THE EFFECT OF A TOTAL ECLIPSE OF THE SUN ON THE VISIBILITY OF THE SOLAR PROMINENCES.

In his recent valuable report on the total solar eclipse of April 16, 1893, Professor J. M. Schaeberle sums up his conclusions with regard to the prominences in the following words: "All visible matter exterior to the Sun's surface is apparently in rapid motion, the path described corresponding to one of the conic sections. The so-called stationary prominences are probably stationary as to the general form only, the matter—which remains visible so long as the density is sufficiently great—in the same being in rapid motion. I have carefully compared the eclipse photographs taken with the 40-foot telescope on April 16, 1893, with the best spectroscopic observations accessible (both visual and photographic), taken of the uneclipsed Sun on the same day, and the result briefly stated is that while the coarser features of the Sun's surroundings are shown in spectroscopic observations of the uneclipsed Sun, the finer and essential details are wanting." On another page (93) Professor Schaeberle concludes, from a comparison of his eclipse photographs with the visual and photographic results obtained by Herr Fényi and myself on the same day at Kalocsa and Chicago, that the reason this structure of the prominences has not been more generally recognized is "the want of sufficient scale and definition." As Professor Schaeberle's photographs of the corona and prominences are undoubtedly superior to any obtained at previous eclipses, he is in possession of the very best of data for a study of the question. The importance of the subject has, however, seemed to me sufficient to warrant a further brief reference to my own observations, in connection with a review of certain other investigations made at various total eclipses since 1870.

The extensive series of observations made by Professor P. Tacchini at the eclipses of 1870, 1882, 1883 and 1886 are of great importance in connection with the work of Professor Schaeberle, and as they are not referred to by him, and seem to have been overlooked in many dis-

* Contributions from the Lick Observatory, No. 4, p. 125.
PLATE XXV.

PROMINENCE PHOTOGRAPHED BY PROFESSOR J. M. SCHAEBERLE DURING THE TOTAL ECLIPSE OF 1893, APRIL 16.
cussions of the nature of prominences, I have brought together below some of the most remarkable results.¹

The eclipse of 1870 was observed by an Italian party stationed at Terranovà, Sicily. During the total phase drawings of the prominences were made by Messrs. Legnazzi and Müller, which agree closely as to their general form. These were compared by Professor Tacchini with drawings of the prominences made with the spectroscope immediately after totality, with the following result: “Da questo confronto ci pare di potere arrivare alla seguente conclusione, che cioè durante gli eclissi totali di sole le protuberanze, che allo spettroscopio si mostrano tutte composte di parti ben distinte e frastagliate, si presentano invece sotto forma di masse compatte o nebulose, la cui forma si addatta però all’ossatura o scheletro che noi vediamo allo spettroscopio; di modo che se le osservazioni spettroscopiche sono fatte prima dell’eclisse, non sarà difficile prevedere quale forma presenteranno le protuberanze durante l’eclisse totale. Esisterebbe dunque un involucro comune, una atmosfera avvolgente le parti, che noi vediamo in pieno sole, la quale atmosfera non riuscirebbe a noi visibile, per debolezza di lume, che nelle sole circostanze di eclissi totali.”²

At the Egyptian eclipse in 1882, Professor Tacchini devoted special attention to a repetition of these observations. On the three days preceding the eclipse drawings of the chromosphere and prominences were made in accordance with the system so long pursued by the same observer at Palermo and Rome, and just before totality another drawing was made with great care, and the height and width of base of the four principal prominences measured with a micrometer. During totality the same prominences were observed with the naked eye, and their dimensions determined with reference to the lunar diameter. The results are given in the following table, together with the heights of the same prominences measured by Professor Riccò at Palermo on the day of the eclipse:

