

III. *An Account of some luminous Arches. In a Letter from Mr. William Hey, F. R. S. to the Rev. Joseph Priestley, LL. D. F. R. S.*

Read December 14, 1786.

REV. AND DEAR SIR,

Leeds, Dec. 31, 1783.

BEFORE I describe the luminous arches which I have seen since the commencement of this year, I shall give you a short account of two, which I saw some years ago, though I made no observations upon them which could at all illustrate their origin.

While I was at Buxton, in March 1774, I was called out by some gentlemen, about half past eight in the morning, to see a luminous arch, which appeared very beautiful in the atmosphere. Being then indisposed, I durst not stay out of doors any considerable time to examine it, and only made the following observations respecting it. Its colour was white, inclining to yellow; its breadth in the crown apparently equal to that of the rainbow. As it approached the horizon, each leg of the arch became gradually broader. It was stationary while I viewed it, and free from any sensible coruscations. Its direction seemed to be from about the N.E. to the S.W. at least its eastern leg was inclined to the north, and its western to the south. Its crown, or most elevated part, was not far from the zenith. The evening was clear, and the stars

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appeared

appeared bright. It continued about half an hour after it was first observed by the company.

In October 1775, I saw a similar arch at Leeds, of the same colour, breadth, and position. It began to disappear in five or six minutes after I had discovered it, without changing its situation. The manner in which it vanished was quite irregular; large patches in different parts, and of different dimensions, ceasing to be luminous, till the whole had disappeared. The evening was rather cloudy. I made no observation on the state of the wind during the appearance of either of these arches.

Having read Mr. CAVALLO's Paper in the Philosophical Transactions*, containing a description of a similar phenomenon, with some remarks upon its nature, I determined to pay a greater attention to this meteor, if I should ever happen to see it again. During the last spring it appeared so often, and with such a variety of circumstances, that I had an opportunity both of gratifying my curiosity, and fixing my judgement concerning it.

As I was travelling in the evening of the 21st of last March, betwixt eight and nine o'clock, I observed something like a bright cloud in the eastern part of the hemisphere; and suspecting that it might be of the kind above described, I looked through the glass in the back part of the chaise in which I was riding, and saw a similar appearance in the opposite part of the heavens. I immediately ordered the driver to stop, that I might make as accurate an observation as my situation would admit. I saw that the luminous bodies, which appeared in the eastern and western parts of the horizon, were connected by an arch of a fainter light; and recollecting that the best

* Vol. LXXI. p. 329.

method of ascertaining the course and dimensions of this arch would be to observe some of the principal constellations before which it passed, I made such remarks as I was able; and afterwards, by the assistance of a celestial globe, while the circumstances were fresh in my memory, I drew up the following account of this, and some other arches which I afterwards saw.

The arch which I saw first arose at E. by N. ascending through the constellation Bootes, and having, with respect to the breadth of the arch, Arcturus in its center. Its southern edge passed a little to the north of Castor in Gemini, and descended close to the star Bellatrix in the left shoulder of Orion. It reached the horizon in the W.S.W. point. In this course it passed about 12° to the south of the zenith. Its breadth was, according to the best judgement I could form, about 9 or 10 degrees. It remained visible about 10 or 12 minutes after I had first discovered it, and then vanished gradually and irregularly. I observed no coruscations, nor any motion in this arch.

I had scarcely travelled a mile farther, when another, and still more beautiful, arch made its appearance. It arose a point or two nearer the N.E. than the former had done. Its southern edge passed up a little to the north of the tail of the great Bear, which was then in a vertical position. Its northern edge appeared at first a little to the south of the polar star; but, during the continuance of the phænomenon, it gradually receded about 10 degrees to the south. The arch descended about the W.N.W.; but neither the eastern nor western extremities reached the horizon; each of them ending in a point gradually formed a little above the horizon. This arch might be about 10 or 12 degrees at its vertex. It continued visible

for half an hour; and although I could not discover any coruscations, or quick motion, in any part, yet the different portions of it were perpetually varying in the density of their light, and the whole arch, or at least its vertex, made a slow and equable motion towards the south. Where the light was the most dense, the smaller stars were rendered invisible by the arch, but stars of the second magnitude were not totally eclipsed by it. This arch disappeared, as the former, by patches; the light gradually becoming less intense. The colour of both these arches was white.

Before the latter arch had entirely disappeared, a small one, not quite so broad as the rainbow, arose from its eastern leg, and ascending in a curvilinear direction to the polar star, terminated there. Its light was more faint than that of the other two arches. It continued visible about a quarter of an hour.

When I use the terms *ascending* and *descending*, I would not be understood to mean, that the appearance of these arches was *progressive* from east to west: they were all completely formed when I first discovered them; even the small and imperfect arch last mentioned, which appeared while I was examining the larger one, had no progressive motion. I first saw it complete, though a few minutes before there was nothing luminous where it appeared.

The evening was very fine when I saw these beautiful phenomena; the stars were bright, and there was not a cloud to be seen except in the horizon. There was a steady light in the north, without the least coruscation, extending from the N.E. to N.W. The wind blew from the N.E.

