XXXIII.—*Contributions to a Knowledge of the Phenomena of the Zodiacal Light.*
By Professor C. PIAZZI SMYTH.

(Read February 7, 1848.)

When preparing to make a night journey over one of the plains of South Africa, in the month of June 1843, a friend called my attention to the peculiar appearance of the sky in the west, as offering a very decided proof, “agreeably with theory,” that there was no “Solar atmosphere” to be seen at that season of the year.

On looking in the direction mentioned, the last portion of the twilight was just visible, and forming a peculiarly level line above the place where the sun had set, for an extent in azimuth, of perhaps 40° , and at a height of about 5° . All the gorgeous colours which had attended the setting of the sun had long since vanished, and there only remained sufficient light within the flattened arc described, to make the space included between it and the horizon appear *light* blue, while all the rest of the sky had attained a deeper colour, nay was almost black, and thickly spangled with small as well as large stars.

There most decidedly was not then any symptom of the so-called “way of the twilight shooting upward.” But as soon as the last illuminated portion of the western sky had set, the phenomenon, *i. e.*, the zodiacal light, appeared in an unmistakeable manner, rising up in the ecliptic, to a height of 50° , with a breadth of perhaps 12° at the horizon; and forming, with the vast extent of its illuminated surface, and the regularity of its contour, one of the most remarkable objects in the starry sky. The form was that usually described, *viz.*, a wedge pointing upwards, with curved sides, and of excessively indefinite outline; but still, as far as could be judged, free from any irregularities; while the light, which was more delicate and transparent than that of the milky way, increased in intensity transversely from either side to the central longitudinal axis; and augmented also in the axis, from the apex downwards, until overpowered by the haze on the horizon.

Now, two circumstances worthy of notice, were pointed out by this night’s observation, *firstly*, that persons did not always know exactly when to look for the zodiacal light, nor what sort of object to expect; and, *secondly*, that the theory was greatly in error; and, for an astronomical matter, grievously wrong. Both classes of mistakes may have been brought about in no small degree by the injudicious mixing up of erroneous theoretical and speculative views with the simple nomenclature of the phenomenon. All that can be asserted from a single observation, and, perhaps indeed, from all the observations that have been made, up to the present time, is that a light appears in the zodiac, and if it be called “the

zodiacal light," no idea except the visible fact itself is included. But to call it the "Sun's atmosphere," is taking for granted a supposed fact which has never been proved, and is imagining the body to obey peculiar laws, to which it may not really be subject. Moreover, as in the case of a phenomenon which is so extremely faint as scarcely to be seen at all, a person may too easily persuade himself that he sees it as he *ought* to see it,—so there seemed to be much necessity for making further observations, which though they might prove, after all, to be not entirely free from errors of judgment and idea, yet would probably not be affected in the same way as those of other observers.

The circumstances in which I was placed were very favourable, so far as the clearness of the sky, the purity of the atmosphere, and the advantage of geographical position were concerned; but being engaged in the active duties of a trigonometrical survey, sometimes on the top of high mountains and sometimes in the plains below, the different character of the stations exercised too great an influence on the phenomenon to be observed, to allow of strict comparison being made between the observations at the various places. But there was at least the possibility of being able to determine a good method of making the observations, by endeavouring to reduce to practice some plan by which the results should be expressed more in numbers than has generally been the case; and of ascertaining at least the degree of accuracy with which observations of place, *i. e.*, of AR. and Decl., could be made, in more or less favourable localities and seasons.

I proposed to myself, therefore, to endeavour to determine each night, the AR. and Decl. of the apex of the light; though the only method which was then available, viz., observing the particular stars amongst which the point was situated, was only of use when there were large stars close by; since even if there had been star-maps to refer to in the desert, to identify the smaller ones, the phenomenon to be observed was not one that would bear close and direct investigation. It was only after having shut the eyes for some little time, or having turned them to some dark part of the sky or earth, that on suddenly directing them to the region of the zodiacal light, but not exactly to the middle of it,—it was seen of a well-defined figure; for by looking straight at it, and still more by coming into contact with any artificial light, the situation of the apex appeared to vary many degrees, or could not be decided on at all. At length, therefore, in 1844, I made a little wooden instrument with equatorial motion, plain sights, and roughly divided circles; which being placed in position in some spot free from any artificial light, readily gave the means of determining the object sought. Then, by the sort of side glance above described, a good notion of the position of the apex being obtained, the plain sights were immediately pointed to the spot, the circles read off, and their index error obtained by reference to known stars on either side. This was usually done two or three times each night, and the mean has been entered in the accompanying table as a single observation.

