed coming back at the point D with a delay relative to the Earth at the point L. Thus the orbital revolutions of the satellite, recorded according to its appearance from the shadow, should be delayed by the time that light travels from L to K. In the reverse case, in the quadrature FG where the Earth moves towards the light, the orbital revolutions recorded according the penetration into shadow should seem shorter as the revolutions recorded according to the appearance from the shadow are longer. In a duration of $42\frac{1}{2}$ hours, in which this satellite undergoes approximately one full revolution, the distance from the Earth to Jupiter changes, in both quadratures, by at least 210 diameters of the Earth. Hence, if light would travel the diameter of the Earth in one second, it would travel each interval FG and KL in $3\frac{1}{2}$ minutes. This should lead to a deviation of about half an hour between two revolutions of this satellite observed in FG and KL respectively. On the other hand, nothing of such a substantial difference has been found.

This fact however does not mean that light requires no time for travel: in his precise study of this subject monsieur Rømer determined that such a deviation, inaccessible to recordings on two revolutions, becomes very substantial for many revolutions taken altogether. For instance, 40 revolutions observed from the side F should be substantially shorter that 40 other revolutions, observed from the opposite side (this effect is independent of any position in the Zodiac where Jupiter would be located), and this is in a ratio of 22 to the interval HE, which is twice the distance from us to the Sun.

The necessity of the new equation of delayed light was established by all the observations obtained at the Royal Academy and the Observatory during the past 8 years. This was verified later, by the appearance of the first satellite from the shadow of Jupiter, observed in the evening $5^{\rm h}35^{\rm m}45^{\rm s}$ on November 9 of this year, in Paris, that occurred 10 minutes later than it was expected on the basis of the observations produced in August, when the Earth was much closer to Jupiter; this was predicted by monsieur Rømer, at the Academy in the beginning of September*.

To remove all doubts that this inequality originates in the delay of light, he shows that this effect cannot appear due to any eccentricity or any other source which are usually employed for explanation of the irregularities in the motion of the Moon and the other planets: through all these he is sure that the first satellite of Jupiter is eccentric, and also that the satellite is orbiting faster or slower while Jupiter approaches the Sun or moves away from it, hence revolutions of this machine are unequal; so he is sure that the last three causes of inequality do not affect the first cause which is obvious.

*Rømer means the Observatory of Paris where he was employed, commencing in 1672, as Giovanni Cassini's assistant, observing eclipses of the satellites of Jupiter. Before that, in 1671, working at the Uraniborg Observatory in Denmark, Rømer, with another astronomer, Jean Picard, recorded the periods of about 140 eclipses of Io, the first satellite of Jupiter. Cassini also recorded the periods of eclipses of the satellites of Jupiter at the Observatory of Paris in the years 1666–1668. In his calculation of 1976 Rømer used his own observations of 1672–1676, the Danish observations of 1671, and also Cassini's data of 1666–1668. — Editor's comment. D.R.

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