<table>
<thead>
<tr>
<th>Latitude of the Prominence</th>
<th>Height observed with the spectroscope</th>
<th>Height observed during the eclipse</th>
<th>Difference</th>
<th>Base observed with the spectroscope</th>
<th>Base observed during the eclipse</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>+18°</td>
<td>72°</td>
<td>180°</td>
<td>108°</td>
<td>100°</td>
<td>180°</td>
<td>80°</td>
</tr>
<tr>
<td>+29°</td>
<td>50°</td>
<td>162°</td>
<td>102°</td>
<td>50°</td>
<td>108°</td>
<td>58°</td>
</tr>
<tr>
<td>-15°</td>
<td>48°</td>
<td>132°</td>
<td>100°</td>
<td>231°</td>
<td>131°</td>
<td>131°</td>
</tr>
<tr>
<td>-22°</td>
<td>36°</td>
<td>144°</td>
<td>82°</td>
<td>231°</td>
<td>149°</td>
<td>149°</td>
</tr>
</tbody>
</table>

¹ Taken for the most part from Professor Tacchini’s work, *Eclissi totali di Sole del 1870, 1882, 1883, 1886 e 1887* (Roma: Tipografia Eredi Botta, 1888).

In the hope of obtaining independent evidence regarding the dimensions of the prominences during totality, I have examined an excellent positive on glass made from one of the photographs taken at this eclipse. Unfortunately the lower parts of the prominences are so covered by the Moon's disk as to render measurement of the full height and width impossible, the time which had elapsed since the beginning of totality not being recorded on the photograph employed. The dimensions of the prominences seem, however, to exceed those found by Professor Tacchini before the eclipse. A most interesting fact is the presence on the photograph of a large number of small prominences not recorded in the spectroscopic observations of the chromosphere. It is well to bear in mind that these observations were made in the $\text{Ha}$ line, and that the photographs taken during totality with the prismatic camera showed differences in the relative intensities of the prominence lines.\textsuperscript{1} The reliability of Professor Tacchini's observations is further indicated by the appearance of the prominences during totality: "Le quattro protuberanze erano tinte in roseo chiaro, e molto più lucenti ai bordi e tanto che sembravano contornate da un filetto lucido bianco."\textsuperscript{2} In view of Professor Tacchini's long experience as an observer of prominences, it may safely be said that these results should be considered to confirm those obtained at Terranova, and may be accepted as establishing an important difference between the spectroscopic and eclipse images of prominences.

In 1883 Professor Tacchini observed the eclipse at Caroline Island, and not only confirmed his earlier work, but discovered a new and remarkable variety of prominence: "Una cosa, che mi sorprese e che aveva un aspetto singolare e per me nuovo, erano dei getti o protuberanze bianche, la cui altezza non doveva essere minore di $\frac{1}{2}$ del raggio lunare. Questi oggetti sembravano proprio come di argento filograno, di una struttura cioè ed apparenza del tutto consimile a quella da me indicata per l'oggetto veduto al 1882 e che si definì per una cometa."\textsuperscript{3} These "white" prominences were not visible in the spectroscope immediately after the eclipse. During totality the chromosphere was found to be much higher than in full sunlight observations.

At the Grenada eclipse in 1886 Professor Tacchini's discovery of white prominences was amply confirmed by the appearance during

\textsuperscript{1}Schuster and Abney, \textit{Proc. R. Soc.}, \textbf{35}, 153, 1883.
\textsuperscript{2}Eclissi totali, p. 16.
\textsuperscript{3}Ibid, p. 58.
totality of a prominence from 10' to 12' high, independently seen by
three observers and recorded on all the best photographs. To Pro-

fessor Tacchini it appeared of a silver white color in its upper part,

with a slight tinge of rose below. Mr. Maunder described it as "of

the intensest silver whiteness," while Professor Turner considered it
to have a rosy tint throughout totality. A searching spectroscopic
examination of the chromosphere made immediately after totality
failed to show any indication of this remarkable object, which was
also invisible with the spectroscope at Rome and Palermo. Profes-

sor W. H. Pickering photographed the spectrum of this prominence,

and found H and K without the hydrogen lines. Captain Darwin
found from an examination of the photographs taken with a prismatic
camera that Hβ, Hγ, Hδ, Hε and f were probably also present, though
they were extremely faint in comparison with the brilliant H and K
lines.

