Notes on some Points connected with the Progress of Astronomy during the Past Year.

**Discovery of Minor Planets.**

The following eleven minor planets were discovered in the year 1886:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of Planet</th>
<th>Date of Discovery, 1886</th>
<th>Discoverer</th>
<th>Place of Discovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>254</td>
<td>Augusta</td>
<td>Mar. 31</td>
<td>Palisa</td>
<td>Vienna</td>
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<tr>
<td>255</td>
<td>Oppavia</td>
<td>31</td>
<td></td>
<td></td>
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<tr>
<td>256</td>
<td>Walpurga</td>
<td>Apr. 3</td>
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<tr>
<td>257</td>
<td>Silesia</td>
<td>5</td>
<td></td>
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<tr>
<td>258</td>
<td>Tyche</td>
<td>May 7</td>
<td>Luther</td>
<td>Dusseldorf</td>
</tr>
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<td>259</td>
<td>Aletheia</td>
<td>June 28</td>
<td>Peters</td>
<td>Clinton</td>
</tr>
<tr>
<td>260</td>
<td>Huberta</td>
<td>Oct. 3</td>
<td>Palisa</td>
<td>Vienna</td>
</tr>
<tr>
<td>261</td>
<td>Prymno</td>
<td>31</td>
<td>Peters</td>
<td>Clinton</td>
</tr>
<tr>
<td>262</td>
<td></td>
<td>Nov. 3</td>
<td>Palisa</td>
<td>Vienna</td>
</tr>
<tr>
<td>263</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>264</td>
<td>Libussa</td>
<td>Dec. 22</td>
<td>Peters</td>
<td>Clinton</td>
</tr>
</tbody>
</table>

Minor planet No. 253, discovered by Herr Palisa on November 12, 1885, has been named Mathilde.

**The Comets of 1886.**

Including the periodic comet of Winnecke, six comets have been discovered during the year. It will be more convenient to describe these in the order of their discovery, than according to their several dates of perihelion passage or catalogue order.

The first (known as 1886, Comet V.) was discovered by Mr. Brooks, of Phelps, New York, on April 27, in the constellation Cassiopeia, and moving south and east. At the time of discovery it was round, tolerably bright, and about one minute in diameter. The comet was approaching both the Sun and the
Earth, and the brilliancy consequently increasing. The maximum brilliancy was attained about June 9, near the date of perihelion passage, when it had twenty times the intensity that it possessed when first seen, but was too near the Sun to permit of observation. After perihelion, the comet was not well situated for observation, and does not seem to have been seen. The observations are well represented by a parabola.

Four days later, on May 1, Mr. Brooks discovered another comet in the constellation Pegasus (designated 1886, Comet III.). This comet was fairly bright, and had on May 3 a short tail, eight minutes in length. Owing to the morning twilight the comet soon became a difficult object to observe, and was apparently lost sight of in the third week of May, but the change of form in the comet was interesting. On May 20, Col. Tupman could see no trace of a head, and the two ends of the tail were so similar, it was impossible to say by mere inspection, which was the head. On May 22 Dr. Tempel gave a very similar description, but suspected two very slight condensations in a spindle-shaped nebulous mass, about twelve minutes long.

As in the previous case the orbit is apparently parabolic, but some interest attaches to the elements, since at the ascending node which the comet passed on July 9, its distance from the Earth was only 0.075, and therefore might have originated a meteor-radiant, visible in the southern hemisphere, the coordinates being approximately $a = 19^\circ$ and $\delta = -42^\circ$.

On May 22, Mr. Brooks discovered a third comet (1886, IV.), which does not appear to have been observed very frequently, the more to be regretted, as the comet’s orbit will probably prove to be elliptic. Dr. Oppenheim, failing to represent the path with sufficient accuracy by means of a parabola, has computed an elliptic orbit of nine years period, which fairly well represents the few observations at his command.

Comet 1886 VI. is the periodic comet of Winnecke, detected by Mr. Finlay at the Royal Observatory, Cape of Good Hope, on Aug. 19, the possibility of the comet being found in the northern hemisphere during the summer months not having been realised. The last return of this comet was in 1856, when, owing to its proximity to the Sun, it passed unobserved. In the interval, 1880–1886, the comet underwent very considerable perturbations from Jupiter, to which planet, in heliocentric longitude $110^\circ$, it can approach within $0.06$. No accurate calculations of the perturbations were undertaken, but Dr. Palisa gave sweeping Ephemerides from elements approximately corrected. These elements show that the chief effect of the perturbation has been still further to diminish the mean motion, which had been steadily decreasing since the re-discovery in 1858. The passage through the perihelion was, however, twelve days earlier than was predicted by Dr. Palisa. It cannot be doubted but that rigorous calculations will be made in order to connect the observations of this year with those of the earlier apparitions,
since, according to the late Dr. Oppolzer, the theory of the comet cannot be satisfactorily reconciled with observation on the purely gravitational theory, but that the mean motion and eccentricity require the correction of small terms, depending on a supposed resisting medium.

On September 26, Mr. Finlay discovered another comet, in the constellation Scorpio, having small south-easterly motion. The comet was round, one minute in diameter, and without tail. As soon as the elements were computed, it was seen that they strongly resembled those of De Vico's comet of short period, which had not been seen since 1844. There are, however, some difficulties in accepting the suggestion that the two comets are identical, and the doubt cannot be cleared up till the mean motion of the comet is sufficiently well determined to permit the rigorous calculation of the perturbations of the comet by Jupiter (and possibly Mars) in the interval.

