ON THE COMPARISON OF LOW AND HIGH VACUUM ELECTRICAL AND RADIANT MATTER PHENOMENA WITH THE AURORA, THE SOLAR CORONA, AND COMETS.*

BY PROF. WALLACE GOOLD LEVISON.

A notable feature of the aurora is that its striking colors always occur in the same order.† When the streamers are fully developed they are invariably red below, green in the middle, and terminate in long reaches of a yellow color.

It seems quite positively established that the aurora consists of high potential electrical discharges reaching through every gradation in density of the terrestrial atmosphere, probably following approximately the lines of force of the terrestrial magnetic field, appearing more intense where they are concentrated near the poles, and being almost or quite invisible in equatorial regions, where they are viewed transversely and are distributed over a large area. Auroral beams have been seen to shoot between the observers on a vessel and cliffs upon a near-by shore, and even between the houses in a village. On the other hand, they usually attain a height of from 60 to 100 miles.‡ It has been calculated that at 62 miles in height the atmospheric pressure is not more than about two millimeters, and rapidly diminishes above that height.

An electrical discharge passing through nitrogen or air reduced to a pressure of a few millimeters affords the red glow or stratified appearance of the Geissler tube, while at a lower pressure of one millionth of an atmosphere more or less it affords the pale blue, pale green, yellow green, or bright green beam of light that is emitted normal to the surface of the cathode in the Crookes tube,§ and that is only faintly visible to the eye, but is very distinctly shown in my photographs of such tubes. This is perhaps the only electrical discharge that can be experimentally developed in the form of rays or beams and it is highly susceptible to the influence of a magnet.

Assuming the correctness of the theory that an auroral beam is such an electrical discharge directed through our atmosphere of graded density, it seems to me that the colors of the aurora may be explained as depending merely upon the degree of rarefaction of the atmosphere at the particular elevation where the particular color occurs.

It might be supposed that this explanation could be easily verified by the comparison of the spectrum of the auroral streamers with the spectra of various electrical discharges in vacuum tubes containing air or nitrogen at different degrees of exhaustion, but attempts to institute such comparisons do not appear as yet to have afforded conclusive results, for several reasons. For example it would seem desirable to examine the spectra of electrical discharges in rarefied gases free from confinement, a condition which we have no means of experimentally securing. It is, however, under such a condition, in a certain degree, that the aurora is developed.

As the solar corona resembles the aurora in presenting an invariable order of colors, it may be a similar phenomenon. Occurring as it apparently does in an atmosphere consisting chiefly of hydrogen below and helium above, it should present about the colors observed in the order maintained, and its extraordinary dimensions would be consistent with the extreme rarity of an atmosphere composed chiefly of the two lightest known elements.

Several theories of comets have been suggested, no one of which is generally accepted. For example, comets may consist, perhaps, of rays of illuminated or self-luminous gaseous matter, developed in a nebulous mass of unknown form more extensively as it approaches the sun, or the tail may be a form taken by the entire gaseous mass under the sun's influence. Again, a comet may consist of a swarm of small material bodies raised to incandescence and repelled by the sun in the form of the tail, the chief reason for the latter theory being that certain comets afford a continuous spectrum in addition to a bright line spectrum.*

Almost all such theories assume that the tail is repelled or illuminated or both by an electrical action of the sun, but no one has yet suggested just what kind of an electrical action would be competent to produce such an effect, or explained how it could be developed by the sun.

The only electrical phenomenon we can experimentally produce, which takes the form of luminous beams, is the high potential electrical discharge in attenuated gases, which would appear capable of producing a comet by the method suggested in the theory first mentioned. Why such an electrical discharge should emanate from the sun yet remains to be explained; but so also does the origin of the electrical discharge which gives rise to auroræ. Comparisons of the spectra of comets with the spectrum of such a discharge, as in the case of the aurora, and for somewhat similar reasons, have not yet afforded results at all conclusive, although we shall be able to make progress in such comparisons when we are visited by a sufficiently bright comet.†

Fig. 4.—PERRINE'S COMET, NOVEMBER 26, 1895. PHOTOGRAPHED AT LICK OBSERVATORY.

