

- I. *An Account of an Aurora Borealis seen in New-England on the 22d of October, 1730, by Mr. Isaac Greenwood, Professor of Mathematicks at Cambridge in New-England. Communicated in a Letter to the late Dr. Rutty, R. S. Secr.*

S I R, *Harvard-College, Oct. 24, 1730.*

**T**HE *Aurora Borealis* has been very frequent with us of late; but none either for Brightness, Variety or Duration, so considerable as what occurred on the last *Thursday* Night, which was the 22d of *October*. This Meteor has been observed in *New-England*, at different Times, ever since its first Plantation; but I think at much longer Intervals than of late Years, and never to so great a Degree as the present Instance: Nor indeed is there any recorded in the *Philosophical Transactions*, that I could think, by their Description, equal to it; excepting only that celebrated one of the 6th of *March, 1716*, observed by the most judicious and learned *Dr. Halley*, and in many Respects that also must give the Preference to it. And on this Account I have thought the most particular Description of this Meteor would not be unacceptable to you; and have therefore sent all my Notes relating thereunto, which are very numerous, almost to every Change and Circumstance of the Appearance. I am perswaded there is no better Way to arrive at the

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true Cause of this extraordinary Phænomenon, than by attending to the minutest Particulars and Circumstances thereof; and if what I have done contributes thereunto, I shall esteem it a sufficient Excuse for the Number and Particularity of my Notes.

## OBSERVATION I. TAB. I. FIG. I.

*Oct. 22, 1730, 6<sup>h</sup> 30' P. M.* There lay near the Horizon an extended dusky Vapour reaching from NW by N. to NE by E. The upper Edge was the Segment of a Circle, whose greatest Height from the Horizon was about  $15^{\circ}$  bearing nearly N by E. Adjoining to this was a concentric Segment of a very light Azure, of a greenish Cast, strongly illuminated, a few Degrees in Breadth, and then dilated more and more till it became blended with an extensive Brightness, or *Aurora*, which lay every where above it for about  $45$  Degrees. There was in several Places a faint Cast of Red. The Heavens were every where else perfectly serene; a small Westerly Wind, and the Moon above  $80^{\circ}$  below the Eastern Horizon.

OBSERVATION II. 6<sup>h</sup> 35'.

Two Striæ rising perpendicularly from different Parts of the illuminated Edge of the Vapour (which I all along suppose to continue its Figure, when there is no particular Note to the contrary) These were of a faint Red, and to the Height of  $45^{\circ}$  at least.

OBSERVATION III. 6<sup>h</sup> 40'.

The Striæ were very numerous to the Left, each about  $45^{\circ}$ ; and one in the Middle (by which I shall always

always mean the Middle of the Northern dusky Vapour) rose to a surprizing Height. It was  $8^{\circ}$  or  $10^{\circ}$  in Breadth; of a light Azure tinged with Green, and in several Places streaked vertically with a bright Flame-Colour. There was also N W by N. a large Area or Body of a very intense Red.

OBSERVATION IV. 6<sup>h</sup> 45'. FIG. 2.

The whole extraordinarily luminous. The Red diffused in all Parts above the greenish Light, which now bounded the dusky Vapour in the North; and indeed several Parts of this were tinged therewith also. But the most intense Red was towards the N W. and N E. by E. between which were various pyramidical Streams of different Colours, some Blue, some Green, others Flame-coloured, &c. many tintured with, and all terminated by the diffusive Rosiness. One Stria was of a surprizing Lustre, of a light Azure turned upon Green, appearing N W. by N. This Scene was very beautiful, the Height of each Column about  $45^{\circ}$ , and many of them well defined.

OBSERVATION V. 6<sup>h</sup> 50'.

