level of sun-spots is possibly the level of the faint lines of such metals as have an atomic weight about 50. To the objection that the lines of metals like calcium and sodium and the lines of hydrogen are also present, the answer seems to be that such elements are not confined to sun-spots, but extend to a great height in the solar atmosphere. Moreover, broad lines, like H and K and the C line, are generally reversed in the region about sun-spots, and the D lines frequently so. Two Vanadium lines in the region under discussion occur in Professor Young's list of chromospheric lines, but one of these is the close double due to Fe and V, which is one of the least widened of all the lines in sun-spots, No. 12 in the table, and is also the most intense of all the lines of the list in the ordinary spectrum; and the other, 6216·5, is not attributed to Vanadium in Rowland's Table. This line, however, is sometimes much widened in sun-spots; but, being of intensity 1, though a faint line, it would be one of the strongest lines of the list, if it is really a Vanadium line.

Stonyhurst College Observatory:
1898 May 7.


Mr. E. W. Maunder's note on the Zodiacal Light in the Monthly Notices for March has been of much interest to me, for since I first came to Madeira in the winter of 1895-96 I have given more or less attention to it, so far as delicate health and the difficulty of obtaining a clear western horizon admitted, and have arrived at conclusions somewhat different from his. Situated as I am, it has been impossible for me to examine directly either the results or conclusions of other observers, and this must be my apology if the results presented in this paper do not contain anything new. I had intended not to publish my conclusions until I had arrived at something more definite, but there are one or two points in Mr. Maunder's paper to which I wish to refer, besides which I have arrived at the conclusion that the mystery which surrounds the Zodiacal Light will never be cleared up until systematic observations are simultaneously undertaken at a number of different stations both in the northern and southern hemispheres. I have shown in the English Mechanic of 1896 July 17 that the variation in the appearance of the light from night to night is largely, if not entirely, due to atmospheric causes; and, as I shall endeavour to show presently, it is necessary to have simultaneous observations from several stations in both hemispheres before we can decide whether the appearances presented by the light are due to a deviation of its plane from that of the ecliptic, or solely to atmospheric absorption.
Mr. Maunder has supposed the light to consist of a disc of matter lying within the Earth's orbit, while a good way outside the Earth's orbit there exists a flat ring of matter reflecting the Sun's light. In the accompanying diagram (fig. 1) let the inner circle represent the outer edge of the inner disc of light, the middle circle representing the Earth's orbit, and the outer the "flat ring" of light, A being the Earth and EW the horizon shortly after sunset. Obviously we should see the light from the inner disc extending up from the horizon, its apex being projected on the sky in the direction AB. This disc will be brightest at its base, where, in the direction AC, we look at the particles of matter about C, which are most nearly "full," and it will fade somewhat gradually upwards, its apex at D being faint and indefinite because the particles of matter at this point will be more or less "new." Immediately above the apex of this inner light we see the outer ring at B, and from its being enormously distant at this point the ring will appear narrow and comparatively faint on account of the gibbosity of its particles. As we approach the zenith the ring will become broader, since it comes nearer to the Earth, and brighter as its particles become more "full," until at opposition to the Sun it assumes its maximum breadth and brightness. So far as I am aware, no such appearances have ever been observed, but I may be mistaken. The fact that Mr. Maunder observed the apex, not of the brightest portion of the light, but at any rate of a brighter portion of it than occurred at opposition to the Sun, at a distance of 164° from the Sun in December, and 102° in February, shows that no such break in its continuity occurred at the point B, as might have been anticipated.

In 1896 February I frequently observed the apex at a distance of 105° from the Sun; by the beginning of April it had shrunk to 70°; throughout April to 60°; on April 28, 65°; on
July 3 (a doubtful observation), 75°; and on the morning of November 14 to 85°. Throughout all this time I had often endeavoured to see the "Band" and the "Gegenschein," but never succeeded in observing either. Ill-health in the spring of 1897, and the fact of my being in Ireland during the summer, prevented observations until my return in November last. On the evening of November 13, at 7:30 p.m., I was taking a preliminary survey of the sky in order to refresh my memory in regard to the constellations and stars previous to keeping a watch for the Leonid meteors when what I have described in my notes as a "hazy, nebulous band" caught my eye somewhat to the east of the meridian. I had not been thinking of the Zodiacal Light at all, and this band, which I had never seen before, was fairly conspicuous. I settled its position with regard to the stars, and found on referring to the maps that it practically coincided with the ecliptic. The Zodiacal Light in the west at the time was visible as a mass of light without any definite borders or apex, so that I could not see whether the band was a continuation of the brighter light or not, i.e. whether the axis of the light also lay in the ecliptic, but the band passed about midway between the Pleiades and Aldebaran on the east. Since then I have seen the band on November 23, when the apex of the brighter portion of the light was 85° distant from the Sun, and on December 14, when the apex of the cone of western light was 105° from the Sun. More recently, on April 15 last, I failed to find this band; but the atmosphere seemed thick, and on the following evening (the 16th) I found the brighter western portion a shapeless mass of glowing light extending to about 60° or 65° from the Sun, and from this I clearly traced the band right across the sky, its breadth being 5° or more. The following stars lay, as nearly as I could estimate, upon its axis; but from the fact that its light was so faint that it could not be seen at all when looked at directly its axis as here indicated may easily be 3° or 4° in error.

