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## OBSERVATIONS OF NEBULÆ.

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THE observations of nebulae here described are of three kinds: first, the determination of the diameters of some planetary nebulae by means of a double-image micrometer; secondly, the determination of the brightness of certain nebulae, chiefly planetary, by photometric methods; thirdly, the observation of nebular spectra by means of a direct-vision prism, used without a slit. The telescope employed in all these observations was the East Equatorial, the aperture of which is 37.95 cm., and its focal length 682.5 cm. The observers were Edward C. Pickering, Arthur Searle, Winslow Upton, and Oliver C. Wendell, denoted in the following tables by the letters P., S., U., and W. Only a few observations were made by the third of these observers.

The apparatus and methods of observation employed for the micrometric and photometric sections of the work are described below.

For measuring the diameters of the nebulae a form of Rochon double-image micrometer was employed. Two double-image prisms of quartz, of the form devised by Wollaston, were moved along the axis of the telescope by means of a rack and pinion. The position of the prisms was read by means of a scale of equal parts, and also by a graduated circle attached to the pinion. A compound microscope was substituted for the eyepiece of the telescope. When the image of a star was viewed through this apparatus it appeared single when the prisms were equally distant from the focal plane of the telescope. Two images were seen when the prisms were moved from this position, the separation being proportional to the amount of motion, and therefore determined directly by means of the scale of equal parts. The value of one division of the scale in seconds of arc was determined by observing transits of the Pole-star over a wire inserted in the eyepiece of the compound microscope. In measuring the diameter of a planetary nebula the prisms were moved first on one side and then on the other of the focal plane, and their positions read when the images of the nebula appeared tangent to each other. Double the diameter was thus measured without the necessity of determining the point of coincidence.

A photometer for measuring the light of the nebulae was devised by the writer in 1876, and a description of it published in the "American Journal of Science," Vol. CXI. p. 482. In the summer of 1877 a trial was made by this method with an instrument which was afterwards converted into Photometer D, and used for the measurement of the satellites of Mars, and for other purposes. See Volume XI. of these Annals, page 6, Figure 4. The first experiments were made with an artificial light as a standard. The theoretical objections to such a standard, owing to its variability, and the changes in the apparent light of the nebula due to variations in the opacity of the air, led to the abandonment of this method.

Later, the plan was tried of comparing the nebula with a star thrown out of focus by such an amount that it would present a disk having an intrinsic brightness equal to that of the nebula. The advantage of this method is that by it the same scale of magnitudes may be used for nebulae as for stars, if we agree to regard the magnitude of a portion of a nebula as equal to that of a star thrown out of focus until its disk shall cover a given area. The standard here adopted is a circle one minute of arc in diameter. Accordingly a nebula will be of the ninth magnitude when it has the same intrinsic brightness as a star of the ninth magnitude spread over a circle one minute in diameter, or when a circular portion of the nebula, one minute in diameter, will emit the same amount of light as the star. If any other area is preferred as a standard, the only effect will be that all the magnitudes must be changed by a constant amount equal to 2.5 times the logarithm

of the ratio of the two areas. The instrument finally employed is designated in our records as Photometer Q, and is represented in Figure 1. It closely resembles Photometer I, which was used for measuring the light of faint stars, and is described in these Annals, Vol. XI. p. 7, Figures 5 and 6. The principal difference is that, instead of varying the aperture, the position of the objective of the auxiliary telescope is altered. In Figure 1, A represents the eyepiece with which the nebula is observed in the right hand half of the field with the full aperture of the large telescope. The comparison star is observed by a small auxiliary telescope, whose objective D may be moved backward and forward by a rack and pinion, C. The amount of motion is shown by a scale of tenths of an inch read by estimation to hundredths of an inch.

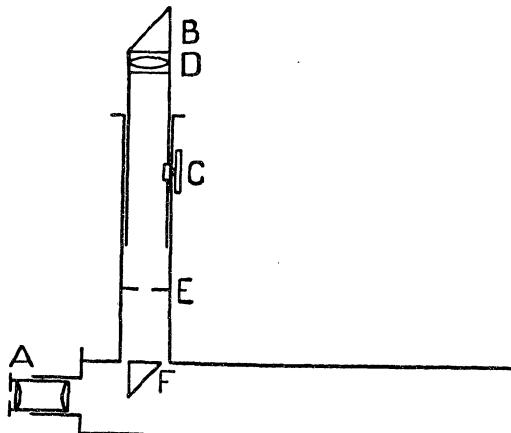


FIG. 1.

hand half of the field with the full aperture of the large telescope. The comparison star is observed by a small auxiliary telescope, whose objective D may be moved backward and forward by a rack and pinion, C. The amount of motion is shown by a scale of tenths of an inch read by estimation to hundredths of an inch.

The star is reflected into this telescope by the prism  $B$ , and is brought into the field of view by the prism  $F$ .  $E$  is a diaphragm which does not move with the objective, and which makes the angular aperture of the small telescope always equal to that of the large telescope. As long as this equality is maintained, the same results will be obtained whether the sky is bright or dark, since its light will affect both portions of the field of view equally, whether the star is in or out of focus.

To reduce the observations made with this photometer we must determine the relative brightness of the star and nebula corresponding to a given reading when the intrinsic brightness of their images is the same.

Let  $L, l$ , respectively denote the quantities of light received by the large telescope from a part of the nebula occupying a circle  $l'$  in diameter, and from the star with which the nebula is compared;  $A, a$ , the available apertures of the large and small telescopes at the moment of observation;  $F, f$ , their focal lengths;  $r_0$ , the reading of the scale when the small object glass forms a distinct image of the star in the focal plane of the eyepiece;  $r$ , the reading of the scale when the small object glass is set so that the light of the star appears equally intense with that of the nebula.

The quantity of light received by the small telescope from the star at the moment of observation is accordingly  $l \frac{a^2}{A^2}$ , and the equivalent in linear measure of one minute of arc in the large telescope is  $\frac{F}{3438}$ . The part of the focal plane of the eyepiece occupied by the light of the star has a diameter of  $\frac{a(r_0 - r)}{f}$ , the unit of linear measure being the single division of the scale.

To equalize the intensity of the light of the nebula and star, the quantities of light received from them must be proportional to the areas they occupy in the focal plane; hence

$$L : l = \left( \frac{F}{3438} \right)^2 : \left( \frac{a(r_0 - r)}{f} \right)^2, \quad \text{and} \quad \frac{l}{L} = \left( \frac{3438 A (r_0 - r)}{F f} \right)^2.$$

Since the factor  $(r_0 - r)$  is squared in the result, its sign is unimportant, and the reading  $r$  may be either greater or less than  $r_0$ .