The enlightned Part of the Hemisphere was every where tinged with Red; its horizontal Bounds the same as before, but its Altitude about  $70^{\circ}$ . Whence it appears the *Aurora* is considerably extended upwards. The reddish Cast on the right Hand from North to East was beautifully distinguished into perpendicular Striæ, which generally observed the following Order of Colours, beginning from the East; *viz.* a deep Azure, which successively proceeded to the lightest

Blues (though each Column was of such Intensity as to be distinguished from the neighbouring Columns) after which followed several Degrees of Green, and then of Red, the deepest being an intense Scarlet. And this Order was repeated several times, filling up the whole Space from N E. to N by W. The Western Regions were at the same Time of an undistinguished Red. Many of the rising Columns were very exactly terminated.

OBSERVATION VI. 6<sup>h</sup> 55'. FIG. 3.

The Red, which in the last lay towards the Zenith, became very intense; darting to the horizontal Vapour, throughout the intermediate Space innumerable Striæ differently coloured. The horizontal dusky Cloud was somewhat raised; an apparent Stratum of Blue just under it, which towards the Horizon was of a fainter Cast, as the Colour of the Sky is when overcharged with Vapours. I should not forget that the upper Surface of Red jutted out, irregularly, in several Places, though in general well terminated; as I have observed the Case has been in some rising Clouds.

OBSERVATION VII. 7<sup>h</sup> 0'.

The distinguished Red towards the Zenith, approaching nearer thereunto; it is about 20° broad upon our Meridian, and thence tapering to the Eastern and Western Horizon. The whole Appearance is of a reddish Hue, its in some Places faintly streaked. At this Juncture appeared E S E. considerably removed from the other Phænomena, a remarkable Oval, the transverse Diameter erect, about 30° in Length, and of a  
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very bright Azure. The whole Scene was very beautiful.

OBSERVATION VIII. 7<sup>h</sup> 2<sup>1</sup>/<sub>2</sub>. FIG. 4.

The Phænomena much the same, excepting that the reddish Cast has rose, and is now diffused to the Southward of the Zenith. The other Parts of the Northern Hemisphere much like the genuine *Aurora*, interspersed with various small Clouds. There are two distinguished Parallelogramic Areas of an intense Red, nearly 30° in Diameter, the one to E by N. the other to N W. which was of the deepest Colour, and crossed in the Middle with a black Bar. The bright Azure Oval still remains towards the E S E.

OBSERVATION IX. 7<sup>h</sup> 5<sup>l</sup>.

The whole Appearance seemingly vanished, excepting that the Northern Regions retained the *Aurora*, which was as bright as about half an Hour after Sun-set. The Eastern Area of Red was distinguishable, though very faint, reaching from 30° to 50° high; also the former Area to the N W. somewhat more intense. This was the same as in the last Article; and the black Bar mentioned then, appeared now to be a Cloud moving Eastward, Part whereof was seen on this red Area, and Part to the North. And in this View the red Vapour appeared vastly more distant than the Cloud. There were several small Spaces of Light interspersed throughout the Scene.

OBSERVATION X. 7<sup>h</sup> 15<sup>l</sup>.

The Appearance somewhat changed. The Area of Red N W. was the most intense. Several rising Columns of a faint Red and Blue between West and North. A deep Red E by N. I have all along observed, that some of the fixed Stars could be seen through all the Colours that have successively laid upon them, though with considerable Differences as to Obscurity and Clearness, according to the Intensities of the Colours. No Clouds in the Southern Regions.

OBSERVATION XI. 7<sup>h</sup> 20<sup>l</sup>.

It is now necessary for me to observe, that the Wind has been all along West and W by N. • and if the strongest Winds be expressed by 10, this was sometimes 2, and, I think, never less than Unity. I am informed that at *Boston*, which lies about three Miles Eastward, it was all the while to the Eastward of the South. The *Aurora* still of the same Dimensions, but the Edge of the dusky horizontal Cloud much abated of its Brightness and Colour. There are four remarkable Spots, or *Aræ* of Red, one E by N. one N E. by N. very intense, as also was another nearly North; and the last bore N W. by N. which, with the E by N. has been of some considerable Duration.