Observations of the Zodiacal Light in Latitude 33° South, and Longitude 1^h 14^m West.

Date.	Place of Observation.	Eastern apex of Z. L.		Sun's		Western apex.		Eastern elongation.	Western elongation.	Remarks on	
		AR.	D.	AR.	D.	AR.	D.			Eastern or following portion of Z. L., or that seen in the morning.	Western or preceding portion of Z. L., or that seen in the evening.
1843.											
June, . . .	Plain, Ft.	h. m.	°	h. m.	°	h. m.	°	°	°	Very conspicuous.	Seen, but not well.
July, . . .	Mountain, 1500	...	...	...	...	...	...	...	...	Do.	Not seen in the morning, though looked for.
August, . . .	Plain, . .	...	...	...	...	...	...	...	...	Do.	
September, . .	Mountain, 2000	...	...	...	...	...	...	...	...	Seen in first part of month.	
1844.											
February, . .	Plain, . .	...	...	...	...	...	...	...	...	...	Nothing visible.
May, . . .	Mountain, 3500	...	...	...	...	...	...	...	...	...	Very strong, long, narrow, and bright.
July, . . .	Do. 6500	...	...	...	...	...	...	...	...	Very bright.	
August and Sept.,	...	...	...	...	...	...	...	...	...	Do.	
Oct. 2. at 7 ^h P.M.	...	16 15	-24	12 34	-4	...	...	56	...		
... 5. at 7 ^h 50 ^m P.M.	...	16 18	-24	12 45	-5	...	...	53	...		
... 10. at 7 ^h 50 ^m P.M.	...	16 20	-22	13 4	-7	...	...	50	...		
December, . .	Do. 4500	...	...	...	...	...	...	...	...	Very doubtful, but a quantity of light in the west long after the time for twilight to cease; the ill-defined apex being observed on Dec. 5, at 9 ^h P.M., had AR. 20 ^h 50 ^m D - 36°.	Not visible.
1845.											
February, . .	Do. 4500	...	...	...	...	...	...	...	...	Not visible.	Well seen in the east, latter part of this month.
March and April,	Do.	...	...	...	...	...	...	...	...	Do.	Very strong.
May, . . .	Do.	...	...	...	...	...	...	...	...	Seen towards the end of the month.	Do.
June 5 at 6 ^h 46 ^m	Do.	9 25	+12	5 3	+23	...	...	66	55		
... at 17 ^h 40 ^m	Do.	...	...	...	...	1 21	+17	...	...		
July 6 at 7 ^h .	Do.	12 27	+6	7 2	+23	...	...	...	...		
Do. do. . .	Do.	...	...	...	...	3 29	+12	79	53		
Sept. 21 at 6 ^h .	Plain, . .	16 30	-23	11 54	+1	...	...	69	...		
Oct. 3. at 8 ^h , 8 ^h 30 ^m , and 9 ^h , }	Do.	17 0?	-22?	12 37	-4	...	...	66	...	Apex of the zodiacal light concealed in the milky way; besides which the brightness and position of Venus render the observations very difficult.	

A few days after the last observation I left the Cape, and the passage thence by St Helena through the tropics, was so uniformly cloudy, that I was unable to obtain another satisfactory look at the zodiacal light, and ever since my residence in Edinburgh in the middle of a city glowing at night with gas, and reeking with smoke, and under a sky but rarely clear, and when it is so, not unfrequently illuminated by the Aurora Borealis, I have been equally unfortunate.