In other respects, the resemblance of the high vacuum discharge to a comet has been often noted. For several years I have been photographing such electrical discharges, and in my photographs of certain Crookes tubes the cathode beam appears to me to bear as close a resemblance to a comet as we could very well expect to obtain experimentally.

In the diagonal view of the Crookes tube (Fig. 1), for example, the cathode discharge is seen to consist of a cylindrical diverging beam, which appears to originate in a central area of the cathode plate, rather than from its entire surface. In the side view of the same tube (Fig. 2) the beam is seen to have a wing-like coma, surrounding the nucleus or head, and both views suggest that the beam would extend to a great length, were it not limited by the dimensions of the vessel. Where it is intercepted by the glass, it produces a patch of green light with a dark spot in the center, showing it to be a hollow beam. The dark central spot appears to be due to a protuberance where the end of the connecting wire is riveted in the center of the cathode plate, but of this I am not certain, as I have not tried a cathode plate without this central elevation. In color and general appearance the resemblance of this cathode beam to ordinary simple comets is at once apparent.

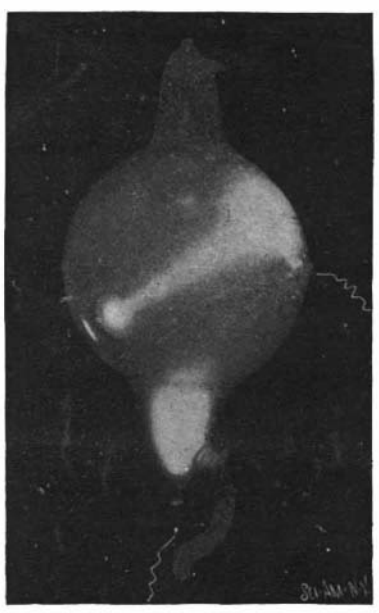

Fig. 1.—CATHODE BEAM IN CROOKES TUBE, DIAGONAL VIEW.

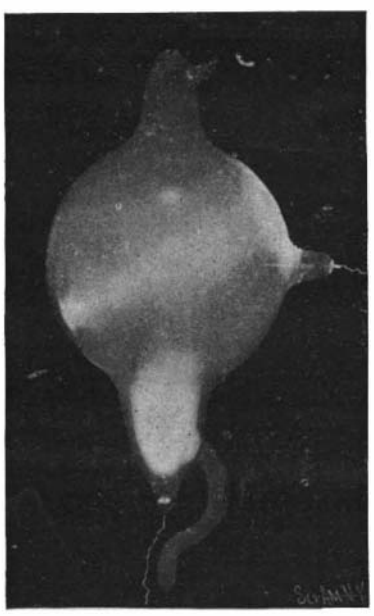

Fig. 2.—CATHODE BEAM, SIDE VIEW, SHOWING RESEMBLANCE TO SIMPLE COMET.

But the most interesting phenomenon presented by the cathode beam in this connection is its behavior under the influence of magnetism. By means of a magnet it may be caused to assume a variety of forms according to the position of the magnet with relation to the beam.

One example, shown in Fig. 3, a side view of the same globular Crookes tube with the poles of a compound U magnet presented behind the cathode, will serve to illustrate the susceptibility of the cathode beam to magnetism. The patch of green light upon the glass is largely moved from its original position and elongated, showing that the beam has flattened and assumed a fan shape. The extent of the deflection of the beam and its spreading and flattening depend upon the position of the magnet.

It will be further observed that the beam has divided in two parts. One preserves nearly the original direction normal to the cathode plate. The other and larger part is deflected and curved away from the first part, thus presenting a close resemblance to a second and common form of comets.