There were several considerable *Striæ* intermixed with Red, and a Flame-colour rising about N N W.

OBSERVATION XII. 7<sup>h</sup> 28'.

The Redness about the North increased in its Dimensions and Intensity very much. It reaches from the North Star to about 20° upwards, and for about 12° is exceedingly bright.

It is distinguished into several perpendicular Columns of various Degrees of Red, and many well terminated.

OBSERVATION XIII. 7<sup>h</sup> 30'.

The Redness NE by N. moves Westward, and is considerably altered in that respect since the first Observation thereof. That about the North Star is now divided in the Middle by a perpendicular Column, very broad, and of a very intense yellow Light. It appears now that this also has a slow Motion Westward: But the Western Redness has all along advanced Eastward at a considerable Rate.

OBSERVATION XIV. 7<sup>h</sup> 37'. FIG. 5.

The three red Areas just mentioned are now united, and nearly confounded with one another. The Distinction is only as to the Degree of Redness. The *Aurora* which lies partly under these is considerably abated of its Lustre; and the horizontal Bounds contracted to about 80°, though the Altitude is rather increased. The Eastern and Western Limits seem still to approach one another very slowly. There was one Stria very considerable, horizontally posited, and about 5° broad, of a bright Flame-colour, reaching from

from the horizontal Bounds throughout the whole Meteor Arch-wise, whose greatest Height was about  $15^{\circ}$ .

OBSERVATION XV. 7<sup>h</sup> 45'.

The Flame-coloured Arch much diminished. The Redness very evident, and contiguous; though in some Places of different Intensities, and visibly increasing about N by W. On each Side of which there was a distinguished Ruddiness.

OBSERVATION XVI. 7<sup>h</sup> 51'.

The Distinction of Redness about N by W. changed to a more intense uniform Redness, which seemed to be by the Union of the aforesaid distinguished Area; and the greatest Intensity was in the middle Space that was between them; *viz.* N by W. At this Juncture I was not a little surprized with an extraordinary Flash of Lightning very bright, which began about the Midst of this congregated Vapour, and ran with an oblique undulatory Motion for  $20^{\circ}$  towards the Horizon.

OBSERVATION XVII. 8<sup>h</sup> 1'.

The Redness still continues, but much abated.

OBSERVATION XVIII. 8<sup>h</sup> 9'.

The Meteor scarce to be distinguished but by the *Aurora*, which reaches from N W. to E. in such Sort of Curve that the highest Part is due North about  $40^{\circ}$  of Altitude. There is still a reddish Cast N N W.



OBSERVATION XIX. 8<sup>h</sup> 30'.

The Colours not very considerable; but the Form entirely new. The Breadth of the Redness was from the Pole Star downwards about 20°; and from thence it run Tapering on the left Hand to W by N. and on the Right to the East. In which Points it was of no discernable Breadth. Its upper Edge was of the deepest Red, which dilated by Degrees to a Flame-colour, and could scarce be distinguished from the neighbouring *Aurora*. However, there were two Spots, one to the Right, and the other to the Left, in the extensive Arch of a remarkable Sadness.

OBSERVATION XX. 9<sup>h</sup> 25'. FIG. 6.

Was an extraordinary beautiful Appearance. From the Zenith about 20° Southward, an uncommon Redness was formed, as it were into a Knot or Canopy, very distinctly terminated (especially on the South Parts) about 20° in Length, which lay East and West, and little less in its Dimensions North and South. From this issued innumerable Striæ throughout the Northern Hemisphere and farther, the horizontal Bounds being W S W. to E S E. These Striæ were dispersed in an exact Order, proceeding from the aforesaid Knot, as Folds equally diverging, and each of the same Colour and Brightness throughout the whole Space to the Horizon. The Order of the Colours was very agreeable, interchangeably Blue, Red, and then Flame-colour; each of which was also distinguished into Striæ of various Intensities, from the deepest Blue to the lightest; from the Bounds of Violet, to a Tincture of Orange;