Professor Tacchini found that of the nine prominences seen during
totality but four were visible in full sunlight, apparently much reduced
in both height and width of base. "Insistiamo intanto nel dire, che
inquanto a cromosfera, ciò che vedesi tutto attorno al sole durante un'ec-

cisse totale, non è paragonabile colla cromosfera veduta in pieno
sole, perchè durante un'eclisse totale si vede uno strato roseo sfumato
fino al bianco, al disopra del quale s'innalzano le grandi protuberanze,
mentre i flocchi lucenti e le piccole protuberanze che noi vediamo allo
spettroscopio si confondono con quell' involucro stupendo, che deve
venire formato dalla nebbia lucida più elevata ed involgente le piccole
flammelle, di cui vediamo costituita la cromosfera in pieno sole."

These various observations have led Professor Tacchini to the fol-

lowing classification of solar prominences:

"1. Protuberanze visibili in pieno sole e durante l'eclisse totale, ma
ben più alte, larghe e compatte, senza cioè il frastagliamento che si
osserva quasi sempre nello spettroscopio a sole non eclissato.

2. Protuberanze visibili in pieno sole e durante la totalità, con poco
differenza nella forma.


Phil. Trans., 180, 345, 1889.

Phil. Trans., 180, 392, 1889.


Phil. Trans., 180, 320, 1889.

Loc. cit., p. 197.
3. Protuberanze visibili durante l'eclisse totale e non visibili in pieno sole.


Let us now consider the observations made at the eclipse of 1893, April 16. Plate XXVI., which is reproduced from a drawing made by my assistant, Mr. Ellerman, brings together the visual and photographic results obtained by four observers. Fig. 1 (the outer circle) represents the prominences photographed by Professor Schaeberle at Mina Bronces, Chile, with a photoheliograph of 40 feet focal length. The drawing was made from a series of beautiful positives on glass from the original negatives, presented by the Lick Observatory to the Yerkes Observatory. While it fails to show all that could be seen on the original negatives, it is perhaps sufficiently complete for our present purpose. On account of the overlying image of the Moon, the forms of the lower parts of some of the prominences are very uncertain. For this reason no attempt was made to indicate the base of the prominence at P. A. 294°. Fig. 2 (from a plate in A. N. 3166) represents the prominences as drawn by Herr Fényi at Kalocsa, Hungary, at the time of totality in Chile. The observations were made in the Ha line with a Hilger 6-prism automatic spectroscope attached to a 7-inch refractor. All of the prominences (excepting one at P. A. 30°, which showed some motion in the line of sight) were of the quiescent type, and changed but very little in form or position during the day. The weather at Kalocsa was particularly favorable. Fig. 3 was drawn from two negatives of the prominences made in the K line with the spectroheliograph attached to the 12-inch telescope of the Kenwood Observatory. It was cloudy here at the time of totality in Chile, and no photographs could be made until about two hours later, when the thick haze which still covered the Sun made satisfactory observations impossible. Considering the circumstances in which they were made, it is not surprising that the photographs are decidedly inferior to those ordinarily obtained here. Fig. 4 shows the two large prominences at P. A. 180° and P. A. 294° as photographed by Mr. A. Fowler during totality at Fundium, Africa. The instrument used was a prismatic camera of 6 inches aperture with a prism of 45° angle. The drawing was copied from the K image on a beautiful glass positive, one of a series of photographs of this

1 Loc. cit., p. 236.
2 A. N. 3166, p. 365, 1893.
3 A. and A. 12, 450, 1893.
PROMINENCES OF 1893, APRIL 16:

(1) Photographed during total eclipse by Professor J. M. Schaeberle at Mina Bronces, Chile (outer circle).

