words, that on a correctly exposed negative differences of ½ per cent. in the intensity of light can be detected. It should therefore be possible by correct exposure to detect the corona on the sky when the skylight forms 99½ per cent. of the light and the corona ½ per cent. The correct exposure to detect this slight shade with faint light is totally different from that necessary to detect it with intense light. A certain absolute amount of light is necessary to begin *any* chemical change in a sensitive film, and in photographing extensions of the corona this limit must be reached and can only be reached by long exposure. In Mr. Burnham's experiments on photographing clouds round the Sun, the difficulty was not to get enough light *to start* photographic action, but to *cut down* the light so as to detect ½ per cent. of the total amount. Hence his experiments do not in any way bear upon the question of photographing the extensions of the corona.

The whole process of photographing the faint extensions of the corona is more fairly comparable with that of photographing nebulæ on a moonlight night, and it can scarcely be questioned that a long exposure and great photographic action in this latter case give the best results.

The most enthusiastic advocate of short exposure and small photographic action in the case of the corona would scarcely prefer 3 minutes to 60 minutes when photographing nebulæ on a moonlight night; and as the conditions are fairly comparable, it is difficult to understand why 3 seconds and small photographic action should be suggested for the corona extensions instead of 60 seconds and great photographic action. Of course short exposures are necessary to obtain the internal portions of the corona, but for the faint outlying portions only long exposures can reasonably be expected to give satisfactory results.

A. Taylor.

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## *Remarks on the Orbit of the Great Comet of* 1811 *and on Comets' Tails.*

For the determination of the orbit of this comet, twenty-nine series of observations, yielding in all 984 observed places, have been used. Some of these observations are here published for the first time. The 984 observations are distributed as follows:— From 1811, March 31 to June 10, there are 68 places; from 1811, Aug. 20 to 1812, Jan. 20, there are 911, and the remaining five from 1812, Aug. 12 to Aug. 17. These latter observations are of great weight in determining the orbit. They were made by Wisniewsky at New Tocherkask in the Caucasus. Up to now there are only two such cases where a comet has been seen for a second time after its perihelion passage. In general, if a comet is not perturbed by external forces, only one orbit, be it parabolic, elliptic, or hyperbolic, can be derived from the observations. But a single curve cannot be found for the comet of 1811 which will satisfy the observations. To avoid as much as possible errors depending on the observer, instrument, &c., the observations in general have been combined so as to form daily means, thus producing 231 equations of condition. The equations solved with regard to their theoretical weights gave the following elements relative to the ecliptic and equinox 1812·0:—

| | |
|---|---|
| ☊ ...... | $140° 25' 4''·46$ |
| $\omega$ ...... | $65 \; 23 \; 52 \; ·99$ |
| $i$ ...... | $106 \; 57 \; 28 \; ·05$ |
| $e$ ...... | 0·9950320 |
| log $q$.... | 0·0151144 |
| T ...... | 1811, Sept. 12·293837 Berlin Mean Time. |

The outstanding errors show a regularity which proves that these elements must not be regarded as definitive. The discordances between the calculated and observed positions in August 1812 are considerable enough to be remarked. The simple means of the errors in R.A. and Dec. are given in the following table ($\alpha$). To ascertain if the great weight which of necessity had been given to the two first series of observations in comparison with the third, in which were only five places, a re-computation was made, giving the third series a six-fold weight. The result gave:—

| | |
|---|---|
| ☊ ...... | $140° 25' 15''·12$ |
| $\omega$ ...... | $65 \; 23 \; 45 \; ·73$ |
| $i$ ...... | $106 \; 57 \; 17 \; ·85$ |
| $e$ ...... | 0·9951240 |
| log. $q$ .. | 0·0151133 |
| T ...... | 1811, September 12·293497 B.M.T. |

A comparison with the observed places gave the differences in column ($\beta$).