The scale of Photometer Q is divided into tenths of an inch. If the centimeter is adopted as the unit of length, the expression for  $\frac{l}{L}$  will become  $\left( \frac{3438 A \times 0.254 (r_0 - r)}{F f} \right)^2$ , and the difference in magnitude corresponding to this ratio of light will be

$$5 \log (r_0 - r) + 5 \log \frac{0.254 \times 3438 A}{F f},$$

in which the sign of  $(r_0 - r)$  is to be regarded as positive.

With the values  $A = 37.95$ ,  $F = 682.5$ ,  $f = 18.4$ , this expression becomes

$$5 \log (r_0 - r) + 2.11.$$

Some of the nebulae were so bright that the comparison star could not be made of equal brightness without bringing it so nearly into focus that the eye would accommodate itself to the image, so as to make it appear as a point instead of a disk. In these cases, it was necessary to diminish the aperture of the large telescope and thus reduce the brightness of the nebula. A cap having an aperture of 12.7 cm. was used for this purpose. The corresponding difference in magnitude will be  $5 \log (r_0 - r) - 0.27$ . In some of the observations another cap was used, the aperture of which was 12.6 cm. For this cap, the difference in magnitude is  $5 \log (r_0 - r) - 0.28$ .

Many of the observations required a correction for the difference of atmospheric absorption due to the different zenith distances of the nebula and the star compared with it. This correction was determined approximately by graphical methods, as the accordance of the observations was not so close as to require minute accuracy in this respect. The magnitudes of the comparison stars were taken from the Harvard Photometry.

In the following record of the observations, the dates are expressed in Julian Days. This method enables some space to be saved in printing, since only the last four figures of each Julian Day are required. In Volume XVIII. of these Annals, pages 306 and 307, a table is given for the conversion of any date in the nineteenth century into the corresponding Julian Day, but it may be convenient here to repeat so much of this table as relates to the years 1879–82, during which the observations of nebulae here described were all made. Within this period, the first three figures of the Julian Day are always 240. The remaining figures are given below. For any given day, the number of that day in its month is to be added to the number given for that month, which represents the last day of the preceding month.

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|-------|------|------|------|--------|------|-------|-------|------|-------|------|------|------|
| 1879  | 7350 | 7381 | 7409 | 7440   | 7470 | 7501  | 7531  | 7562 | 7593  | 7623 | 7654 | 7684 |
| 1880  | 7715 | 7746 | 7775 | 7806   | 7836 | 7867  | 7897  | 7928 | 7959  | 7989 | 8020 | 8050 |
| 1881  | 8081 | 8112 | 8140 | 8171   | 8201 | 8232  | 8262  | 8293 | 8324  | 8354 | 8385 | 8415 |
| 1882  | 8446 | 8477 | 8505 | 8536   | 8566 | 8597  | 8627  | 8658 | 8689  | 8719 | 8750 | 8780 |

Table I. contains the results of the observations made to determine the diameters of the nebulae. The first two columns contain the number of each nebula in Dreyer's

New General Catalogue, and the last four figures of the Julian Day corresponding to each date of observation. The third column, which is the mean of the four micrometric readings in each observation, expresses the point upon the scale at which the images would coincide. The fourth and fifth columns give the sum of the two differences between the two readings of each pair, and the product of this quantity by 0.428, which expresses the diameter of the nebula in seconds of arc. The sixth column gives the initial of the observer, as explained on page 135. In

TABLE I.

## DIAMETERS OF NEBULÆ.

| N. G. C. | J. D. | Coinc. | Sum of Diff. | Diam. | Obs. | Rem. | N. G. C. | J. D. | Coinc. | Sum of Diff. | Diam. | Obs. | Rem. |
|----------|-------|--------|--------------|-------|------|------|----------|-------|--------|--------------|-------|------|------|
| 1501     | 7643  | 60.08  | 135.55       | 58.1  | S.   |      | 6905     | 7618  | 60.36  | 75.34        | 32.4  | S.   |      |
| "        | "     | 60.44  | 128.90       | 55.2  | P.   |      | "        | 7636  | 60.84  | 88.38        | 37.8  | S.   |      |
| 1535     | 7728  | 58.95  | 27.19        | 11.6  | S.   |      | "        | "     | 60.87  | 93.19        | 39.9  | P.   |      |
| "        | "     | 59.54  | 25.55        | 10.9  | P.   |      | 7009     | 7617  | 60.45  | 58.41        | 25.0  | P.   | g    |
| "        | 7746  | 59.58  | 78.66        | 33.7  | P.   |      | "        | "     | 60.44  | 51.24        | 21.9  | W.   | g    |
| 2022     | 7720  | 61.13  | 67.29        | 28.8  | P.   |      | "        | "     | 60.07  | 49.77        | 21.3  | S.   | g    |
| "        | "     | 60.76  | 65.85        | 28.2  | S.   |      | 7627     |       | 59.86  | 54.63        | 23.4  | P.   | g    |
| 6210     | 7619  | 58.92  | 29.31        | 12.5  | P.   |      | "        | "     | 60.87  | 59.24        | 25.4  | W.   | g    |
| "        | "     | 59.32  | 26.62        | 11.4  | W.   |      | "        | 7617  | 60.37  | 43.41        | 18.6  | P.   | 1    |
| 6543     | 7722  | 60.02  | 50.74        | 21.7  | P.   | g    | "        | "     | 60.08  | 42.95        | 18.4  | W.   | 1    |
| "        | "     | 60.39  | 47.22        | 20.2  | S.   | g    | "        | "     | 60.21  | 41.54        | 17.8  | S.   | 1    |
| "        | "     | 59.98  | 50.02        | 21.4  | W.   | g    | "        | 7627  | 60.01  | 41.77        | 17.9  | P.   | 1    |
| "        | 7725  | 61.03  | 53.49        | 22.9  | P.   | g    | "        | "     | 60.69  | 46.87        | 20.1  | W.   | 1    |
| "        | "     | 61.08  | 54.70        | 23.4  | S.   | g    | 7027     | 7728  | 59.03  | 27.17        | 11.6  | P.   |      |
| "        | 7722  | 60.07  | 41.42        | 17.7  | P.   | 1    | "        | 7729  | 59.04  | 26.65        | 11.4  | S.   | g    |
| "        | "     | 59.90  | 37.46        | 16.0  | S.   | 1    | "        | 7736  | 58.82  | 28.09        | 12.0  | S.   | g    |
| "        | "     | 60.12  | 40.93        | 17.5  | W.   | 1    | "        | "     | 58.93  | 25.61        | 11.0  | P.   | g    |
| "        | 7725  | 61.38  | 50.48        | 21.6  | P.   | 1    | "        | "     | 58.94  | 25.02        | 10.7  | W.   | g    |
| "        | "     | 61.20  | 46.63        | 20.0  | S.   | 1    | "        | 7728  | 59.30  | 20.93        | 9.0   | S.   |      |
| 6818     | 7619  | 59.00  | 55.70        | 23.8  | P.   |      | "        | 7729  | 58.93  | 19.12        | 8.2   | S.   | 1    |
| "        | "     | 59.32  | 54.28        | 23.2  | W.   |      | "        | 7736  | 59.03  | 18.49        | 7.9   | S.   | 1    |
| "        | "     | 58.89  | 54.31        | 23.2  | S.   |      | "        | "     | 58.92  | 18.56        | 7.9   | P.   | 1    |
| "        | 7627  | 60.38  | 55.92        | 23.9  | P.   |      | "        | "     | 58.84  | 19.14        | 8.2   | W.   | 1    |
| "        | "     | 60.29  | 58.63        | 25.1  | W.   |      | 7662     | 7620  | 59.40  | 56.45        | 24.2  | S.   |      |
| "        | 7630  | 58.08  | 56.87        | 24.3  | P.   |      | "        | "     | 59.10  | 58.82        | 25.2  | W.   |      |
| 6826     | 7723  | 59.46  | 55.62        | 23.8  | P.   |      | "        | "     | 59.07  | 58.93        | 25.2  | P.   |      |
| "        | "     | 59.84  | 54.84        | 23.5  | S.   |      | "        | 7636  | 60.56  | 57.28        | 24.5  | P.   |      |
| "        | 7725  | 60.79  | 53.35        | 22.8  | S.   | g    | "        | "     | 60.57  | 55.25        | 23.6  | S.   |      |
| "        | "     | 61.28  | 65.07        | 27.8  | P.   | g    | "        | 7643  | 59.39  | 54.20        | 23.2  | S.   |      |
| "        | "     | 61.50  | 44.98        | 19.2  | S.   | 1    | "        | "     | 59.59  | 58.67        | 25.1  | P.   |      |
| "        | "     | 61.13  | 59.55        | 25.5  | P.   | 1    | "        | 7702  | 59.59  | 59.19        | 25.3  | P.   |      |
| 6905     | 7618  | 58.83  | 85.31        | 36.5  | P.   |      |          |       |        |              |       |      |      |

