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PAPER I.—ON SOLAR SPOTS.

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IN opening the Session of the Literary and Historical Society for this winter, you will allow me to congratulate you on our prosperity. Never since its foundation have we had so many members, nor were the funds ever in better condition; and I trust, by making additions to our Library annually of the most valuable books, we shall be able to offer to the Student of Literature attractions equal to that of any other Institution in Canada.

Since we last met, our land has been invaded by a "band of fierce barbarians," which was driven back by a handful of young men unaccustomed to arms; but, nevertheless, they gave a very fair sample of what Canadians would do, if called upon to defend their homes.

But the most important event of the year, is the successful laying of the Telegraph Cable between the old and new world, and the still more wonderful event of picking up the Cable of last year, that was lost in the ocean, at a depth equal to two miles; and if the "Great Eastern" never does anything else, still she has been the means of accomplishing the greatest wonder of the age.

I may also mention that the contest between guns *versus* armour is still going on. Now, the target is unable to be penetrated by any projectile; and, again, a gun is made that goes through anything that is opposed to it. Then, Her Majesty's ship "Warrior" is covered with an armour that defies all missiles; and, lastly, the Woolwich gun is made that throws a chilled shell that penetrates and knocks to pieces the strongest armour that at present can be carried by a ship. What will follow, who can say? *Punch* remarks, that we once threw red-hot shot at our enemies, but now we throw chilled iron.

Before reading my observations on "Solar Spots," it will be requisite that I should first give a general outline of what is known on the subject, and, in so doing, I quote from the "Researches on Solar Physics," by Warren de la Rue, Esq., and gentlemen of the Kew Observatory:—

"We are first indebted to Gallileo, if not for the first "discovery of sun spots, at least for the first attempt to "ascertain through their means the period of rotation of "our luminary.

"The next great advance in solar physics is due to "Alexander Wilson, Professor of Astronomy at Glasgow, "who, in 1773, communicated a paper to the Royal Society "describing certain phenomena with regard to spots, "which in his opinion, and in that of many others, appear "to indicate that spots are cavities in a luminous photo-"sphere which surrounds the sun. The accuracy of this "conclusion has recently been questioned; but whatever "may be said regarding the theory, there can be no doubt "regarding the importance of the fact that was first "revealed by Wilson.

"The next step is due to Hofrath Schwabe, of Dessau, "who has shown, as the result of nearly forty years' labo-"rious observations, that the number of spots which break "out on the sun's surface is not the same from year to "year, but has a maximun about every ten years—a "remark which led General Sabine to observe that the "various epochs of maximum spot frequency were also "those of maximum magnetic disturbance on our own "globe.

" Carrington is the next observer who has greatly ex-
" tended our knowledge of this subject. In a large and
" most remarkable work recently published, and contain-
" ing the result of many years' observations, he has
" shown that sun spots have a proper motion of their own,
" those near the solar equator moving faster than those
" near the Poles; and he has also interesting remarks on
" the distribution of spots in solar latitude for different
" years. In addition to these new facts, he has furnished
" us with very accurate data regarding the sun's rotation.

" We ought also to mention the discovery by Dawes ,that
" what is regarded as the umbra of a spot, consists in
" many cases of two well-defined and separate parts, the
" exterior part being less luminous than the interior.

" But there is another phenomenon connected with our
" luminary, not less curious than solar spots. We allude
" to the red flames, or protuberances, which are seen to
" surround the sun's disc on the occasion of a total eclipse.

" We may be allowed to mention here that very lately
" Mr. James Nasmyth, during the course of his observa-
" tions of the sun's surface, has come to the conclusion
" that when circumstances of observation are very favour-
" able, the whole surface will be found to be composed of
" separate luminous bodies, of great similarity of figure,
" interlacing one another; and he has given the name of
" 'Willow Leaves' to those appearances. The existence
" of these is still disputed: but some of our best observers
" in this country have seen them under very favourable
" atmospheric conditions, and they have been seen more
" frequently by Secchi and other Italian observers."

