

X. *On the Height of the luminous Arch which was seen on Feb. 23, 1784.* By Henry Cavendish, *Esq. F. R. S. and A. S.*

Read February 25, 1790.

**T**HIS arch was observed, at the same time, at Cambridge by Mr. WOLLASTON; at Kimbolton in Huntingdonshire, by the Rev. Mr. HUTCHINSON; and at Blockley near Campden in Gloucestershire, by Mr. FRANKLIN; and is described in letters from those gentlemen read to the Royal Society in December 1786 \*.

It has been remarked, that as the arches of the kind described in these Papers have usually but a very slow motion, their height above the surface of the earth may readily be determined, provided they are observed about the same time, at places sufficiently distant; and they seem to be the only meteors of the aurora kind whose height we have any means of ascertaining.

The three places at which this phenomenon was seen are not so well suited for this purpose as might at first be expected from their distance, because they lie too much in the direction of the arch; they however seem sufficient to determine its height within certain limits, and perhaps are as well adapted for it as any observations we are likely to have of such phenomena.

The latitude of Cambridge is  $52^{\circ} 12' 36''$ : that of Kimbolton is said by Mr. HUTCHINSON to be  $52^{\circ} 20'$ , and,

\* See p. 43—46. of this Volume.

according to the survey of Huntingdonshire, published by JEFFERIES, is  $52^{\circ} 19' 50''$ ; so that we may suppose it to be seven geographical miles north of Cambridge, and by the maps it seems to be about 18 such miles west of it: and Blockley is by the map 12 geographical miles south and 72 west of Cambridge.

At Cambridge the observations of its track seem to have been made at about 9 h. 15' P.M. or 8 h. sidereal time. At Kimbolton, allowing for the difference of meridians, they could hardly have been made more than 5' sooner; and at Blockley they were most likely made nearly at the same time as at Cambridge.

At Blockley the arch passed about  $7^{\circ}$  south of the zenith; but it is unnecessary to determine this point with precision. At Kimbolton it was found by a quadrant to pass  $11^{\circ}$  to the south of it; and at Cambridge it was observed to pass through  $\delta$  and  $\epsilon$  Tauri,  $\beta$  Aurigæ,  $\theta$  Ursæ majoris, Cor Caroli, and Arcturus. Now, if an arch was drawn through these stars, it must, I think, have appeared sensibly waved to the eye; whereas Mr. WOLLASTON did not take notice of any crookedness in this part of its course. It is most likely, therefore, that the middle of the arch must have passed to the south of  $\beta$  Aurigæ, and to the north of  $\theta$  Ursæ; and if a circle is drawn through  $\delta$  Tauri, Arcturus, and a point one degree north of the zenith, it will differ but little from a great circle, will agree as well with the positions of these stars as any regular line which can be drawn, and will pass  $2\frac{1}{2}$  degrees below  $\beta$  Aurigæ, and as much above  $\theta$  Ursæ; which is not a greater difference from observation than may well have taken place, considering how much care and acquaintance with the fixed stars are required to determine a path by them so nearly.

The direction of the arch here described in that part near the zenith is W.  $18^{\circ}$  S.; and if a line is drawn through Cambridge in this direction, Kimbolton is 12,8 geographical miles north of it; and therefore, as the arch appeared  $12^{\circ}$  more south at Kimbolton than at Cambridge, the height of the arch above the surface of the earth must be  $61\frac{1}{2}$  geographical or 71 statute miles. If we suppose that the middle of the arch really passed through  $\beta$  Aurigæ, the height comes out 52 statute miles. On the whole, I should think, the height could hardly be less than 52 miles, and is not likely to have much exceeded 71.

The common aurora borealis has been supposed, with great reason, to consist of parallel streams of light shooting upwards, which, by the laws of perspective, appear to converge towards a point; and when any of these streams are over our heads, they appear actually to come to a point, and form a corona. Hence, from analogy, it seems not unlikely, that these luminous arches may consist of parallel streams of light, disposed so as to form a long thin band, pretty broad in its upright direction, and stretched out horizontally to a great length one way, but thin in the opposite direction. If this is the case, they will appear narrow and well defined to an observer placed in the plane of the band; but to one placed at a little distance from it, they will appear broader, fainter, and less well defined; and when the observer is removed to a great distance from the plane, they will vanish, or appear only as an obscure ill-defined light in the sky.

There are two circumstances which rather confirm this conjecture: first, that though we have an account of another arch besides this\* having been seen at great distances in the

\* That of Feb. 15, 1750. Phil. Trans. XLVI. p. 472. and 647.

direction of the arch, we have none of any having been seen in places much distant from each other in the contrary direction; and, secondly, that most of them have passed near the zenith, whereas otherwise they ought frequently to appear in other situations; for if they appeared near the zenith to an observer in one latitude, they should appear in a very different situation in a latitude much different from that.

I wish it to be understood, however, that I do not offer this as a theory of which I am convinced; but only as an hypothesis which has some probability in it, in hopes that by encouraging people to attend to these arches, it may in time appear whether it is true or not. If it should hereafter be found, that these arches are never seen at places much distant from each other in a direction perpendicular to the arch, it would amount almost to a proof of the truth of the hypothesis; but if they ever are seen at the same time at such places, it would shew that the hypothesis is not true.

Supposing the hypothesis to be well founded, the height above determined will answer to the middle part of the band, provided the breadth of it was small in respect of its distance from the earth, but otherwise will be considerably below the middle. If the breadth of the band was equal to the distance of its lower edge from the earth, the height of the lower edge would be three-fourths of that above found; and if the breadth was many times greater, would be half of it.

In the common aurora borealis, an arch is frequently seen low down in the northern part of the sky, forming part of a small circle. What this is owing to, I cannot pretend to say; but it is likely that it proceeds from streams of light which appear more condensed when seen in that direction than in any other, and consequently that the streams which form the arch to an observer

in one place are different from those which form it to one at a distant place, and consequently that no conclusion as to its height can be drawn from observations of it in different places. Attempts, however, have been made to determine the height of the aurora from such observations, and even from those of the Corona\*; though the latter method must surely be perfectly fallacious, and most likely the former is so too.

\* BERGMAN. Opusc. Vol. V.