TABLE II.

## LIGHT OF NEBULÆ.

| N. G. C. | J. D. | H. P. | Magn. |      | Obs. | N. G. C. | J. D. | H. P. | Magn. |      | Obs. | N. G. C. | J. D. | H. P. | Magn. |      | Obs. |    |
|----------|-------|-------|-------|------|------|----------|-------|-------|-------|------|------|----------|-------|-------|-------|------|------|----|
|          |       |       | Star. | Neb. |      |          |       |       | Star. | Neb. |      |          |       |       | Star. | Neb. |      |    |
|          |       |       |       |      |      |          |       |       |       |      |      |          |       |       |       |      |      |    |
| 1501     | 7643  | 801   | 5.37  | 11.7 | S.   | 3242     | 7783  | 1797  | 1.42  | 5.9  | S.   | 6210     | 7612  | 2807  | 3.91  | 3.8  | S.   |    |
|          | "     | "     | "     | 11.2 | P.   | "        | 7807  | "     | "     | 6.5  | P.   | "        | "     | "     | "     | 4.0  | S.   |    |
|          | 7814  | 836   | 4.41  | 10.3 | W.   | "        | "     | "     | "     | 6.6  | W.   | "        | 7836  | 2594  | 2.37  | 5.8  | W.   |    |
|          | "     | "     | "     | 10.0 | S.   | 3310     | 7814  | 1941  | 3.12  | 9.4  | S.   | "        | "     | "     | "     | 5.9  | P.   |    |
|          | "     | "     | "     | 9.7  | P.   | "        | 7819  | 1923  | 2.60  | .8   | P.   | "        | 7847  | "     | "     | 6.4  | W.   |    |
|          | "     | "     | "     | 9.0  | S.   | "        | "     | "     | "     | 8.9  | S.   | "        | "     | "     | "     | 6.4  | S.   |    |
| 1535     | 7728  | 797   | 1.00  | 6.5  | P.   | "        | 7844  | "     | "     | 9.3  | W.   | 6229     | 7562  | 2959  | 3.92  | 8.2  | P.   |    |
|          | "     | "     | "     | 6.0  | W.   | "        | "     | "     | "     | 9.1  | P.   | "        | "     | "     | "     | 8.1  | S.   |    |
|          | "     | "     | "     | 5.9  | S.   | 3587     | 7816  | 1926  | 1.96  | 9.2  | P.   | "        | "     | 2937  | 2.97  | 7.9  | P.   |    |
|          | "     | 7746  | "     | 5.8  | W.   | "        | "     | "     | "     | 9.3  | W.   | "        | "     | "     | "     | 8.0  | S.   |    |
|          | "     | "     | "     | 6.4  | P.   | "        | 7842  | 1923  | 2.60  | 11.6 | P.   | "        | 7594  | 3009  | 2.35  | 8.2  | S.   |    |
|          | 7716  | 975   | 3.49  | 8.8  | W.   | "        | "     | "     | "     | 11.8 | W.   | "        | "     | "     | "     | 6.6  | P.   |    |
| 2022     | 7720  | 1045  | 1.89  | 9.7  | P.   | "        | "     | "     | "     | 11.6 | S.   | "        | "     | "     | "     | 7.4  | W.   |    |
|          | "     | 1039  | 2.36  | 7.8  | P.   | "        | "     | "     | "     | 11.6 | P.   | "        | "     | 2937  | 2.97  | 7.8  | S.   |    |
|          | "     | 1045  | 1.89  | 9.6  | S.   | "        | "     | "     | "     | 11.7 | S.   | "        | "     | "     | "     | 7.5  | P.   |    |
|          | "     | 1039  | 2.36  | 8.3  | S.   | "        | 7844  | "     | "     | 11.8 | W.   | "        | "     | "     | "     | 7.4  | W.   |    |
|          | "     | 7748  | 1045  | 1.89 | 9.2  | P.       | 5144  | 7842  | 2356  | 4.71 | 11.4 | W.       | "     | 7601  | "     | "    | 7.1  | P. |
|          | "     | "     | "     | 9.1  | S.   | "        | "     | "     | "     | 10.4 | P.   | "        | "     | "     | "     | 7.4  | W.   |    |
| 2488     | 7750  | 1373  | 3.58  | 10.2 | W.   | "        | "     | "     | "     | 11.4 | W.   | "        | "     | 3009  | 2.35  | 7.0  | P.   |    |
|          | "     | "     | "     | 10.4 | P.   | 5247     | 7867  | 2390  | 4.29  | 10.5 | W.   | "        | 7846  | 2937  | 2.97  | 8.5  | W.   |    |
|          | "     | 7783  | "     | 10.6 | W.   | "        | "     | "     | "     | 10.6 | P.   | "        | "     | "     | "     | 8.9  | P.   |    |
|          | "     | 8131  | "     | 10.2 | W.   | "        | "     | "     | "     | 11.3 | S.   | "        | 7847  | "     | "     | 8.8  | W.   |    |
|          | "     | "     | "     | 10.2 | P.   | "        | 7876  | 2408  | 4.56  | 11.0 | W.   | 6369     | 7581  | 2868  | 2.62  | 8.8  | S.   |    |
|          | 7752  | 1442  | 0.46  | 6.3  | W.   | 5493     | 7581  | 2468  | 3.72  | 7.0  | S.   | "        | 7582  | "     | "     | 9.0  | S.   |    |
| 2440     | "     | "     | "     | 6.5  | P.   | 5574     | 7510  | 2373  | 4.36  | 11.7 | P.   | "        | 7876  | "     | "     | 9.7  | S.   |    |
|          | "     | 7783  | 1350  | 1.85 | 8.2  | W.       | "     | "     | "     | 10.1 | S.   | "        | "     | "     | "     | 9.0  | W.   |    |
|          | "     | "     | "     | 7.0  | P.   | 5576     | 7510  | "     | "     | 9.5  | P.   | "        | 7910  | "     | "     | 8.6  | W.   |    |
|          | "     | 7813  | "     | 7.0  | W.   | "        | "     | "     | "     | 8.5  | S.   | "        | "     | "     | "     | 9.3  | P.   |    |
|          | "     | 7814  | 1949  | 2.75 | 7.4  | P.       | 5577  | 7510  | "     | "    | 13.3 | P.       | 6543  | 7604  | 2500  | 2.13 | 5.8  | W. |
|          | "     | "     | "     | 7.0  | W.   | "        | "     | "     | "     | 12.6 | S.   | "        | 7608  | "     | "     | 5.1  | W.   |    |
| 2818     | 7811  | 1795  | 4.60  | 9.9  | P.   | 5746     | 7863  | 2539  | 2.74  | 11.2 | W.   | "        | "     | 7722  | 3307  | 3.21 | 5.9  | P. |
|          | "     | "     | "     | 10.1 | S.   | "        | "     | "     | "     | 11.3 | S.   | "        | "     | "     | "     | 5.9  | S.   |    |
|          | "     | 7813  | "     | 10.3 | P.   | "        | "     | "     | "     | 10.9 | P.   | "        | "     | "     | "     | 5.9  | S.   |    |
|          | "     | "     | "     | 10.4 | S.   | 5846     | 7569  | 2627  | 2.71  | 8.0  | S.   | "        | 7853  | 2878  | 3.27  | 4.0  | P.   |    |
|          | 7811  | 1893  | 3.26  | 8.3  | P.   | "        | "     | "     | "     | 8.3  | U.   | "        | "     | "     | "     | 4.3  | W.   |    |
|          | "     | "     | "     | 8.9  | S.   | 5904     | 7569  | 2627  | 2.71  | 5.6  | S.   | 6553     | 7910  | 3084  | 2.83  | 9.8  | W.   |    |
| 3132     | "     | "     | "     | 8.4  | W.   | "        | "     | "     | "     | 6.2  | U.   | "        | "     | "     | "     | 9.5  | P.   |    |
|          | "     | 7813  | "     | 8.5  | P.   | 6210     | 7563  | 2807  | 3.91  | 4.1  | S.   | "        | "     | "     | "     | 9.6  | S.   |    |
|          | "     | "     | "     | 9.4  | S.   | "        | "     | "     | "     | 5.4  | P.   | "        | 7951  | 3111  | 3.06  | 9.3  | W.   |    |
|          | 7439  | 1797  | 1.42  | 6.2  | P.   | "        | 7612  | "     | "     | 6.5  | P.   | "        | "     | 3084  | 2.83  | 9.3  | W.   |    |
|          | "     | 7783  | "     | 5.4  | W.   | "        | "     | "     | "     | 7.1  | W.   | 6563     | 7927  | 3084  | 2.83  | 9.8  | S.   |    |
|          | "     | "     | "     | 5.3  | P.   | "        | "     | "     | "     | 6.0  | P.   | "        | "     | "     | "     | 9.8  | S.   |    |

