ASTRONOMY.

THE LATE PARTIAL ECLIPSE OF THE SUN, AND PENNULE'S COMET.

To the Editor of "SCIENCE:"

Though rather late in the day, I send the results of our eclipse observations on the morning of December 30 and 31: I observed the last contact with the diffraction spectroscope attached to the 9½ inch equatorial. The observation was made through the C line, the slit being *tangential* to the limb at the point of contact, and somewhat widely opened. Although the air was very unsteady, and the seeing simply "horrible," yet the instant of the moon's leaving the limb of the sun, as shown by the sudden reappearance of the chromosphere, was well marked. The time was $20^h\ 49^m\ 51^s.0 \pm 0^s.5$, Princeton mean time, or $20^h\ 40^m\ 16^s.5$ Washington mean time.

Mr. McNeill, with a telescope of 3 inches aperture and power of about 40, lost sight of the moon at $20^h\ 49^m\ 36^s$ P. M. T., 15 seconds earlier.

I may mention in this connection that Pennule's comet, as observed here December 18th, 19th and 22d, showed *two* faint tails. One of them was directed, as usual, very nearly opposite to the sun. The other was pointed roughly towards the sun, though deflected some degrees toward the north; the two streamers made an angle of about 150° with each other. Each was about 30′ long on the 18th, and neither was seen after the 22d.

C. A. YOUNG.

PRINCETON, N. J., January 12, 1881.

To the Editor of "SCIENCE:"

Mr. Edwin F. Sawyer has given a very interesting description ("SCIENCE" No. 19, p. 236), of the large bolide of October 25, and the special meteor stream, to which it probably owed its origin, is one which merits prominent notice from the fact that it supplies fireballs of the largest type.

I have collected accounts of no less than 26 bolides, seen during the interval October 26 to November 9, within the last 15 years, which distinctly radiated from this remarkable shower near ε Arietis.

I saw a large meteor belonging to it on Oct. 30, ($9^h 50^m$), 1880. While engaged in telescopic observation I was somewhat startled by two prolonged brilliant flashes, which caused me to turn quickly and I saw at once a very intense meteor streak projected on the sky just S. of α Arietis. It was broken in the middle and endured 25 seconds. Its position was from 38°+18° to 26°+22°.

I received a letter the following day from Mr. I. Baxendell, F. R. A. S., of Southport, saying he had observed a large meteor on October 29, at $9^h\ 50^m$, with a path from 31°—1½° to 16°—17°. The time agreed exactly with that recorded at Bristol, and the two paths gave the radiant at 46°+15°, which agrees fairly well with that of the notable shower alluded to by Mr. Sawyer.

In further confirmation I may add that on November 1, $10^h\ 50^m$, Mr. H. Corder, of Chelmsford, observed a bright meteor = Jupiter, which had an apparent path from 275°+56° to 257°+43° and obviously took its departure from the same radiant as that of the fireballs of October 25 and 30.

W. F. DENNING.

ASHLEY DOWN, Bristol, England.

The "Report of the Kew Committee for the year ending October 31, 1880," contains some interesting information connected with an institution which is engaged in a department of research not, as yet, covered by any observatory in this country. The work at Kew is divided into seven sections:—Magnetic observations; Meteorological observations; Solar observations; Experimental in connection with either of the above departments; Verification of instruments; Aid to other Observatories; Miscellaneous.

The Magnetic observations, embracing the automatically registered curves of the Magnetograph, and observations of Declination, Dip, Deflection and Vibration, seem to indicate the approach of a more disturbed period than has occurred for several years. In order to collect more accurate data relating to this subject, arrangements have been made with other magnetic observatories in different parts of the globe to carry on a series of synchronous observations, and the comparison of the results will probably throw some light upon the laws which govern many of these phenomena. In the Meteorological department, self-recording instruments for the continuous registration, respectively, of atmospheric pressure, humidity, wind (direction and velocity) and rain have been maintained in regular operation throughout the year, in addition to standard eye observations made five times daily for the control of the automatic records. Abstracts of the meteorological results are published weekly.