Between κ and δ Geminorum

δ Cancri

θ Virginis

31 Leonis

Between λ and κ Virginis

α and β Librae.

It therefore seems to lie entirely to the north of the ecliptic, the light of Regulus having evidently affected my estimate of its position in this neighbourhood. Last night (April 17) I again saw it in identically the same position. To make absolutely certain that I was not deceived—for its faintness is such that unconscious deception might readily occur—upon three different occasions between 8 and 10 o'clock I swept over it to the north and south with an opera glass, in different portions of the sky and without having first looked for it, and upon each occasion I readily located it correctly, being conscious of having run the glass across something which I could not see when looked at.
directly. Now, the fact that I never saw this band in 1896, when I had often looked for it, but picked it up when nothing was further from my thoughts in 1897 November, strongly supports Mr. Maunder's conclusion that the Zodiacal Light is at present brighter than usual. But I have certainly not observed this to be the case with the cone proper, and had, indeed, decided that it was more brilliant in the spring of 1896 than now.

If we suppose the Zodiacal Light to be a flat luminous ring extending continuously from the neighbourhood of the Sun to a short distance beyond the Earth's orbit (fig. 2), then, looking

![Fig. 2.](image)

along the horizon shortly after sunset, we shall be looking through a vast number of particles of matter more than half of which, viz. those farthest away from the Earth, are almost "full," their light being diffused, and the definiteness of the edges of the further side of the ring being obliterated by the nearer, and therefore broader, mass of particles which turn a very small crescent of their illuminated hemispheres to us. As we view the Light further up from the horizon we at length come to a point, for example, between B and C, at which the extra quantity of more or less gibbous particles through which we look exactly counterbalances the smaller quantity of "fuller" particles on the side of C next E, and from this point we shall have a practically uniform band of light down to the horizon at E. After some hours the apex of the cone at B will sink below the horizon, which is then represented by the line B D, and we shall have nothing but the band remaining until the opposite process begins to take place on the eastern horizon before sunrise. Mr. Maunder states that "if the Light were due to a disc of matter extending uninterruptedly outwards from the Sun to a considerable distance beyond the Earth's orbit . . . the opposition portion
would tend to appear much broader than is actually the case." This, I think, would only be so if we assume a greater thickness for the disc than is necessary, or indeed probable, at its outer edges. Let fig. 3 represent a section of the outer border of the Light at right angles to the ecliptic, the Light having a thickness of, say, 10,000 or 15,000 miles where the Earth, Y, is immersed in it, and tapering off towards the edge, it is quite possible that we shall only see a thickness of it sufficient to render its feeble light visible at all when we are looking toward that part of it which is included in the angle X Y Z, say a band about 5° or 10° wide, its edges being, as is actually the case, quite indefinable.

This view satisfies all the existing visible facts as to the intensity of the Zodiacal Light, so far as I am aware, except perhaps that of the Gegenschein, a phenomenon which I have often carefully sought for, but have never yet seen, although I do not see how it could have escaped me had it existed since my observations of the Light began.

![Diagram](https://example.com/diagram.png)

**Fig. 3.**

But it is quite possible that the Zodiacal Light does not everywhere extend beyond the Earth's orbit, and it is here, and when we come to deal with the plane in which it lies, that simultaneous observations in both hemispheres are necessary. As I have already shown, the Light is readily overcome by atmospheric absorption, so that when it rises from the horizon at a less angle than 90° that border of it which is nearer the horizon is liable to, and must, become more or less obliterated, throwing the axis of the visible cone to one side of its real position.

