THE TOTAL SOLAR ECLIPSE OF JULY 29TH, 1878.

"THERE is no doubt whatever that the eclipse which will sweep over the United States next July will be observed as no eclipse has been observed before. The wealth of men, the wealth of instruments, and the wealth of skill in all matters astronomical, already accumulated there, makes us Old Country people almost gasp when we try to picture to ourselves what the golden age will be there, when already they are so far ahead of us in so many particulars.

"Draper, Hall, Harkness, Holden, Langley, Newcomb, Peters, Peirce, Pickering, Rutherford, Trouvelot, and last, but not least, Young, are the names that at once run easily off the pen to form a skeleton list, capable of considerable expansion with little thought when one thinks of the men who will be there. One knows, too, that all the enthusiasm of devoted students and all the appliances of modern science—appliances in the creation of which many of those named have borne a noble part—will not be lacking, so that we may be sure that not only old methods but all possible new ones will be tried to make this year one destined to be memorable in the annals of science side by side with 1706, 1851, 1860, and other later years."

It is thus that the eminent English astronomer and physicist, J. Norman Lockyer, F.R.S., F.A.S., began, a few months ago, an article on the then "Coming Total Solar Eclipse" of July 29th. The conclusion of the same article is couched in the following complimentary terms: "I have little doubt that the preparations of the skilled astronomers of the United States include many surprises and daring attempts among the solid work which we are quite certain of. All here wish them the extremest measure of success, which I am sure their efforts will do more than command."

These words, so flattering to us Americans, are not the only mark of the unlimited confidence which English scientists place in

us. One of these gentlemen being asked why England had failed to send out an eclipse expedition, replied that it would be an unwarranted expenditure of public funds, since others could make the desired observations at much less expense, and, to say the least, quite as well as English astronomers. Though neither England nor any other European power felt called upon to make an appropriation for the benefit of observers, evidently by reason of their confidence in the ability of American scientists and of the interest they knew our government would manifest in the matter, yet this fact did not prevent several foreign astronomers, Mr. Lockyer among others, from visiting the line of totality at their own expense.

It may seem egotistic to attribute this apparent neglect of foreign powers to their trust in us, but a glance at the enormous outlay made by the same powers on the occurrence of similar events in the past will at once establish our claims to merit. And now it is a source of national pride to be able to aver that what was done here in the United States during the late total solar eclipse justifies the confidence which Europe placed in our ability and scientific zeal.

As the newspapers kept the public informed of the incredible number that responded to the call of science, we need not attempt an exact enumeration; suffice it to remark, that besides the many observers sent out by the Naval Observatory at Washington—fifteen, if we mistake not, for which purpose Congress, at the request of Admiral Rodgers, appropriated $8000—nearly every large educational institution in the land sent representatives, to whom not a few intelligent and skilful assistants, mostly amateurs, were joined. The Fathers of the Society of Jesus, following the example of their European brethren in the past, also inaugurated an expedition, composed of professors from their colleges of Georgetown, D.C., and Woodstock, Md., and placed it under the direction of Rev. B. Sestini, formerly of the Roman College Observatory.

It is hoped that the following summary, incomplete as it must necessarily be, of the work performed during the eclipse, will prove in some measure interesting to the readers of the AMERICAN CATHOLIC QUARTERLY REVIEW. We feel called upon to submit at once an account of this work, since an exhaustive discussion and examination of the various observations made by different parties may require years for completion.