(2) Observed visually in full sunlight by Herr J. Fényi at Kalocsa, Hungary.

(3) Photographed in full sunlight by Professor George E. Hale at Chicago, U. S. A.

(4) Photographed during total eclipse by Mr. A. Fowler at Fundium, Africa (many prominences not shown in the drawing).
eclipse which I owe to the kindness of Mr. Fowler. As some of the prominences are hidden on this positive by the Moon's disk, it has been thought sufficient to reproduce only those shown in Fig. 4.

The following table gives the approximate position angles and heights of the prominences recorded by Professor Schaeberle, Herr Fényi and myself. The lack of agreement of the position angles in many cases seems to be due in part to the different methods of designating the prominences adopted by the several observers.

<table>
<thead>
<tr>
<th>Schaeberle</th>
<th>Fényi</th>
<th>Hale</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. A.</td>
<td>Height</td>
<td>P. A.</td>
</tr>
<tr>
<td>4° to 7°</td>
<td>0'.8</td>
<td>10°</td>
</tr>
<tr>
<td>8° to 11°</td>
<td>0'.8</td>
<td>11°</td>
</tr>
<tr>
<td>12° to 17°</td>
<td>0'.5  to 0'.2</td>
<td>28°30' to 33°</td>
</tr>
<tr>
<td>30° to 35°</td>
<td>1'.0  at 30°</td>
<td>24°; 53'16' to 51°</td>
</tr>
<tr>
<td>36° to 40°</td>
<td>0'.7</td>
<td>48°</td>
</tr>
<tr>
<td>41° to 45°</td>
<td>1'.0</td>
<td>77°  to 83°</td>
</tr>
<tr>
<td>87° to 90°</td>
<td>1'.1</td>
<td>94°  to 101°</td>
</tr>
<tr>
<td>91° to 100°</td>
<td>1'.3</td>
<td>124° to 130°</td>
</tr>
<tr>
<td>101° to 106°</td>
<td>3'.2  at 168°</td>
<td>48°  to 51°</td>
</tr>
<tr>
<td>107° to 110°</td>
<td>1'.5  at 192°</td>
<td>160° 30' to 201° 4'</td>
</tr>
<tr>
<td>111° to 120°</td>
<td>3'.8  at 202°</td>
<td>301° at 201° 4'</td>
</tr>
<tr>
<td>121° to 130°</td>
<td>226°</td>
<td>(small)</td>
</tr>
<tr>
<td>131° to 140°</td>
<td>229° to 232°</td>
<td>233°48'</td>
</tr>
<tr>
<td>141° to 150°</td>
<td>3'.0</td>
<td>235°</td>
</tr>
<tr>
<td>151° to 160°</td>
<td>1'.0</td>
<td>286° 30' to 287° 8'</td>
</tr>
<tr>
<td>294° 295° to 298°</td>
<td>2.8</td>
<td>295° 24'</td>
</tr>
<tr>
<td>300° to 302°</td>
<td>0'.8</td>
<td>303° to 304°</td>
</tr>
<tr>
<td>359°</td>
<td>1'.0</td>
<td>339°</td>
</tr>
</tbody>
</table>
In comparing together these results the following summary of data relating to them will be of service:

**Schaeberle.**—Eclipsed Sun. Clear sky. Large image. Superposition on photographic plate of images due to hydrogen, calcium and other substances, some of them necessarily not in perfect focus. Plate sensitive only in more refrangible part of spectrum: red, yellow and green images consequently lost or greatly underexposed. Base of many prominences covered by Moon.

**Fényi.**—Full sunlight. Clear sky. Small image, magnified by eyepiece of spectroscope. $H\alpha$ line used, hence the prominence forms are those given by the red hydrogen line, which produced no effect upon the plates of the other observers. Necessary imperfections of hasty drawings, affected by insensitiveness of observer's eye to small contrasts. Time: about that of totality at Mina Bronces.

