

Stellar aberration was discovered by James Bradley and Samuel Molyneux. They observed the star Gamma Draconis beginning December 3, 1725 and continued their observations the following year and throughout much of 1727, accumulating a total of 80 position measurements over two years. They discovered that Gamma Draconis wobbled 40 arcseconds a year. The wobble had a 365 day cycle so it was suspected that the wobble was linked to the earth's orbital motion around the sun.

The timing of the wobble was contrary to what was expected for a parallax shift: The star's maximum southward deviation occurred in March, not in December; its maximum northward deviation occurred in September, not in June.

Beginning in August 1727 and continuing over the course of a year Bradley observed many other stars. The wobble was not unique to Gamma Draconis; it occurred in every star he observed.

Here is the explanation of stellar aberration. Whenever an observer views a star the orientation of his telescope is determined by the combined effect of the velocity of light and the orbital velocity of the earth. Were the earth stationary, as Ptolemy or Tycho would have it, a telescope would show the star in its true position; the tube would be aligned parallel to the incoming light rays, which travel unimpeded down the tubes length. However, since the earth moves, the

telescope is constantly swept along with the planet while starlight streams down the tube. Therefore, to center a star in the eyepiece, the telescope must be tipped slightly in the direction that the earth moves; otherwise the star's light will be swept up by the telescope's inner wall before the light reaches the eyepiece. Thus, the observer sees the star, not in its true position, but skewed a maximum of 20 arcseconds in the direction of the earth's motion.

The telescope Bradley and Molyneux used was 24 feet in length. The wobble or southward creep of Gamma Draconis began in December and didn't halt until March at which time the star was a full 20 arcseconds south of its December position. Relative to its starting orientation in December the telescope was now tipped at an angle of 20 arcseconds, less than $6/1,000$ of a degree; the eyepiece now sat $3/100$ of an inch sideways from where it had initially been.

The speed of light is about 1 foot per nanosecond. The speed of the earth in its orbit around the sun is about 18 miles per second. The telescope Bradley and Molyneux used was 24 feet in length, therefore, a light beam would take 24 nanoseconds to travel the length of the tube. Since the earth is moving at a speed of about 18 miles per second in its orbit around the sun, the earth moves about $3/100$ of an inch in 24 nanoseconds. The telescope is swept along with the

earth. The light beams inside the telescope are not swept along with the earth because they are not effected by the motion of the earth or any other object. The lens at the top of the telescope focused the light beams on the eyepiece, but by the time the focused light beams reached the eyepiece, it had moved about 3/100 of an inch.

There is a discrepancy. The earth and therefore the eyepiece of the telescope travel about 3/100 of an inch in 24 nanoseconds, yet according to the results of Bradley and Molyneux the eyepiece of the telescope only has to be adjusted 3/100 of an inch in about 3 months in order to keep the star centered in the eyepiece.

Here is the formula that describes stellar aberration: $\sin\delta = v/c \sin\theta$

δ = the angle of aberration

v = the speed with which the earth orbits the sun

c = the speed of light

θ = the angle the telescope forms with the ground which in the instance of Gamma Draconis will always be very close to 90°.

$v/c = 1/10,000$

$\sin(20 \text{ arcseconds}) = \sin(.0056^\circ) = .000098$

$\theta = 90^\circ \sin(90^\circ) = 1$

If we substitute these values into the formula the result is: $.000098 \cdot 1/10,000 \cdot (1)$. The formula will

only be valid for aberration angles of 20 arcseconds or very near 20 arcseconds. In the instance of Gamma Draconis the aberration angle is near 20 arcseconds only in the months of March and September for the rest of the year it is a substantially lower value.