

THE AURORA<sup>1</sup>

## I.

MR. TROMHOLT has rendered a great service to science by the travels and observations recorded in these volumes; indeed, it would not perhaps be going too far to say that we have here, brought before us in the most interesting manner, one of the best organised attempts to study the aurora that has been made for many years, the credit for which must be given to the organisers of the International Polar Research Expedition of 1882-83. Mr. Tromholt's duty was to observe all auroral phenomena in the Lapp settlement of Koutokæino, and above and beyond this to observe in such a way that, in combination with other observations arranged for at the Norwegian station at Bossekop in Finmarken and the Finnish one at Sodankylä in the centre of Finland, certain conclusions might be arrived at regarding the height at which the various displays take place.

The results, however, recorded in these volumes are by no means limited to the height of the aurora. The constant study afforded to Mr. Tromholt and his *confrères* at the other stations of one of the most awe-inspiring phenomena which it is given to man to witness have permitted generalisations to be reached and hypotheses to be broached of the greatest scientific interest; and this must be our excuse for dwelling on the general results of this recent work in the present article, including also a notice of those of Nordenskjöld in the *Vega* Expedition 1878-79.

Let us begin by considering the general phenomenon of an aurora as seen in Northern Europe. Mr. Tromholt gives the following general description of a great display:—

"It is a lovely evening in spring or autumn. The light is fast fading away in the west, and one star after another comes out of the azure sky. Suddenly a peculiar vibrating luminosity appears high up in N.E., now with a soft purple tinge, and now diffused with long narrow streamers, reaching to the Pole star, or beyond. It is wafted to and fro like a curtain before a light breeze, and its light becomes more and more intense as Night spreads her dark veil over the sky. Suddenly the luminous cloud is furrowed from one end to another by a bunch of streamers, the lower, emerald-green ends of which rest almost on the horizon, while the upper diffuse points, which flame with a purple lustre, reach right up to the Zenith. Streamer oscillates by streamer, more and more follow, and, with a rapidity almost startling, the aurora expands westwards, and shortly after the whole northern sky is a bath of fire. Like a curtain woven of light and colour the streamers hang fairy-like in the air; here and there they form large graceful folds and sway to and fro in wonderful beauty, as if the wind played on the radiating drapery. Red and green play alternately in the lower border of the curtain. For a few minutes longer the marvellous play of light lasts, the varying forms, colours, and motions charm the mind as much as the eye—the forces are then exhausted, the lovely picture grows more and more obscure, and the forms are dissolved into large soft clouds of light, covering nearly the entire northern half of the heavens.

"Down by the horizon there is still, however, great activity, as here a couple of arcs have formed, the constant-changing play of which enchains the spectator during the *entracte* between the past and coming scene of the sublime drama which Nature performs on the great stage of heaven: now faint, then strong, soon symmetrical, soon serpent-like, in one moment split into three or four arcs, and again gathering into one, now woven with all the lovely colours of the rainbow, now throwing forth rays and resembling the ornamental pipes in an enormous organ—such is the spectacle I gaze on.

"At this moment a narrow, white streamer suddenly leaps up from the horizon in the east, a similar one appears in the west; they both grow rapidly in length, their points meet, and a grand arc spans the sky right above the observer. Simultaneously two long and broad sheafs of streamers, woven of white and red filaments, develop at the bases of the arc. The luminosities on the northern sky again catch fire, and soon after the whole heavens in the north is again ablaze. Quicker and quicker the motions become and intenser the colours, higher and higher the streamers travel, the points approaching the great arc, which is moving slowly southwards. Other groups of streamers form at greater altitudes, in east and west, and the luminous masses cover more and more of the sky. Now a number of white bands suddenly appear overhead, shoot right across the sky from east to west, and then rush southwards, and vanish. By this time the luminous masses have crossed the zenith, the points of the streamers meet in a spot high in the southern sky, while in the east and west the sphere of the streamers moves gradually southwards. A wonderful spectacle is now presented to view. In every direction the whole sky is covered with bunches of streamers, all of which point to this spot—the magnetic zenith—and transform the vault of heaven into one gigantic lustrous cupola, the beauty of which no pen can describe, no brush depict. All the marvellous *nuances* of colour of the rainbow contribute to ornament the vault; here is the tender green of the emerald, the grand purple of the ruby, and the charming blue of the sapphire, all blended together in a thousand shades. Here gambles a flock of yellow-green flames, and there mighty pillars rise as if to support the luminous vault, while yonder the sky is covered with a transparent drapery shot with red, behind which dazzling white streamers stand forth. It is the auroral corona.