The period assigned by Dr. Brunnow was 5'466 years, and if we assume that either eight or seven returns of the comet had occurred between 1844 and the present time, we must admit either the action of very considerable perturbation, which is not likely, or that Brunnow's period was more in error than seemed possible, though it is admitted that the change of form in the comet during visibility in 1844 may explain the existence of a larger error than has hitherto been suspected. The more accurate elements that have been computed from a more extended series of observations, and in which no assumption of the axis major has been made, agree in giving a period considerably longer than that found by Dr. Brunnow, so that it is not impossible that the two comets may not be identical, but two moving in a similar orbit, an example of which was seen in the case of Comets 1843 I., 1880 I., and 1882 II.

The sixth comet of the year was discovered on October 4 by Mr. Barnard, and independently by Dr. Hartwig on the following day. The comet at discovery was round and tolerably bright, and was increasing in brilliancy. By October 29 a short broad tail was visible, and early in December this tail had increased to several degrees in length, and a shorter tail of 15' in length, and distant 40° of position angle had been developed. These details have been satisfactorily photographed by Von Gothard, of the Physical Observatory of Herény. It was seen with the naked eye in Turin on November 21, but was too near the morning twilight to become a conspicuous object. The orbit is apparently parabolic.

In addition to these comets, it is well to remark that Olbers' Comet, to which reference was made in the last Annual Report, has not yet been detected, and that as the most probable time of perihelion passage has now been reached the search should be severely maintained. A comet, which was discovered by Tempel on November 27, 1869, and re-discovered by Swift on October 11, 1880, has probably passed this year through perihelion unde-
tected. The orbit has been rigorously computed by M. Bossert of the Paris Observatory, who gave an ephemeris to assist the search. It is a peculiarity of the comet that it is well situated for observation at alternate returns, and this approach was unfortunate, the theoretical brilliancy never attaining one-tenth of that possessed by the comet at the last recorded observation.

W. E. P.

The Total Solar Eclipse of 1886, August 28–29.

The expedition sent out to Grenada, West Indies, to observe this eclipse, consisted of the following persons: Captain Darwin, Mr. Lockyer, Mr. Mannert, Father Perry, Dr. Schuster, Professor Thorpe, and Mr. Turner. Professor Tacchini also accompanied the expedition on behalf of the Italian Government. The observers divided into several parties on reaching Grenada, as a precaution against purely local masses of cloud, or bad weather; it being also arranged that observations should be made as far as possible in duplicate. Although the weather at the time of the eclipse was not all that could be desired, successful observations were secured at three stations; at the fourth the Sun was obscured by heavy clouds.

The following is a brief account of the results obtained, taking the stations in order from the south:

Station I.—Prickly Point, lat. 12° 0' N., long. 61° 46' W. Captain Darwin with the coronograph exposed six plates during totality, one for five seconds, one for ten seconds, and four instantaneous. During the partial phases he obtained more than twenty satisfactory photographs, and on the day before the eclipse, fifteen. These were all taken with the object of testing Dr. Huggins's method for photographing the Corona without an eclipse, and the result, as far as is yet known, is unfavourable to that method, under such conditions of hazy sky and low sun as were obtained.

Captain Darwin also took one photograph with the prismatic camera.

Dr. Schuster obtained four photographs of the Corona with a 5-foot camera, and two of the coronal spectrum, with slits radial and tangential respectively.

Station II.—Hog Island, lat. 12° 0' N., long. 61° 44' W. Professor Thorpe, assisted by Mr. Lawrance, obtained a satisfactory series of photometric measures of the intensity of the Corona. He made in all fifteen separate and independent comparisons of the coronal and diffused light beyond the visible edge with a Swan electric lamp of known photometric value, by a method arranged by Captain Abney. During the latter part of totality
the coronal light was dimmed by haze, but he sees no reason for thinking the measures made in the first hundred seconds other than perfectly trustworthy. Relying on these seven only, the final photometric values obtained are not very different from those found by Professor Harkness in the 1878 eclipse.

Station III.—Boulogne, near Grenville, lat. 12° 9' N., long. 61° 38' W. Professor Tacchini made a careful comparison of the prominences detected by the spectroscope before and after totality with those seen during totality, and found important differences between them, viz.: all prominences showed themselves larger and taller during an eclipse, the upper portions being white when the prominence exceeds 1' of arc in height, while some very fine prominences seen during totality were not discernible in full sunshine at all; these latter were almost entirely white, and their luminous intensity was small, so that they were not visible to the naked eye unless they extended beyond the brightest part of the Corona. He also observed the spectrum of the "flash" noticed by Professor Young in 1870, and traced it to a much greater height than before.

Mr. Turner obtained a qualified confirmation of Mr. Lockyer's Egyptian observations with regard to the order of appearance of the bright lines near F in the spectrum of the inner Corona. During totality he looked for currents in the Corona, but obtained no satisfactory results.

Station IV.—Green Island, lat. 12° 14' N., long. 61° 35' W. Cloudy during totality. Mr. Lockyer considers, however, that important information was obtained by preliminary drills as to the number of photographs which could be taken during totality by careful management.

Station V.—Hermitage, Carriacou, lat. 12° 27' N., long. 61° 29' W. Father Perry made observations of the order of appearance of lines in the coronal spectrum near E., and observed 1474 K and other short bright lines two minutes before totality. During totality he looked for the carbon flutings seen by Professor Tacchini, but with a negative result.

Mr. Maunder obtained seven photographs of the Corona with a 5-foot camera, exposures varying from 0°2 to 40°, and two photographs of the coronal spectrum with slits radial and tangential.

Almost at the last moment another observer arrived on the scene. Mr. W. H. Pickering, from Boston, Mass., took up his position in Fort George, lat. 12° 3' N., long. 61° 45' W., armed with a photoheliograph of 38 feet focal length. He exposed a number of plates during totality, and also organised a series of observations of the shadow bands.