**Hale.**—Full sunlight. Very white sky. Small image, photographed by spectroheliograph without enlargement. K line used, giving distribution of calcium in prominences. Spectroheliograph of old type, in which image is distorted, making measurement of heights and position angles somewhat uncertain; motion of slits unsatisfactory, so that K line did not remain on the second slit during the entire time of one of the exposures. Time: about two hours after totality at Mina Bronces.

**Fowler.**—Eclipsed Sun. Sky slightly hazy. Small image, photographed at focus of prismatic camera. Chromosphere and prominence images corresponding to a large number of lines shown on photographs, but only a portion of that corresponding to K reproduced here. Time: about two hours after totality at Mina Bronces.

A comparison of the hydrogen and other images with the calcium (K) image on Mr. Fowler's plates shows that the latter is the largest and brightest in the case of all the prominences. This was also found to be true at the eclipse of 1882, and might have been predicted from our knowledge of the relative length and brightness of the lines in the spectrum of the prominences. In Mr. Fowler's photographs the upper part of the prominence at P.A. $210^\circ$ is shown in the $H\zeta$ line, though its images in the less refrangible hydrogen lines seem to have been hardly bright enough to affect the plate. It is faintly shown on my own plates, but was not seen by Herr Fényi in the $H\alpha$ line. Quite apart from the question of brightness, however, it has been found at the Kenwood Observatory that the forms of prominences in the hydrogen and cal-
MINOR CONTRIBUTIONS AND NOTES

Cium lines are in some cases distinctly different. Hence Herr Fényi's results should differ to a certain extent from the others, and, in general, the prominence forms observed visually should be somewhat smaller than the calcium images photographed with the spectroheliograph, or the composite forms photographed during a total eclipse. This failure of the ordinary visual method to render the true prominence forms visible in their full extent in sunlight must be regarded as having already been established by Professor Tacchini.

It is clear that on account of the greater size and brightness of the K image, photographs taken with the spectroheliograph should resemble eclipse photographs more closely than Ha images do. It remains to be determined in what degree the results obtained with this instrument fall short of those obtained during total eclipses. Had the sky been clear in Chicago at the time of the eclipse it might have been possible to give a definite answer to this question. The fact that the prominences photographed by Professor Schaeberle considerably exceed in height those shown on my negatives is doubtless partly due to the difference in the atmospheric conditions and in the size of the image photographed. It is probable, however, that with apparatus such as that used by Professor Schaeberle during this eclipse, his conclusion is justified that faint details can be photographed which cannot be observed either visually or photographically in full sunlight. But before this can be considered definitely established it will be necessary to compare with eclipse results photographs taken simultaneously with a telescope of equal focal length and a spectroheliograph of the most approved type, under good atmospheric conditions.

In a paper published in 1891, I showed that the photographic method of recording the forms of prominences in the H and K lines, which was then giving its first results, would in all probability render possible the study of the “white” prominences in full sunlight. After pointing out the many advantages to be expected from the use of these lines in photographic observations of the prominences, I cited the fact that H and K, without the less refrangible hydrogen lines, were present in the spectrum of the great “white” prominence of the 1886 eclipse, in support of the conclusion that such prominences should be shown on spectroheliograms. Since that time I have devoted some attention to a comparison of visual (Ha) and photographic (K) observations, but

I have not had an opportunity to investigate the matter thoroughly. I now wish to suggest that the prominence at P.A. $210^\circ$, which was photographed in South America, Africa and Chicago, but was not seen at Kalocsa in the $\text{Ha}$ line, may have been an object of this class. I have found from an examination of Mr. Fowler’s objective prism plates that, although the H and K lines were bright in this prominence, the hydrogen lines were so feeble as to make only the slightest impression on the plate. In some of the other prominences the hydrogen lines were nearly as strong as H and K, thus confirming the discovery of the different relative intensities of these lines made by Abney and Schuster at the Egyptian eclipse in 1883. Thus, in spite of the unfavorable atmospheric conditions which prevailed at Chicago, this prominence was photographed in the K line, while under the best of conditions it was invisible at Kalocsa in $\text{Ha}$.

