The Discovery of Stellar Aberration

D. E. Blackwell

In 1729 Bradley published his celebrated paper in the Philosophical Transactions of the Royal Society announcing the discovery of stellar aberration. The circumstances of the discovery were these.

At this time no one had detected with certainty the parallax of a star, and in 1725 Bradley and his friend, Samuel Molyneux, decided to attempt this problem. They reasoned that the stellar parallax should show itself as an annual variation in the zenith distance of a star, and therefore resolved to measure this quantity for a bright star throughout one year. They considered this method to be a particularly suitable one because the correction for atmospheric refraction is small for a star near to the zenith, and it could not be expected to vary appreciably from night to night throughout the year.

Molyneux then had a vertical telescope made by Graham. The telescope was mounted on a pivot at the top so that it could move only in the meridian through a small angle on each side of the vertical. The eyepiece end was pulled to one side by a weight and string against a micrometer screw, and its inclination to the vertical measured against a plumb line. In use the telescope was rotated about its pivot and the micrometer screw turned until the chosen star ran along a cross-wire; changes in the zenith distance could then be followed as small rotations of the micrometer screw.

Molyneux’s instrument was 24 feet long with an aperture of 3\frac{3}{4} inches, and it was mounted at Molyneux’s private house at Kew. The upper pivot was set into a chimney stack, and as can be imagined, Molyneux had to cut holes in the floorboards to let the telescope through. The objective was in an upper room, and the telescope was pointed through a hole in the roof.

The telescope was ready for use on 1725 December 3, and Bradley and Molyneux then started to observe $\gamma$ Draconis, which was chosen because it reached the meridian quite close to the zenith. They observed also on December 5, 11 and 12, and then on December 17 Bradley observed that the star had shifted. Thinking that they had made a mistake Molyneux and Bradley again observed on December 20 and found that

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System
the star had shifted still further. In Plate 3 we reproduce a photograph of the original scrap of paper on which Bradley noted this observation. It reads,

Dec 21st Tuesday 5h 40' sider time
Adjusted the mark to the Plumb line
and then the Index stood at 8 4h 48' 22" the star entered
49 52 1/2 Star at the Cross
51 24 Star went out
could
As soon as I let go the course screw I perceived the star too much to the right hand and so it continued till it passed the Cross thread and within a quarter was
of a minute after it [had] passed
graduat
I turned the fine screw till I saw the light of the star perfectly bisected and after the obser vation I found the index at 11 3/4, so that by this observation the mark is about 3" 3/4 too much south but adjusting the mark and plumb line I found the index at 8 1/2

Having confirmed that the star really had moved, Bradley at once began to think about the interpretation of his observations. In Figure 1 we show the effect of parallax on the position of a star, and we see that the maximum displacements occur at positions A and B; Bradley realized that he could not be observing a parallax because the phase of the displacement was wrong. He thought that the displacement could have been due to a nutation, that is, a tipping of the Earth's axis. If this were the cause, then a star to the south of the zenith should have its zenith distance changed by an exactly equal amount as a star in the north, except in the opposite direction. Within a fortnight Bradley was observing such a star, and he found that although it was displaced in the expected direction, the amount of the displacement was not the expected value; hence he had to seek another explanation.
Dec. 21st. Tuesday 5h 40m sidereal line
Adjusted ye mark to ye Plumb line
When ye index stood at 8
4h. 48m. ye star entered
49. 51m. Star at ye cross
51. 24m. Star went out

As soon as I let go ye course
screw I perceived ye star too
much to ye right hand &
so it continued till it passed
ye cross thread & within a quar.
of a minute after it was past
I turned ye fine screw till I saw
ye light of ye star perfectly
resticked & after ye other
variation I found ye mark
at 11h. so that by ye
observation ye
motion ye about 3
too much south.
but adjusting
ye mark & plumb line
I found ye hour 8

J. Bradley
At this stage Bradley decided to set up his own instrument. He was then living in Oxford, and not being willing to disturb the family with whom he was living he decided to set up his instrument in his Aunt’s house at Wansted—his Uncle James Pound having died two years earlier.

The new instrument was shorter than the one at Kew and with it he was in a position to observe some 200 stars. This instrument gave him the law of the variation of shift with position of the star and phase of the year so that when he had his idea of stellar aberration he was immediately able to check it geometrically. In particular, he realized that the maximum aberration occurred at points C and D and was able to confirm from his observations that this was indeed so.

![Diagram]

Fig. 1.

He was also able to provide a second check. The constant of aberration gives a value for \( \psi/\epsilon \) where \( \psi \) is the velocity of the Earth in its orbit and \( \epsilon \) the velocity of light. The solar parallax was known from observations of the transit of Venus, and hence \( \psi \) could be calculated, and in turn \( \epsilon \) was known. The value obtained agreed very well, actually to within 1 part in 500, with that determined from observations of the eclipses of Jupiter’s satellites.

When he continued his investigation with a great number of stars he found that aberration would not entirely account for their apparent motion, and he was forced to the conclusion that the Earth’s axis oscillates. He guessed that the effect, called nutation, was due to the disturbing action of the Moon, and this explanation was confirmed when in 1745, after a lapse of eighteen years which is the period of rotation of the nodes of the Moon’s orbit, he found that the stars were restored to their original places.

Department of Astrophysics,
University Observatory,
South Parks Road,
Oxford.