The observers owe a very large debt of gratitude to the Governor of Grenada, who helped them in every way, and they received invaluable assistance from the leading officials, and from the officers and crews of H.M.S. Fantôme, H.M.S. Bullfrog, and
H.M.S. Sparrowhawk, both in transport and preparations for observing, and in the actual observations. A number of discs had been taken out with the view of repeating Professor Newcomb's observation of 1878 on the coronal extension, and fairly accordant results were obtained by the following observers at the different stations:—

I. Captain Maling, Colonial Secretary.
II. Captain Archer, of H.M.S. Fantôme.
III. Lieut. Smith, of H.M.S. Sparrowhawk.
IV. Captain Hughes, Protector of Immigrants, and Mr. Belton.
V. Captain Masterman and Mr. Osburn, of H.M.S. Bullfrog.

At Station II. also Lieuts. Douglas and Bairnsfather, of H.M.S. Fantôme, made a series of photometric measures with an integrating apparatus, which agree with Professor Thorpe's general results. The Governor of Grenada, the Chief of Police, the Clerk of the Council, Dr. Boyd, Mr. Elliott (Government Botanist), and Captain Oldham, of H.M.S. Sparrowhawk, were all busily engaged at Station IV., and were prepared to assist in the photographic operations.

On the whole, the expedition may be considered a very successful one, and the passing clouds which obscured part of the phenomenon at the more fortunate stations served perhaps to remind the observers how nearly they had escaped complete failure.

H. H. T.

Professor Hall's Researches on the Orbits of the Six Inner Satellites of Saturn.

In Appendix I. of the Washington Observations for 1883 Prof. Asaph Hall communicates the positions of the six inner satellites of Saturn, observed with the 26-inch refractor, and the results of the computations to which they have been subjected.

The observations of Titan, which extend over nearly ten years, from August 1874 to February 1884, consist partly of measurements of differences of Right Ascension and Declination between the satellite and the centre of the planet, and partly of measurements of position-angle and distance. The observed positions are compared with the corresponding places computed with the values of Bessel's tables in vol. 9 of the Astron. Nachrichten. Bessel's determination of the elements of the orbit there given is founded upon the first series of his own heliometrical measurements of Titan, taken in 1839, the mean motion of the satellite in its orbit and the motion of the line of apses being deduced from a careful discussion of the scanty observations of conjunctions of the satellite with the centre of the planet made by Halley, Cassini, Herschel, and Köhler. The
Washington computations show that only small corrections of the tabular values are demanded by the Washington observations. Indeed, the correction of the motion of the apses is left doubtful: for, while the earlier series of observations made from 1874 to 1882 indicate a slight augmentation, only the last series made 1883–84 show a diminution, and it will have to be decided by further evidence what is the true motion.

From his computations of the micrometrical measurements of Rhea, Dione, and Tethys, which were made in the years 1874 and 1875, Prof. Hall draws the conclusion that the eccentricities of the orbits are left practically undetermined, and also that the planes of the orbits probably coincide very nearly with the plane of the ring. For the determination of the mean motions of the satellites he assumes that the mean longitudes for the epoch 1858, which Jacob has deduced from his Madras observations, are free from error, and the values of the daily motion resulting from the positions of 1858 and 1875 are then partly corrected with the help of the conjunctions observed at Washington in the years 1882 to 1886. In the case of Mimas, the mean motion is simply deduced from seven conjunctions, observed within three years and a quarter. But, as the adopted motion leaves an error of about half an hour in Herschel’s trustworthy observation of October 18, 1789, the value cannot be accepted as sufficiently correct.

A. M.

The Argentine General Catalogue of Stars.

It was only in the middle of the year 1872 that observations with the Cordoba Meridian Circle were commenced, and by the end of 1880 no less than 145,000 observations had been made, suitable for the General Catalogue, and more than 105,000 zone observations. It is probable that the whole of the meridian work of all the other observatories in the world put together during the same interval would fall short of these numbers. Only seven years ago the state of our knowledge of the southern heavens was deplorable. The publication, in 1881, of Mr. Stone’s great work at the Cape and of the present truly wonderful work of Dr. Gould and his able assistants, during the last few months, has suddenly turned the scale so completely that the southern heavens are now more thoroughly surveyed than the northern, and must remain so until all the zones of the Astronomische Gesellschaft have been united into a complete catalogue. The rapidity with which the reductions have been effected and published is no less amazing than the observations themselves. Nothing like it has been known in the history of astronomy.

The instrument is described in the introduction to the observations in 1872. Several volumes of the observations and the Zone Catalogue have already been published. The present
volume forms No. XIV. of the series. It contains the places of 32,448 stars south of the parallel of N.P.D. 113° in the body of the Catalogue, and of 1126 stars in remarkable clusters arranged as separate small catalogues. The epoch is 1875°. The arrangement of the Catalogue exhibits separately each year's results for each star. The annual precessions and secular variations, the epoch of observation, the number of observations and references to other catalogues are given. Most of the stars have been observed at least three times. The adopted mean places of the time and circumpolar stars, used for the determination of the instrumental corrections in each year, are given in the corresponding volumes of observations.

The Right Ascensions of the Catalogue depend exclusively upon 75 time stars of the American Nautical Almanac. The declinations are independent.

The stereotype plates of the Catalogue have been presented to the Royal Astronomical Society by Dr. Gould, with the consent of the Government of the Argentine Republic.