Whether or not this prominence appeared white to the naked eye during totality, the published reports of this eclipse do not seem to say. It should be stated, however, that Mr. Fowler’s plates apparently offer no evidence that this prominence was characterized by a continuous spectrum. But I venture to doubt whether a “white” prominence necessarily has a continuous spectrum. It is true that the striking object of this class observed at Grenada in 1886 had, according to Professor W. H. Pickering, “a brilliant continuous spectrum in the visible region,” but I do not know that any confirmation of this result was obtained by the other observers. If it is true that H and K are the only intense bright lines in the spectra of the “white” prominences, it is perhaps unnecessary to seek further in order to discover the cause of the “white” color of these objects. Light of this wave-length, when observed in the spectrum of the electric arc, all other light being excluded from the eye, is of a distinctly violet color. Even the carbon flutings beginning at $\lambda 3890$ appear violet to the eye. But when the H and K lines are bright enough to be seen in the spectrum of a prominence, as is not infrequently the case, their violet color is so far diminished as to be hardly noticeable, and they appear distinctly white. I can account for this apparent difference only by supposing that the violet color is far less appreciable when the eye is exposed to the bright spectrum of the sky, as is the case when a prominence is under observation. The conditions existing during the total phase of a solar eclipse are very similar, for while observing the prominences the eye

\footnote{Annals of Harvard College Observatory, 18, 99.}
MINOR CONTRIBUTIONS AND NOTES

is exposed to the bright light of the corona. The light of the "white" prominences is also compared by the observer with the light of the corona and with the brilliant pink or red light of the ordinary prominences. As a result the violet color which must characterize all prominences in which the H and K lines predominate seems to escape attention. This may perhaps be due to a considerable admixture of white light radiated from or reflected by particles distributed throughout the mass of the prominence. I have occasionally found that eruptive prominences give a continuous spectrum, but quiescent ones apparently do not, if we may judge from the fact that the spectrum of the sky is not materially brightened over such prominences. It is probably impossible to say at present whether the "white" prominences belong to the eruptive class, or to draw any a priori conclusions regarding the character of their spectra. It is to be hoped that special attention will be directed to this point at the coming eclipse.

1 A. and A. 11, 813, 1892.

An examination of the literature of total solar eclipses will show that the depth of color of the prominences undoubtedly varies considerably. After due allowance has been made for personal equation, there seems good reason to believe that their color, which is ordinarily described as pink or rose, is sometimes deep ruby red and less frequently nearly white. Without attempting an exhaustive study of the literature with reference to this point, I have thought it worth while to append certain observations which are of interest in the present connection, though the scientific value of many of them is evidently doubtful.

In his History of Astronomy Grant quotes the following observations of the color of the prominences at the eclipse of 1842: Baily, red, tinged with lilac or purple; Biela, dark reddish color, approaching purple; Littrow, red, with a tinge of blue . . . . "their aspect, which was first white, changed to rose color and then to violet, and afterwards passed in a reverse order through the same tints . . . . The protuberances were visible before they assumed a coloured hue, and they continued to be visible after their colour was dissipated;" Valz, white, like the Sun. In 1868 Hennessy saw a prominence which differed in color from the others: "Its left edge was a bright blue, like a brilliant sapphire with light thrown upon it; next to that was the so-called rose-colour, and, at the right corner, a sparkling ruby tint" (Proc. R. Soc. 17, 86, 1868).