To be able to make a good observation of the zodiacal light, the sky should be quite free from clouds, the air pure and transparent; not the slightest vestige of the twilight should remain, the milky way should be far from the neighbourhood, the moon should not be visible, or the brighter planets, such as Venus and Jupiter. If these circumstances be secured, and a person look out at that period of the year, as hereinafter detailed, when the ecliptic makes a large angle with the horizon of the place of observation, he can hardly fail to see the phenomenon in the most marked degree. A beginner must be especially cautioned not to begin looking too soon in the twilight to discern the "Sun's atmosphere," under the idea, happily, of catching it before all traces of the sun's light on the horizon are completely gone; and he should also be forewarned of the immense influence which climate and geographical position have on the visibility and apparently on the form and size of the phenomenon. Thus, in 56° N. Lat., and still less further north, even were the elongation of the light E. and W., equal in every respect, it would still never appear equally visible, and would but seldom be seen either way. In the summer the twilight would render the sight impossible, and in winter, the sun's path is too low and oblique. In the spring evenings, the light would be well seen, because then the twilight is of a moderate length, and the zodiacal light rises at an angle to the horizon of 30° greater than the equator, and therefore does not set till long after the twilight has disappeared; but as the other end rises in the morning at that season, necessarily at an angle 30° less than that of the equator, the apex in its standing position, hardly rises above the mists of the horizon before the twilight illumines the sky. In the month of September matters are just reversed, and the zodiacal light rising in the morning at a greater angle than the equator, is then well seen, but is not at all visible in the evening, when, from the standing position of the body, the apex sets very soon after the sun. And in these two short appropriate seasons, so many of the nights may be rendered untoward by clouds, strong moonlight, and other causes, that an opportunity of seeing the zodiacal light may even then but very rarely be enjoyed.

Similarly in the southern hemisphere in 56° S. Lat., supposing also, as before, that the zodiacal light stretches out equally from the sun on every side in the plane of his equator, the two most favourable opportunities in the course of the year for viewing the body would be, in the evening in the month of September, and in the morning in the month of March. And that this would really be the case, the observations made in Lat. 33° S. sufficiently attest.

In order to give a clearer description of what may be expected to be seen, than can be conveyed in words alone, I have subjoined a number of drawings,* both of what the zodiacal light is, and what it is not, the latter being the great comet of 1668 and 1843, mistaken on both occasions for the more permanent members of the system. The object in the construction of the drawings has been, in so far as it was possible to be compassed by the small skill of the author, to give so complete a reproduction of all the attendant phenomena, and circumstances of climate or country, as to enable any one who looks at them, to form a tolerable idea, whether any of the accompanying conditions under which the original view was obtained, were likely to produce an erroneous judgment in the spectator, of the exact form and appearance of the zodiacal light. A larger portion of the landscape has therefore been introduced, than would otherwise have been altogether appropriate in astronomical drawings.

A more important addition is, however, that which I was advised to make by my friend Mr W. A. CADELL, viz., the insertion in the margin of the circles of Right Ascension and Declination, which shew what particular projection has been employed, and serve to identify the stars, fix the latitude in which the observations were made, the time at the instant, and to give an idea of the dimensions of the body under discussion, and the region of the sky in which it is found.

To represent the eastern or western portion of the sky, in their perfection, or as would be thrown on paper by the camera lucida, as Mr CADELL has shewn, the horizon should be defined by a straight line in the picture, and the E. or W. point must be in the middle of that line; then the eye of the spectator being directed toward it as such, the equator, being a great circle, will be represented by a straight line drawn through that point, and rising at an angle to the horizon, equal to the latitude of the place; and the meridian lines on the parallels of right ascension, being also great circles, must be expressed by straight lines crossing the equator at right angles; on the other hand, the parallels of declination being small circles, will appear as conoidal curves. A great circle becomes a straight line on the picture, since it is a plane passing through the eye, and the common section of this plane with the planes of the picture, is a straight line. A small circle is a conoidal curve on the picture, because a small circle is seen as a cone of which the apex is at the eye, and the common section of this cone with the plane of the picture is a conic section. The form of the conic section will vary as the inclination of the cone's axis to the plane of the picture varies.