The questions to be answered by the "Researches on Solar Physics," are—

1. Is the umbra of a spot nearer the sun's centre than its penumbra? or, in other words, is at a lower level?

2. Is the photosphere of our luminary to be viewed as composed of heavy solid, or heavy liquid matter? or is it rather of the nature of a cloud?

The telescope with which I made my observations has an aperture of eight inches, nine feet focal length, mounted equatorially and driven by clock-work—power used varied from 100 to 600.

I had frequently examined the surface of the sun with a small glass by Dolland, and I admit that, without reasoning on the subject, but merely from the appearance of the spots, I was wholly impressed with the received opinion—that I was looking down upon the dark body of the sun through the bright envelope that is supposed to surround our luminary. However, the moment I observed the sun with an aperture of eight inches, the appearance was completely changed, and the spots, instead of caverns, now appeared to be matter floating on its surface.

I considered that I had nothing whatever to do with accounting for how it got there, but simply to state what the opinions of eminent astronomers that have been expressed on the subject, but to make and collect observations, and, if possible, to find out any general law by which they are governed; and, after two years' close attention, I find—

1st. That, as a very general rule, the spots are first formed on that side of the sun which is farthest from the earth, and that they are first seen on the limb, and then, by the rotation of our luminary, cross his disc.

2nd. That a spot not unfrequently consists of a round, black nucleus, without penumbra. The nucleus is rarely of the same degree of blackness, some parts being much lighter than others. The penumbra forms afterwards and enlarges, and always, when viewed with a high power, appears to be broken up into detached pieces.

3rd. The nucleus divides generally into two large pieces, and very often these pieces are again subdivided.

4th. These pieces have a motion among themselves,—that is, without altering their respective shapes, they alter their relative positions to each other.

5th. The nucleus and penumbra gradually become lighter and fade away.

6th. Sometimes the nucleus is surrounded by a border very much brighter than any portion of the sun's surface.

7th. Occasionally in the middle of the nucleus is seen a bright speck, as bright as the luminous border.

If the spots are openings in a bright envelope whose thickness we may suppose to be about one-thirtieth the diameter of the sun, then the perspective view of such an opening, when central, and at 30° and 60° from the central line, would appear as shewn in Plate 1, fig. 1.

Refraction would tend to displace the nucleus in the penumbra; but as it is only the medium that fills the cavity (and not that which surrounds the sun) that can have any effect, and as we may take it for granted that the medium that fills the cavity is of a very high temperature, I think that refraction may safely be left out in arriving at a general solution of the question, "Are spots cavities in a bright envelope?"

Admitting that these supposed openings are formed by hurricanes, causing an upward or downward rush of a medium, that breaks and forms openings in this envelope, and therefore these cavities may have any inclination to the vertical, then no matter how the openings are inclined; if it is favourable for seeing the bottom of the cavern in one position, it will be unfavourable for seeing it in another, and the view of a spot must more or less follow the rules of perspective and go through the different phases as shewn in Plate 1, fig. 1. And it would be utterly impossible to see the nucleus of a spot first on one limb of the sun, and then keep sight of it until it reaches the other limb, and in both cases not only to see the nucleus, but also to see the penumbra equal on both sides of the nucleus, if the spots were cavities.

I will now shew drawings of some spots that will illustrate some of the above remarks.

On Thursday, 12th April, 1866, a large spot was seen near the limb of the sun, as shewn in Plate 1, fig. 2, sur-

rounded by penumbra which appeared broken up into detached pieces, and although the spot was only a few hours from the limb, yet the penumbra was about equal on both sides of the nucleus. The nucleus appeared in two separate pieces, with a little piece alongside.

Friday, 13th.—Spot appeared as shewn in fig. 3. Two islands, *a* and *b*, are of much lighter color than the larger pieces of nucleus.