On the 26th of March, about the same time in the evening, I was entertained with a similar appearance, as I was travelling

in the country. I first observed two or three columns of *aurora borealis* shooting upwards in the north; and in a short time after I saw a complete arch, like those already described, though somewhat different in its position. It arose between the E. and N. and N.E. points, passed obliquely to the south below Arcturus, and descended in the west through Orion, having almost the same direction through that constellation which the equator has. It was the most luminous in Orion, and just below Arcturus. A small black cloud crossed it in the east, and hid a part of it, equal to the breadth of the cloud, from view. Its light was the most faint about the vertex of the arch. Its most dense parts were continually varying in the intensity of their light. The larger stars were visible through its densest parts. It varied its position, which I could best observe where it passed through Orion; for there it moved not less than 10 degrees towards the southern part of that constellation. It continued visible about half an hour; and, although I paid as strict attention to the changes which passed in it as my situation would admit, yet I observed nothing which could be called a shooting or quick coruscation. There was a steady northern light all the evening, or at least till the arch had disappeared.

The most grand specimen of this phenomenon which I have seen appeared on the 12th of April, betwixt nine and ten in the evening. I had observed, for above half an hour, as I was travelling, a light in the western part of the atmosphere; but as this lay in the direction of some iron-works then before me, which often shoot out a flame illuminating the air to a considerable distance, I did not pay much attention to the appearance. But having passed the foundery, and still seeing the light before me, I looked through
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the hind-glass of the carriage, and saw the same luminous appearance in the east. This roused my attention; and immediately letting down the glasses, I looked out and perceived a broad arch of a bright pale yellow, arising between Arcturus and Lyra, about the right leg of Hercules, and passing considerably to the south of the zenith, its northern border being a little south of Pollux, and descending to the horizon near Orion, which was then setting.

This arch seemed to me to be about 15 degrees in breadth, and was of such a varied density, that it appeared to consist of small columns of light, which had a sensible motion.

I had scarcely viewed this arch above ten minutes, when I saw innumerable bright coruscations, shooting out at right angles from its northern edge, which was concave, and elongating themselves more and more till they had nearly reached the northern horizon. As they descended, their extremities were tipped with an elegant crimson, such as is produced by the electric spark in an exhausted tube. After some time this *aurora borealis* ceased from shooting, and formed a range of beautiful yellow clouds, extending horizontally about a quarter of a circle.

The eastern leg of this arch seemed to me to make an angle of about 60 degrees with the horizon; and when I traced out the course of the arch upon the celestial globe, I judged that the center of it must have passed about 30 degrees to the south of the zenith. The crown of the arch appeared convex towards the south, and concave towards the north. The greatest part of the *aurora borealis* which darted from this arch towards the north, as well as the cloud-like and more stationary *aurora*, were so dense, that they hid the stars from view. The moon was eleven days old, and shone bright during this scene, but

did not eclipse the brightness of these coruscations. The wind was at north, or a little inclined to the east.

The last phænomenon of this kind which I saw was on the 26th of April. Having gone into my study about a quarter before ten in the evening, when the window-shutters were by accident left open, I observed in the W. a luminous appearance, of the colour of the most common *aurora borealis*. From this mass or broad column of light issued three luminous arches, each of which made a different angle with the horizon. That nearest to the south seemed to arise at right angles with the horizon; while that nearest to the north made the smallest angle, and passed towards the N.E. through the constellation Auriga, having Capella close to its upper edge. The houses adjoining to my own prevented me from seeing the termination of any of these arches; and neither the time during which they remained visible, nor the obscurity of the atmosphere, would permit me to trace their course with more accuracy. I had not viewed them many minutes when they were rendered invisible by a general blaze of *aurora borealis*, which possessed the space just before occupied by these arches.

As there was nothing peculiar in the appearance of this *aurora borealis*, except that it seemed to proceed from the W. where I had first observed the large column of light, I attended to the effect which the coruscations had in obscuring the light of the stars. I was soon satisfied that where the *aurora borealis* was dense, it intirely hid from view the stars of the second magnitude. I observed this particularly with respect to the star β in the left shoulder of Auriga. But the coruscations were never so dense, while I staid to look at them, as to render Capella invisible. The wind was betwixt the N. and N.E. this evening.

After

After comparing the phænomena above described with each other, and with those observed by Mr. CAVALLO, in London, March 27, 1781; by Mr. SWINTON, at Oxford, Oct. 12, 1766, and April 23, 1764; by Dr. HUXHAM, at Plymouth, Feb. 15 and 16, 1749-50; and by Mr. SPARSHAL, at Wells in Norfolk, Jan. 23, in the same year*; I cannot entertain a doubt, that these arches had all the same origin; and that they ought to be considered as a species of that kind of meteor called *aurora borealis*.