In all the drawings given herewith, the line of sight is seldom directed exactly to the E. or W. points, but generally between them and the northern or (point of culmination for the southern hemisphere.) Were the spectator to face the

* On account of the expense of first-class engravings, one of the drawings only has been put upon metal. This one, "the appearance of the zodiacal light at the Cape of Good Hope, in July 1845," will be found amongst the plates at the end of the volume.

northern point exactly, then the equator would be represented by a straight line, parallel with the horizon, and elevated above it at an angle equal to the colatitude of the place. And, according to the degree to which the spectator turns round from the E. or W. points towards the north, the inclination of the equatorial line will vary, from the angle of the latitude of the place, to perfect horizontality.

This varied inclination of the equator has been strictly attended to in all the accompanying cases; but it has been found advisable for simplicity in practice, to represent the declination circles also by straight lines, for there is hardly any sensible difference caused thereby in the central region of the picture, where all the important part of the subject to be delineated, lies; and although the configuration of stars near the borders might not be such as would exactly appear to the eye of a spectator, or as they should be represented by the usual rules of perspective, still the amount of discordance is so extremely small, that the unassisted eye would hardly perceive it; and, what is more important than having a representation perfectly similar, in the minutest particular, to that found in the retina,—the particular projection of the sphere which was actually employed, being inserted in the margin, gives just as good, and rather simpler, means, than would have been available on the other plan, for the identification of the stars.

The application of instrumental measurement, hereinbefore described, to determine the phenomena of the zodiacal light, is believed to be new; and the observations so obtained, seem to shew very decidedly, especially those of October 1844, that numerical measures of the place of the apex of the light may easily be obtained,—with a probable error of not more than two degrees: so that vague estimations and notes of mere ideas should not be allowed to form the data in this particular branch of astronomy any longer.

The general results to be deduced from the data given in the Table, are,

1st, That the zodiacal light is a body of a lenticular form, spread out nearly in the plane of the earth's orbit, and extending almost equally from the sun in every direction. Were the ordinary European observations made about the time of the spring equinox the only ones existing, we should merely be entitled to conclude the existence of a one-lobed projection from the sun; but when we combine therewith the Cape observations, we find that the body is seen all through the year, and on both sides of the sun, of pretty nearly the same size and shape, viz., a curvilinear-sided wedge, in which the light continually increases from the borders towards the centre of the base, or the actual position of the sun; appearances which can only be satisfied by a lenticular body seen in section.

2d, The zodiacal light is proved to be excentrically disposed about the sun, by the elongations observed east and west on the same day being different; shewing, indeed, at various times an excentricity of from $\frac{1}{20}$ to $\frac{1}{10}$.

3d, The zodiacal light may also be considered to rotate about the sun, and to be brighter in some parts than in others; because it is observed to be of different lengths and degrees of brightness at corresponding periods in successive years. For

although such an effect might be produced by a periodical alteration in the size and general lustre of the body, still the supposition of such a rapid material change in so large a member of the solar system, is extremely improbable: whilst this body's revolving may be held to be necessary according to the principles of gravitation; for otherwise the component particles would speedily fall into the sun; and that some portions are brighter than others, follows partly as a consequence of the observed unequal size of the two sides. Were the light stationary, then the greatest and least lengths and brightnesses should occur at the same time in successive years, because on arriving again at the same points of its orbit, the earth should again see the same parts of the zodiacal light pointing to the same direction in space; but, as already stated, the contrary to this has been observed.

The greatest elongation observed was 79° , and the least 50° , but from the varying circumstances and positions in which the observations were made, the short period of time over which they extend, together with the small number of favourable opportunities, and the distance of the place from the equator, which these conditions afforded, no numerical results of much accuracy can be derived from them alone; but some advantage may be gained by comparing them with the results of former observers.