This work, which represents a large part of the labours of Prof. W. A. Rogers for the last fifteen or sixteen years, forms Part I. of vol. xv. of "Annals of Harvard College Observatory." The observations on which it depends were made with the large Meridian Circle, described in vol. viii., between 1870 November and 1879 January. The stars are of two classes; 492 being fundamental stars from Dr. Anwers' Catalogue in "Publication der Astronomischen Gesellschaft," XIV., the remainder, termed secondary stars, being miscellaneous stars observed for various purposes. The observations were concurrent with those of the zone +50° to +55°, A.G.

The observations of the fundamental stars have been printed in vol. xvi. with an elaborate and masterly Introduction by Prof. Rogers, giving the method of reduction in great detail. The Introduction to the present Catalogue contains the mean places of these fundamental stars separately for each year, and the star ledgers of such of the other stars as are not given in vol. x. or xii.

Instead of the usual spider-lines, a reticule ruled upon glass was employed. The Declinations were measured by recording on the chronograph transits over very oblique lines. For a number of years only two microscopes were used for reading the circle; but Prof. Rogers has elaborately investigated the reduction of the mean of two to the mean of four from the observations of subsequent years.

The Right Ascensions of Publication XIV. were used in determining clock error; hence, for the fundamental stars the
Right Ascensions of the Catalogue are almost exactly reproductions of Auwers'. The same applies to the Declinations. The errors of the circle and accumulated errors of the microscopes were determined by and expressed in terms of Auwers' system of Declinations. The discussion of the observations of the fundamental stars (which are very numerous and of a high degree of accuracy) demonstrates the homogeneity of Auwers' systems. The places of the remaining 720 stars have a corresponding degree of accuracy. For Bradley's stars, Dr. Auwers' original proper motions are given in the Catalogue, and were used for reduction to mean epoch.

The Pulkowa Catalogue of 3542 Stars for 1855°.

This Catalogue, which forms a portion of vol. viii. of the "Pulkowa Observations," has been formed from the observations published in vols. vi. and vii. It contains all Bradley's stars from the Pole to 105° N.P.D., except the Pulkowa fundamental stars, all other stars down to the 6th magnitude inclusive in Argeander's Uranometria Nova in the same portion of the heavens, and some other stars which have been added to the observing list from time to time for special purposes. The observations were made with the Repsold Meridian Circle, described in the introductory volume, between the years 1840 and 1869, by M.M. Sabler, Döllen, Lindhagen, Winnecke, and Gromadski. The reductions were conducted throughout by M. von Asten.

Each star was observed four times; once in each of the four positions of the instrument obtained by reversing the axis and interchanging the object-glass and eyepiece. The Right Ascensions depend upon those of the Pulkowa Fundamental Catalogue, the Sun not having been observed with this instrument. The Declinations are independent, having been determined from observations of the horizontal collimators combined with the known colatitude. The large number of stars and the completeness with which the plan of observation was carried out make this one of the most valuable catalogues in existence. The delay in the publication has enabled Dr. Auwers' new proper motions to be inserted in the work, and to be used in the reduction to mean epoch.

Professor Schönfeld's Extension of the "Durchmusterung."

An important work has been issued within the last few months from the Royal Observatory of Bonn. Argeander's Durchmusterung, or survey of the northern heavens from the Pole to 2° of South Declination, has been carried down by
his successor, Professor Schönfeld (who in conjunction with Professor Krüger was associated with the late Professor Arge-
lander in the former part of the work), to 23° South Declination,
and the results are now in the hands of astronomers.

Professor Schönfeld commenced observing on January 6,
1876, and at first proposed to carry his survey down to 24° or
25° South Declination, so as to overlap by a degree or so the
northern limit of the Cordoba zones. It was found, however,
that –23° was the extreme limit for satisfactory observation.
In view of the lower altitude of the stars to be observed, it was
decided to substitute for the small comet-seeker of 34 lines
aperture, employed in the earlier work, a telescope by Schröder
of 6 inches aperture and 6 feet focal length—a change which
was further recommended by the fact that for several years
Professor Schönfeld had been engaged in magnitude comparisons
with a telescope of the same aperture at the Mannheim Obser-
vatory. With this instrument, fitted with an eyepiece of
26 mag. power, having a field of 1° 44′, the survey was
worked in zones; and the stars thus observed number 133,659
between –2° and –23°, with an additional 1173 stars falling
beyond these limits. At the same time, with a view to the more
satisfactory designation of the fainter stars, the magnitude limit
was extended to 10.°. The resulting catalogue is arranged in
zones of 1° of Declination on the same plan, and calculated for
the same epoch (1855.0) as the sections of the earlier work, and
forms Vol. VIII. of the “Astronomische Beobachtungen auf der
Sternwarte zu Bonn.”

The catalogue is accompanied by an Atlas, in which the
charts are arranged in sheets of one hour of Right Ascension
each, with an overlap of four minutes on either side, and extend
in Declination from –1° to –23°. The Atlas will be completed
in four parts, of which two only have as yet appeared. These
contain Hours 0 to xi. (with the exception of Hour vii.), and
Hour xxiii.

This valuable work, completing the survey of the heavens on
a uniform plan within the limits effectively practicable at an
Observatory in central Europe, is appropriately inscribed by
Professor Schönfeld to Argelander's memory.

The Second Armagh Catalogue of Stars.

This Catalogue embodies the whole of the meridian work
done at the Armagh Observatory since the publication of the
first Armagh Catalogue. It contains the places of 3300 of
Lalande's stars, from observations between 1859 and 1883
inclusive, reduced to the epoch 1875.0.

The Right Ascensions depend on the standard stars of the
Nautical Almanac of the period, four or five of which were
observed on each night. These stars were not observed in Polar Distance. The Declinations of the Catalogue depend upon the Nadir observation which was made every night, the assumed colatitude, and the division errors determined by Dr. Robinson many years ago. The refractions employed were Dr. Robinson's. The precessions are given to three places and two places of decimals in R.A. and N.P.D. respectively, but not the secular variations. The references to other catalogues are copious, and are apparently complete. The observations upon which Dr Robinson's Catalogue of 1000 Lalande's stars depend are included in the present volume.

