Historic Measurements of the Speed of Light

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Intro


Why is it that nothing can travel faster than the speed of light?

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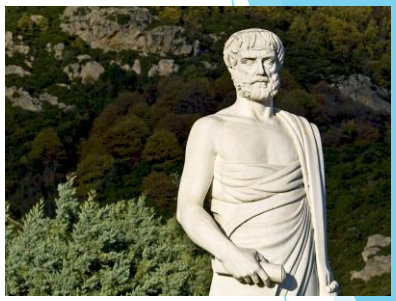
It’s just the way that the universe is built.

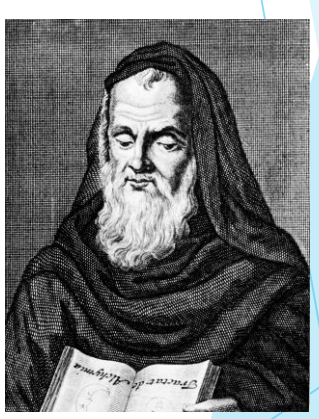
Why is it that nothing can travel faster than the speed of light?

Early Philosophers Weigh In



"light is due to the presence of something, but it is not a movement" - *Aristotle*

Euclid and Ptolemy speculated that light was emitted from the eye which enabled sight.
Later Heron of Alexandria argued that the speed of light is probably infinite since distant objects, stars etc., appear immediately when you open your eyes.
Roger Bacon had a crack at the question in the 13th century. He postulated that the speed of light in air was not infinite. He used philosophical arguments backed by the writings of Alhazen and Aristotle.