and lastly, from the Colour of the *Aurora* to the brightest Flames. And this Order was repeated innumerable Times throughout the whole Scene. The whole was as bright, and in many Respects resembled a Series of Rainbows vertically posited; and in this View the Generality of People will always remember it. And indeed were the Heavens to be disposed into innumerable Rainbows (excepting only the greater Number of primitive Colours) it would scarce exceed this Phænomenon in Beauty: And the Knot from whence it seemed to proceed, far surpasses any of the Redness of that Meteor, and even Blood itself. It may not be amiss to observe here, that the Western Breeze has been for some time since perfectly lulled; nor is there the least Motion in any Part of the Heavens.

The Northern Bank of Vapours has all along continued, and now reaches from W. to E. by S. its greatest Height about 8°.

OBSERVATION XXI. 9<sup>h</sup> 35'.

The bloody Knot wholly vanished; though several of the descending Striæ remain entire, and in many Places Parts of others, all of the same Direction, and a fainter Colour than before. The Sky is perfectly calm and serene.

OBSERVATION XXII. 9<sup>h</sup> 42'.

The Northern Regions retain a bright *Aurora*, interspersed with a reddish Cast. From the Zenith is diffused a very extensive red Vapour, reaching to the Southward near 30° from the Zenith, and from thence converging towards the Eastern and Western Horizon, where it meets, the one E by S. and the other W S W.

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The Southern Edge was of the deepest Red, and the most distinguished Redness W S W. There appeared a falling Star S W. of a considerable Duration.

OBSERVATION XXIII. 10<sup>h</sup> 21'.

The Meteor much advanced to the Southward, its greatest Height being not above 40° from the Horizon : Its horizontal Bounds E S E. and W by S. Its Redness much abated ; but the *Aurora* diffused every where throughout the Scene, as conspicuous to the South as towards the North Parts of the Zenith ; which was an uncommon Sight. The Sky was now remarkably hazy, and full of Vapours.

OBSERVATION XXIV. 10<sup>h</sup> 18'.

The *Aurora* advanced considerably to the Southward of the red Vapour, which now is much diluted, about 20° in Breadth, a Part of it at least 50° to the Southward of the Zenith, and tapering towards the Eastern and Western Horizon, where the Bounds are much the same as before.

OBSERVATION XXV. 10<sup>h</sup> 25'. FIG. 7. in which Z denotes the Zenith, and N. E. S. W. the Horizon.

The *Aurora* separated from the reddish Vapour considerably, in the upper Parts, though joined in the Horizontal, and not above 25° from the South Horizon. Not any distinguishable Red to the Northward, but an Arch of the *Aurora* of much the same Height, though much inferior in its horizontal Measure. The Southern and Northern *Aurora* each

very bright. There were several temporary Flashes in many Parts of the red Vapour. At this Juncture the *Aurora* seemed to appertain as much to the Southern as Northern Horizon; and the Redness considerably more: But there was a great Difference just towards the Horizons; the one being covered with the dusky Vapour so often mentioned, and the other appearing of its natural Blue.

OBSERVATION XXVI. 10<sup>h</sup> 35'.

The Appearance over, excepting a reddish Cast to the Eastward, and a faint *Aurora* in the Northern Regions, of but small Extent from the dusky Horizontal Vapour.

OBSERVATION XXVII. 11<sup>h</sup> 35'.

There have not been any remarkable Phænomena since the last. The Northern *Aurora*, with the dusky Vapour, still continue, and I think as evident as at any of the foregoing Periods.

Here I ended my Observations. I am informed by others, who were occasionally on the Water, that its Beginning was just after Sun-set, in the Form of an extended darkish Cloud rising Northward; a few Minutes after the Appearance of which, there was, towards the Eastern and Western Regions, a very distinguishable Tincture of Red. And the next Change was my first Observation.

