

NOTES ON SOME POINTS CONNECTED WITH THE PROGRESS OF
ASTRONOMY DURING THE PAST YEAR.

Discovery of Minor Planets, 1882.

The following eleven minor planets were discovered in the year 1882:—

No.	Name of Planet.	Date of Discovery. 1882.	Discoverer.	Place of Discovery.
(221)		January 18	J. Palisa	Vienna
(222)		February 9	"	"
(223)		March 9	"	"
(224)		March 30	"	"
(225)		April 19	"	"
(226)		July 19	"	"
(227)	Philosophia	August 12	Paul Henry	Paris
(228)		August 19	J. Palisa	Vienna
(229)		August 22	"	"
(230)	Athamantis	September 3	De Ball	Bothkamp
(231)		September 10	J. Palisa	Vienna

The Supplement of the *Berliner Jahrbuch* still retains its distinctive character as the almost sole authority for the calculated ephemerides of the minor planets. In the Supplement recently received may be found daily ephemerides for the year 1883, for 43 members of the group, near the times of opposition, the places being given for midnight, Berlin time. There are also 20-day ephemerides giving less approximate places for noon for 112 planets throughout the year. The minor planets which appear to approach nearest the Earth in 1883 are *Isis*, *Phoebe*, *Clio*, *Flora*, *Virginia*, *Polyhymnia*, *Fortuna*, *Metis*, and *Juno*, the least distances ranging between 0.895 for *Isis* and 1.180 for *Juno*, the radius of the Earth's orbit being unity.

E. D.

The Comets of 1882.

The number of comets that have actually been seen for the first time during the year is perhaps five, but of these only three have been continuously observed. The remaining two objects of a cometary character that have been reported, though interest-

ing of themselves, are, from various causes, not likely to find a permanent place in our catalogues. Each of these objects will be referred to in chronological order.

At the commencement of the year Comet VIII. 1881 (Swift) was the only comet visible, and observations were procured till the middle of January. As this comet was mentioned in the last Annual Report, no further notice of it is necessary here.

On March 17 a comet was discovered at Albany, U.S., by Mr. C. S. Wells, which was destined to attract considerable attention. At the time of its discovery it was small, bright, with distinct nucleus, and narrow tail. On March 19, from which date observations became frequent and continuous, Prof. Lewis Boss described the object as a great comet in miniature. The breadth of the head was about $30''$, the length of the tail $6'$ or $8'$, and the nucleus shone with the light of a star of the eighth magnitude. An increase in brilliancy was steadily maintained, and early in May the comet was visible to the naked eye. Astronomers had been prepared for this increase of brilliancy, as well as for the subsequent display, by the determination of the orbit, which had been effected by several computers. Dr. Kreutz, from his first elements, predicted a theoretical brilliancy at the time of perihelion passage of nearly 6,000 times the brightness of the comet on March 20; and though subsequent discussion of the elements from improved data modified and somewhat diminished this value, no doubt remained of the interesting character of the orbit and the brilliant spectacle the comet was to present. The small altitude of the comet after sunset, and the bright background of the sky on which it was projected, interfered in some measure with its appearance, but the theoretical brilliancy was sufficiently great to warrant the conjecture that the comet would be visible in daylight. This actually proved to be the case. The comet was seen close to the Sun at many observatories. Possibly the smallest telescope with which it was so seen was the 6 ft. Refractor at Athens, where, on June 10, Dr. Schmidt saw the comet, $2^{\circ}8'$ distant from the Sun's limb. After perihelion passage, in July, the comet was seen, but with greatly diminished splendour, and observations were discontinued in August.

Many sets of elements have appeared; the most trustworthy orbit, though not definitive, is by M. Stefan Wolyncewicz. The perihelion distance is there given as 0.060768 that of the Earth's distance. Notwithstanding this close approach to the Sun, there is no difficulty in reconciling the observations previous to perihelion passage with those made subsequently, a point of some interest in connection with another comet discovered this year. When the observations made at the anomalies -160° and $+152^{\circ}$ are represented, a very satisfactory agreement is found to exist at intermediate points on the curve.