But let us premise a few remarks bearing upon the subject in hand. Total eclipses of the sun have in all ages attracted the attention of man, but with very different effects. Objects of terror to the ignorant and superstitious, they are longed for by the astronomer as presenting the best, though exceedingly rare, phe-

nomena for studying the principal body in our system. An uninformed reader on learning the fact that of the seven possible eclipses in a year five are of the sun, and that, at least, two solar eclipses occur yearly, while there are years destitute of a lunar eclipse, may be at a loss to understand how total solar eclipses are so rare. Without entering into the scientific explanation, suffice it to produce the subjoined facts. On any one spot of the earth's surface lunar eclipses are more frequent than solar. Thus, while the former were often seen at Paris during the eighteenth and nineteenth centuries, only one total eclipse of the sun was visible to the Parisians during the same period, that of 1724. London beheld one since 1140, namely, in 1715. Thus, too, the line of totality of a coming total solar eclipse will, from present calculations, pass through Berlin on the 19th of August, 1887, offering the first and last opportunity to its inhabitants to employ their smoked glass in the present century. The reason that these phenomena are so rare is evident. Lunar eclipses are visible to about one-half the earth's surface, whilst the solar, which are often partial and annular, are seen in comparatively few localities. Many times, too, since three-fourths of our globe is covered by water, they are visible only at sea, and when the line of totality does reach the land, it is often in points almost inaccessible.

From these few remarks we understand at once why the eclipses of August, 1869, and of July, 1878, were so precious to the scientific mind of America. It is only since 1842 that astronomers, by reason of the perfection attained in scientific apparatus, have been able to observe eclipses with successful results. The principal ones observed from that date till 1860, when the corona was first photographed by Rev. A. Secchi, S.J., and Warren de la Rue, in Spain, were that of 1842, which swept over France, Italy, and Austria, an admirable report of which was given by the well-known Englishman, Baily; that of 1851, observed in Sweden by English, German, and Russian astronomers; and that of 1853 and 1857, visible in South America. Chili was visited by one a little later, and a very good drawing of the corona was executed by Rev. P. Cappelliti, S.J. But the success attending observations made during the eclipses of August, 1868, and August 7th, 1869, the first visible in Asia and Oceanica, the second in the United States, surpassed all preceding efforts, the perfection which photography had reached and the novel application of spectrum analysis producing unlooked-for results. These results were fully confirmed during the subsequent eclipses of 1870 in Spain and Italy, of 1871 in Sweden, and 1875 in Southern Africa and Asia. The late eclipse was regarded as the return of that of July 18th, 1860. The dark shadow of the moon first struck the earth at sunrise, in the province of Irkoutsk,

Siberia, in longitude 165° 25′ west of Washington, and latitude 54° 14′ north. Its course was first east-northeast, but gradually changed to east, and, after leaving Asia, to southeast. It crossed Behring's Straits, in latitude 66° 40′ north, in an easterly direction, passed a little northeast of Sitka, crossed the British Possessions towards the southeast, and entered the United States in longitude 38° west of Washington. The shadow, about 116 miles in breadth, swept over the western end of Montana Territory, the Yellowstone National Park, Wyoming Territory, Colorado, and Northern and Eastern Texas, and entered the Gulf of Mexico between New Orleans and Galveston. It then passed over most of the island of Cuba and Southern San Domingo, and left the earth a little southeast of the latter island.

The moon's shadow, according to the *English Nautical Almanac*, struck the earth at 2h. 9m. 59.9s. Washington mean time, and left it at 7h. 7m. 35.9s., hence the absolute time occupied by the shadow in sweeping over the earth was 4h. 57m. 36s. The greatest duration of the total phase, 3m. 10s., occurred in the British Possessions. This was much less than the possible duration for that latitude, which is about 6m., whilst on the equator it may reach 7m. 58s. In the United States the maximum time of the phase did not exceed 3m. 7s. This was reached in Montana Territory, and diminished southward.

To enumerate the devoted scientific groups scattered along the line of totality would surpass the limits of the present paper; we can only mention a few. In Wyoming Territory, where the favorable points of observation were Creston, Rawlings, and Separation, along the Union Pacific Railroad, were stationed Professors Newcomb, Watson, and Harkness, Dr. Draper, Mr. Lockyer, Prof. Edison, and others. The desirable locations in Colorado were Denver, Pike's Peak, where General Myer, chief signal officer, observed; Central City, at which Prof. Holden was stationed; and in the southern part, West Las Aminas, Fort Lyons, and La Junta, where Professors A. Hall, Eastman, and others had taken up their positions. At Denver, latitude 39° 45′ north, and longitude 28° 1′ west of Washington, were stationed the Princeton College Expedition, under the direction of Prof. Young, and that of Vassar College, under Miss Mitchell. Our own little band occupied a position a mile east of the city, on an eminence about 5500 feet above sea-level.