The number, however, of these, *i. e.*, of actual observers, is comparatively small, and they are all very recent; for, strange to say, no notice of the zodiacal light is found amongst the writings of astronomers or natural philosophers until 1661. And indeed, when we consider that this phenomenon may be generally described as a broad and tall light seen in the western sky after sunset, and in the eastern before sunrise, with a length of about 60° , a breadth of 20° , combining with a brightness nearly equal to that of the milky way, a regular mathematical figure, which makes it far more remarkable, and rising, as it does, at a greater angle to the horizon, so as to be better seen in countries nearer the equator than ourselves, and being probably of as great antiquity as the sun itself,—truly it is astonishing that all these notabilia should have been passed over in the earlier ages of the world, when civilization flourished more to the south, and the men of ancient Athens and Babylon lived under a clear sky, in a genial climate, which invited rather than forbade the contemplation of the firmament by night. It remained, however, for the inhabitants of these cloud-vexed northern islands to be the first to take notice of the phenomenon, and so supply another instance of the indomitable perseverance of an iron race overcoming all the untoward obstacles of an unpropitious position, and rising superior to other races revelling in the most luxurious advantages of nature.

Claims have been put up for KEPLER and DESCARTES, as being the original discoverers of the zodiacal light; but the passages in their respective works*

* KEPLER'S *Epit. Astron. Copernicanæ*, t. i., p. 57; and t. ii., p. 893; DESCARTES, *Principes*, iii., Art. 136, and 137.

are so very meagre and obscure, that they require all the knowledge of the phenomenon acquired up to the present day, to be applied to make them mean anything. MAIRAN, with whose theory KEPLER's fancy seems to agree, when discussing, in 1754, the history of the phenomenon, gives the German full credit; but HUMBOLDT, in 1844, with different theoretical views, dismisses the case of his countryman in a very summary way.

An earlier claim still has been brought forward, on account of the mention, in a letter from ROTHMANN to TYCHO BRAHE, that in the spring the twilight ceased not till the sun was 24° below the horizon; and as the true twilight would have ceased long before the sun was so low,—it is contended that ROTHMANN must have seen the zodiacal light, though without remarking anything peculiar in it, or different from the ordinary course of the evening.

So that the first satisfactory and clear description is still that of CHILDREY in 1661, already alluded to. “There is another thing,” says he, in his *Britannia Baconica*, p. 183, “which I recommend to the observation of mathematical men; which is, that in February, and for a little before and after that month (as I have observed for several years together), about six in the evening, when the twilight hath almost deserted the horizon, you shall see a plainly discernible way of the twilight, striking up towards the Pleiades, and seeming almost to touch them. It is so observed any clear night, but it is best *illâc nocte*. There is no such way to be observed at any other time of the year. But what the cause of it in nature should be, I cannot yet imagine, but leave it to further inquiry.”

Here, then, is a clear and simple account of one phase of the phenomenon, marking it as a something unusual, as different from ordinary twilight, as constant in that anomalous difference, and therefore well worthy of being carefully inquired into.

In his *Travels in Persia* in 1668,* CHARDIN mentions having seen the tail of the great comet of that year above the western horizon after sunset; the head being visible only in the southern hemisphere. CASSINI and MAIRAN, writing some years after, under the influence of the then new discovery of the zodiacal light, asserted that it must have been this which CHARDIN saw; and he is even made out by DELAMBRE to have been the original discoverer of it. The comet of 1668 having, however, appeared again in 1843 (that is, they are supposed, with the greatest probability, to be identical; and if not identical, still they are at least both specimens of the comet genus), has given us the opportunity of determining whether CHARDIN's description applies to the zodiacal light or to the comet, which though so very unlike each other, were not only confounded at the former apparition, but at the latter also; when the tail, as before, was the only part visible in the northern hemisphere. The slightest glance at the accompanying drawings

* Edit. de Langles, t. iv., p. 326; and t. x., p. 97.

of the two objects, however, will probably convince every one, that CHARDIN'S Persian expression "niazouk," or in French "petit lance," which was applied by the Persians to the phenomenon they saw, could only be considered as at all suitable in the case of the comet's tail.