Saturday, 14th.—The large spot appears as shewn in Plate 2, fig. 1; but, strange to say, the island *b* has floated outside of penumbra, leaving a clear channel through the penumbra where it has floated out.

This observation I consider most important. And a very similar occurrence was seen by R. C. Carrington, Esq.—(*See* Monthly Notices, vol. XV. page 177.)

Monday, 16th.—The penumbra appears to have cleared away between the nuclei, the upper piece is greatly reduced, and the lower piece is divided into two; but the island *b* is still intact, and the island *a* appears to have broken into two; there are three detached pieces floating away from upper part.
—(Fig. 2.)

Tuesday, 17th.—The spot has completely changed its character and a portion of nucleus has broken into pieces, and these detached pieces are distributed about.

Wednesday, 18th.—Spot slightly altered, being much smaller, and the detached pieces at the end appear as mere stains, without any appearance of closing up, but rather to have faded away.

Observations of this spot were taken until the 23rd, but as no striking peculiarity occurred, I pass on to August 8th when a spot appeared, contrary to general rule, on the side of the sun nearest the earth. The penumbra is radiated, and on one end of the nucleus appears a bright spot as if it were burning, and also one portion of the nucleus is of much lighter color than the rest. There are outlying small specs, which I have not drawn.

Friday, 10th August.—Small specs gone, and light piece of nucleus has floated on to the edge of penumbra.—(Fig. 2.)

Saturday, 11th August.—The part that was on the edge of penumbra is now clearly outside. There are some outlying specs.—(Fig. 3.)

Thursday, Sept. 20th.--After some days of bad weather, I saw this spot well on the disc.—(Plate 3, fig. 4.)—

Saturday, 22nd.—Not much changed; the triangular piece not quite detached.—(Plate 4, fig. 1.)

Monday, 24th.—The two parts have closed up. The nucleus is nearly round, with one part of the nucleus much lighter than the other. There are three small pieces of penumbra detached.—(Fig. 2.)

This spot was first seen on the 1st, and was remarkable in having its penumbra much lighter than is generally seen. On the 4th, a part of penumbra appeared to have been broken off, and there are pieces, at a short distance, that look very much like the part broken off, which appears to have floated away.—(Fig. 3.)

This spot had detached pieces which are now mere specs, and, as I have long thought, are assuming the appearance of granulations, which cover the surface of the sun. Friday, 5th.—The only change appears to consist in a bridge having formed near the middle, and the piece that floated away is not to be seen.—(Fig. 4.)

In referring again to the "Researches on Solar Physics," published by the Officers of the Kew Observatory, we read that they have carefully measured the position of the nucleus with regard to the penumbra of a spot, when in different positions of the sun's disc—three positions to the left of central line, and three positions to the right of central line—and tabulated them in columns, shewing the penumbra is in excess on the side that would shew that the nucleus is further from the surface of the sun than the penumbra; and they sum up in the following words:—"The " whole number of cases observed is 605; excluding there- " from 75, where the penumbra is equal on both sides,

" there remain 530; of which 456 are for, and 74 against, " the assumption that spots are cavities in the sun." Now, the excluding the 75 cases where the penumbra is equal on both sides, is simply a mistake; for if 75 spots crossed the sun's disc with penumbra equal on both sides, then there were 75 cases that did not shew any appearance of a cavity and those 75 cases must be put on the other side, and the case will stand thus—for the assumption, 456; against it, 149.

But when we come to examine these 456 cases, there is not one that follows any law of perspective; and we might have expected that, out of that large number, at least one would have crossed the sun's disc, gradually assuming that appearance which, if they are cavities, we might naturally expect to see. But, as an illustration of a case, which it would be almost impossible to account for on the cavernous view of the case, I will take spot No. 361 of the Kew Catalogue, which was observed oftener than any other spot.