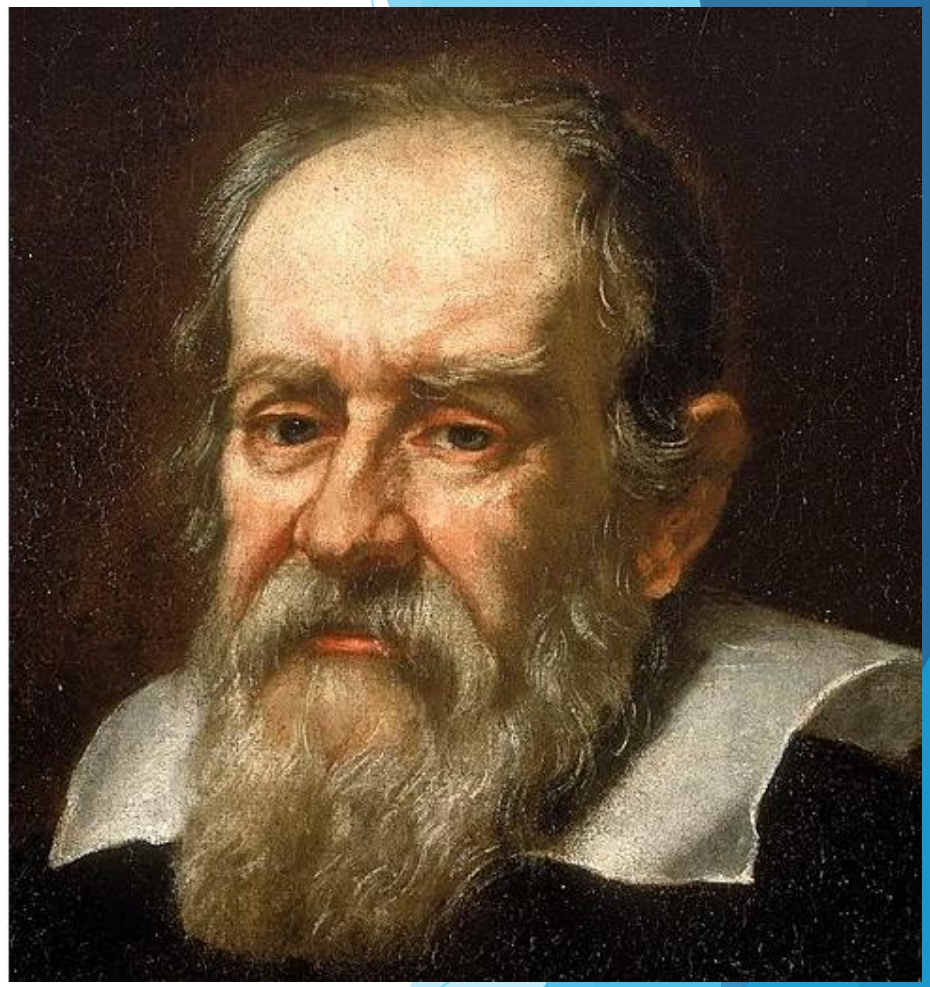


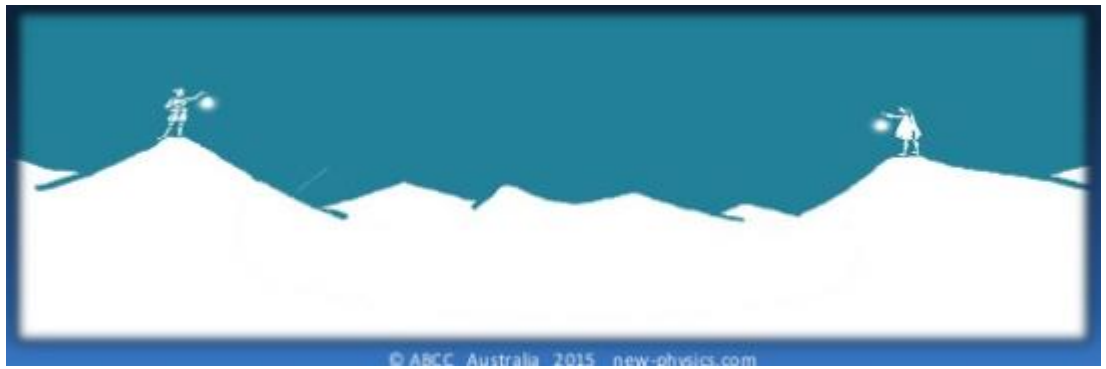
Early Attempts at Measurement, 1629

One of the first serious attempts to measure the speed of light came from Dutch Scientist Isaac Beeckman. In 1629, using gunpowder, he placed mirrors at various distances from the explosions/flashes. He asked observers whether they could see any difference in when the explosion flash was reflected from each mirror with their eyes. The results were inconclusive.

Early Attempts, 1638

Galileo's suggests having two people at a known distance from one another with covered lanterns. One of the lantern bearers uncovers their lantern. The other one observing the first lantern's light, immediately uncovers their own. This process should be repeated several times so that the participants become well practiced to improve reaction times to as small as possible. The reaction time is subtracted to determine the round trip time.
The method failed to produce a measurement.





Early Attempts

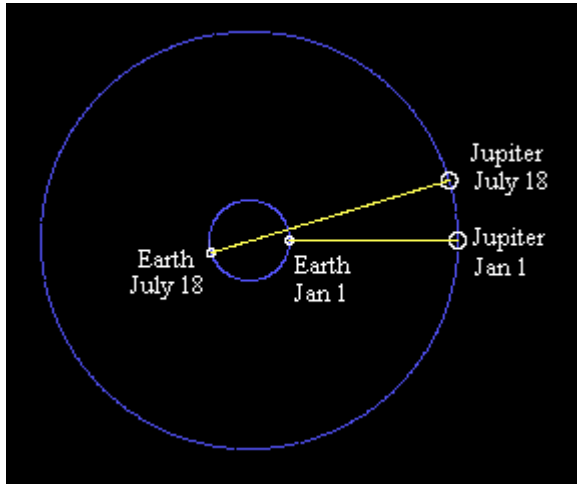
An Early Success! 1676

In the year 1676, Danish astronomer Ole Romer measured the speed of light to within 27%.