It was only in February 1882 that Dr. Dreyer was appointed to the directorship of the Observatory, at which time most of the work was unreduced.

Dr. Kam's Catalogue of 5455 Small Stars.

Scattered through the volumes of the Astronomische Nachrichten are a great number of determinations of the places of small stars, generally comparison stars, not to be found elsewhere. Prof. Schjellerup formed a most useful index to all these stars in the first sixty-six volumes, by reducing all their places approximately to 1855°, and giving a reference to the volume and page where the accurate place could be found ("Publication der Astron. Gesell." VIII.). That work still remains useful for all stars determined by equatorial comparison with others. Dr. M. Hoek, late Director of the Utrecht Observatory, commenced the task of forming a proper catalogue of all such stars as had been observed with meridian instruments, and his successor, Dr. Kam, has completed it. The body of the work is a catalogue of 4890 meridian observations of 4350 stars, reduced to the epoch 1855° by the application of precession. The precessions, secular variations, and third terms are given for the same epoch, a reference to the volume and page of the Ast. Nach., and the name of the observer and observatory. This is accompanied by copious notes and a comparison of every star with its place in the Bonn Durchmusterung—the whole involving an immense amount of labour which will be duly appreciated by all who are engaged in equatorial comparison work, and will ultimately assist in determining the proper motion of these small stars.

The Great Comet, 1882. II.

Dr. Gill has recently published a complete account of the observations of this comet, which were made at the Royal Observatory, Cape of Good Hope.
Utilising all the means at his disposal, Dr. Gill succeeded in securing a fairly continuous series of positions of the comet from 1882, September 7, to 1883, May 12, to accomplish which, observations were made with the Indian Theodolite, the Transit Circle, the Heliometer, and the 6-inch and 7-inch Equatorials.

In Table I. is given the daylight observations made with the Indian theodolite on September 16, 17, and 18, before and after the comet passed on to the Sun's disc; and the resulting R.A. and declination are computed for the times of observation.

Table II. gives the meridian observations with the Transit Circle. These consist of three observations by Dr. Gill in September 17, 18, and 22, and a series between January 9 and 30, made by Mr. Maclear, who endeavoured to observe the brightest part of the nucleus.

Table III. gives the apparent places of the comet in R.A. and N.P.D. from a long series of observations, with comparison stars made with the Equatorials from 1882, September 7, to 1883, May 12. In the majority of these observations, the centre of the nucleus, or patch of light, was supposed to be observed, but towards the end of the series it was found that one of the observers always observed a more condensed part which slightly followed this centre.

The results of Dr. Elkin's observations with the Heliometer are given in Table IV. In these observations, as in those made with the Equatorials, the same portion of the nucleus was not always observed. The complex character of the nucleus of this comet, and the uncertainty that must exist as to which portion of it the observations refer, will present serious difficulties to the computer.

The memoir is illustrated by several interesting sketches of the head and nucleus of the comet, and by copies of the unique series of photographs so happily secured by Dr. Gill.

Professor Hall's Determinations of Stellar Parallaxes.

Professor Asaph Hall has published in an Appendix to the Washington Observations for 1883, a further series of observations for stellar parallax.

The method adopted was the same as that employed for the earlier observations, viz. to observe the differences of Declination of the principal stars with respect to small stars near them which are supposed to have no physical connection with the large stars. The method of measuring differences of Declination was chosen because the measurement of distances with the filar micrometer of the Naval Observatory has been found more accurate than that of angles of position; and also because observations had shown that there was no sensible term depending on the temperature in the value of a revolution of the micrometer screw.
Professor Hall’s results for the four stars observed give the following values of the parallax:—

\[
\begin{align*}
40 (\alpha^2) \text{ Eridani} & \quad \pi = +0^\prime 223 \pm 0^\prime 0202 \\
6 \beta \text{ Cygni} & \quad \pi = -0^\prime 021 \pm 0^\prime 0077 \\
\alpha \text{ Lyrae} & \quad \pi = +0^\prime 134 \pm 0^\prime 0055 \\
61 \text{ Cygni} & \quad \pi = +0^\prime 270 \pm 0^\prime 0101
\end{align*}
\]

The parallax of 40 (\alpha^2) \text{ Eridani} was obtained by measures of the difference of Right Ascension of a star of the eleventh magnitude 32\,^\prime following and 48\,^\prime south of the principal star. The distance was so great that, with the power of 383 employed, it was necessary to move the eyepiece in order to bring the stars successively into the field, which introduced an element of considerable difficulty. Dr. Gill’s value of the parallax of this star is 0^\prime 166 \pm 0^\prime 018.

The negative value of the parallax obtained for 6 \beta \text{ Cygni} is suggested by Professor Hall as indicating a parallax of the star of comparison or some systematic error in the observations of the summer and winter months. The result is strikingly different from Sir R. S. Ball’s provisional determination—

\[
\pi = 0^\prime 482 \pm 0^\prime 054
\]

An error having been detected in the reduction of the observations for determining the parallax of \alpha \text{ Lyrae} and 61 \text{ Cygni}, made in 1880 and 1881 (noticed in the Report for 1882), the result now given for \alpha \text{ Lyrae} is from a re-reduction of the original observations. In the case of 61 \text{ Cygni} two additional series of observations, near the times of the maximum positive and negative coefficients of parallax, were made in 1885 and 1886 and combined with the earlier series re-reduced. Professor Hall’s concluded value of the parallax is much smaller than what has been determined by other observers. The author calls attention to the discrepancy, but considers that the results appear to be the best that can be derived from the observations.