"A lovelier spectacle is not given the human eye to behold; he who has not seen it cannot form an idea of its magnificence—it defies description.

"For a moment the glorious, luminous vault remains thus in majestic beauty, then the supporting arches tremble for a moment, and fall, the faint light-clouds remaining in the southern sky vanish, and the aurora recedes to the northern sky. Here the streaming and play of colour continues for a while in manifold variation; but the area of the luminosity grows smaller and smaller, and moves steadily downwards to the horizon. A remarkable phenomenon now occurs in the soft luminosities, which still stand high in the northern sky: they appear to leap upwards with the rapidity of lightning, and then disappear; in several other spots similar clouds come forward and chase each other over the sky. The eye is hardly able to follow their strange gambols. Again the streamers grow in length, the light-clouds cease their play, and once more the streamers approach the zenith. But now they do not cross it; they remain in majestic rest for a few seconds, and then slowly disappear.

"Hour after hour this marvellous display continues in the northern sky, now stronger now fainter, and often it does not cease before the first streaks of dawn appear in the east."

It must not be imagined, however, that the displays generally are of this brilliancy; auroræ are generally much weaker, and in these cases the phenomena are different. Here is a general description of a weak aurora:—

"The sun set some hours ago. The purple glow in the west has disappeared, myriads of stars stud the dark canopy. Far down on the horizon, in north-west and north, lies a faint vague cloud of light, upwards and downwards fading into the sky . . .

"Soon after, tiny spots of intense light begin to appear in the luminous cloud, while at times the entire oscillating luminosity disappears from the sky. But still the light is

<sup>1</sup> "Under the Rays of the Aurora Borealis." By S. Tromholt. Edited by Carl Siewers. (London: Sampson Low and Co., 1885.)

increasing in force, and in a few moments a broad arc of light stretches along the north-western sky, resting both its bases on the horizon in north-east and west, and whose highest point lies a few degrees above the horizon in north-north-west. Upwards the light is gradually lost in the sky, downwards the intensity is greatest, and the lower edge stands sharply out. Solitary, stronger spots of light, now here, now there, travel, with an unsteady motion, at times right or left through the arc, again to disappear in the cloud. Following the arc attentively it will be seen to rise gradually, its point of culmination travels upwards, and the distance between the two bases becomes greater and greater. The colour of the light is nearly white, with a weak yellow-green tinge, which is easily discovered by comparing it with the cold, white light of the Milky Way. Suddenly energy and life become manifest in the phenomenon. The lower edge of the arc changes in an instant into a small, intense stream of light, which is sharply defined by the dark space below—the 'dark segment'—appearing black or faintly violet. Higher up the luminosity gathers into a broad, but fainter

arc, running parallel with the other. Only for a moment does the aurora retain this distinct form; stronger waves of light begin to appear in the lower arc, which soon generate groups of intense, short, and perpendicular streamers, reaching the upper arc, which sway right and left, at the same time travelling east or west. Below, the ends, strong in light, cut down into the dark segment, whose sharp curve is thereby broken. Of the upper arc only fragments now remain, while the lower is dissolved into quivering bunches of streamers, which die out one after another as new ones are being lit in their place. They move, here slowly, there quickly, oscillating apparently to the right or left, but it is impossible to say whether it is really the streamers which move horizontally, or merely the light which passes from streamer to streamer without the latter shifting their position.

"But this display is only of short duration, the streamers soon lose their motion and light, and in a few minutes there remain only some pale, diffuse luminosities. Slowly these now gather, until another arc is formed. It is not so symmetrical, and does not possess the classical rest of

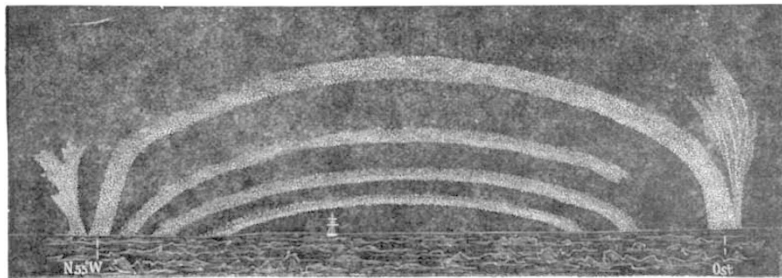


FIG. 1.—Auroral Arcs, Nordenskjöld.

