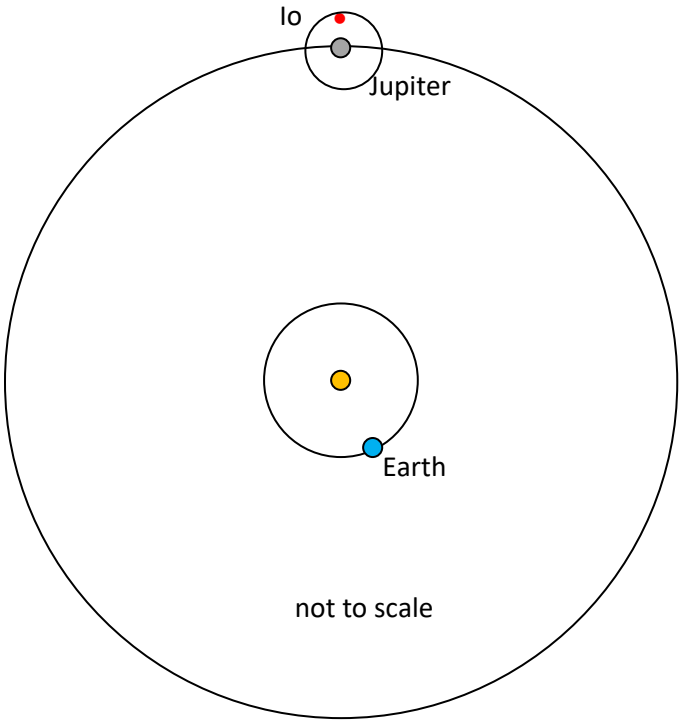
Teacher notes

Another spectacular measurement: the measurement of the speed of light by Ole Rømer.

The Danish astronomer Ole Rømer (1644-1710) was the first to measure the speed of light (in 1676) at a time when many thought light travelled at infinite speed. His method is ingenious in its simplicity.

This is a simplified description of what Rømer did. The diagram shows the orbits of Earth and Jupiter around the Sun. Io is a moon of Jupiter and orbits Jupiter with a period of about 42 hours. It is the innermost moon of Jupiter discovered by Galileo.



Io is eclipsed by Jupiter once in every orbit. Rømer measured how often the eclipses occurred by observing them over time. It was expected that the eclipses would occur at regular time intervals. But he found something strange. The eclipses were occurring more frequently as the Earth moved towards Jupiter and less frequently as Earth moved away from Jupiter. When the Earth was closest to Jupiter the eclipses occurred about 11 minutes earlier than expected and when the Earth was furthest from Jupiter, they occurred 11 minutes later than expected.

Rømer interpreted this to be the consequence of a finite speed of light. Light had to travel a longer distance to get to Earth when the Earth was furthest from Jupiter. He concluded that light took 22 minutes to cover a distance equal to one diameter of the Earth's orbit. This would give a speed of light of

$$v = \frac{2 \times 1.5 \times 10^{11}}{22 \times 60} = 2.3 \times 10^{8} \text{ m s}^{-1}$$

This is lower than the actual speed. The discrepancy comes from an overestimate of the time to cover the Earth's orbit diameter; the correct time is 16.7 minutes. And the Earth orbit diameter was not accurately known at the time.

This was a phenomenal speed and was not immediately accepted but it did have the support of Huygens and Newton.

It is interesting that Rømer was not actually trying to measure the speed of light! He was interested in obtaining a more accurate value of Io's period. It was a big challenge to mariners of the time to be able to determine their longitude. As suggested by Galileo himself, using Io's period as a global clock and comparison with the local solar time would allow determination of the longitude. The method, although valid, was abandoned as impractical when new accurate clocks could be carried aboard ships.

As mentioned in the beginning this is an oversimplified description of Rømer's work. For an interesting discussion of this discovery and the role of Giovanni Domenico Cassini in this story see the article by Albert van Helden in *Journal for the History of Astronomy*, Vol.14:2, No.40, P.137, 1983, available at the site https://ui.adsabs.harvard.edu/