| N. G. C. | J. D. | H. P. | Magn. |      | Obs. | N. G. C. | J. D. | H. P. | Magn. |      | Obs. | N. G. C. | J. D. | H. P. | Magn. |      | Obs. |    |
|----------|-------|-------|-------|------|------|----------|-------|-------|-------|------|------|----------|-------|-------|-------|------|------|----|
|          |       |       | Star. | Neb. |      |          |       |       | Star. | Neb. |      |          |       |       | Star. | Neb. |      |    |
| 6563     | 7993  | 3084  | 2.83  | 9.7  | P.   | 6781     | 7988  | 3349  | 4.80  | 11.5 | S.   | 6905     | 7636  | 3418  | 2.77  | 9.6  | S.   |    |
| "        | "     | "     | "     | 10.5 | W.   | "        | "     | "     | "     | 10.6 | P.   | 7009     | 7613  | 3795  | 3.14  | 4.4  | S.   |    |
| 6572     | 7928  | 2774  | 2.76  | 3.5  | P.   | 6818     | 7605  | 3514  | 3.39  | 7.4  | W.   | "        | "     | "     | "     | "    | 4.4  | P. |
| "        | "     | "     | "     | 2.2  | S.   | "        | 7608  | 3418  | 2.77  | 6.8  | S.   | "        | "     | "     | "     | "    | 4.3  | W. |
| 6629     | 7925  | 3199  | 2.30  | 7.2  | W.   | "        | "     | "     | "     | 6.6  | P.   | "        | 7630  | "     | "     | "    | 4.4  | P. |
| "        | 7926  | "     | "     | 6.9  | S.   | "        | 7630  | 3343  | 3.46  | 6.4  | P.   | "        | "     | "     | "     | "    | 3.9  | S. |
| "        | "     | "     | "     | 7.5  | W.   | 6826     | 7631  | 3631  | 1.47  | 6.3  | S.   | "        | 7642  | "     | "     | "    | 6.6  | S. |
| 6629     | 7945  | 3084  | 2.83  | 7.2  | W.   | "        | 7723  | 3419  | 3.05  | 7.1  | P.   | "        | "     | "     | "     | "    | 6.2  | P. |
| 6643     | 8014  | 2657  | 4.49  | 11.9 | S.   | "        | 7725  | "     | "     | 7.0  | P.   | 7026     | 8380  | 3687  | 4.09  | 9.4  | W.   |    |
| "        | "     | "     | "     | 12.4 | W.   | "        | "     | "     | "     | 6.8  | S.   | "        | "     | "     | "     | "    | 10.4 | P. |
| 6720     | 7562  | 3147  | 0.19  | 8.3  | S.   | 6853     | 7990  | 3648  | 2.69  | 9.4  | P.   | "        | 8382  | "     | "     | "    | 9.2  | W. |
| "        | "     | "     | "     | 7.9  | P.   | "        | 7995  | "     | "     | 10.0 | W.   | "        | "     | "     | "     | "    | 8.7  | S. |
| "        | 7594  | "     | "     | 7.4  | P.   | "        | 7990  | "     | "     | 10.4 | P.   | 7027     | 7728  | 3631  | 1.47  | 4.9  | P.   |    |
| "        | "     | "     | "     | 7.7  | S.   | "        | 7995  | "     | "     | 10.6 | W.   | "        | "     | "     | "     | "    | 4.7  | S. |
| "        | "     | "     | "     | 7.4  | W.   | "        | 7990  | "     | "     | 8.7  | P.   | "        | 7729  | "     | "     | "    | 3.2  | S. |
| "        | 7601  | "     | "     | 7.8  | P.   | "        | 7995  | "     | "     | 10.5 | W.   | "        | 7736  | "     | "     | "    | 4.7  | P. |
| "        | "     | "     | "     | 7.6  | W.   | "        | "     | "     | "     | 11.7 | W.   | "        | "     | "     | "     | "    | 4.2  | S. |
| "        | 7853  | "     | "     | 8.8  | P.   | 6894     | 7631  | 3564  | 4.09  | 10.3 | S.   | "        | "     | "     | "     | "    | 4.6  | W. |
| "        | "     | "     | "     | 7.7  | S.   | "        | 7658  | 3583  | 4.13  | 11.4 | P.   | 7302     | 7636  | 3940  | 4.32  | 11.8 | P.   |    |
| 6772     | 7630  | 3343  | 3.46  | 11.7 | P.   | "        | "     | "     | "     | 11.4 | W.   | "        | "     | "     | "     | "    | 11.5 | S. |
| "        | 8368  | 3260  | 3.62  | 12.6 | P.   | "        | 7718  | "     | "     | 11.5 | P.   | "        | 7642  | "     | "     | "    | 10.5 | P. |
| "        | "     | "     | "     | 13.0 | W.   | "        | "     | "     | "     | 11.7 | S.   | "        | "     | "     | "     | "    | 10.9 | S. |
| "        | 8369  | "     | "     | 12.5 | P.   | "        | 7720  | "     | "     | 11.2 | S.   | 7662     | 7643  | 4073  | 3.77  | 6.9  | P.   |    |
| 6781     | 7984  | 3349  | 4.80  | 11.0 | W.   | "        | "     | "     | "     | 11.2 | P.   | "        | "     | "     | "     | "    | 6.4  | S. |
| "        | "     | "     | "     | 10.8 | P.   | 6905     | 7605  | 3429  | 0.97  | 9.1  | W.   | "        | 7722  | 4183  | 442   | 7.5  | P.   |    |
| "        | "     | "     | "     | 11.4 | S.   | "        | 7630  | 3648  | 2.69  | 7.8  | S.   | "        | "     | "     | "     | "    | 6.9  | S. |
| "        | 7987  | 3368  | 4.68  | 11.1 | P.   | "        | "     | "     | "     | 9.0  | P.   | "        | "     | "     | "     | "    | 6.0  | P. |
| "        | "     | 3349  | 4.80  | 11.3 | S.   | "        | 7636  | 3418  | 2.77  | 9.2  | P.   | "        | "     | "     | "     | "    | 6.0  | S. |