| | Elements ($\alpha$) | | Elements ($\beta$) | | |
|---|---|---|---|---|---|
| | $\Delta\alpha \cos\delta$. | $\Delta\delta$. | $\Delta\alpha \cos\delta$. | $\Delta\delta$. | No. of normal places. |
| | '' | '' | '' | '' | |
| 1811 April........... | − 3·55 | +11·35 | −13·24 | +16·84 | 4, 3 |
| May ........... | −15·55 | +13·62 | −24·45 | +18·93 | 5, 5 |
| August ......... | − 2·86 | + 6·72 | −10·03 | +11·23 | 19, 19 |
| September...... | − 4·34 | + 3·76 | − 9·44 | + 8·60 | 20, 16 |
| October ......... | − 2·51 | − 2·74 | − 2·31 | − 1·31 | 20, 16 |
| November...... | − 1·35 | −12·25 | − 4·39 | −17·18 | 15, 10 |
| 1811 December ...... | − 3·22 | − 2·85 | − 9·00 | − 9·02 | 9, 6 |
| 1812 January......... | + 8·42 | +32·27 | + 1·61 | +25·26 | 4, 3 |
| 1812 August ......... | +31·46 | +47·86 | +14·08 | +25·42 | 1, 1 |

The errors are somewhat reduced, but are still too large. There are two chief sources which cause the deviation of the computed orbit from the actual one. Observations are generally made of the centre of light, which may or may not coincide with the centre of gravity. In the case of the present comet it evidently did not coincide.

Herschel saw a luminous point which, in spite of its exceeding minuteness, was evidently separate from the surrounding nebulous matter. This planetary body was $0''.775$ in diameter, and was always displaced from the centre on that side remote from the Sun. Measurements of its distance from the centre are not given, so that the reduction of the observed point to the centre of gravity cannot be computed. It may be that a rigorous examination of the orbit would yield limits for the distance, and thus furnish means to bring the observed and calculated places into more accordance.

Again, in addition to this optical cause, there is a real mechanical difficulty. If the tail of the comet is produced from the body itself, there must be set up a phenomenon known as "reaction." The normal path of a body thus affected must of necessity be disturbed, and if the velocity of emission is known, the perturbation can be computed. This is, however, unknown; it depends upon the distance of the comet from the Sun. Olbers has computed it for a normal and quiescent condition by Newton's method. He found that the particles travelled 12 million leagues in not quite eleven days. This is a velocity of 94 kilometres per second. By a more rigorous method Bessel found for Halley's comet an initial velocity of 15·5 diameters of the Earth's orbit daily, therefore 1·1 kilometres per second. The theory of streaming of matter in the tails of comets, on which matter the Sun acts with a repulsive force, has found a vigorous defence in the works of Zöllner and Bredichin*. Zöllner started with the following proposition:—"Between the mass of every body left to itself and the elasticity of its vapour at the actual temperature must exist a quantitative determinate relation, if the stability of that body, or a portion of it, is to be possible." This proposition leads to an exact solution of the problem—what would be the history of a universe filled with vapour, which ultimately formed the celestial bodies? It is that cometary bodies coming near the Sun must acquire a higher temperature, and consequently may be, at least, partly resolved into vapour; but it is not at all exact to assume a velocity of the emission which neglects the resistance of that medium which must in consequence be dispersed through the universe. And in respect to this medium the velocities of the streaming, originally perhaps very large, must diminish rapidly, and the theory does not therefore explain the largeness of *quiet* tails in some comets, much less various appearances which have been observed in some tails, viz.:—the more or less vigorous extension or contraction in parts of the tail, the almost sudden apparition or vanishing of side-tails, double or manifold-tails, apparitions which are called "darting," "playing," "fluctuation" in the tails.

Directly opposed to the supposition of streaming of cometary matter is the fact of the exceedingly small curvature of the tails,

* [We must not neglect the work in this direction which has been done at Cincinnati.—Eds.]

especially at the comet's perihelion, where the velocity in the orbit is very large. The great Comet *b* 1882, for instance, had a perihelion velocity of 238 kilometres per second; and if the tail was only $1^\circ\ 25'$, the extreme points of it must have moved round the Sun with a velocity of 1000 kilometres per second.