Mr. Maunder says, referring to his observations of February 16–21, "The heliographic latitude of the Earth was then 7°.2 S. If, therefore, the disc extends to within a few million miles of our orbit, and if it lie in the plane of the Sun's equator, it should have shown an enormous displacement to the north of the ecliptic, which was most certainly not the case. In fact, the light appeared, if anything, to lie further south in February, when the Earth was at its maximum south heliographic latitude, than in December, when its latitude was only 3°." This last observation is exactly what we should expect if the light lie in the plane of the Sun's equator, for it is not, as Mr. Maunder appears to have assumed, those particles of matter lying between us and the Sun which give out the great portion of the visible Light, but those more or less on the further side of the Sun, as, for instance, those
near W, fig. 2. In December, however, Mr. Mauder's observations clearly show that the Light lay as nearly as possible on the ecliptic, when, if it lie in the plane of the Sun's equator, it should have been, in the evening, a long, narrow cone the apex of which lay below the ecliptic, and the axis of which was inclined to it, and crossed it at about the Sun's place. For if the plane of the Light be in the plane of the Sun's equator we should see, in the evenings, a long, narrow beam of Light in November and December the apex of which would lie to the south of the ecliptic, the Light being brightest at its centre, and fading off about equally towards both its northern and southern edges. It should then grow broader until about the beginning of March, its southern edge being brighter and better defined than its northern, because of its particles being at the further side of the Sun, and consequently being almost full, and of its increased narrowness through distance, its apex lying more or less on the ecliptic. It will again become narrow until about the end of May or beginning of June, its apex now lying to the north of the ecliptic, and its edges equally defined, and then it will grow broader until September, its northern edge now, however, being the better defined, and its apex again coinciding roughly with the ecliptic. The position of the apex, however, may vary considerably, depending largely, as it will, upon the relative densities of the outer and inner portions of the ring; and as the particles of which the Light is composed must be in constant motion, and continually taking up new relative positions, the apex may be expected to shift both in longitude and latitude within certain limits.

My observations given below, fragmentary though they be, go some way towards strengthening this view. The base of the Light most certainly becomes broader and narrower in a way which I cannot explain if the Light lie in the plane of the ecliptic.

Piazzi Smyth, in a paper published in 1852 in the Transactions of the Royal Society of Edinburgh, vol. xx. Part III., states that during the whole period of summer in the northern hemisphere, during which the Light was invisible to Cassini, it was most visible at the Cape. Cassini, he states, believed its invisibility in summer to be mainly due to the long twilight. "But these ideas (of Cassini), 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." But what Cassini contended was that the Light should be visible in the winter of the southern hemisphere, so that how his ideas fall to the ground
does not appear. Besides, when we see the ring edgewise, we are looking at the further and brighter portion through the entire mass of particles which are almost "new," and it therefore does not follow that the ring must be brightest when thus seen.