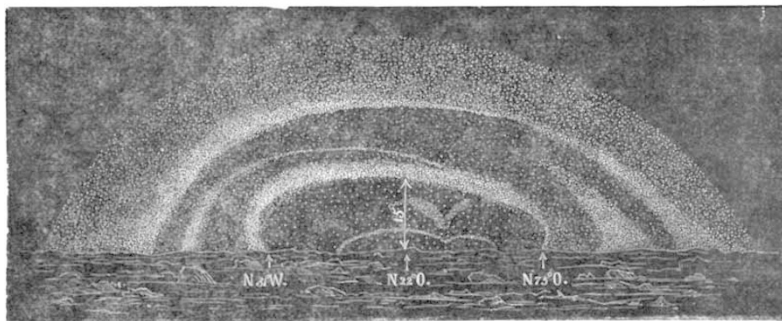


FIG. 2.—Auroral Arcs, Nordenskjöld.

the former. Constantly it changes form, position, and intensity until a fresh burst of streamers occurs; in two or three places the light shoots up into bunches of long streamers between which the space is nearly dark; in another second the streamers are isolated in groups, which, like the former, gracefully sway to and fro, their faint points reaching nearly up to the Pole star. The lower ends are broken at various heights, and develop as they move the soft colours of the rainbow. The culminating point in the display has been reached. The streamers vanish one by one, the light pales, and the remnants in the sky again form into a long, low-lying arc. Only for a short time it retains this pronounced form, the edges become obscure, the centre follows, and finally the last faint indications of the aurora sink into the unfathomable darkness of space."

Now the great variety in the appearance of the aurora depends to a great extent upon the various mixtures of

certain component features. These have been designated *auroral arcs*, often very narrow, often degenerating into broad bands; *auroral streamers*, single or multiple shafts of light of various colours, nearly always vertical in direction, and long or short, with lateral and vertical motions; the *auroral corona*, a brilliant point near the zenith, from which, in most brilliant displays, streamers seem to radiate in every direction, the heavens putting on the appearance of a bright ribbed dome; and, finally, *auroral clouds*, which are amorphous and most irregular in their distribution.

Before we proceed further with more detailed descriptions of these various features, each of which in the main is seen more richly from certain positions on the earth's surface than in others, or puts on different aspects, a word must be said about the magnetic basis of the whole phenomenon, since it has long been known to be connected with the *magnetic poles* of the earth.

In the first place, the mariner's compass or decli-



nation-needle indicates the direction of the magnetic pole. At the present time in London the needle points  $18^\circ$  to the west of true or astronomical north; hence, if auroral arcs were seen here to-night, their highest points would be nearly certain to be west of north. Next, the dipping- or inclination-needle (a very cheap and admirable form of which is now sold by Mr. Casella) points to the magnetic zenith, which now in London lies  $22^\circ$  north of the true or astronomical zenith, in the magnetic meridian joining the north and south magnetic points of the horizon. Hence, if an auroral corona were seen here to-night, it would be nearly certain to lie in a point  $22^\circ$  north of the zenith.

Let us limit ourselves for the present to the arc. In our latitudes, as has been said, it is seen to the west of north, generally low down near the horizon; but in the far north on the same magnetic meridian as ourselves it is seen east of south, while also in the far north, but in a widely different longitude—that of Behring's Straits—it is seen north-north-east.

Evidently, then, this arc—this "common auroral arc," as it has been called by Nordenskjöld—is produced by a ring at some height between us and the north pole, but its centre does not lie at the north pole. Putting such observations as those referred to together, Nordenskjöld inferred the centre to be near the magnetic pole but not at it, in  $81^\circ$  N. lat. and  $80^\circ$  W. long., the thin ring of light having a radius of  $18^\circ$  and a height of 200 kilometres.

This, then, was Nordenskjöld's main conception—an immovable common arc (a permanent stria, to speak in vacuum-tube language), though he acknowledged additional ones sometimes, and shows by his observations that they are not always concentric.

He also attempted to explain the frequency and positions of arc auroræ in different places by dividing the polar lands into five concentric regions (see NATURE, vol. xxv. p. 368).

In Mr. Tromholt's volume we find what may prove to be an immense advance on this view. He holds that *the auroral zone moves northwards and southwards daily, yearly, and eleven-yearly.*

Again, to speak in vacuum-tube language, instead of one rigid stria, we may have many striæ, and these moving towards or away from the auroral pole as ordinary striæ move towards or away from the negative pole.