Observations of the sun were made on 246 days, and on only 27 of those days was the sun's surface found to be without spots. A complete copy of the solar drawings made by Schwabe between 1825 and 1867 having been obtained, the Observatory has now in its possession a complete record of the condition of the sun's surface from November, 1825, to the present date. Transit observations of the sun have also been obtained at intervals to correct the local time.

The Experimental department embraces work upon a "Winstaneley's Recording Radiograph," for registering the amount of radiation from the sky, a "Glycerine Barometer," a "Standard Air Thermometer," and various other instruments. A large number of meteorological instruments have been verified and their constants determined for other Observatories and for instrument makers, and facilities for study and experiment have been furnished to a number of individuals interested in the various branches of the institution.

The new observatory which is being erected at Nice under the auspices of the *Bureau des Longitudes*, will probably cost over two million francs. The buildings are partly finished, and Thollon has already done some excellent work there, in spectroscopy. Besides a small equatorial, a meridian circle, and accessory instruments, there is to be a large equatorial of 29.9 in. aperture and 59 ft. focal length, constructed by M. M. Henry, of the Paris Observatory.

W. C. W.

WASHINGTON, D. C., *January* 12, 1881.

THE OBSERVATORIES OF THE UNITED STATES,

I.

CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

The United States is fortunate in possessing a greater number of well equipped astronomical observatories than any other country in the world. These are distributed over a wide extent of territory, ranging from the shores of the Atlantic to the Pacific coast, and extending from the tropical regions of the Gulf of Mexico, to Lake Superior on the North.

A brief description of some of these Observatories and the appliances at their command may be of interest to our readers, and we propose on this occasion to offer some interesting facts regarding one which has been more recently organized.

The course of instruction in Astronomy at Carleton College, Northfield, Minn., appears to be well organized, and, although the College was fully organized so recently as 1874, it appears to have a well equipped astronomical observatory and every requirement for teaching Astronomy. We are informed by Professor W. W. Payne, in charge of the Observatory, that the instruments in use are a Clark equitorial telescope, focal length 10½ feet, aperture 8¼ inches; a portable equatorial made by John Byrne, of New York, aperture 4.3 inches; a Howard sideral clock; a Howard mean-time clock, a Bond sideral chronometer, a Fauth transit instrument with telescope of 3 inches aperture, a Clark chronogragh; meteorological apparatus, and a complete set of Johnson's large astronomical maps, recently imported. By courtesy of Lieut. Edw. Maguire, Chief Engineer of the Department of Dakota, the Observatory has also the use of an excellent zenith telescope for special work.

The time of the Observatory is the standard for the State of Minnesota and parts of those States adjoining, and given to the railroad companies daily by telegraph. The distribution of the time of the Northfield meridian by the aid of excellent instruments, is said to be easy, exact and reliable.

The object of erecting this Astronomical Observatory appears to have been three-fold. 1. To give instruction to undergraduate students. 2. To offer opportunities for a complete course of study in Theoretical and Practical Astronomy. 3. To aid in useful investigations.

ON THE LIMIT OF PLANETARY STABILITY.

By Professor Daniel Kirkwood.

Laplace, in his *Système du Monde*, pointed out the limit at which, according to his estimate, the moon's attraction could have retained an elastic atmosphere.* The question of a satellite's stability was also considered by the late Professor Vaughan, of Cincinnati.† I have seen no attempt, however, to obtain for the different members of our system any definite numerical results. In the present paper it is proposed to find the approximate limits of stability in the cases of the eight major planets and certain of the satellites, on the hypothesis that their primitive condition was either liquid or gaseous.