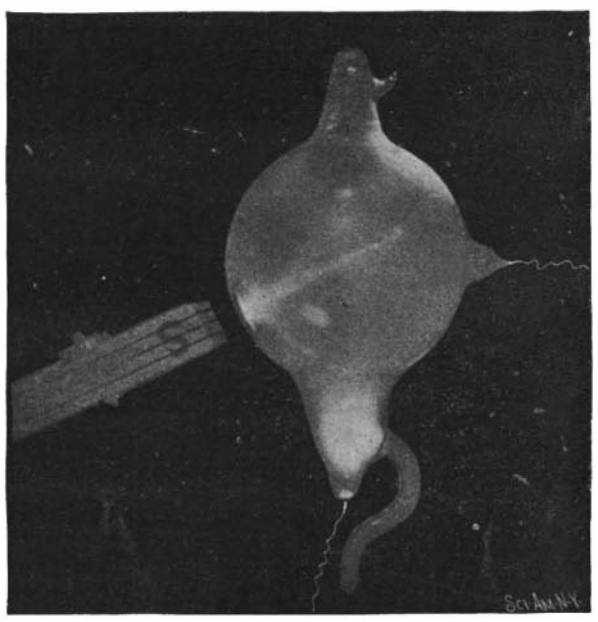

Fig. 3.—CATHODE BEAM BIFURCATED BY A MAGNET.

I have been able to procure for comparison but one photograph of a comet. This is shown in Fig. 4, and is a photograph of Perrine's comet, taken at the Lick Observatory by one hour's exposure from 4 h. 27 m. to 5 h. 42 m. November 26, 1895. It appears to closely resemble the magnetized cathode beam in Fig. 3. If this resemblance be not accidental, and be due to a common origin and cause, comets may be explained perhaps as follows:

Suppose a non-luminous nebula to arrive within the influence of the solar system or of the sun itself and be caused, by gravitation, to change its direction of motion from a straight line to an elliptical or parabolic orbit. Suppose that, as it approaches the sun, a high vacuum discharge is created within it by an electrical action of the sun in some way at present suspected but unknown. Such a discharge, taking normally the form of a conical beam of luminous ray, diverging slightly from a head or point of origin at the nearer side of the nebula, would appear as an ordinary single-tail comet, becoming more extensive and brighter as the nebula nears the sun. Suppose, however, that the sun be like the earth, a powerful magnet, and that the influence of its magnetism changes the form of the beam to some abnormal shape, depending on the position of the comet with relation to the sun's magnetic poles. If, for example, the comet approaches somewhere nearly in the plane of the sun's magnetic equator, perhaps the form would be that of Perrine's comet. If it approach nearly in a line with the sun's magnetic axis, it might at first appear in another form; but in passing around the sun in the plane of the sun's magnetic axis, it would assume several forms in pretty rapid succession, thus giving rise to such changes as have been noted in certain comets and appeared to be inexplicable. If this theory be tenable, the curves of comets' tails and all the rapid changes in form and dimensions of recorded comets may be perhaps attributed to their position at various times with relation to the solar magnetic axis, but it must be borne in mind that the magnetism of the various planets would also probably be concerned in shaping them. Having no facilities at present for properly pursuing the subject, it is my purpose in this note merely to anticipate a line of investigation which, it seems to me, is suggested by my photographs, and may assist in solving the problem of auroral, coronal and cometary phenomena.

* Abstract of a note read before the New York Academy of Sciences, May 4, 1896.

† Becquerel, Traite d'Electricité et de Magnetism. Paris, 1855, vol. iii, p. 442 et seq.

‡ Encyc. Brit., art, Aurora.

§ Crookes on Radiant Matter. Lecture before the Brit. Ass. Ad. Sci., August 22, 1879.

‖ The discovery of argon may assist in explaining some of the difficulties.

* This may prove to be a characteristic of the high vacuum discharge. See Crookes, Phil. Mag., January, 1879.

† Schellen, Dr. H., Spectrum Analysis. N. Y., 1872, p. 394.

American Explorers Lost.

The State Department has received from Consul Jastremenski, at Callao, Peru, a report regarding the rumored loss of an exploring party in the Inamburi River region, led by an American named Cooper. According to the report of the occurrence received here, the party, consisting of Cooper and seven others, after traveling for ten days along the Inamburi, lost all reckoning. For two more days they walked at random through the dense forests, and on the succeeding night were attacked by savages belonging to the numerous Campa tribe. The party fought with their rifles as best they could till, four of their number having fallen, two others, Germans, sought safety in flight. The American consul is investigating the occurrence.