Next, as to the proofs of this movement, some more quotations from Mr. Tromholt may be given:—

"The daily period is apparent by a maximum of frequency and development which in most places in the globe occurs one to two, or three hours before midnight. This maximum seems, however, to occur *later* the nearer we approach the magnetic pole. This will be clear from the following series, in which the figure in parenthesis denotes the geographical latitude and the other the hour when the aurora attains its maximum in the place named:—

"Prague (50),  $8\frac{3}{4}$ ; Oxford (52),  $9\frac{1}{4}$ ; Kendall (54),  $9\frac{3}{4}$ ; Makerston (56),  $9\frac{1}{2}$ ; Upsala (60),  $9\frac{3}{4}$ ; Christiania (60), 10; Bergen (60),  $9\frac{5}{8}$ ; Bossekop (70),  $10\frac{1}{2}$ ; Pustosersk (70), 11-12; Quebec (47),  $10\frac{3}{4}$ ; Fort Carlton (53),  $12\frac{1}{4}$ ; Fort Simpson (62), 12; Point Barrow (71),  $13\frac{1}{2}$ .

"For the Aurora Australis continuous series of observations are almost entirely wanting. It seems, however, from the fragmentary material which we possess, that the daily period for this does not differ from that of the Aurora Borealis.

"The individual types of the Aurora Borealis seem, like the phenomenon itself, to be confined to periods, and to attain their greatest frequency and highest development at certain periods. Thus, it appears from the observation of the previously mentioned French expedition to Bossekop, that the arcs appear on an average at 7h. 25m.; the streamers at 8h. 26m.; the auroral clouds at 11h. 18m.; the auroral waves between 13h. 12m. and 13h. 53m.;

the intensest colours at 10h. 11m., and the greatest brilliancy between 10h. and 11h."

Next as to the yearly change.

Weyprecht was the first to advance the view that the auroral zone is furthest south at the equinoxes, and furthest north at the solstices. On this point Mr. Tromholt writes:—

"My researches have led me to endorse Weyprecht's theory. I feel satisfied that the *Aurora Borealis* moves towards the autumnal equinox southwards, and then northwards, reaching its furthest northern limit about solstice. After this it again moves southwards, being in its most southern position at the vernal equinox, when the movement is again in a northerly direction.

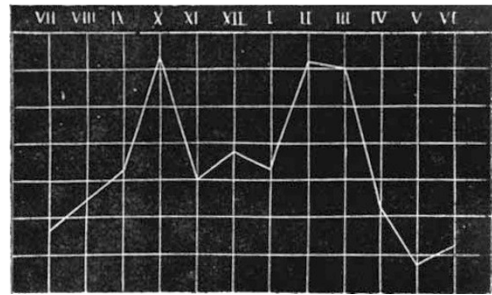


FIG. 3.—Curve of yearly auroral frequencies, Fritz. The Roman figures indicate the months.

"From this it follows that the two maxima occurring in the Temperate Zone at the equinoxes must approach each other more the further north the point of observation is situated. This is, in fact, the case. As some examples, I may mention that, whilst the two maxima occur [in March and September in St. Petersburg, Åbo, Stockholm, Christiania, Worcester (Mass.), and New Haven, they occur in February and October in Aalesund, Newberry, Quebec, and Newfoundland; in December to January in Hammerfest and in January at Fort Reliance. Very instructive in this respect are also the observations from the three Greenland stations: Upernivik, Jacobshavn, and Ivigtut. At Ivigtut, the southernmost of the stations, the yearly maximum must certainly be said to occur in January, but there is a second maximum towards the autumnal equinox. At Jacobshavn, eight degrees further north, there is but one distinctly marked maximum, in January, and at Upernivik, the northernmost of the stations, the maximum falls at the winter solstice more marked and dominant than anywhere else in the world."

(To be continued.)

#### THE ECLIPSE OF CHUNG K'ANG

IN China an eclipse of the sun is, and has in all ages been, considered as a bad omen. Indeed anything which disturbs the regularity of the movements or appearances of the heavenly bodies is so considered. "On the first day of the last month of autumn the sun and moon did not meet harmoniously in Fang." This passage occurs in the ancient classic, the "Shu Ching," in the "Yin Cheng," one of the books of the Hsia dynasty. Chinese commentators say that this passage refers to an eclipse of the sun in Fang, the fourth of the Chinese twenty-eight constellations. The last month of autumn, according to the Hsia Calendar, is the ninth month, the month after that month which contains the autumnal equinox.

The constellation Fang extends from about  $\pi$  to  $\sigma$  Scorpii, a distance measured along the ecliptic almost