The sky at Denver, for several days preceding the 29th, was overcast, and the dread of an insignificant clump of clouds creeping over the solar disk on the day of the eclipse haunted the waking and dreaming hours of not a few. But a cloudless sky, never

before beheld so thankfully, greeted our eyes on the morning and during the day of the 29th.

The orbital rate of the moon from west to east, being about thirteen times more rapid than the apparent yearly motion of the sun in the same direction, hence on the occasion of a solar eclipse any telescope, which does not reverse the image, will present the moon first coming into contact with the solar disk, and then passing over it from west to east. This first contact occurred at our station at 2h. 19m. 30s., mean Denver time. The second contact, or beginning of totality, took place at 3h. 29m. 3s., and ended at 3h. 31m. 43s.; hence the totality lasted 2m. 40s. The last contact or end of the eclipse occurred at 4h. 34m. 55s., the total duration being 2h. 15m. 25s. It may not be out of place to note here the changes observed near our station in the thermometer and psychrometer. It will be noticed in the following table, that the thermometer exposed to the rays of the sun indicated a lower temperature than the one in the shade.

The maximum during the day, 34° C., was reached at about 5 P.M.

Variation of the Thermometer and Psychrometer during the Total Eclipse of the Sun, July 29th, 1878.

Centigrade Scale.	Time of observation. h. m.	Thermometer exposed to the sun.	Dry thermometer in the shade.	Wet thermometer in the shade.	Relative humidity.
	2.10	45.0	31.1	16.1	13.3
Begin'g of eclipse,	2.20	44.7	31.1	16.1	13.3
	2.30	42.2	31.7	16.1	11.9
	2.40	38.1	31.7	16.1	11.9
	2.50	37.5	31.4	16.4	13.4
	3.00	35.3	31.1	16.6	15.7
	3.10	32.8	30.8	16.6	17.2
	3.20	31.1	30.0	16.6	18.9
	3.30	29.2	29.5	16.6	20.6
Total eclipse, . .	3.31	28.3	29.2	16.4	19.7
	3.32	27.7	29.2	16.4	19.7
	3.40	28.6	28.6	16.4	21.5
	3.50	29.4	28.3	16.1	21.5
	4.00	31.1	28.9	16.6	22.4
	4.10	33.3	29.7	17.0	20.6
	4.20	35.8	30.3	17.2	20.7
End of eclipse, . .	4.30	37.2	31.1	17.7	20.7
	4.50	35.8	32.2	17.7	17.5

The variations of the barometer were not so remarkable. Excepting a slight deflection of the column at 2.45 no other sensible change was noted, even during totality.

The impression produced on man and beast by the sudden disappearance and reappearance of the sun, and the changes effected in the surrounding landscape by the rapid advance of the moon's shadow, defies description. It is enough to quote the words of Fr. Secchi. "The descriptions given are often exaggerated, but the very exaggeration proves the awe-inspiring tendency of the phenomena." Observers, though previously cautioned, experience so great an emotion, that, as Fr. Secchi adds, "they detach themselves with difficulty from an inactive contemplation of the grand spectacle nature then presents." "Mr. Warren de la Rue," he continues, "affirms in his report that he would travel any distance to experience unmolested the impressions which he felt, but was obliged to master, during the eclipse of 1860."

Our own emotion on the occasion of which we write, was in no wise different from De la Rue's.