Researches on curvature of tails have recently been made by Bredichin, and are published in the 'Annals of the Observatory of Moscow.' Bredichin adopts the hypothesis that the tails are exhalations of comet-matter, on which the Sun acts with a repulsive force; which hypothesis had already been indicated by Herschel and Olbers, and pursued in the calculations of Halley's comet by Bessel. Bredichin found three kinds of tails corresponding to three intensities of disturbing force. Adopting, as the unit of force, that force which the Sun exercises on a body situated at the mean distance of the Sun from the Earth, the actual repulsive force will be denoted by $-\mu$, and the total action at the adopted unit of distance $1-\mu$. The first class of tails corresponds to $1-\mu=10$, the second class with $1-\mu=1{\cdot}4$, the third with $1-\mu=0{\cdot}3$; and each tail falls into one or other of these classes. The differences in the forces proceed from the matter's diversity; the action is larger as the molecular weight increases. Putting the action for hydrogen 12, Bredichin constructs the following scale:—

| | | | | | |
|---|---|---|---|---|---|
| H | 12 | Na, Mg | 0·5 | K, Ca | 0·8 |
| Li | 1·7 | P, S | 0·4 | Fe, Co, Ni, Cu | 0·2 |
| C | 1·0 | Cl | 0·3 | | |
| N | 0·9 | | | | |
| O | 0·8 | | | | |

For other elements, of which the molecular weight is larger, $1-\mu$ does not exceed 0·1.

This scale seems to bring out in a prominent way the distinction between the first class and the two other classes, even at the tail's formation. But the separation of these last ones is only apparent and not at all as exact as it seems. The tail-formations in the first class can be brought in concordance with forces $1-\mu=6$ to 12 and more. In many cases a computation of $1-\mu$ is not made, but only a hypothesis formed by the tail's appearance.

Moreover, it is not evident why the force should be dependent on the matter of the tail. In gravitation such experiences are unknown, and if the forces depended on the kind of electricity, the molecular weights cannot be joined directly with the ponderable matter. Moreover, spectroscopic observations have shown that the tails are almost exclusively composed of hydrocarbon, and they have also shown that the light of the tails is owing to electrical disruptive discharges.

Taking all these circumstances into consideration, it seems probable that the tails are different from the comets' matter, and only optical phenomena, due to an electrical discharge between the comet's body or nebula and a surrounding medium. Considering the notorious experiences over the tail's direction—directly opposite to the Sun—the following hypothesis will be made probable.

The Sun, as a central body of light and also of electricity, produces through induction an electrical state in the surrounding medium, and also in bodies near it. The uniform electrical field will be disturbed by bodies which come like comets from space to very small distances from the Sun, and then the body itself, and even the surrounding medium, will be polarized, so that if the polarization is strong enough, discharges will follow. Considering the direction of the polarity, it will be evident that the discharge must be ordinarily in the same direction; those discharges give the light to a tail. Its splendour is dependent on the electrical state of the comet's body, and also on its distance from the Sun. Really an evaporation may take place at very small distances from the Sun, but that evaporation will be partly diminished through the pressure of the surrounding medium, and will not be of long duration ; also the electrical discharges are bounded by the matter, but in this case there will most likely be a change, but not a considerable loss of matter.

Then on this hypothesis, in which the tail is considered only an optical appearance, the velocity of the comet in its orbit will not depend upon the form of the tail; generally its direction will be opposite to the Sun, and only exceptionally it will be otherwise, conditional on disturbing bodies—for instance, minor planets, meteors, &c. in the electrical field. Such bodies may be also the cause of the appearances already mentioned and called "darting," "playing," "fluctuation."

In the analytical researches on the comet's form and motion it will be unnecessary to regard a "streaming" of matter and also a difference in the place of the centre of gravity proceeding from a hypothetic "mass" of the tail. But regard must be paid to the electrical state of the comet itself and of the surrounding medium. The perturbations in the comets' forms and motions and also the modifications in the tails then may be retained at least in their principal points. NORBERT HERZ.

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## *The Total Solar Eclipse of* 1893 *April* 15–16.

THE preparations to observe this eclipse are being completed with considerable rapidity, and are on a scale comparable with the importance of the eclipse, which is, as Prof. H. S. Pritchett has recently pointed out, "the last in the present century which is likely to add to our knowledge of Solar Physics." The shadow of the Moon first touches the Earth in the Southern Pacific, and passing to the North-east strikes the coast of Chili close to