In 1683, the subject was taken up by DOMINIC CASSINI, and to him belongs the merit of first scientifically investigating the laws of the phenomenon, determining its cosmical nature, and giving it the appropriate name of the zodiacal light. His series of observations, extending over nearly six years, is still unrivalled; and if he is not correct in all his conclusions, it is chiefly because his observations were almost entirely confined to his own high northern latitude; and were therefore affected to a great and unknown extent by circumstances of climate and geographical position. He had much wished to eliminate these effects by means of observations made in the southern hemisphere, but unfortunately was not able to obtain any; and indeed those which have been made by the author, and recorded in this paper, are perhaps the first which have been published and brought to bear on the theory of the subject.

CASSINI'S conclusions were, that the zodiacal light is a flat luminous ring encircling the sun, nearly in the plane of his equator, and is therefore seen always more or less in profile, and perfectly so at two periods of the year, April and August, when like Saturn's ring, and for similar reasons, he supposed it to vanish to our sight; while the nonvisibility at *any* period between these two months, he considered to be produced mainly by the overpowering effect of the lengthened summer twilight. But these ideas, on being tested by the Cape observations, completely fall to the ground; for during the *whole* period of invisibility to CASSINI (caused in reality by the lengthened twilight of summer in his northern hemisphere), the phenomenon was most visible at the Cape, as winter then prevails in the southern hemisphere; and, indeed, the very reverse effect from that expected by CASSINI should follow, when a transparent and oblate luminous ring is viewed in profile, for it will then be seen at its brightest, on account of all the infinitely small light-giving particles being brought closer together; so small are they, that they can by no means be distinguished separately, or when thinly scattered over the sky, but only make themselves sensible to the eye, and the telescope, when they are crowded together in a smaller space. The idea, moreover, of the zodiacal light being in the form of a *ring* at all, is discountenanced by the observed appearances, they being all conformable to the phenomena which would be afforded by a thin *lenticular* body, excentrically situated and revolving about the sun.

CASSINI'S friend, M. FATIO, made observations of the zodiacal light about the same time, as did also M. KIRCH, and EIMMART, and Mr DERHAM.

But the subject was not carried further, until taken up by MAIRAN, in 1731. He was rather wild in his notion of the manner in which the body was formed,

viz., by particles thrown off from the sun, in consequence of the rapidity of his rotation; nor was he very happy in his name of the "Sun's atmosphere," by which he led both himself and others to reason upon it, as if it were proved to be, and actually was of a kindred nature with the earth's atmosphere. His conclusions, however, that the whole of the luminous body was of a lenticular form, nearly in the plane of the earth's orbit, somewhat excentric with regard to the sun, and, indeed, with a rotation about that luminary, seem to be remarkably good. And his opinion, so far as the lenticular shape is concerned, is also held by OLBERS and by Sir J. HERSCHEL, both of them observers.

OLBERS in a letter to HUMBOLDT in 1833, says, "What you tell me of the changes of brightness in the zodiacal light, and the causes to which, in the tropics, you ascribe such variations, has excited my interest the more, because I have been for a long time past particularly attentive every spring to this phenomenon in our northern latitudes. I, too, have always believed the zodiacal light to rotate; but I assumed it (contrary to POISSON's opinion, which you communicate to me), to extend the whole way to the sun, increasing rapidly in intensity. The luminous circle which in total eclipses shews itself round the darkened sun, I have supposed to be this brightest portion of the zodiacal light. I have satisfied myself that the light is very different in different years, sometimes for several years being very bright and extended, and in other years scarcely perceptible. I have not myself been able to observe the sudden fluctuations in the light, probably on account of the faintness with which it appears to us in this part of the world. You are certainly right in ascribing the rapid variations in the light of celestial objects, which you have perceived in the climate of the tropics, to changes taking place in our atmosphere, and especially in its higher regions. This shews itself in a more striking manner in the tails of great comets. Often, and particularly in the clearest weather, pulsations in the tails of comets are seen to commence from the head or nucleus as the lowest part, and to run in one or two seconds through the whole extent of the tail, which, in consequence, appears to lengthen several degrees, and contract again. That these undulations, which engaged the attention of ROBERT HOOKE, and in later times of SCHRÖETER, and CHLADNI, *do not take place in the cometary tails themselves*, but are produced in our atmosphere, appears evident if we reflect that the several particles of these cometary tails (which are many millions of miles in length) are at *very different distances* from us, and that the light from them can only reach our eyes at intervals of times which differ several minutes from each other. I will not attempt to decide, whether what you saw on the banks of the Orinoco, not at intervals of seconds, but of minutes, were actual coruscations of the zodiacal light, or whether they belonged solely to the upper strata of our atmosphere. Nor can I explain the remarkable lightness of entire nights, or the anomalous increase and prolongation of this light in the year