But let us speak in detail of the phenomena observed. The shadow of the moon, advancing from the northeast with an enormous velocity, was preceded by alternately dark and bright streaks, termed diffraction bands. By our party they were observed very distinctly immediately before totality, but not at the end; yet others are reported to have noticed them even then. In 1842, Baily observed, at the moment of the second and third contacts, a charming phenomenon, to which the name of Baily's beads has since been given. The moon's disk in hiding the solar crescent leaves some bright points along the edge, which present the appearance of brilliant beads. This phenomenon is produced by the solar light darting through the valleys, or indentations existing on the lunar surface. Through our large telescope the appearance was truly magnificent. Even a telescope of moderate power presented a fine view of them, and many noticed them with the naked eye. With the disappearance of Baily's beads began the beautiful phase of totality, of which we give a drawing sketched by Rev. B. Sestini.[1] As in preceding eclipses the lunar disk was surrounded by a bright crown, or ring of silvery light, called the corona. It had apparently no determined outline, but gradually faded away on the dark background of the sky. From the corona, faint rays of irregular breadth streamed out in every direction, surrounding the moon like a glory, similar to the rays ordinarily represented around the heads of saints. The shape, dimensions and brightness of the corona are found to vary for different eclipses. The greater number of those who have observed former eclipses, affirm that the corona on this occasion was the most brilliant they had ever witnessed.

[1] In the drawing the north is represented above, as is usually done, the west being at the left.

The shape, too, and dimensions which the corona assumed, were very striking. During totality three planets, Venus, Mars, and Mercury, and four stars became visible to the naked eye. And several parties observed with powerful telescopes the star δ of Cancer through the corona. Many succeeded in obtaining fine photographs of the corona. But though photography is useful, it does not dispense with drawings, since, as Fr. Secchi remarks, there seems to be a difference between the actinic and luminous powers of the coronal light. Those in charge of the Naval Observatory, as well as the Chief Signal Officer, being aware of this fact, instructed observers to secure as many drawings of the corona as possible. The drawing of Fr. Sestini is an exact representation of the phenomenon as seen by us. We say, as seen by us, for many causes tend to vary the general aspect of the corona, as the hygrometric state of the atmosphere, the power of the telescope employed, and the eyesight of the observer. The corona, as seen at our station, bore but little resemblance to drawings executed on previous occasions. These changes, observable in different eclipses and even during various stages of the same eclipse, go far to establish the belief that the solar atmosphere is subject to violent hurricanes. Rays of light shot out almost in the direction of the ecliptic, extending on each side of the lunar disk one and a half diameters of the moon. We noticed others shorter than these, and almost perpendicular to them. The former called to mind the zodiacal light, caused, it is supposed, by the solar atmosphere.

During total eclipses flamelike protuberances of variable form are usually perceived around the moon's disk. It was for a time doubted to which orb they pertained, but closer observation has revealed the fact that they belong to the sun, and are apparently, as many believe, connected in some way with the solar spots. The absence of protuberances during the late eclipse, only two having been noted, strengthens this opinion, since the present time is an epoch of minimum solar spots; none, in fact, were visible on July 28th and 29th.

Though protuberances were wanting, the chromosphere presented a beautiful sight about five seconds prior to the end of totality, in the shape of a reddish cloud extending over 90° or 100° of the moon's edge on the northwestern border of the sun. Those familiar with the recent theories regarding the constitution of the sun, will understand how much may be deduced from such phenomena when telescopic, photographic, and especially spectroscopic apparatus are skilfully employed. But before speaking of the observations bearing on the constitution of the sun, which formed the principal of the three problems which astronomers hoped to

solve by observing the late eclipse, we shall briefly touch on the other two.