OBSERVATION XXVIII. 11<sup>h</sup> 45'. FIG. 8.

It appeared in a new and very surprizing Form. The Edge of the horizontal Vapour was strongly illuminated,

luminated, as though it had been fired; and this was in Height about  $8^{\circ}$ . From hence arose up continually, following one another, very extensive horizontal Columns of a bright Flame-colour, which in scarce a second of Time reached some to  $40^{\circ}$ , others above  $60^{\circ}$  of Altitude, and many to the intermediate Altitudes. Each of these Columns were as though an horizontal Train of Gunpowder had been suddenly fired, and the Flashes regularly propagated to such enormous Heights in an horizontal Posture. And there were innumerable Successions of these rising Flashes, the Phænomenon continuing nearly a quarter of an Hour. This Comparison will also illustrate several other Particulars at this Juncture. Sometimes there were several of these Flashes ascending together, at a little Distance from one another, as though there had been several horizontal Trains successively and almost instantaneously kindled after one another. Sometimes the rising Line of Light would be continued horizontally throughout the whole Scene, in other Places three quarters, an half, one third, a quarter, &c. of the same Length, as though these Trains had been unequally extended. Sometimes the Flash would begin in the Middle, and run kindling to the Extrems: Then, at one Extream, moving towards the other; and at other Times in more Places than one: But in all these Varieties, the horizontal Motions ceased, and the whole became one uniform Line before it had passed the enkindled Edge of the Cloud, which was not above  $8^{\circ}$ , as I observed before. All which may be well represented by the aforefaid Trains of inflammable Matter, sometimes enkindled in one Place, sometimes in another,

another, but always propagated through the whole Train, with so swift a Motion, that there could be no considerable Difference as to the Height of one Part above another. The greatest Extent of these horizontal Flashes was from N W. to NE. After these Phænomena the Meteor assumed its usual Form; *viz.* a bright *Aurora* settled upon a dusky horizontal Vapour.

OBSERVATION XXIX. 2<sup>h</sup>.

The Meteor was again formed into much the same Form as was described in Observation the twentieth, but of fainter Colours considerably. It vanished also again in the same manner.

OBSERVATION XXX. 6<sup>h</sup> 30<sup>'</sup>.

The *Aurora* continued till Day-light; and the Phænomena, at different Times, and without any certain Periods, were much the same as I have described in one or another of the foregoing Articles.

I shall conclude these Notes, by observing, that the Day before this Meteor was very warm for the Season, though early in the Morning there was a very considerable Hoar-Frost. The Morning following was remarkable for an abundant Dew. The Temper of the Air much the same as the preceding Day. About Eight o'Clock the Heavens fair and calm. Barom. 30. 1. Therm.  $\frac{58}{60}$ .

You may observe, that in the Figures I have attempted the *Stereographic Projection* of the most considerable Scenes, which may be a considerable Assistance

sistance to the Imagination; though I think the Expressions do not absolutely require any Schemes.

I have compared these Observations with what I could find relating to the *Aurora Borealis* in the *Philosophical Transactions*, &c. and think there are few Particulars mentioned there, but what occurred in this wonderful Instance; some that are rare confirmed, and a few altogether new; but the chief Advantage, I suppose, in these Notes, is the Process, Crisis, and Decay, which is so obvious in many of the most remarkable Scenes.

I have nothing more at present, than the Pleasure of styling myself,

*Your most Obedient Humble Servant,*

ISAAC GREENWOOD.

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II. *An Account of the same Aurora Borealis, by Mr. Richard Lewis; communicated in a Letter to Mr. Peter Collinson, F. R. S.*

*Annapolis in Maryland, Dec. 10, 1730.*

S I R,

WE were entertained with a Phænomenon on the 22d of *October* last; which, as it was never observed before in this Quarter, was very surprizing to most People.

About

Tab. I.