1831, particularly if, as it has been said, the *lightest part* of these singular twilights did not coincide with the place of the sun below the horizon."

Sir JOHN HERSCHEL's views, published only five years ago, were called forth by the tail of the great comet of 1843 having been by some so pertinaciously mistaken for the zodiacal light.

"The zodiacal light," said he, "as its name imports, invariably appears in the zodiac, or, to speak more precisely, in the plane of the sun's equator, which is 7° inclined to the zodiac, and which plane, seen from the sun, intersects the ecliptic in longitude 78° and 258° , or so much in advance of the equinoctial points. In consequence, it is seen to the best advantage at, or a little after, the equinoxes, after sunset at the spring, and before sunrise at the autumnal equinox, not only because the direction of its apparent axis lies at those times more perpendicular to the horizon, but also because at those epochs we are approaching the situation in which it is seen most completely in section.

"At the vernal equinox, the appearance of the zodiacal light is that of a pretty broad pyramidal, or rather lenticular, body of light, which begins to be visible as soon as the twilight decays. It is very bright at its lower or broader part near the horizon, and (if there be broken clouds about) often appears like the glow of a distant conflagration, or of the rising moon, only less red; giving rise, in short, to amorphous masses of light, such as have been noticed by some as possibly appertaining to the comet. At higher altitudes its light fades gradually, and is seldom traceable much beyond the Pleiades, which it usually however attains and involves; and (what is most to my present purpose) its axis at the vernal equinox is always inclined (to the northward of the equator) at an angle of between 60° and 70° to the horizon; and it is most luminous at its base, resting on the horizon, where also it is broadest, occupying, in fact, an angular breadth of somewhere about 10° or 12° in ordinary clear weather."

The ring hypothesis of CASSINI has, however, been followed in a greater or less degree, by LA PLACE, SCHERBERT, and POISSON, as well as by HUMBOLDT, who is an observer, and publishing in 1844 is the latest of all the authorities.

His description of the general appearance of the light is most vivid and truthful, and can perhaps only be fully appreciated by those who have seen it under similar favourable circumstances.

"Those who have dwelt long," says he, "in the zone of Palms, must retain a pleasing remembrance of the mild radiance of this phenomenon, which, rising pyramidally, illumines a portion of the unvarying length of the tropical nights. I have seen it occasionally shine with a brightness greater than that of the milky way, near the constellation of Sagittarius; and this not only in the dry and highly rarified atmosphere of the summits of the Andes, at elevations of thirteen to fifteen thousand feet, but also in the boundless grassy plains or *llanos* of Venezuela, and on the sea-coast under the ever-clear sky of Cumana. The phenomenon is