the last column, the letters g and l denote respectively that the greatest or the least diameter of the nebula was measured.

Table II. contains the results of the observations of the light of nebulae made with Photometer Q. The first two columns contain the number of each nebula in Dreyer's New General Catalogue, and the last four figures of the Julian Day corresponding to each date of observation. The third and fourth columns contain the number and magnitude of each comparison star, according to the Harvard Photometry. The last two columns contain the magnitude of the nebula, in the sense explained on page 136, and the initial of the observer.

Table III. contains the results of the observations made with regard to the general character of the spectra of the nebulae examined with the direct vision prism. The first two columns contain the number of each nebula in Dreyer's New

TABLE III.

## SPECTRA OF NEBULÆ.

| N. G. C. | J. D. | Sp. | Obs. | N. G. C. | J. D. | Sp. | Obs. | N. G. C. | J. D. | Sp. | Obs. | N. G. C. | J. D. | Sp. | Obs. | N. G. C. | J. D. | Sp. | Obs. |
|----------|-------|-----|------|----------|-------|-----|------|----------|-------|-----|------|----------|-------|-----|------|----------|-------|-----|------|
| 16       | 7636  | C   | P.   | 2438     | 7750  | G   | W.   | 3242     | 7807  | Ge  | W.   | 5247     | 7867  | d   | P.   | 6210     | 7563  | Ge  | S.   |
| 40       | 7725  | ns  | P.   | "        | "     | G   | P.   | "        | "     | Ge  | P.   | "        | "     | g   | W.   | "        | 7612  | Ge  | P.   |
| 404      | 7658  | C   | P.   | "        | 7783  | G   | W.   | 3310     | 7814  | C   | S.   | "        | "     | fe  | S.   | "        | "     | Ge  | W.   |
| 676      | 7658  | C   | S.   | "        | 8131  | G   | W.   | "        | 7816  | d   | P.   | "        | 7876  | Cd  | W.   | "        | 7836  | Ge  | W.   |
| "        | 7725  | dc  | W.   | "        | "     | G   | P.   | "        | "     | Cg  | W.   | 5493     | 7522  | C   | S.   | "        | "     | Ge  | P.   |
| 934      | 8014  | fg  | W.   | 2440     | 7729  | Ge  | W.   | "        | 7819  | C   | P.   | "        | "     | C   | P.   | "        | 7847  | Ge  | W.   |
| 936      | 7643  | C   | P.   | "        | "     | Ge  | S.   | "        | "     | C   | S.   | "        | 7550  | C   | P.   | "        | "     | Ge  | S.   |
| "        | "     | C   | S.   | "        | 7748  | Ge  | W.   | "        | 7844  | c   | W.   | "        | 7581  | C   | S.   | 6229     | 7562  | C   | P.   |
| "        | 7658  | Cg  | W.   | "        | "     | Ge  | P.   | "        | "     | C   | P.   | 5506     | 7550  | d   | P.   | "        | "     | C   | S.   |
| 1253     | 7702  | ns  | P.   | "        | 7752  | G   | P.   | 3521     | 8544  | C   | W.   | 5507     | 7522  | C   | S.   | "        | 7619  | C   | P.   |
| "        | 7717  | c   | P.   | "        | 7783  | Ge  | W.   | "        | "     | C   | P.   | "        | 7550  | d   | P.   | "        | 7846  | C   | P.   |
| "        | "     | C   | W.   | "        | "     | Ge  | P.   | "        | "     | C   | S.   | 5560     | 7509  | C   | S.   | "        | "     | C   | W.   |
| 1287     | 7717  | c   | P.   | "        | 7813  | Ge  | P.   | 3556     | 8610  | C   | P.   | "        | 7522  | e   | S.   | "        | 7847  | C   | W.   |
| 1325     | 7720  | G   | W.   | "        | "     | Ge  | W.   | 3587     | 7816  | g   | P.   | 5566     | 7509  | C   | S.   | "        | 7876  | C   | S.   |
| 1326     | 7746  | eg  | P.   | "        | 7814  | Ge  | W.   | "        | "     | G   | W.   | "        | "     | C   | P.   | 6369     | 7548  | G   | S.   |
| "        | "     | e   | W.   | 2452     | 7752  | g   | W.   | "        | 7844  | G   | W.   | "        | 7522  | C   | S.   | "        | "     | G   | P.   |
| 1501     | 7643  | G   | S.   | "        | 7783  | c   | W.   | 3610     | 8609  | C   | S.   | 5569     | 7509  | d   | S.   | "        | 7581  | G   | P.   |
| "        | "     | G   | P.   | "        | "     | d   | P.   | "        | "     | C   | P.   | 5574     | 7509  | C   | S.   | "        | "     | G   | S.   |