\textbf{Stellar Photography.}

The most notable records in relation to stellar photography during the past year are embodied in—

I.—\textit{A remarkable article entitled “An investigation in Stellar Photography,” forming part of vol. xi. of the Memoirs of the American Academy, by Professor Pickering.}

II.—\textit{A Monograph on Astronomical Photography, by Admiral Monchez, in the Annaire du Bureau des Longitudes, Paris, 1887.}
III.—The article on Stellar Photography contained in the February number of the Nineteenth Century, by Mr. Common.


V.—A paper in the Astronomische Nachrichten, No. 2737, on the photographic work executed in the Imperial Observatory of Potsdam.

Of some of these records it is proposed to give a very rapid outline, referring the Fellows of the Society to the original documents for the various details connected with each. It may be remarked, in limine, that in the publications enumerated, there is prefigured nothing short of an entire revolution in the application of instrumental methods to astronomical research. The superb instruments now existing, monuments as they are and ever must be of the genius of a long line of highly gifted men, will not indeed be wholly superseded, but will be mainly valuable as instruments of verification of labours and results obtained, not in painful dribblets, but in groups and masses by shorter processes. Astronomers' attention will, in the near future, not be confined to the direct scrutiny of the heavens alone, but to the study of the faithful pictures thereof, taken at will in rapidly occurring successive periods. The consideration of these pictorial views will take the place of laborious catalogues. Potentially they will be such in themselves.

I. The Harvard Memoir.—In this memoir Professor Pickering describes a modification of existing forms of camera, consisting mainly of an adjusted compound photographic lens of about eight inches diameter and forty-five inches focal length and controlled by a standard clock, by means of which he can, among other adaptations to be presently described, take pictures of the heavens with considerable facility and sufficiently accurate for maps. With one hour's exposure, stars of a brightness such as those in Peters' and Chacornac's charts can be photographed, and when conveniently enlarged, copies can be printed in permanent ink by some of the many processes known at present. Such maps will be sufficient as charts, but unavailable for the determination of small changes in position. Perhaps these pictorial charts might be supplemented by smaller and more accurate pictures of selected portions of the heavens for purposes of great precision. He entertains the thought that in two observatories, respectively north and south of the Equator, the whole heavens might be charted (to mag. 15?) in less than twelve months. Whether a much wider division of labour and a somewhat extended scale in the order of faintness might not be more desirable will probably be best discussed in the proposed convention at Paris in April next.

Of greater originality, and possibly of even greater value, is...
the proposition of Professor Pickering to determine the relative brightness of stars, by availing himself of the traces made by stars on the photographic plate while passing, either by unaltered diurnal motion, or instrumentally retarded, across the field of view. In his hands the method assumes a scientific value entirely different from the haphazard estimates of magnitude hitherto put into practice. For the brighter stars (that is, brighter than the eighth magnitude), even when near the Equator, a trace is formed when the camera is stationary; for others less bright the duration of the transit can be regulated as need requires. It is obvious that as the stars approach the Pole, the traces made during a given exposure of the plate become shorter and therefore necessarily are actinised to a greater extent, depending on their length. When the camera has been pointed to the Pole, traces of stars, even of the thirteenth and fourteenth magnitudes, have been photographed with a stationary telescope. A scientific method of estimating relative brightness thus becomes available, it being always premised that a scale of magnitudes, depending on the breadth and length of the traces, has been carefully prepared beforehand. The details of the process must be gathered from the original memoir, and will amply repay the attention of the reader. It should be added that Professor Pickering has successfully applied his method numerically to stars in the Pleiades, and to others near the Pole.

The most remarkable and valuable part of Professor Pickering's memoir is that in which he applies the method of trails or traces to the photography of stellar spectra. Hitherto the method of using a narrow slit, supplemented or not by a cylindrical lens, and requiring extreme accuracy in the driving clock, and even then a continued personal vigilance for the manual correction of its irregularities, has proved a most serious drawback in the register of stellar spectra by the aid of photography. By the method of traces the slit, the cylindrical lens, and the painful watching are dispensed with. A prism (of 15°, as used by Professor Pickering) is placed in front of the objective, with its refracting edges horizontal when the star is on the meridian. In this way the star impresses its own spectrum, with the lines thereto peculiar, on the sensitised plate. In the case of the brighter stars the telescope itself remains stationary during the time of exposure; in the case of fainter stars, which require a longer time to impress their traces on the plate, the instrument is driven at any convenient rate, so as to produce in a given time a line of the necessary length. In point of fact, the light of the star itself, by diurnal motion, becomes virtually a line of light, or illuminated slit, which is dispersed into its spectrum by the refracting prism. Professor Pickering, in his memoir, gives an enlarged photographic picture, containing examples of this method applied to the Pleiades and some of the brighter stars. The process gives the promise of great facility, and probably great accuracy, amply sufficient for the determi-
nation of the class of a star's spectrum, even in the case of stars of the eighth magnitude. This part of the Harvard labours should not be dismissed without reference to the remarkable coup d'œil of the spectra of stars in the Pleiades. It is impossible to look at it without the suggestion of a community of origin in the material and formation of this historic group. And the deduction of this cosmical fact is the result of the intelligent labour of a single hour! Altogether this valuable memoir indicates a very distinct advance of the application of photography to astronomical research.