How did he do it?

The orbital period (time between eclipses) of Jupiter's moon Io was know to be 1.769 days. Predictions of eclipses to happen in July (180 eclipses later) were performed based on observations in January.

The observations were late by about 22 minutes, because of the time needed by light to travel the longer path (equal to the diameter of earth's orbit).

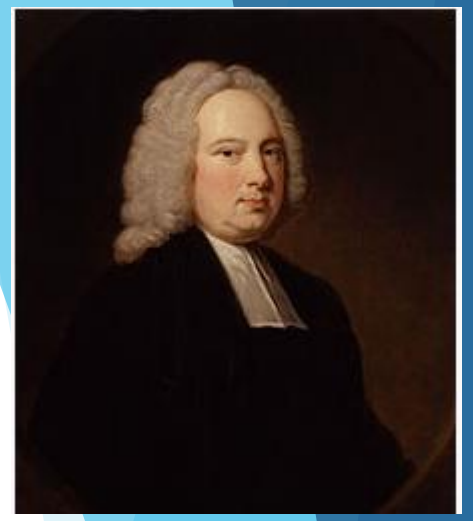


Jupiter as seen through binoculars

The speed of light is not infinite.

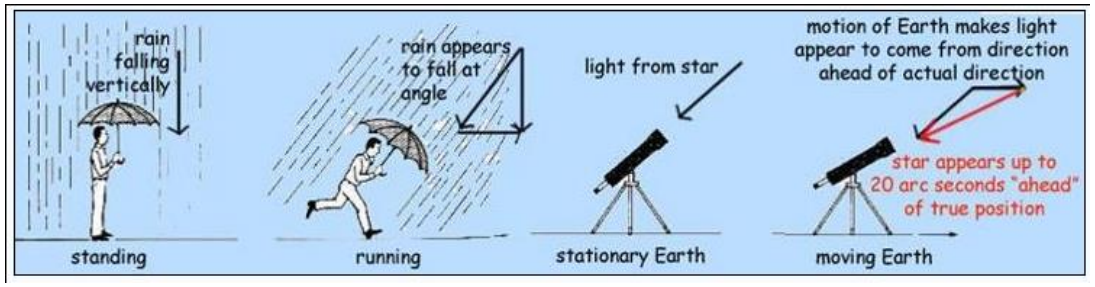
Correct order of magnitude measurement.

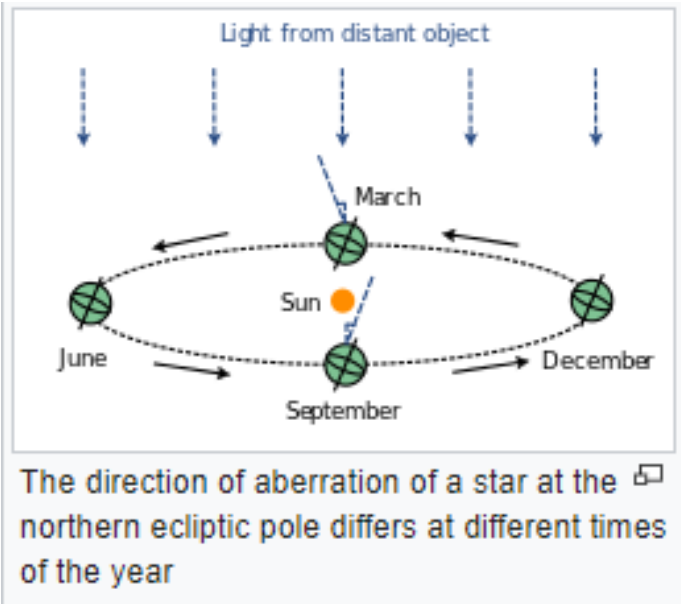
Another Early Success! 1728



James Bradley determined the ratio of the Earth's speed/Speed of light,
By measuring in aberration- change in apparent position of stars at different times of year.