one of peculiar beauty, when a small fleecy cloud is projected against the zodiacal light, and detaches itself picturesquely from the illuminated back-ground. A passage in my journal during a voyage from Lima to the West Coast of Mexico, notices such a picture. ‘For the last three or four nights (between 10° and 14° of north latitude), the zodiacal light has appeared with a magnificence which I have never before seen. Judging also from the brightness of the stars and nebulae, the transparency of the atmosphere in this part of the Pacific must be extremely great. From the 14th to the 19th of March, during a very regular interval of three quarters of an hour after the disc of the sun had sunk below the horizon, no trace of the zodiacal light could be seen, although the night was perfectly dark; but an hour after sunset, it became suddenly visible, extending in great brightness and beauty, between Aldebaran and the Pleiades, and, on the 18th of March, attaining an altitude of $39^{\circ} 5'$. Long narrow clouds, scattered over the lovely azure of the sky, appeared low down on the horizon, as if in front of a golden curtain, while bright varied tints played from time to time on the higher clouds: it seemed a second sunset. Towards that side of the heavens the light diffused appeared almost equal to that of the moon in her first quarter. Towards ten o'clock, in this part of the Pacific, the zodiacal light usually becomes very faint, and at midnight I could only see a trace of it remaining. On the 16th of March, when its brightness was greatest, a mild reflected glow was visible in the east.’ ”

He describes also several anomalous features, as that sometimes it did not appear for three-quarters of an hour after sunset, though the twilight had been for some time ended; that then it appeared suddenly, and continued long of very great brightness; that at other times it would continue to shorten and lengthen many degrees in a few minutes, and have an undulatory sort of motion. But these peculiarities, when not accounted for by the atmospheric circumstances of which he himself takes notice, seem rather to be produced in the eye of the observer by reason of the extreme faintness of the object to be observed; by the length of time that a retina,—which has been initiated by watching the setting sun, or even when acted on by ordinary daylight,—requires to recover its full degree of sensitiveness; as well as by the deceptive phantasmagoric effect produced on the nerves when strained to a greater extent than they can well bear.

Taking all the above facts into consideration, we are perhaps entitled to conclude, on pretty good foundation, that the zodiacal light is an extremely oblate, lenticular, revolving body, nearly in the plane of the sun's equator, rather excentrically situated, of so vast a size as nearly to fill the whole orbit of the earth, and sometimes actually to reach it. But whether it does actually at the present time correspond exactly with the sun's equator, and if it has always done so, and always will; whether the manifest changes in the intrinsic brightness, and the form and size of the light that have been observed, be due merely to a rotation of the excentric or oval body, or to a real periodical increase of the intensity of its

emanation, or an enlargement of its dimensions; and whether this be any concomitant symptom with the appearance of spots on the sun, or magnetical disturbances on the earth,—are matters still to be determined by observation.

The physical constitution of the zodiacal light seems also well worthy of being inquired into. The most probable supposition is, that which makes it consist of innumerable small planetary particles revolving about the sun, and shining by reflected, or not impossibly by direct light. Not impossibly, because while, on the one hand, the occasional crossing of the earth's orbit by the extremer portions of the zodiacal light, has been by many held to be the origin of the shooting stars; and many of them have been found to be, at the time of their incandescence, several hundred miles above the earth's surface, and thus far above the limits of the atmosphere, whose friction might have imparted such a degree of heat to a body at a lower altitude, moving with a velocity of 1000 miles per minute;—on the other hand, M. MATHIESON has recently made some most interesting experiments, in which the thermomultiplier shewed evident indications of *radiant*, and therefore *direct heat*, proceeding from the zodiacal light.*

But in its present stage, the subject can only be profitably and successfully prosecuted in other climates, in countries where the twilight is shorter, where the ecliptic makes, all through the year, a larger angle with the horizon than here, and where there are clearer skies, and a more transparent atmosphere.

As such conditions are well commanded by some of the magnetical and meteorological observatories which have been lately established on a similar footing to that of Makerstoun, in connection with the Royal Society of Edinburgh; and as the species of phenomenon is one that belongs eminently to those departments,—we might expect ere long to enjoy much more intimate and exact knowledge of the laws and relations of this wondrous and extensive member of the solar system, if the Royal Society were to give its testimony that the phenomenon was one of a nature worthy of scientific investigation; as well as that all that has been done hitherto is insufficient, except for mere approximative purposes, and has been labouring under geographical disadvantages, which need not by any means continue to shackle observation in the present day.

* Comptes Rendus, t. xvi., p. 687; Ap. 1843.

C.P.S. del.

W. Forrest sc.

THE ZODIACAL LIGHT.
AT THE CAPE OF GOOD HOPE, JULY 1845.