I believe that a series of observations carried on simultaneously at several favourably situated stations in both hemispheres could not fail to definitely settle, at any rate, the form and plane of the Zodiacal Light. Is it not of the greatest importance to ascertain the nature of matter, in which we probably live and move and have our being, which we may be actually breathing into our lungs—matter probably having a diameter of not less than 200 millions of miles, and yet incapable of obliterating the light of the faintest stars, except when it shines, which it sometimes does and sometimes does not? Telescopes and cameras have photographed stars through the Zodiacal Light and Band again and again, and yet not a trace of either appears upon the negatives, although they are visible to the unaided eye! Photography would, no doubt, yield good results in determining the axis of greatest brightness in the neighbourhood of the eastern and western horizons, but it does not seem to be capable of yielding any results with regard to the fainter extensions of the Light.
<table>
<thead>
<tr>
<th>Date</th>
<th>Hour</th>
<th>Position of Apex.</th>
<th>Brightest or Best Defined Border.</th>
<th>Width of Base.</th>
<th>Distance of Apex from Sun.</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb. 1</td>
<td>7.15 p.m.</td>
<td>R.A. 3 h 40 m Dec. +20</td>
<td>Indefinite</td>
<td></td>
<td>105</td>
<td>Appears conical, not lenticular.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7.15</td>
<td>3 h 40 m Dec. +20</td>
<td>15° at γ</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7.0</td>
<td>2 h 40 m Dec. +15 South</td>
<td>30°</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>8.0</td>
<td>4 h 0 m Dec. +20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td></td>
<td>1 h 40 m Dec. +10</td>
<td></td>
<td>65</td>
<td>Faint.</td>
</tr>
<tr>
<td>March 3</td>
<td>7.15</td>
<td></td>
<td>3 h 40 m Dec. +20</td>
<td>50°</td>
<td>75</td>
<td>Very bright.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td>3 h 40 m Dec. +20 South</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 3</td>
<td>8.45</td>
<td>ζ Tauri South</td>
<td>30°</td>
<td></td>
<td>70</td>
<td>Pleiades in centre of cone.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>8.30</td>
<td>ζ Tauri</td>
<td>Indefinite</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
<td>Just N. of ζ Tauri</td>
<td>Very diffused</td>
<td>60</td>
<td>Light very diffused.</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td></td>
<td></td>
<td>Faint and diffused</td>
<td></td>
<td>Very faint and diffused. Could make nothing of it.</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>8.0</td>
<td>β Geminorum</td>
<td>Invisible in haze</td>
<td>65</td>
<td>Base appears to lie north of ecliptic.</td>
</tr>
<tr>
<td>July 3</td>
<td>9.0 p.m.</td>
<td>R.A. 11 h 40 m Dec. +5</td>
<td>8°</td>
<td></td>
<td>75</td>
<td>Base lies between α and γ Leonis, apex about half-way between β and ν Virginis. Extremely faint.</td>
</tr>
</tbody>
</table>
1896.  Nov. 14  4.15 A.M.  h in π Leonis  o  10°  85  Morning observation. Spica lies much nearer S. edge of base than N.
1897.  Nov. 13  7.30 P.M.  Indefinite  Traced Band right across sky, apparently nearly coincident with ecliptic. Base very indefinite.
23  7.0  Behind a cloud  80  Axis about coincident with ecliptic at δ Capricorni. From this onwards across sky Band was about 5° broad, and seemed north of ecliptic, as β Arietis touched its N. edge. It passed about midway between Pleiades and Aldebaran.
Dec. 14  7.30  ζ Tauri  About 20°  105  Base very diffused. Band right across sky, about on the ecliptic.
1898.  April 15  8.0  ζ Tauri  Very indefinite  55  Pleiades in centre of base. Air seems thick. Band not seen.
16  8.30  Milky Way  Light very indefinite.

Band traced right across sky, about 5° or more broad. Passed between κ and δ Geminorum, crossed δ Cancri, 31 Leonis, θ Virginis, between λ and κ Virginis, and between α and β Librae. Band had no defined edges, and when I swept over it rapidly I thought I could trace it out to 10° broad. Western horizon glowing with diffused, indefinite light.

Funchal, Madeira:
1898 April 18.
The Markings on Venus. By A. E. Douglass, A.B.

(Communicated by the Secretaries.)

The reading public has been recently addressed on the subject of the markings on Venus in various attempts to show that the discoveries made at this observatory are unworthy of credit. No matter how futile such criticism must prove to be in the long run, some persons will be influenced by it if we do not from time to time make some rejoinder, or give out some statement which will show our continued activity in this line of work, our undiminished confidence in the results obtained, and our answering attitude towards adverse opinion.

In the last six years many thousands of hours have been spent by us at telescopes of 13, 18, and 24 inches aperture and their smaller finders, when the seeing was sufficiently good for profitable work on the finest known planetary detail. Expressed in standard terms, the seeing was practically always such that in a 6-inch aperture the spurious disc of the interference pattern was well defined, and a very large part of the time the rings of the same pattern were unbroken. I consider that any astronomer who cannot say the same for the seeing during his hours of work, and whose hours of work do not reach a commendable number, has no right to criticise our results; for he lacks the experience by which alone he becomes capable of judging.

Under proper conditions of air and aperture the markings on Venus are absolutely certain. Under proper conditions they are to me about as easy or difficult to see as the irregularities on the terminator of the Moon when it is near the first quarter, viewed by the naked eye. I have on a few occasions seen a large projection perfectly distinct. So it is with Venus. At the best seeing the markings are visible at the first glance.

To say that no markings save M. Antoniadi's symmetrical shadings of atmospheric contrast exist, or that the detail seen here is due to pressure on our objective, or to defective densities in the eye-piece, or to our own eyes, or to the imaginations of our brains; or, most ridiculous of all, to our looking all day at some map and then seeing it on the planet, is to offer suggestions too absurd to be taken seriously.

We use the telescope in both positions, normal and reversed: that shows that the markings are not in the lens. We use different eye-pieces and twist them in varying position angles: that shows that the markings are not there. We sit in different positions, so the markings cannot be in our eyes; and different persons in perfect independence find the same detail, so it is not a mental phenomenon.

In order to test our results in a formal manner, I made the following experiments on the afternoon of April 19, when the