In his report on the eclipse of January 1, 1889 (Reports on the Observations of the Total Eclipse of the Sun of January 1, 1889, published by the Lick Observatory, p. 204) Dr. Swift quotes the following observations of prominence colors made at the eclipse of 1869: Alexander, white, later portions were tinted pale rose; Halstead, red, afterwards white; Hines, white, later brilliant rose; Browne, white, bordered with delicate rose; Zentmayer, white, tinged with blue; Moelling, white; Cutts, white; Schott, two prominences white, others delicate pink; Swift, bright red. In 1889 Kinne saw "a small, reddish purple Sun-flame near the north pole of the Sun"; Irish saw a
It has seemed to me worth while to point out, in the absence of
more complete knowledge, that all of Professor Tacchini's classes of
prominences can be accounted for with some degree of probability by
the well-established fact of a considerable variation in the relative
intensities of the hydrogen and calcium lines. His first class includes
prominences which are visible in full sunlight and during a total eclipse,
but in the latter case are much higher, broader and more compact, with-
out the structure ordinarily observed with a spectroscope and an une-
clipsed Sun. The photographs seem to show that the structure exists,
though in a naked eye view during totality it might easily be overlooked.
In attempting to explain the difference here noted let us remember (1)
that such prominences were seen by Professor Tacchini to be bordered
by a "white" fringe; (2) that H and K frequently seem to extend to a
greater height than that attained by the Ha line in prominences, and
that consequently the prominence image is often larger in K than in
Ha; (3) that the spectroscopic images of many prominences do not
end abruptly at a certain height above the limb, but disappear at a
point where the ratio of their brightness to that of the spectrum
of the sky does not exceed a certain quantity, which probably lies
between $\frac{1}{3}$ and $\frac{2}{3}$. The reduction in the brightness of the sky dur-
ing totality is probably great enough of itself to render visible faint
parts of prominences that are invisible in Ha in full sunlight. The
prominences must thus appear larger than they do in the spectroscopic,
and as the calcium extends further than the hydrogen, the pink image
(which takes its color from the great visual intensity of the Ha light)
must be bordered with violet, which, as I have already indicated,
would not improbably appear white.

The second class comprises prominences visible in full sunlight
and during totality, with little difference in form. These are probably
bright prominences, which terminate abruptly or decrease very rapidly
cone-shaped prominence, having "a hue of ashes of roses"; Swift was much surprised
to find the prominences "as white as burnished silver" (Lick Observatory Report, pp.
155, 193 and 203). Among the conclusions drawn by Secchi from his observations of
the eclipse of 1860 is the following: "Les protubérances sont des amas de matière
lumineuse ayant une grande vivacité et possédant une activité photogénique très-
remarquable. Cette activité est si grande, que plusieurs des protubérances que nous
voyons sur nos épreuves, et précisément la protubérance E (figured in Le Soleil), n'ont
pu être observées directement, même avec de bons instruments: c'est peut-être parce
qu'elles n'émettaient que des rayons chimiques et peu ou point de rayons lumineux."
(Le Soleil 1, p. 385).
ERUPTIVE PROMINENCE PHOTOGRAPHED AT THE KENWOOD OBSERVATORY
1895, MARCH 24, 22°, 40°, CHICAGO M. T.
PLATE XXVIII.

ERUPTIVE PROMINENCE PHOTOGRAPHED AT THE KENWOOD OBSERVATORY 1895, MARCH 24, 22h 58m CHICAGO M. T.
in brightness at a certain distance from the limb, and give very bright hydrogen lines.

The third class comprises prominences visible during a total eclipse, but not visible with a spectroscope (using $H\alpha$) in full sunlight, i.e., the "white" prominences. These seem to be prominences of moderate brightness, in which the hydrogen lines (particularly $H\alpha$) are very faint in comparison with H and K; they may perhaps also have a continuous spectrum. It is probable that they can be photographed full sunlight with a spectroheliograph.

Finally, the chromosphere may have a "white" border and appear higher during totality, for the reasons given in the case of the first class of prominences.