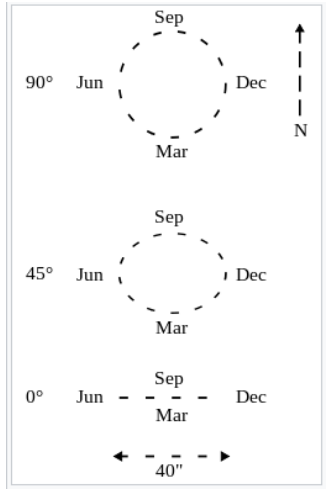
"Like running through the rain".





The direction of aberration of a star at the northern ecliptic pole differs at different times of the year

0.40% accuracy!

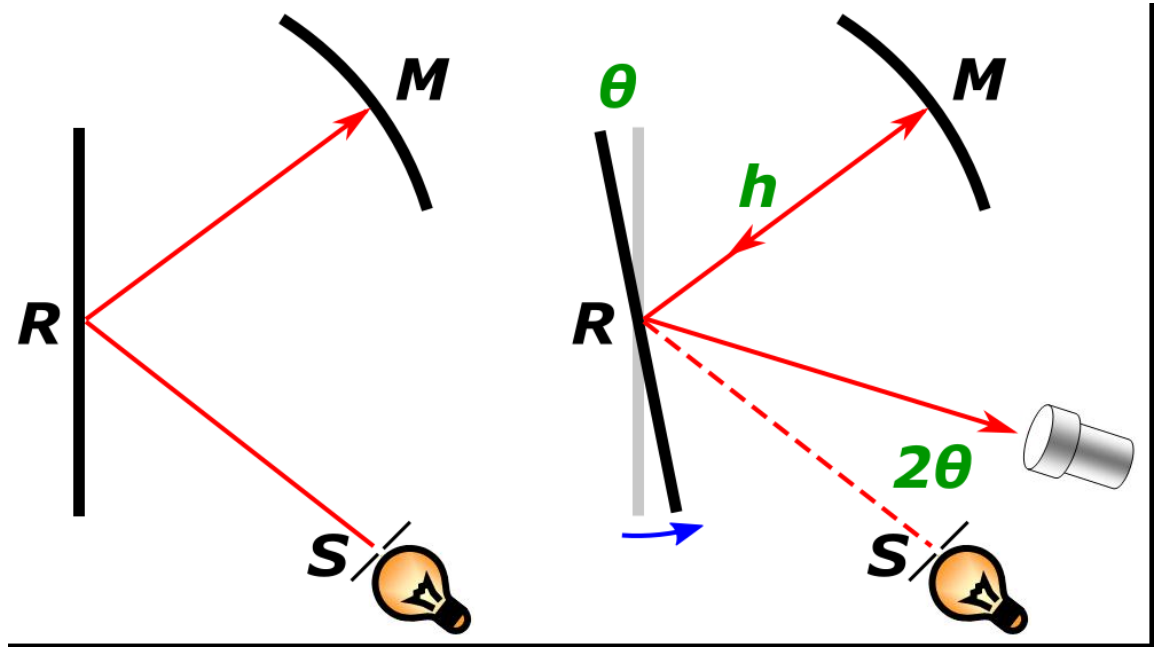


0.00003 deg.

The effect does not depend on distance to the star.

Measurements Using a Rotating Mirror

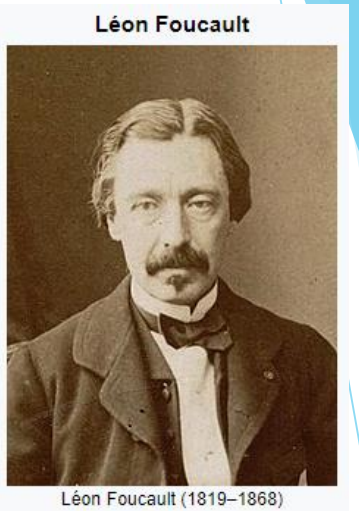
Fixed spherical mirror



Distance **h** was about 8 meters for Foucault, 1 mile for Michelson.
Reflector rotates at 512 Rev/s, Michelson.