Let $M =$ the mass of the larger or central body,
$m =$ that of the dependent planet or satellite,
$x =$ the distance from the centre of the former to the limit of stability of the latter,
$a =$ the distance between their centres; then, since the disturbing or separating force of the larger upon the smaller mass is the difference between the attraction of the former on the nearest point of the surface of the latter and that on its centre of gravity, we have

$$\frac{M}{x^2} - \frac{M}{a^2} = \frac{m}{(a-x)^2} \qquad (1)‡$$

or putting $a = 1$ and reducing,

$$x^4 - 2x^3 + \frac{m}{M}x^2 + 2x = 1. \qquad (2)$$

If we adopt the masses and distances given in Newcomb's Popular Astronomy and solve equation (2) for each of the eight principal planets we shall obtain the distance from the centre of each to its limit of stability, as given in the second column of the following table. If, moreover, the planets, with their present masses, be reduced to the sun's mean density their radii as stated in the third column are found by the formula

$$r^n = 430{,}000 \left(\frac{m_n}{M}\right)^{1/3},$$

and the respective ratios of the limits of stability to these radii are seen in column fourth.

* Syst. du Monde, B. IV., Ch. X.

† Pop. Sci. Monthly for Sept. 1878. See also the Proc. of the A. A. A. S. for 1856.

‡ We neglect the centrifugal force due to the planet's rotation, as the modification would be slight and we propose to obtain merely approximate results.

Table.

Planet.	R_n	r_n	$\frac{R_n}{r^n}$
Mercury	165,165 ms	2,514 6 ms	65.7
Venus	701,746	5,719.2	122.7
Earth	1,059,386	6,242.7	169.7
Mars	764,900	2,951.1	259.2
Jupiter	37,354,287	42,335	882.35
Saturn	45,859,381	28,317	1619.48
Uranus	49,512,900	15,209	3255.51
Neptune	81,663,510	16,009	5101.10

On the assumption that in each case the mean density of the separated mass was equal to that of the central body, the sun's present radius multiplied by the respective numbers in column fourth will give the radii of the solar nebula when the planets extended to their respective limits of stability. These radii are less than the mean distances of the planets in the ratio of 1 to 1.265. This fact may have some significance in regard to the former oblateness of the solar nebula or the law of its density.

The Earth and the Moon.—For the moon, which in perigee approaches within 221,500 miles of the earth, the limit of stability is about 38,000 miles. Were the moon's density reduced to that of the earth its radius would be 916 miles, the ratio of which to the limit of stability is 1 : 41.6. The moon's least distance diminished by 38,000 miles is 183,500 miles. If our satellite originally extended to the limit, and if the moon and the earth had the same form and density, the radius of the latter was 165,000 miles.

The Martian System.—The diameter of Phobos, according to Prof. Pickering, is 5.57 miles. If its density, therefore, be equal to that of Mars the limit of stability is about two miles exterior to the surface; or, if the density be to that of the primary in the same ratio as the density of the moon to that of the earth, the limit is less than a mile from the surface of the satellite; and finally if the density were no greater than that of water the satellite, if fluid, would be unstable, the limit being actually within the surface. Since, therefore, the satellite could never have existed at its present distance in a nebular state, it must follow, if any form of the nebular hypothesis is to be accepted, that its original distance was much greater than the present. Can we find a probable cause for this ancient disturbance?

If we suppose the former period of Mars to have been very nearly one-sixth that of Jupiter the close commensurability would render the orbit of Mars more and more eccentric. The planet in perihelion would thus pass through the sun's atmosphere, or rather through the outermost equatorial zone of the solar nebula. This resisting medium would not only accelerate the motion of Mars but also in a much greater degree that of his extremely small satellite. The solar mass contracting more rapidly than the orbit of Mars would finally leave the latter moving in an eccentric path without sensible resistance.

Other Secondary Systems.—For the first satellite of Jupiter the limit is 5250 miles, or 4½ times the radius of the satellite. For Mimas, the innermost satellite of Saturn, it is less than twice the radius. The rings of Saturn, in all probability, could not exist as three satellites, the limits of stability being interior to the surface.*

The effect of preturbation in the dismemberment of comets is known to all astronomers. The nucleus of the great comet of 1880, which approached within less than 100,000 miles of the sun's surface, must have had a den-

* It has been recently shown that Bessel's mass of the ring is much greater than the true value.