| "        | 7757  | G   | W.   | "        | 7814  | c   | W.   | 3613     | 8609  | c   | P.   | "        | 7522  | C   | S.   | "        | 7876  | G   | S.   |
| "        | 7814  | G   | W.   | 2818     | 7807  | g   | W.   | "        | "     | C   | S.   | 5576     | 7509  | C   | S.   | "        | "     | G   | W.   |
| "        | "     | G   | S.   | "        | 7811  | g   | W.   | 3675     | 8617  | C   | W.   | "        | 7522  | C   | S.   | "        | 7910  | G   | P.   |
| "        | 7816  | G   | S.   | "        | "     | g   | P.   | 4085     | 8609  | df  | P.   | 5577     | 7509  | c   | S.   | "        | "     | G   | W.   |
| "        | "     | Ge  | P.   | "        | 7813  | G   | W.   | 4088     | 8609  | C   | P.   | 5634     | 7525  | C   | S.   | 6514     | 7549  | c   | P.   |
| 1514     | 7702  | Ge  | P.   | 2841     | 8609  | C   | P.   | "        | "     | d   | S.   | 5746     | 7816  | C   | P.   | 6523     | 7548  | c   | P.   |
| 1535     | 7728  | Ge  | P.   | "        | "     | C   | W.   | 4157     | 8609  | C   | P.   | "        | 7863  | C   | W.   | "        | "     | d   | S.   |
| "        | "     | Ge  | W.   | 2903     | 8544  | Cg  | W.   | 4216     | 7526  | c   | S.   | 5813     | 7548  | C   | S.   | 6543     | 7602  | Ge  | P.   |
| "        | 7746  | Ge  | P.   | "        | "     | C   | S.   | 4303     | 7526  | c   | S.   | 5846     | 7548  | C   | S.   | "        | 7604  | Ge  | W.   |
| "        | "     | Ge  | W.   | 2985     | 8610  | C   | P.   | 4621     | 8524  | C   | P.   | "        | 7569  | Cg  | S.   | "        | 7608  | Ge  | S.   |
| 1700     | 7720  | Cg  | W.   | 3115     | 8544  | C   | W.   | 4638     | 8524  | C   | P.   | "        | "     | C   | U.   | "        | "     | Ge  | W.   |
| 1904     | 8528  | C   | P.   | "        | "     | C   | P.   | 4647     | 8524  | C   | P.   | 5904     | 7521  | C   | S.   | "        | 7722  | Ge  | P.   |
| 1931     | 8524  | c   | P.   | 3132     | 7811  | Ge  | P.   | 4649     | 8524  | C   | P.   | "        | 7569  | C   | U.   | "        | "     | Ge  | S.   |
| 1960     | 8524  | C   | P.   | "        | "     | Ge  | S.   | 4736     | 7494  | C   | P.   | "        | "     | C   | S.   | "        | 7853  | Ge  | W.   |
| 1964     | 7720  | C   | P.   | "        | "     | Ge  | W.   | "        | "     | C   | S.   | 5915     | 7521  | c   | S.   | "        | "     | Ge  | P.   |
| "        | "     | Cg  | W.   | "        | 7813  | Ge  | S.   | 4753     | 7525  | C   | S.   | 5937     | 7521  | d   | P.   | 6553     | 7910  | c   | S.   |
| 1999     | 7720  | C   | P.   | "        | "     | Ge  | P.   | 4800     | 7494  | d   | P.   | 6014     | 7522  | c   | S.   | "        | "     | c   | P.   |
| "        | "     | C   | W.   | 3166     | 8544  | C   | P.   | "        | "     | d   | S.   | 6093     | 7519  | C   | P.   | "        | 7951  | g   | W.   |
| 2022     | 7716  | Ge  | W.   | "        | "     | C   | W.   | 4958     | 7525  | C   | S.   | "        | "     | C   | S.   | "        | "     | d   | P.   |
| "        | 7720  | G   | W.   | 3169     | 8544  | C   | P.   | 5144     | 7842  | c   | S.   | "        | 7520  | C   | S.   | 6563     | 7927  | G   | W.   |
| "        | "     | Ge  | P.   | "        | "     | C   | W.   | "        | "     | c   | P.   | "        | 8618  | C   | S.   | "        | "     | G   | S.   |
| "        | 7748  | Ge  | S.   | 3242     | 7493  | ge  | S.   | "        | "     | c   | W.   | "        | "     | C   | W.   | "        | 7993  | G   | P.   |
| "        | "     | G   | P.   | "        | 7494  | G   | P.   | "        | 7846  | fe  | S.   | 6144     | 7520  | c   | S.   | "        | "     | G   | W.   |
| "        | "     | Ge  | W.   | "        | 7783  | Ge  | S.   | "        | "     | C   | P.   | 6210     | 7521  | Ge  | P.   | 6565     | 7911  | G   | P.   |
| 2068     | 8528  | d   | P.   | "        | "     | Ge  | P.   | "        | 7847  | C   | S.   | "        | 7563  | Ge  | P.   | "        | "     | Ge  | W.   |