If the appearance of the comet owing to its unfavourable situation was disappointing, there are not wanting rigorous

observations to show that its brilliancy was even greater than might have been anticipated from the law of reflected light. Dr. Müller, of Potsdam, observing with a Zöllner Photometer, has determined that the light of the comet increased very rapidly, and that on June 6, when last seen, it possessed nearly forty times the brilliancy assigned by theory. Unfortunately, the small altitude of the comet necessitated the employment of a very serious correction, depending upon the extinction of light in the Earth's atmosphere. Dr. Müller has not given the data from which this correction has been taken, though, as he states that he has been engaged some years in investigating its amount, it is to be hoped that this doubtful element has been satisfactorily eliminated, and that Dr. Müller's interesting result will be entitled to implicit reliance.

The spectrum of this comet has increased the interest which its brilliancy awakened. Ever since 1864, when the spectrum of a comet was first observed by Donati, great uniformity has pervaded the spectra examined. All have shown the characteristic bands of hydrocarbon, but in this case, as soon as the comet had attained sufficient brilliancy for its spectrum to be observed, a marked deviation from the ordinary type was apparent; and inasmuch as the comet would approach very near the Sun, it was anticipated that some unexpected phenomena would be manifested. On April 7 the spectrum of the nucleus was seen to be continuous, though feeble and narrow, in which three ill-defined brighter points, corresponding approximately to the carbon bands, were just perceptible. By the 21st the difference between this spectrum and the ordinary type was so strongly marked, that the cometary nature of the object would hardly have been recognised. At the end of May the bright sodium line in the nucleus and neighbouring regions was detected at Dunecht. In the early part of June, when the comet attained its greatest brilliancy, this line under adequate dispersion was seen to be double, and the behaviour of the more refrangible line indicated to Prof. Vogel that the density of the incandescent gas was very great. A want of exact coincidence between the bright sodium lines and the Fraunhofer lines was noticeable on June 6, when the comet had a motion in the line of sight of 3.7 miles per second. The more refrangible portion of the spectrum was photographed by Dr. Huggins after an exposure of the plate for seventy-five minutes, and showed that the essential difference observed in the visible spectrum was maintained at the more refrangible end. On the plate was seen a strong continuous spectrum extending from F to a little beyond H, without any Fraunhofer lines, from which Dr. Huggins concludes that the part of the comet's original light which gives a continuous spectrum, is much stronger relative to the reflected solar light than was the case with the comet last year. The groups in the ultra-violet, presumably due to cyanogen, were not present. In the continuous spectrum five places of greater

brightness were evident, possibly owing to the sodium detected in the visible spectrum.

On May 17, during the total eclipse of the Sun at Sohag, a comet was seen and photographed on the plates prepared to receive the picture of the corona. The comet was distant from the Sun about a solar diameter, and had a tail of half a degree in length. It was never seen again. This observation, possibly unique, recalls, however, the obscure but interesting account of the comet of 418, quoted by Pingré in his *Cométo-graphie*.

On Sept. 13, Mr. Barnard, of Nashville, Tennessee, discovered a faint telescopic comet. Never attaining any great brilliancy, and moving rapidly southwards, it failed to attract much interest. It remained in view of northern Observatories some weeks, passed through its perihelion on Nov. 12, and has been observed since at the Cape of Good Hope, so that ample materials exist for the determination of the orbit, which is probably parabolic.