As Mr. CAVALLO has given some reasons for dissenting from this opinion, with respect to the arch which he describes, I shall take the liberty of communicating my thoughts upon his arguments. His words are as follows: "This extraordinary appearance to me seemed quite distinct from the aurora borealis, for the following reasons; viz. because it eclipsed the stars over which it passed; because its light, or rather its white appearance, was stationary, and not lambent; and because its direction was from east to west."

1. Mr. CAVALLO certainly mistakes in supposing that the stars are not eclipsed by the *aurora borealis*. The coruscations which I saw on the 12th and 26th of April were more dense than the white arches seen in March. The former rendered stars of the second magnitude invisible; but these I could discern through the white luminous arches. The *aurora borealis*, seen by Mr. ARDERON, at Norwich, Jan. 23, 1750, eclipsed stars of the first magnitude.

2. The stationary appearance of some of these arches does not, I apprehend, invalidate the opinion I have entertained concerning their nature. For the more common *aurora borealis* may now and then be observed to remain stationary for a time.

* See Philosophical Transactions for these several years.

That which I saw on the 12th of April, and which appeared like a range of bright yellow clouds, continued fixed for a considerable time, though apparently formed by the combination of some coruscations, which a little before had been moving with rapidity. Besides, though there were no coruscations observable in the arches which I saw in March, yet all of them, except the imperfect one, were perpetually varying in the intensity of their light; a circumstance which sometimes takes place in the *aurora borealis*, when little or no shooting motion can be perceived.

Mr. SWINTON observed in the white arch, seen by him in 1764, an appearance which approaches still nearer to that of the common *aurora*. "An internal undulating motion of the "the particles constituting the luminous matter," which "was "discernible from the first to the last moment of its existence." And Dr. HUXHAM describes an appearance in the luminous arch seen by him, Feb. 15, 1750, which approaches still nearer to that of the *aurora borealis*. "Near the top of "the arch, several very lucid, white, short, vibrating columns were attached to it" at right angles, as appears by the annexed drawing, some of which were six or seven degrees in length. But the appearance of the arch which I saw the 12th of April would, in my opinion, have precluded or removed all doubt in any spectator with regard to the nature of this phænomenon.

The luminous arches which I have seen exhibited a pleasing diversity with respect to their motion; some of them having none other than such as resulted from a varying intensity of their light, or an internal undulation; others moving slowly and equably in all their parts; and others seeming to consist of united coruscations, or emitting the most vivid flashes of coloured light.

3. The direction of these arches from east to west seems to me to afford no sufficient objection to our considering them as a species of *aurora borealis*: for if we suppose them to be formed by streams of electric matter, flowing in a meridional direction, which are either stopped in the atmosphere, or rendered visible at a certain distance from the north or south; this electric matter must acquire the form of an arch, the position of which will be from east to west. This idea, respecting the origin of these luminous arches, is naturally suggested by Dr. HUXHAM's description above quoted, and other of the preceding observations. The phenomenon of the 12th of April last almost forces this idea upon the mind, and demands assent.

After weighing the preceding observations, you will not, I hope, think me precipitate, if I venture to give a name to the meteor I have been describing, and call it the **ARCHED AURORA BOREALIS**.

Some luminous arches of this kind, which I did not see, were observed by others in the course of last spring. An account of one was published in the Newcastle Paper, and another was seen at Leeds.

It is remarkable, that the greatest part of those which have been publicly noticed appeared near the equinoxes. The poles of all the complete arches which I have seen had a western variation from the pole of the equator. The arches ascended obliquely towards the south; and in all the instances in which I observed the course of the wind, it blew from some point between the N. and N.E. That seen by Mr. SWINTON, in April 1764, was the reverse of these in several particulars. Its pole was directed to the N.E. It ascended obliquely to the north of the zenith, and was preceded by a wind blowing from between the N. and N.W.

These circumstances were perhaps merely accidental; though, in our present state of imperfect knowledge respecting these meteors, it may not be amiss to take notice of them. In one of the instances related by Dr. HUXHAM, the wind was N.W. by N.; in the other it was east.

Before I conclude this account, already I fear too much protracted, let me hazard a conjecture respecting the white colour and stationary continuance of some of these arches. Experiments in electricity, made with what is called an *exhausted* receiver, shew, that the colour and motion of the electric spark vary in proportion to the rarity of the air in the receiver. The more the air is rarified, the more moveable and coloured is the electric *aura* passing through it. On the contrary, the colour of the spark approaches to whiteness, and moves with greater difficulty, as the air is admitted. Will this observation serve in any measure to account for the difference in colour and motion of these electric arches, for such I presume to call them? May we not suppose the more coloured and transient coruscations of *aurora borealis* to be made in the rarer parts of the atmosphere, while the more white and stationary ones possess the denser parts*? The whitest arches which I saw were the most fixed; that seen April 12. was the most coloured, and had the most internal motion.

I am, &c.

WILLIAM HEY.

* The luminous arch seen by Mr. SWINTON, Oct. 12, 1766, the edges of which were in a vertical position, seems clearly to have been formed in the lower part of the atmosphere: for, while "the upper or exterior limb was white and resplendent, the lower was obscure, and scarcely distinguishable from the clouds."