"Annuaire du Bureau des Longitudes."—Admiral Monchez has herein given an interesting account of celestial photography from the time of the well-aimed but unsuccessful attempts of Niépce and Daguerre, in 1839, to the superb results now being achieved at Paris by the brothers Henry. The labours of these latter savants are now happily so well known to the astronomical world that an account of them here would be superfluous. One of the most striking features in the photographic enlargements of the plates is the definite roundness and general neatness of the impressions of the stars; features which indicate the remarkable perseverance, or it may be termed the endurance, of the observer in the manual control of the driving clock during the usual exposure of an hour. For any purpose of exact measures this definiteness of outline is indispensable. On some of these plates there are traces of impressions of stars which may probably be regarded as of the sixteenth magnitude. In submitting these photographs to enlargements, and subsequent printing in some permanent material, such as a modification of printer's ink, there is at present an unavoidable loss of the faintest stars, amounting in general to about a magnitude and a half; this will apparently limit printed copies to about the fourteenth magnitude on Pogson's scale, and requires an exposure at present exceeding an hour. We believe it is the present proposition of the Paris astronomers to effect arrangements for the photography of the entire stellar regions to this extent of brightness. This scheme is much more extensive, and perhaps more ambitious, than that proposed by the American astronomer, and instead of its completion at two observatories, in less than a twelvemonth, will require the co-operation of eight or ten at least, extending the labour through four or five years. Indeed, if there be a duplication of the photographic plates—and this seems to be indispensable for securing reliable results—the time occupied in the work and the number of the observers employed must be further extended. But these are points, as already suggested, which must be submitted to the consideration of the convention at Paris, summoned by Admiral Monchez, in April next.

In the Annuaire (page 785) there is a very interesting and instructive plate of highly magnified images of stars impressed on a photographic film. But impressions of this nature, and thus highly magnified, would be far too loose and scattered in
form to admit of micrometric measurement; they greatly differ in appearance from the round and definite and solid-looking formations submitted to measurement at Oxford; nevertheless they do afford a good idea of the mode in which the sensitised material is blackened and deposited. But it should be remembered that this form of actinised deposit was distinctly noticed and described by Bond some thirty years ago.

The direction of the valuable work so ably accomplished at the Paris Observatory will be seen from the following catalogue, taken from the last annual report of that institution. It includes forty-two large plates of the Milky Way and of other regions, viz. the neighbourhood of ε Lyrae and of Vega, showing after two hours' exposure, stars much feebler than the debilissima of Sir J. Herschel, and feebler than the sixteenth magnitude, some of which have probably not been seen before. Clusters in Hercules (two plates), in Ophiuchus, in Perseus, and more than six hundred double or multiple stars; short exposures of groups intended for micrometrical measurement, such as the Pleiades, Praesepe, and M. 23 Ophiuchi.

Mr. Common's Article in the "Nineteenth Century."—It is quite unnecessary to refer to the highly interesting particulars discussed in this paper with all the authority of a master in the art; it will be in the hands of all astronomers interested in the progress of their science.

In even this condensed reference to the advances in Celestial Photography, certainly established by Mr. Common, it is right to add that Mr. Roberts' photographs, which are in the possession of the Society, seem in some respects to have surpassed the Orion Nebula of that gentleman, as well as the Pleiades Group of MM. Henry.*

The Parallax of 61 Cygni.—So far, the foregoing records refer in the main to what may, without derogation or offence, be termed the pictorial or delineation-side of astronomical photography. We have already stated what the brothers Henry have been able to achieve in the way of celestial charts; possibly even more remarkable results have been accomplished by Mr. Common, who has produced a representation of the Orion Nebula surpassing, it may be, in accuracy and in minuteness of detail the united labours of Herschel and Rosse in England, and of Bond and Holden in the United States. One potential only of the new art remained still to be examined; can it be relied on as presenting an amount of accuracy in delicate micrometrical measurement equal to that derived from the use of the Equatorial Telescope and the Heliometer? In the hands of Bond thirty years ago it did indeed furnish the means of measuring the relative positions of the components of such double stars as he could then photograph; but the important question remains, can it now, in its more important modern development, vie with

* See Monthly Notices for January 1887 and Admiral Mouchet's note on p. 813 of the Paris Annuaire for 1887.
the Heliometer in the determination of such minute quantities as are discussed in problems connected with Stellar Parallax? In a word, can it be relied on in the conduct of varying measures when they are extended through a series of many months and over hundreds of sensitised plates? There is reason to believe that a reply in the affirmative has been given to this crucial question by the very recent and successful determination of the Parallax of 61 Cygni at the University Observatory in Oxford. No less than eight independent determinations of the relative parallax of the two components of this star, in relation to four faint stars in their neighbourhood, present an accordance that was scarcely to be hoped for anterior to the result. A collateral advantage presented by this method consists in this, that the relative parallax is obtainable not merely in respect of four stars, but in respect of all the other stars upon the photographic plate. In this way the resulting mean becomes not merely relative parallax, but approaches the absolute. In the case of this particular star, the result of the computations is a parallax lying as a mean between those determined by Bessel, Auwers, and Ball.

Dr. Lohse, at Potsdam, has successfully applied the ordinary refracting telescope to the subject of Stellar Photography, and this he has done without separating the lenses of the object glass or the introduction of a subsidiary lens. It is stated that after one hour's exposure of the plate in the proper focal position, the faintest stars visible in the telescope to the eye are distinctly impressed on the photograph.

For information on the valuable and interesting work in Stellar Photography, now in process of execution under the direction of Dr. Gill, the reader is referred to the Report from the Royal Observatory at the Cape of Good Hope, printed in the present number of the Monthly Notices.