It should be added that these suggestions are made only hypothetically, in the hope that they may be of some service in clearing up a long standing problem. The rather full statement of Professor Tacchini's observations, which I have thought it well to give on account of the slight recognition this important work has received from many writers on solar phenomena, may perhaps serve to direct renewed attention to the prominences on the occasion of the coming eclipse.

As the prominences photographed at the Kenwood Observatory 1893, April 16, are not suitable for reproduction, I have thought it

1 Former explanations of the "white" prominences include Lockyer's conclusion that they are descending masses of cooled vapor (Eclissi totali, p. 189) and the following from Proctor's Old and New Astronomy, p. 401: "This discovery (Tacchini's) seems only explicable by my theory that the ruddy, jet-like portion of the prominence owes its light, and therefore its heat, to the velocity of outrush with which ejected matter passes through the hydrogen and helium already outside the Sun, and not to the outrush of those gases themselves in an intensely heated condition. For outrushing gases brought from a region of great pressure to a region of very small pressure would expand rapidly and be quickly cooled, so that the outlines of the heated and luminous portion would be sharply defined, and they would be surrounded by a region not only cooler than the ejected matter, but even cooler than the surrounding atmosphere. On the other hand, ejected matter would travel outwards with diminishing velocity owing to the retarding action of solar gravity, while such portions as return after reaching a certain height would not only be scattered around somewhat widely, but would reach the Sun's surface with less velocity than they had at leaving it, because of the effects of frictional resistance. Hence, above and around the region of rapid outrush, intense heat, and brilliant light, there would be a region where the hydrogen and helium in the Sun's atmosphere would be heated by the rush of matter through it, and would therefore be luminous, but would be less heated than the region of outrush. This exactly corresponds with what Tacchini has discovered."
well to select from our collection three photographs (Plates XXIII., XXVII., and XXVIII.) for comparison with the largest prominence shown on the Mina Bronces negatives; this is the object at P. A. 210°, which may perhaps be a “white” prominence. Professor Schaeberle has been kind enough to prepare a special enlargement (Plate XXV.) for the present purpose, which brings out as many of the details of the original plate as can readily be shown in this rather unsatisfactory way. It may be said of all the plates that the beauty of the positives on glass from which they were made is for the most part lost. Contrasts that were before scarcely noticeable are now harsh and offensive, detail and definition is lost, and nothing is gained to offset these losses. In some cases the grain of the plate is especially conspicuous; this is particularly true of the great eruptive prominence from the Kenwood collection. To explain this it may be mentioned that our photographs were taken with a 50 mm focal image of the Sun, while the image photographed by Professor Schaeberle was 112 mm in diameter. In order to reproduce all the plates on the same scale, it was therefore necessary to enlarge the Kenwood negatives more than twice as much as Professor Schaeberle’s. As the scale of the reproductions is about 16.2 inches to the solar diameter, an eightfold enlargement was required for our plates; this was sufficient to bring out the granulation together with the chance defects of the originals in a disagreeable manner. The sharpness of the photographs must be judged from the image of the prominence itself, and not from the outline of the metal disk which covers the Sun. The latter was necessarily out of focus, as it was considerably above the plane of the spectroheliograph slit, and separated from it by a plate of blue glass.

With these circumstances in mind the eclipse photograph by Professor Schaeberle, which may fairly be considered as one of the best of its kind, may be compared with the spectroheliograms. I think it will be seen that in sharpness of definition, and apparently in the rendering of faint details, the latter do not fall far behind. These are not shown as average results. They represent some of the best results obtained at the Kenwood Observatory. They serve, however, to give some idea of what can be photographed with apparatus which is open to very decided improvement. Were eclipse results obtained on the same dates available for comparison, such photographs would do much to assist in determining the exact nature of the apparent changes in prominence forms brought about by the reduction in brightness of the glare around the Sun.
QUIESCENT PROMINENCE PHOTOGRAPHED AT THE KENWOOD OBSERVATORY
1894, JULY 3, 4, 10 TO 16 CHICAGO M. T.
PLATE XXIV.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.