Notwithstanding the progress of astronomy and the wonderful precision of calculations hitherto made, there still exists some little doubt with regard to the position of our satellite. As an instance, we may mention the fact that English astronomers located the limits of the moon's shadow for the late eclipse four miles farther west than the American astronomers. Though this error, everything considered, is trifling, yet those who are familiar with the methods employed at sea in directing the course of vessels, will appreciate the paramount importance of attaining mathematical precision in our lunar tables. Now total solar eclipses offer the most favorable opportunity for detecting the slight existing error. For, as by knowing the moon's position we can infer that of its shadow, so, the exact location of its shadow being determined, we can find the true position of the body casting it. Hence, Prof. Harkness of the Naval Observatory, in the instructions published for the guidance of observers, urged upon all the importance of determining the exact limits of the moon's shadow and the duration of the different phases. From these elements, after a comparison of various reports, astronomers hope to be able to introduce the necessary correction in the lunar tables. Besides the longitude of various localities would be rectified to the advantage of science. The second object of science in the late eclipse was the search for intra-Mercurial planets. The illustrious French astronomer, Leverrier, whose recent death is regretted by all lovers of science, shortly after his prediction and the subsequent discovery of Neptune, announced the existence of at least one planet between the orbit of Mercury and the centre of our system. The almost prophetic ken of celestial mechanics manifested in the discovery of Neptune is an ofttold tale, yet it reflects so much honor on science that we cannot refrain from its repetition. Herschel on discovering Uranus determined its elements and calculated the table of its orbit; but after some years it was found that the planet did not occupy the position indicated in Herschel's tables. The thought came to several, to Arago among others, that beyond the orbit of Uranus there wandered still another member of the solar system, whose gravitating influence caused the unexplained perturbations of this planet. Sir John Herschel, speaking of Neptune's discovery, says: "We see it as Columbus saw America from the shores of Spain. Its movements have been felt trembling along the far-reaching line of our analysis with a certainty hardly inferior to ocular demonstration." Two astronomers, both then quite young, Adams in England, and Leverrier in France, succeeded, independently of each other, in determining the elements of the unknown planet, *i. e.*, its position,

size, and distance from the sun. Leverrier not having the requisite star maps in France, communicated the result of his calculation to Prof. Galle in Berlin, who the very evening he received the communication found the predicted planet at a distance less than a lunar diameter from the spot designated. Arago termed the discovery the greatest triumph of human intelligence. And what grander achievement can be conceived than that of a man, without scanning the heavens, directing the eye of another to an unknown planetary orb twenty-five hundred millions of miles distant. This same able calculator, whose revised and corrected tables of the planets are in general use, having noted some unexplained perturbation in Mercury's motion, announced, as we have said, the existence of at least one planet, to which he gave the name of Vulcan, between Mercury and the sun. For reasons well known to astronomers, he could not calculate its elements with the same certainty as he did those of Neptune; yet he asserted that if such a planet existed, the perihelion of Mercury would be displaced at the epoch of its transit, May 6th, 1878. This displacement actually occurred as he had indicated. Now a planet so near the sun must necessarily be very diminutive, and consequently invisible under ordinary circumstances; and a total eclipse, at least with our present means of observation, affords the only opportunity for its discovery. Many observers, we among others, searched for it, but, so far as we know, only two claim to have caught a glimpse of the planetary Vulcan: Prof. Watson,[1] of Ann Arbor, Michigan, and Prof. Loder, F.A.S., of England. The former was stationed at Separation, Wyoming; the latter at Denver. We trust that their observations and those of others, who perhaps saw it, may agree, and thus science will have achieved another glorious triumph.

The main motive that led the lovers of science thousands of miles

[1] With regard to Watson's discovery, we find in the astronomical column of "Nature," August 22d, 1878, an article from which we make the following extract.