On taking a general survey of the foregoing records of the potency and astonishing progress of this new application of a recent art, placing the whole starry heavens as a picture in our hands, one's thoughts irresistibly turn to the existence of considerable groups and sections of learned men, who persuade themselves that astronomy, as a science, culminated in the researches of Lagrange and Laplace, and, as an art was worn out in the hands of Bessel and the Herschels. It has been still further affirmed that, amidst the modern developments and activities of other branches of knowledge, astronomy, whether as a science or an art, has ceased to possess human interest. An unprejudiced perusal of the above and similar records is sufficient to indicate the utter unreasonableness of the latter thought. It would be far nearer to the truth to affirm that at the present hour, both as an art and a science, astronomy possesses the elasticity and the hopeful enterprise of robust youth. It would be a still securer belief to rest assured that as long as the human mind retains its experience of the past, and its incentives to curiosity...
in respect of the future, no true art can ever culminate, and no true science can become effete.

C. P.

The Velocity of Light.

Professor Newcomb has published in the second volume of the important series of astronomical papers prepared for the use of the American Ephemeris and Nautical Almanac his measures of the velocity of light made during the years 1880–82. Chapter I. is devoted to an interesting historical account of previous researches on the subject. The method adopted in the present investigation was that of Foucault, with certain modifications, principally in the optical arrangements. The form of the apparatus and the conditions of the problem are fully described in Chapters II. and III.

The revolving mirror consisted of a rectangular prism of polished steel, the vertical faces of which were nickel-plated, and thus formed the surface from which the light was reflected. At each end of the prism a fan-wheel was fixed, and the mirror was driven by an air blast playing upon the opposite side of each wheel. For the fixed mirror, two concave mirrors, each about 40 c.m. in diameter, were used side by side, so as to obviate any slight displacements from a single mirror, and in order to strengthen the return image. The radius of the curvature of the mirror was about 3000 mètres.

In 1880 the locations of the mirrors were at a distance apart of 2550.95 mètres, but in 1881 and 1882 the longer distance of 3721.21 mètres was employed.

All the observations are given in detail, and the results are very fully discussed on the hypotheses (1) that the motion of the revolving mirror is uniform in running; (2) that the figure of the mirror remains invariable; and (3) that the changes in direction of the reflected ray are correctly measured by the angular motion of the receiving telescope around the axis of the revolving mirror. This discussion shows certain systematic differences in the results obtained for each year, the final result depending entirely upon the measures of 1882.

Professor Newcomb gives the concluded velocity of light in vacuo as 299860 kilomètres, with a probable error of ±30 kilomètres. Combining this result with Nyrén’s value of the constant of aberration, the corresponding solar parallax is $8''794$.

To this very important investigation are appended some interesting researches by Mr. Michelson on the velocities of white and coloured light in air, water, and carbon disulphide. The conclusions (which the author advances with great diffidence), are that the velocity of light in carbon disulphide is to that in air as 1.00 to 1.76, with an uncertainty of two units in the second place of decimals; and that orange-red light travels in carbon disulphide from 1 to 2 per cent. faster than greenish-blue light.
The Royal Society of Edinburgh has published during the year (Transactions, vol. xxxii. Part III.) a remarkable study of the solar spectrum by the Astronomer Royal for Scotland. The work was undertaken by him with the leading idea of ascertaining whether the spectroscope would offer any evidence as to changes in the absorption of our atmosphere resulting from the great volcanic outbursts of 1883, and especially from that of Krakatoa. The conditions at Edinburgh being unfavourable for work of the kind, Professor Smyth selected as his observing station a country-house called "Kurn Hattin," about two miles to the north of Winchester, and proceeded thither early in June 1884. He was provided with a fine Rowland grating of 14438 lines to the inch, and had attached a recording apparatus of special form to his spectroscope, which enabled him to record with great rapidity the positions of the lines observed. It was his intention to form three complete and independent charts of the entire spectrum, and this design he was enabled to carry out in its entirety, despite very unpropitious weather, by the assistance of Colonel Knight. The results of his observations are given in sixty plates, giving five views of the spectrum, the first two being reproductions of the work of some standard observer for the sake of comparison, the maps of Ångström and Pizey being used for the most part, and the last three the three successive "Winchester" spectra. All are reduced to the same scale, which is not the usual one of wave length, but of wave frequency to the British inch; the wave length expressed in tenth-mètres is however added. The part of the spectrum shown in any plate is clearly and agreeably indicated by tinting it of one homogeneous colour, approximately the average colour of the region; whilst the relative intensities of the dark lines are indicated by variations in their heights. The wave lengths are not absolute determinations, but differential only, Ångström's values for the principal lines being assumed throughout. Even so, however, there are occasionally, as Professor Smyth himself points out, some striking discrepancies between the positions of lines as recorded in the three charts: but when the unfavourable conditions, under which the greater part of the work was carried out, are remembered, and the great rapidity with which the observations were made—nearly the whole of the second spectrum, extending from A to B, and embracing about 7000 lines, having been mapped in three mornings, 1865 lines being laid down in three hours—the general accord between the three independent maps is very remarkable. Perhaps not the least important result of the work will have been to
show how rapidly a detailed chart of the entire visible spectrum can be formed when a suitable recording apparatus is employed.

With regard to the immediate purpose of the charts, the principal result Professor Smyth deduces from them is, that the visual solar spectrum in 1884 showed a marked general dulling at the two ends, the red and violet, "such as should arise from the upper air, being at that time overcharged with opaque dusty particles." The evidence for the existence of fresh atmospheric lines was much less satisfactory, although a strong line, wave length 4733 tenth-mètres, was repeatedly observed at Winchester, which is not shown on Fievez's chart. The repetition of such a survey of the spectrum as Professor Smyth has here carried out, at intervals of two or three years apart, would probably lead to the detection of changes in it which could scarcely fail to be instructive. In the meantime, Professor Smyth has supplied a valuable record of its appearance in the summer of 1884.

E. W. M.