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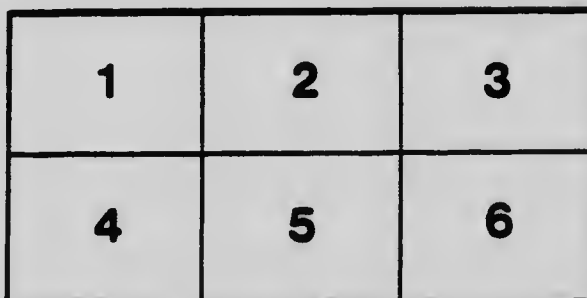
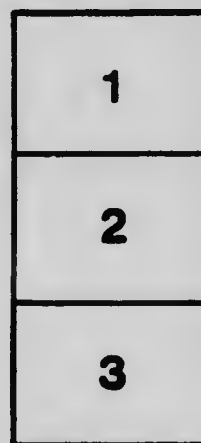
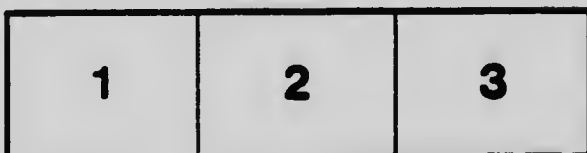
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IS THERE A MORNING MAXIMUM OF THE
AUKORA?

BY

A. F. HUNTER, M.A.



IS THERE A MORNING MAXIMUM OF THE AURORA?*

BY A. F. HUNTER

ABOUT twenty-five years ago, Dr. M. A. Veeder, of Lyons, N.Y., published several articles on the aurora, in the course of which he brought forward two important points:— (1) There is a time, two or three hours after sunset, when the aurora attains its maximum and tends to flare up with greater brilliancy than at any other time of the night. (2) When the aurora is arising from the positions of sunspots, (with which phenomena the aurora seems to be intimately connected,) are favorable to displays of aurora being visible, we have, instead of the expected aurora, an outbreak of thunderstorms sometimes all over the whole of a continent; in other words, the aurora and the thunderstorm would appear to be interchangeable. Dr. Veeder's enunciation of these two fundamental principles is an example of how the work of an amateur may sometimes be in advance of the work of the professional men. He did not, however, indicate the existence of any other than the evening maximum of the aurora, and Professor Chant's curve of their diurnal frequency† shows substantially the absence of any other than the evening maximum. If the cathode theory of the aurora deserves the serious attention of the scientific world, and I believe it does, the question must be answered:— Why is there no morning maximum two or three hours before sunrise, just the same as the evening maximum two or three hours after sunset? Cathode rays coming up from the east would be bent around the earth just as much as those coming up from the west.

* Remarks made in the discussion upon a paper by the Editor on "The Aurora" at the meeting of the Society in Toronto, February 9, 1915.—Ed.

† Drawn from data in *Encyclopædia Britannica*, Vol. I., Art. "Aurora."—Ed.

There is nothing in the nature of the question to suggest any difference between the two circumstances, and the purpose of my present remarks is to describe some observations which may tend to throw light upon the morning maximum.

Soon after the publication of Dr. Veeder's articles, Professor Roentgen announced in 1895 his epoch-making discovery of X-rays, or rather his discovery of the method of recording their presence by photography, the radiations themselves having been known to scientific men before his time. The discovery created a great wave of popular interest, and immediately everyone interested in such phenomena became familiar with photographs of the bones in the hands and feet, as well as other marvellous appearances. It also became obvious at once why a flash of lightning may be seen with closed eyelids, — the X or other rays of the electric discharge passing through the eyelid and producing a strong effect upon the retina of the eye. The X-ray* effects of lightning occupied my attention, and I made calculations of the distances of the discharges in comparison with the effects produced upon the retina, the distance of a discharge being of course calculated by the time in seconds before the arrival of the sound of the thunder. Speaking generally, the X-ray effects of lightning discharges at a distance of more than five miles are feeble, yet many of the distant flashes are discernible when a person acquires familiarity with phenomena of the kind, notwithstanding that it is known by experiment that X-rays fall off rapidly in strength as they leave their source, on account of absorption by air.