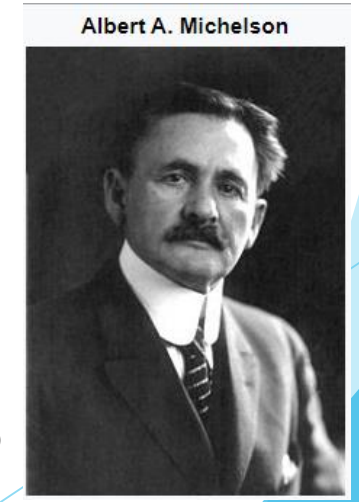
https://books.google.com/books?id=UigDAAAAMBAJ&pg=PA18#v=onepage&q&f=false

1862



0.60% accuracy

1926



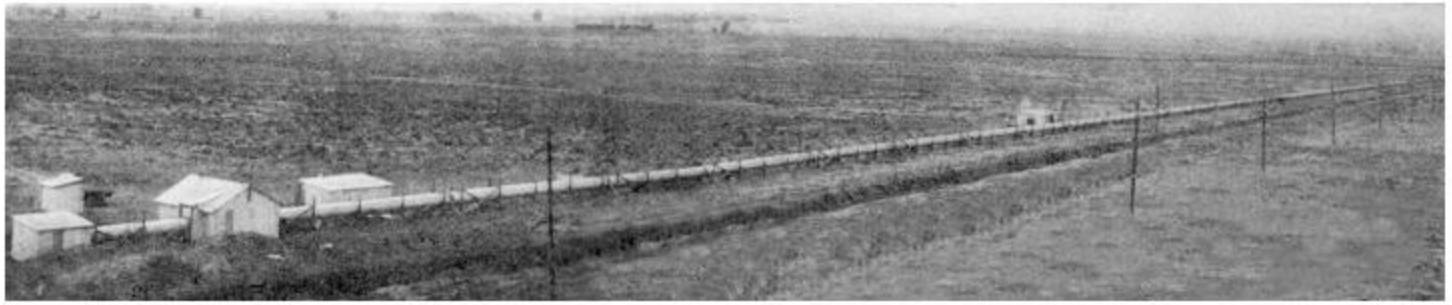
12 ppm accuracy

Summary-

Some failed attempts, some clever methods, many unsung heroes.

History of measurements of *c* (in km/s)

<1638	Galileo, covered lanterns	inconclusive[116][117][118]:1252[Note 13]	
<1667	Accademia del Cimento, covered lanterns	inconclusive[118]:1253[119]	
1675	Rømer and Huygens, moons of Jupiter	220 000[91][120]	–27% error
1729	James Bradley, aberration of light	301 000[101]	+0.40% error
1849	Hippolyte Fizeau, toothed wheel	315 000[101]	+5.1% error
1862	Léon Foucault, rotating mirror	298 000 ± 500[101]	–0.60% error
1899	Max Planck, Planck units	299,792,422.79	–0.0001% error
1907	Rosa and Dorsey, EM constants	299 710 ± 30[106][107]	–280 ppm error
1926	Albert A. Michelson, rotating mirror	299 796 ± 4[121]	+12 ppm error
1950	Essen and Gordon-Smith, cavity resonator	299 792.5 ± 3.0[109]	+0.14 ppm error
1958	K.D. Froome, radio interferometry	299 792.50 ± 0.10[113]	+0.14 ppm error
1972	Evenson *et al.*, laser interferometry	299 792.4562 ± 0.0011[115]	–0.006 ppm error
1983	17th CGPM, definition of the metre	299 792.458 (exact)[89]	exact, as defined



Albert Michelson conducted his historic experiment in a bean field parallel to what is now Armstrong Avenue, between Barranca Parkway and Main Street.