| N.G.C. | J. D. | Sp. | Obs. | N.G.C. | J. D. | Sp. | Obs. | N.G.C. | J. D. | Sp. | Obs. | N.G.C. | J. D. | Sp. | Obs. | N.G.C. | J. D. | Sp. | Obs. |
|--------|-------|-----|------|--------|-------|-----|------|--------|-------|-----|------|--------|-------|-----|------|--------|-------|-----|------|
| 6572   | 7911  | Gc  | W.   | 6720   | 7492  | Gc  | S.   | 6818   | 7619  | G   | W.   | 6905   | 7636  | G   | S.   | 7129   | 7725  | d   | P.   |
| "      | "     | Gc  | S.   | "      | 7853  | G   | P.   | "      | "     | Gc  | S.   | "      | "     | G   | P.   | 7208   | 7989  | c   | P.   |
| "      | "     | Gc  | P.   | "      | "     | G   | S.   | "      | 7630  | Gc  | P.   | 6956   | 8754  | C   | S.   | "      | "     | cf  | S.   |
| "      | 7916  | Gc  | W.   | 6772   | 7608  | G   | P.   | 6826   | 7631  | Gc  | S.   | 7009   | 7613  | Gc  | P.   | "      | 7990  | e   | P.   |
| "      | 7925  | Gc  | W.   | "      | "     | g   | S.   | "      | 7723  | Gc  | P.   | "      | "     | G   | S.   | "      | "     | c   | W.   |
| "      | "     | Gc  | S.   | "      | "     | G   | W.   | "      | "     | Gc  | S.   | "      | 7630  | Gc  | S.   | 7302   | 7636  | e   | P.   |
| "      | 7927  | Gc  | W.   | "      | 7630  | gf  | P.   | "      | 7725  | Gc  | P.   | "      | 7642  | Gc  | P.   | "      | "     | gf  | S.   |
| "      | 7928  | Ge  | P.   | 6781   | 7984  | G   | W.   | "      | "     | Gc  | S.   | "      | "     | Gc  | S.   | "      | 7642  | c   | P.   |
| 6629   | 7925  | Gc  | W.   | "      | "     | G   | P.   | 6894   | 7631  | G   | S.   | 7023   | 7725  | Cd  | P.   | "      | "     | e   | S.   |
| "      | 7926  | Gc  | W.   | "      | "     | G   | S.   | "      | 7658  | G   | P.   | 7027   | 7728  | Gc  | P.   | 7662   | 7620  | Gc  | S.   |
| "      | "     | Gc  | S.   | "      | 7987  | G   | W.   | "      | "     | G   | W.   | "      | "     | Gc  | S.   | "      | "     | Gc  | W.   |
| "      | 7944  | G   | W.   | "      | "     | G   | P.   | "      | 7718  | G   | P.   | "      | 7729  | Gc  | S.   | "      | "     | G   | P.   |
| "      | 7945  | Gc  | W.   | "      | "     | G   | S.   | "      | "     | G   | S.   | "      | 7736  | Gc  | P.   | "      | 7636  | Gc  | P.   |
| "      | 7951  | Gc  | W.   | "      | 7988  | G   | P.   | 6905   | 7605  | G   | W.   | "      | "     | Gc  | S.   | "      | "     | Gc  | S.   |
| 6643   | 8014  | gc  | W.   | "      | "     | G   | W.   | "      | 7618  | G   | P.   | "      | "     | Gc  | W.   | "      | 7643  | Gc  | P.   |
| "      | "     | Cg  | S.   | "      | "     | G   | S.   | "      | "     | Ge  | S.   | 7078   | 7620  | C   | S.   | "      | "     | Gc  | S.   |
| "      | 8047  | G   | W.   | 6818   | 7605  | G   | W.   | "      | 7630  | G   | S.   | "      | "     | C   | W.   | "      | 8045  | Gc  | P.   |
| "      | "     | e   | P.   | "      | 7619  | G   | P.   | "      | "     | G   | P.   |        |       |     |      |        |       |     |      |

General Catalogue, and the last four figures of the Julian Day, corresponding to each date of observation. The third column contains letters exhibiting the character of the observed spectrum, and the fourth gives the initial of the observer. The letters employed to indicate the character of the spectrum are chiefly C and G, which denote respectively "Continuous" and "Gaseous." When small letters are used instead of capitals, the result of the observation was less decided: thus, c denotes "apparently continuous"; Gc, "a distinctly gaseous spectrum, with the addition of a faint continuous spectrum"; gc, "partly gaseous, partly continuous, but neither well marked"; and Cg, "a distinctly continuous spectrum, but apparently a gaseous spectrum also." The letter d denotes "doubtful"; and, if added to c or g, implies that little confidence was placed by the observer in his estimate of the character of the spectrum. The letters ns, used on a few occasions, show that the observer considered that the faint spectrum or spectra which were visible did not represent the nebula itself, but merely small stars in its vicinity. In these cases, it was supposed that the nebular spectrum was too faint to be visible. The letter f denotes that the spectrum was visible, but very faint.

Table IV. contains a summary of results from Tables I., II., and III. The first three columns contain the number of each nebula in Dreyer's New General Catalogue, and its right ascension and declination for 1900. The next two columns contain the mean result for each measured diameter, from Table I., and the prob-

able error of one observation of that quantity. The next two columns contain a mean result for the magnitude of the nebula, from Table II., and the probable error of one observation. The final column contains letters indicating the general character of the spectrum, according to the separate observations in Table III. The meaning of these letters has been explained on page 143.

TABLE IV.