The amount of penumbra towards the right being equal to unity, that towards the left is equal to			The amount of penumbra towards the left being equal to unity, that towards the right is equal to		
Within 30 ° of left limb.	Between 30 ° and 60 ° of left limb.	Within 30 ° of central line.	Within 30 ° of central line.	Between 30 ° and 60 ° of right limb.	Within 30 ° of right limb.
Aug19th 20th	Aug21st 22nd	Aug23rd 24th	August 26th	August 28th	Aug29th 30th
2.0 2.0	1.3 1.2	1.1 1.1	0.9	0.9	0.6 0.8

We may suppose that the spot crossed the central line on the 25th, and penumbra should begin from that date to increase on the right of the nucleus, but instead, it gradually gets less; and although there are irregularities between the 29th and 30th, still the nucleus up to that date moves gradually in one direction.

But the observations and opinions of those who advocate the cavernous view of the case, are most unsatisfactory.—*See* Observations on Solar Spots, by Rev. F. Howlett: Monthly Notices, vol. xxii, page 7.

My own opinion is, that the spots are formed by meteor planets falling into the sun, and after they have melted and spread out they become visible. The penumbra is the dross and the nucleus the molten mass that splits and cracks into pieces.

Let us suppose that there are innumerable small asteroids, or small meteor planets, that revolve in orbits, whose inclination to the sun's equator vary from about 27° south to 30° north, Now, as the catastrophe of falling into the sun would happen at their perihelion, this in conjunction with the sun's rotation on its axis, would produce a zone or belt, to which the spots would be confined. Then, such being the case, it naturally follows that there should be a maximum and minimum period, according to the conjunction of their periodic times.

Granting that, there is a circle of corpuscles interior to the orbit of Mercury, which, according to Mr. Le Verrier, will fully account for the perturbations of that planet, and therefore probably does exist.

I need not refer to the many well-authenticated observations of dark bodies having crossed the disc of the sun, some of which most probably were planetary bodies, as these are not the source of solar spots; but we may suppose that there are countless planetary bodies whose diameters do not exceed 120 miles,—therefore, when crossing the solar disc, they would not be visible until they had melted and expanded into a large surface. Now, it is probable that a molten mass of metal, four yards thick, floating on the surface of the sun, even at a white heat, would appear as a dark body; and a planet of 100 miles diameter would cover a space four yards thick, equal to two hundred and thirty millions of square miles—very much larger than the nuclei of ordinary spots. It is, therefore, possible for the spot to be derived from this source.

But I fancy that our sun is a nebulous star, and that the nebula consists of much smaller atoms, which are seen as the zodiacal light, and that they are falling on the sun as fast as flakes in a snow-storm, giving heat and energy to our luminary, and are seen as the granulations which

cover the surface. And as a chicken lives on the yolk of the egg before it is hatched, so our sun may be living on its surrounding nebula until another phase in creation takes place.

The idea of the heat of the sun being kept up by matter falling into it, is ably advocated by Professor Tindal, and much strengthens the supposition.

Now, what would be the consequence and probable appearance of a small asteriod falling into the sun? At first it would not be visible; but, after it had come to the surface and spread out, it would appear as a round, black nucleus without penumbra; then, after awhile, the dross would form round the sides, and if the surface was in a great state of agitation, then we might expect that the dross or penumbra would be separated from the mass interval; it certainly might be expected that after the planet had melted into a level surface, the intense heat would split it and shew the bright surface of the sun through it; and, finally, the nucleus would fade away, leaving only dross or penumbra, which would ultimately be indistinguishable from the mottled appearance of the sun's surface.

This is the general course that a spot takes—not that any exception to the general rule would be at all fatal to the argument.

As Venus and the Earth are the principal disturbing forces, I have no doubt that the position of these bodies will be found mainly to determine the side of the sun that the spots are formed on.

In conclusion, I may say that I am preparing to enter into "Solar Photography," when I hope to give drawings of our luminary for a large portion of each year.