"At the instance of M. Mouchez, the Director of the Bureau des Calculs of the Observatory at Paris, M. Gaillot, who so long assisted Leverrier in the formation of his planetary tables, has examined how far the position of the object seen by Prof. Watson will accord with the more probable of the orbits which Leverrier inferred for a hypothetical planet, from the observations of suspicious spots in transit over the sun's disk. . . . . He notes that the most serious objection which opposes itself to the identification of the object observed, with a planet moving in the orbit indicated by Leverrier's formula, is that we should see a very small part of the disk illuminated; and without denying that there is reason in this objection, M. Gaillot adds that Prof. Watson describes 'as being of the fourth magnitude, a star, the diameter of which may be comparable with that of Mercury, and which, in superior conjunction, may appear of the first magnitude.' He further remarks that while it is not possible to decide with certainty upon the identity of Prof. Watson's planet with that of which Leverrier has indicated the track, he believes he has shown that there is no incompatibility between the observed and the hypothetical objects."

into the distant West was the hope of acquiring a better knowledge of the constitution and dimensions of the ruling body in the solar system. A slight digression is necessary here, for the purpose of glancing briefly at the theories thus far advanced regarding the nature of the sun. Old astronomers, to whom spectrum analysis and many notable facts gleaned from phenomena observed during recent eclipses were unknown, regarded the sun as a somewhat dark nucleus surrounded by a double atmosphere; the exterior and brighter of the two they called the photosphere. They explained the solar spots as rents existing in these atmospheres, the interior one forming the penumbra, and the nucleus the central portion of the spots. This theory, advanced by Sir W. Herschel, held the preponderance till the application of spectrum analysis led Kirchhoff to propose a different one.

Kirchhoff's theory regards the sun as composed of a central portion called the photosphere, which is in an incandescent state, and which presents a continuous spectrum, *i. e.*, one entirely destitute of lines. But whether the photosphere is a liquid, as Kirchhoff maintains, or a gaseous body, as Fr. Secchi, with others, holds, is a question whose discussion would lead us far from our subject. This photosphere is surrounded by an incandescent atmosphere whose temperature is less than that of the central portion, yet not so low as not to contain in the vaporized state most of the metals known on the earth. Furthermore, this atmosphere, in the higher regions, is composed mainly of hydrogen and of another substance unknown on earth, probably of great tenuity, which gives the line 1474 in the solar spectrum. The celebrated Fraunhofer lines, the theory maintains, are produced by the absorptive power of this envelope. But space will not permit us to exhibit the theory in full, or to point out how Kirchhoff was led to its adoption; how the identity of certain lines in the solar spectrum with those of the metals was established; how the lines of the metallic spectra can be reversed, etc. We shall content ourselves with briefly examining how the theory stands the test of direct experiment. If the theory be founded on fact, then during an eclipse, the photosphere of the sun being hidden by the lunar disk, the solar atmosphere, which by its absorption produces the Fraunhofer lines, should reverse the same, just as the vapor of sodium when examined with the spectroscope presents a bright band on the same part of the spectrum where a dark line appears when this vapor is interposed between the electric light and that instrument. Now this is exactly what does occur, as was first observed by Fr. Secchi, and better still by Prof. Young in 1870; since which date it has been confirmed by many, and was evident at Denver July 29th. Prof. Young's observations, "which," as Schellen remarks, "seem to en-

able us to fix with precision the birthplace of the Fraunhofer lines," are described by Prof. Langley as follows:

"With the slit of his spectroscope placed longitudinally at the moment of obscuration, and for one or two seconds later, the field of the instrument was filled with bright lines. As far as could be judged during the brief interval, every non-atmospheric line of the solar spectrum showed light;" an interesting observation, confirmed by Mr. Pye, a young gentleman, whose voluntary aid proved of much service. From the concurrence of these independent observations, we seem to be justified in assuming the probable existence of an envelope surrounding the photosphere and beneath the chromosphere, usually so called, whose thickness must be limited to two or three seconds of an arc, and which gives a discontinuous spectrum consisting of all, or nearly all, the Fraunhofer lines, showing them *bright* on a dark ground.