The Great Comet.—Information of the discovery of this comet first reached Europe on Sept. 12, by a telegram from M. Cruls, of Rio Janeiro; but in the southern hemisphere the comet had been seen as early as the 3rd, and observations had been made by Mr. Tebbutt and Mr. Finlay on the 8th. The announcement of the appearance of another comet, visible to the naked eye, the fourth which had been seen in twelve months, was however of inferior interest to the intelligence of the independent discovery of the same comet by Mr. Common, who, following a plan of observation which he had for some time pursued, detected it near the Sun's limb on the morning of Sept. 17. Mr. Common's observation showed that the comet was approaching the Sun at the time, but owing to clouds the object appears to have been lost sight of a little after noon. The interesting phenomenon therefore of the approach of the comet to the Sun's limb, and the actual transit over the Sun's disk, was missed; but more favourable weather at the Cape of Good Hope permitted Mr. Finlay and Dr. Elkin to make this unique observation. The comet was traced right up to the limb of the Sun, where it disappeared as suddenly and as effectually as the occultation of a star by the Moon. The distance of the comet from the Earth was $[9.99191]$, the radius vector of the Sun $[0.00192]$, so that it passed between us and the Sun, but the observers did not know at the time whether the comet was transiting the Sun or whether it was occulted by it, so completely had every trace of the nucleus, which was $5''$ in diameter, vanished. Similar observations to those recorded by Pastorff and Stark, and which have been thought to refer to the transit of comets over the Sun, would seem therefore to need a different explanation.

The elements of the orbit when they appeared disclosed an unexpected feature—namely, their close agreement with those of the comets of 1843 and 1880, a coincidence that has given rise to various hypotheses, specious and startling. The identity of

the comet of 1843 with that of 1880 had been rather reluctantly admitted, since the classical investigation of Hubbard had shown that the earlier comet was moving in an orbit of 533 years, and it had been first necessary to prove that the observations of 1843 could be represented by an orbit of about 37 years. This attempt was only partially successful. If a period of 37 years is to be substituted for that which is rigorously deduced from the observations, it necessitates an increment of $-.000498484$ to the excentricity, and corresponding corrections to the other elements. Since Prof. Hubbard has calculated the effect on the elements of an arbitrary change in the excentricity, these corrections can be immediately introduced. This alteration in Hubbard's elements has been effected by Prof. Weiss, who has shown that when the observations are compared with the theoretical places derived from the new elements, the probable error of a single observation is increased from $8''.4$, the value found by Hubbard, to $39''.4$. If fresh elements be sought, which is desirable, since the coefficients of the variations of the elements are only applicable so long as the functions can be considered linear, the residual errors, though considerably reduced, remain conspicuously greater than those found by Hubbard, as shown in the table below.

Date. 1843.	Independent Orbit.		Deduced Orbit.		Hubbard's Orbit.	
	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$
Mar. 5	+ 7 ^o 0	+ 18 ^o 4	- 117 ^o 9	+ 73 ^o 2	+ 25 ^o 7	+ 12 ^o 9
25	+ 19.4	- 48.6	+ 39.5	- 12.9	+ 4.6	+ 5.5
Apr. 19	- 14.5	+ 35.1	- 54.3	+ 61.1	- 8.7	+ 9.3

This want of agreement was, however, explained away by supposing that the centre of gravity did not correspond with the centre of condensation, and that an argument drawn from the comparative smallness of the residuals was not final.

There was but little difficulty in representing the observations of the 1880 comet by an ellipse of 37 years' period, but in this Dr. Meyer, of Geneva, was greatly assisted by the small length of the comet's heliocentric path—viz. three degrees. He has decided that the observations can only be satisfied with an ellipse whose period lies between the limits 31.5 and 47.7 years, but this conclusion is arrived at simply by considering the effects of the variation of the excentricity on the other elements. No attempt has been made to represent the observations by an ellipse of 533 years, the other elements of the orbit being independently derived, though the necessity of so doing was proved by Prof. Weiss in the previous case.

But after it had been decided to accept the period given by the supposition of the identity of the two bodies, rather than that derived from the discussion of the 1843 observations, which were scattered over an arc of only eight degrees of true anomaly, it was inconvenient and perplexing to find another magnificent