After acquiring some familiarity with distant flashes of lightning in this way, I began to realize the existence of frequent distant electric discharges of some kind when there was no thunderstorm of any sort in the country around. The most rigid enquiry and search in meteorological reports failed to yield any trace of thunderstorms anywhere upon this continent at times when the retina of my eye, familiarized with the X-ray

* It is not suggested that these rays are certainly identical with those usually so-called, but the effects are somewhat similar.

effects of atmospheric electrical discharges, announced the occurrence of such phenomena. The flashes, unattended by electric storms, were of distant origin, as their effects were always feeble, and yet they were always as distinct as those having an origin in some distant thunderstorm. Phenomena of this kind are better observed in a wooden house than in a brick one, because the salts of iron or other substances in the bricks effectively screen the X-ray effects from an observer, and he receives only what reach him through the windows. For a similar reason a tin roof or other metallic covering destroys the value of a station for any observer. And there are other precautions that will be obvious to any person acquainted with X-rays who wishes to witness the X-ray effects of atmospheric discharges.

By accumulating a number of observations of such flashes of distant origin, unattended by electric storms, I was able to arrive at two inductive inferences regarding them:—

(1) For the most part they centre around the morning maximum of the aurora, or rather the time when such maximum might be expected, two or three hours before sunrise.

(2) They are coincident with a falling barometer, or just after a fall but not with a rising barometer: in other words, they belong to periods when the station of the observer is in the front of a cyclone, *i.e.*, when cirro-stratus clouds, an indispensable condition of the aurora, might be seen if daylight permitted their observation. These frequent, though distant, electric discharges in the atmosphere, of which the X-ray effects continually arrested my attention at the times when the morning auroral maximum would occur if the same conditions existed as in the evening, probably belong to the class of phenomena commonly known as sheet lightning, when it is viewed as an ordinary optical phenomenon.

Paulsen's cathode theory of the aurora came forward about the time when the chief characters of these phenomena began to force themselves upon me in the course of numerous observations, along with the development of the same theory by the excellent work of Messrs. Stormer and Birkeland in Norway,

and every difficulty became clear, at least to my own satisfaction, their studies on the aurora furnishing the explanation for every question that might arise. Remembering the interchangeable nature of the aurora and lightning, as pointed out by Dr. Veeder, we are not baffled by any difficulty over the apparent absence of a morning maximum. The electrification of the higher parts of the atmosphere, due to the cathode rays from the sun deflected into helixes around the earth by magnetic attraction, may take place morning and evening alike. But the dissipation of the charges when cirro-stratus clouds are present may take place in two different ways: —

- (1) As a brush discharge, which we see as the aurora; or
- (2) As the electric flash of lightning, either in a single stroke to the earth, or in a sheet from one cloud to another, the sheet-form being confined to the higher regions of the atmosphere where the air pressure is reduced, just as in the Plücker or Crookes tubes of our laboratories the single spark under normal pressure takes the diffused form under reduced pressure, and yet in both cases is attended with X-ray effects.

Under the same conditions as prevail in the evening, therefore, *viz.*, when cirro-stratus clouds are present in any quantity, the morning maximum appears at the time expected, but as it happens, the maximum is manifested in a way entirely different from the usual aurora of the evening. The hygrometric conditions of the atmosphere in the morning are totally different from those of the evening, as everyone knows from the deposition of dew, greater cloudiness and other common phenomena. And the changed conditions bring about the change we find in the method of dissipation of the electrification from the solar cathode rays.

The delicate retinal effects of atmospheric electric discharges, whether of distant lightning strokes, or of sheet discharges unattended by any storms, are not by any means new in science; text-books in physiology mention such phenomena, calling them all Photopsia, but so far as I have seen they give only vague unscientific conjectures of their origin, failing to recognize the

connection of at least a portion of them with X-ray effects and assigning them all to some morbid condition of the person's own optic nerve and organism.

It may also be of interest to mention that on two or three occasions since I became familiar with the X-ray effects on the retina of atmospheric electrical discharges, I have recognized "dark" flashes, that is, instantaneous withdrawals of existing light instead of pulses of actual light. In view of the recent announcement from Ottawa of the identification of dark flashes of lightning amongst the ordinary lightning strokes, the occurrence of similar phenomena amongst the X-ray effects upon the retina may be of some interest. It would seem that Milton's paradoxical "darkness visible" has a real existence, and I have been forced to wonder if Milton in his blindness, familiar with X-ray flashes, as many who are blind are known to be, had actually witnessed pulsations of the "dark" or inverted kind.