These results go far to establish Kirchhoff's theory, the only noticeable discrepancy between his first assertion and actual experiment being this: that whereas he supposed the absorbing layer to be quite thick, the latter seems to prove that it is only one or two seconds of an arc, that is, about nine hundred miles. Some observers, it is true, saw a continuous before perceiving a reversed spectrum, and others noticed the former but did not see the latter at all. Now these observations do not militate against the theory, but can be explained, either by admitting with Fr. Secchi, that the continuous spectrum is only a partially reversed spectrum, and is sometimes perceived before the other and sometimes alone, because the power of the telescope or adverse circumstances prevent the observer from noticing the reversed spectrum; or, it can be supposed with Young, that the phenomenon of the coronal light is a mixed one, that is, that the corona not only contains light coming from a gaseous substance producing the Fraunhofer lines, but likewise light emanating from a solid or a liquid capable of giving rise to a continuous spectrum. Polariscopic observations seem to strengthen Young's explanation, since they show that there must exist in the corona a substance capable of reflecting light, from the fact that the coronal light is partially polarized. Now, could not this solid or liquid substance produce a continuous spectrum? However this may be, certainly the theory is not destroyed. Nor does it experience any difficulty in explaining the solar spots, for, to say nothing of the supposition that these spots may be clouds of vapor at a lower temperature than that of the solar atmosphere itself, the very analysis of the spectrum of the spots seems to confirm the theory, as could easily be shown did space permit.

But we must hasten to the close of this already lengthy article. A total solar eclipse furnishes a favorable opportunity for deter-

mining the sun's dimensions. When this luminary shines with all its splendor, we only see the photosphere or that defined disk visible in the field of the telescope, but when this is hidden by the moon, then the solar atmosphere constituting the chromosphere and corona becoming visible, we can determine approximately its dimensions. We say approximately, for the real dimensions cannot probably be determined with absolute certainty; for, as we previously remarked, much depends upon the circumstances in which the observer is placed. Thus, while Prof. Newcomb telegraphed from Wyoming on the 29th, "Saw rings of light, supposed to be zodiacal, extending 6° on each side of the moon, in the direction of the ecliptic," and Prof. Langley sent a dispatch to the same effect, a third skilful observer, stationed in South Colorado, asserted that their extent was but three lunar diameters as seen with his telescope, while his spectroscope revealed the lines to only 0.45 of the moon's diameter. This variation in the action of light on the telescope and spectroscope calls to mind the difference of the actinic and luminous power of the solar rays alluded to above.

Eclipses further disclose to us the shape of the corona and of the protuberances, which protuberances, extending at times as far as ten terrestrial diameters from the sun, are mainly due, as is generally admitted, to solar eruptions of hydrogen. It is true, that although the remarkable discovery of Lockyer and Janssens enables us to observe these protuberances at any time, and observations are daily made upon them, still an eclipse affords the most favorable occasion for successful observation. During an eclipse, too, the spectroscope, skilfully employed, reveals to us the nature of the substances constituting the corona and the protuberances. It has been found that the corona is partly composed of that unknown substance termed by some "helium," which gives the line 1474 in the spectrum. On the 29th the remarkable fact was noted, that whereas the corona extended irregularly around the sun, this unknown substance was diffused about the luminary with great regularity.

Many minor details, revealed by the spectroscope, the polariscope, and other instruments of observation, we must omit for brevity's sake. We will mention but one point more. Among others, Prof. Lockyer and Dr. Draper succeeded in securing fine photographs of the corona's spectrum. The latter, in an article just published in the *American Journal of Science and Arts*, arrives at a conclusion regarding the nature of the corona at variance with the opinion commonly entertained. We quote the following from the above-mentioned article: "The general conclusion that follows from these results" (viz., the observations made by his party) "is, that on this occasion we have ascertained the true nature of the

corona, viz., it shines by light reflected from the sun by a cloud of meteors surrounding that luminary, and that on former occasions it has been *infiltrated with materials thrown up from the chromosphere*, notably with the 1474 matter and hydrogen." Notwithstanding the above conclusion, we must patiently await the full examination and comparison of the various observations taken on the 29th before the truth can be reached on this and many other points open to discussion. Meanwhile, we confidently assert that the observations made on the late eclipse will be found to have materially augmented our knowledge regarding the central orb of the solar system.