comet moving in the same track, after an interval of only $2\frac{1}{2}$ years. To account for this phenomenon, a theory, to which the name of Prof. Klinkerfues is particularly attached, was resuscitated and obtained some favour. This astronomer had supposed that the comets of 1880, 1843, 1668, and B.C. 371 were each apparitions of the same object, whose orbit was being gradually curtailed by successive passages through the "resisting medium." It was contended that if one-thirteen hundredth part of its initial velocity was destroyed by the resistance of the solar vapour, the contraction of the orbit would be such as to approximately coincide with the appearances observed, and that the next return might be anticipated in 1897. A reappearance in 1882 was of course premature, and necessitated a still further reduction of the axis major, yet as there was some difficulty in reconciling the observations made before perihelion with those made immediately after, and as this difficulty could be easily removed or explained by supposing some resistance to have been offered to the comet when in the neighbourhood of the Sun, this hypothesis did obtain for a time some sanction. Continued observations have, however, to some extent removed this apparent disagreement between the observations made on the two arcs of the ellipse, and have conclusively proved that no very short period will satisfy the observations. On the other hand, no parabola nor very extended ellipse will represent the observed path. Definitive elements are not yet known; but the best orbits yet published give such periods as 794, 843, or $652\frac{1}{2}$ years, indicating axes major not greatly different from that found by Hubbard.

An alternative theory which was suggested in 1880 obtains now a more general support—namely, that the three comets have had in the past a common origin, but by a process of gradual disintegration, the original mass has detached fragments which, pursuing slightly different paths, arrive at their perihelia at irregular intervals. The bifurcated orbit of the dichotomised comet of Biela furnishes an example of the diverging paths, along which portions of the same comet may move, becoming gradually separated in space.

The gradual dissolution of the comet itself, suggested by the latter theory, receives some support from the behaviour of the comet while under observation. Not only has the inconstant form of the nucleus been so pronounced as to introduce additional difficulties in the determination of the orbit, but Dr. Schmidt has observed (Oct. 9) a nebulous object in the neighbourhood of the comet, which there is some reason to believe is a detached fragment of it. This nebulous body was seen only on three consecutive mornings at a very low altitude, and with condensations so ill defined that the observations were only approximate. The consequent determination of the orbit is therefore very insecure. The elements, however, that have been derived do show some similarity, particularly in the small perihelion distance, with those of the great comet, and suggest

strongly the idea of a past intimate connection. But the final settlement of the entire question must await the complete discussion of the observations now in progress.

The appearance of the comet, the structure of the tail, the formation of the head, &c., have been graphically described by many observers in current scientific periodicals of easy access; and photographs taken at the Cape and elsewhere have preserved the general features. The spectrum has been the subject of special study, and has indicated some fresh facts of interest. It is curious to notice, that while the spectrum of comet *Wells* was continuously observed as the comet approached the Sun, and illustrated the effects of great and increasing excitement, the spectrum of this comet could only be observed as it receded from perihelion, and consequently the phenomena that were observed in the preceding case might be expected to exhibit themselves here in a reversed order. This, to a great extent, actually occurred. When the spectrum was first seen on Sept. 18, the sodium lines were at once seen distinctly double, both in the nucleus and parts adjacent, while a number of other bright lines coinciding with the more prominent iron lines were visible. Of the ordinary banded spectrum there was no trace. On Sept. 29 the iron lines had quite disappeared, the D lines were not separable, and indications of the ordinary comet spectra were apparent, while at the end of October, when the comet had reached the Earth's distance from the Sun, all trace of the sodium lines had vanished, and the three bands of hydrocarbon were distinctly present. It has been suggested by Dr. Hasselberg and others that the entire explanation of the phenomena witnessed cannot be found in the simple increase or diminution of temperature, depending on the distance of the comet from the Sun. For though an increase of temperature might account for the appearance of metallic lines, it does not satisfactorily explain the simultaneous disappearance of the characteristic carbon bands. The entire solution, it is submitted, is to be found by supposing that the cometary light is to some extent due to electric discharges, a supposition the more tenable, since laboratory experiments conducted on hydrocarbons and sodium vapour, have shown how preferential is the electric discharge when both these vapours are present.

W. E. P.

The Comet of 1812.

For this comet Encke had computed an orbit of about 70 years period, and consequently the return of the comet might have been expected very shortly. It was therefore desirable, as the time approached, to have a more rigorous investigation, in order to predict the date of its return within narrower limits, and supply the means for a systematic search for its discovery.