## SUMMARY OF RESULTS.

| N. G. C. | R. A.<br>1900. |      | Dec.<br>1900. |    | Diam. | P. E. | Light. | P. E. | Sp. | N. G. C. | R. A.<br>1900. |      | Dec.<br>1900. |    | Diam. | P. E. | Light. | P. E. | Sp. |
|----------|----------------|------|---------------|----|-------|-------|--------|-------|-----|----------|----------------|------|---------------|----|-------|-------|--------|-------|-----|
|          | h.             | m.   | °             | '  | "     | "     | "      | "     |     |          | h.             | m.   | °             | '  | "     | "     | "      | "     | C   |
| 16       | 0              | 3.9  | +27           | 10 | ...   | ...   | ...    | ...   | C   | 3521     | 11             | 0.7  | +0            | 30 | ...   | ...   | ...    | ...   | C   |
| 40       | 0              | 7.6  | +71           | 58 | ...   | ...   | ...    | ...   | ns  | 3556     | 11             | 5.7  | +56           | 13 | ...   | ...   | ...    | ...   | C   |
| 404      | 1              | 3.8  | +35           | 11 | ...   | ...   | ...    | ...   | C   | 3587     | 11             | 9.0  | +55           | 34 | ...   | ...   | 11.07  | .82   | G   |
| 676      | 1              | 43.7 | +5            | 25 | ...   | ...   | ...    | ...   | C   | 3610     | 11             | 12.6 | +59           | 20 | ...   | ...   | ...    | ...   | C   |
| 934      | 2              | 22.5 | -0            | 42 | ...   | ...   | ...    | ...   | g   | 3613     | 11             | 12.8 | +58           | 33 | ...   | ...   | ...    | ...   | C   |
| 936      | 2              | 22.5 | -1            | 36 | ...   | ...   | ...    | ...   | C   | 3675     | 11             | 20.7 | +44           | 8  | ...   | ...   | ...    | ...   | C   |
| 1253     | 3              | 9.1  | -3            | 11 | ...   | ...   | ...    | ...   | C   | 4085     | 12             | 0.3  | +50           | 54 | ...   | ...   | ...    | ...   | df  |
| 1287     | 3              | 13.5 | -3            | 6  | ...   | ...   | ...    | ...   | c   | 4088     | 12             | 0.5  | +51           | 6  | ...   | ...   | ...    | ...   | C   |
| 1325     | 3              | 20.1 | -21           | 53 | ...   | ...   | ...    | ...   | G   | 4157     | 12             | 6.0  | +51           | 3  | ...   | ...   | ...    | ...   | C   |
| 1326     | 3              | 20.5 | -36           | 50 | ...   | ...   | ...    | ...   | cg  | 4216     | 12             | 10.8 | +13           | 42 | ...   | ...   | ...    | ...   | e   |
| 1501     | 3              | 58.4 | +60           | 39 | 56.65 | 1.73  | 10.81  | .39   | G   | 4303     | 12             | 16.8 | +5            | 2  | ...   | ...   | ...    | ...   | e   |
| 1514     | 4              | 3.0  | +30           | 31 | ...   | ...   | ...    | ...   | Ge  | 4621     | 12             | 37.0 | +12           | 12 | ...   | ...   | ...    | ...   | C   |
| 1535     | 4              | 9.6  | -13           | 0  | 11.25 | .42   | 6.12   | .26   | Ge  | 4638     | 12             | 37.8 | +11           | 59 | ...   | ...   | ...    | ...   | C   |
| 1700     | 4              | 52.0 | -5            | 1  | ...   | ...   | ...    | ...   | Cg  | 4647     | 12             | 38.5 | +12           | 8  | ...   | ...   | ...    | ...   | C   |
| 1904     | 5              | 20.1 | -24           | 37 | ...   | ...   | ...    | ...   | C   | 4649     | 12             | 38.6 | +12           | 6  | ...   | ...   | ...    | ...   | C   |
| 1931     | 5              | 24.8 | +34           | 10 | ...   | ...   | ...    | ...   | e   | 4736     | 12             | 46.2 | +41           | 40 | ...   | ...   | ...    | ...   | C   |
| 1960     | 5              | 29.7 | +34           | 4  | ...   | ...   | ...    | ...   | C   | 4753     | 12             | 47.2 | -0            | 39 | ...   | ...   | ...    | ...   | C   |
| 1964     | 5              | 29.1 | -22           | 1  | ...   | ...   | ...    | ...   | C   | 4800     | 12             | 50.0 | +47           | 5  | ...   | ...   | ...    | ...   | d   |
| 1999     | 5              | 31.6 | -6            | 47 | ...   | ...   | ...    | ...   | C   | 4958     | 13             | 0.6  | -7            | 29 | ...   | ...   | ...    | ...   | C   |
| 2022     | 5              | 36.6 | +9            | 2  | 28.50 | .36   | 8.95   | .44   | Ge  | 5144     | 13             | 20.0 | +71           | 2  | ...   | ...   | 11.05  | .37   | C   |
| 2068     | 5              | 41.6 | +0            | 1  | ...   | ...   | ...    | ...   | d   | 5247     | 13             | 32.6 | -17           | 22 | ...   | ...   | 10.82  | .30   | d   |
| 2438     | 7              | 37.3 | -14           | 30 | ...   | ...   | 10.32  | .12   | G   | 5493     | 14             | 6.3  | -4            | 34 | ...   | ...   | 6.97   | ..    | C   |
| 2440     | 7              | 37.4 | -17           | 58 | ...   | ...   | 7.08   | .40   | Ge  | 5506     | 14             | 8.0  | -2            | 44 | ...   | ...   | ...    | ...   | d   |
| 2452     | 7              | 43.8 | -27           | 6  | ...   | ...   | ...    | ...   | d   | 5507     | 14             | 8.2  | -2            | 41 | ...   | ...   | ...    | ...   | d   |
| 2818     | 9              | 12.0 | -36           | 12 | ...   | ...   | 10.15  | .19   | g   | 5560     | 14             | 15.0 | +4            | 27 | ...   | ...   | ...    | ...   | C   |
| 2841     | 9              | 15.1 | +51           | 24 | ...   | ...   | ...    | ...   | C   | 5566     | 14             | 15.3 | +4            | 25 | ...   | ...   | ...    | ...   | C   |
| 2903     | 9              | 26.5 | +21           | 56 | ...   | ...   | ...    | ...   | C   | 5569     | 14             | 15.5 | +4            | 25 | ...   | ...   | ...    | ...   | d   |
| 2905     | 9              | 26.5 | +21           | 58 | ...   | ...   | ...    | ...   | e   | 5574     | 14             | 15.9 | +3            | 42 | ...   | ...   | 10.87  | .95   | C   |
| 2985     | 9              | 41.4 | +72           | 45 | ...   | ...   | ...    | ...   | C   | 5576     | 14             | 16.0 | +3            | 44 | ...   | ...   | 8.98   | .60   | C   |
| 3115     | 10             | 0.3  | -7            | 14 | ...   | ...   | ...    | ...   | C   | 5577     | 14             | 16.2 | +3            | 54 | ...   | ...   | 12.95  | .47   | e   |
| 3132     | 10             | 2.8  | -39           | 57 | ...   | ...   | 8.70   | .34   | Ge  | 5634     | 14             | 24.4 | -5            | 32 | ...   | ...   | ...    | ...   | C   |
| 3166     | 10             | 8.6  | +3            | 55 | ...   | ...   | ...    | ...   | C   | 5746     | 14             | 39.9 | +2            | 23 | ...   | ...   | 11.13  | .14   | C   |
| 3169     | 10             | 9.1  | +3            | 58 | ...   | ...   | ...    | ...   | C   | 5813     | 14             | 56.1 | +2            | 6  | ...   | ...   | ...    | ...   | C   |
| 3242     | 10             | 20.0 | -18           | 8  | ...   | ...   | 5.97   | .44   | Ge  | 5846     | 15             | 1.4  | +1            | 59 | ...   | ...   | 8.12   | .19   | C   |
| 3310     | 10             | 32.6 | +54           | 1  | ...   | ...   | 9.29   | .25   | C   | 5904     | 15             | 13.5 | +2            | 27 | ...   | ...   | 6.10   | .17   | C   |

## OBSERVATIONS OF NEBULÆ.

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| N. G. C. | R.A.<br>1900. | Dec.<br>1900. | Diam. | P. E. | Light. | P. E. | Sp. | N. G. C. | R. A.<br>1900. | Dec.<br>1900. | Diam. | P. E. | Light. | P. E. | Sp. |
|----------|---------------|---------------|-------|-------|--------|-------|-----|----------|----------------|---------------|-------|-------|--------|-------|-----|
| 5915     | 15 16.0       | -12 45        | ...   | ...   | ...    | ...   | c   | 6826     | 19 42.1        | +20 17        | 25.30 | .18   | 6.81   | .25   | Gc  |
| 5937     | 15 25.6       | - 2 29        | ...   | ...   | ...    | ...   | d   | "        | " "            | " "           | 23.65 | 2.99  | ...    | ...   | ... |
| 6014     | 15 51.0       | + 6 13        | ...   | ...   | ...    | ...   | c   | "        | " "            | " "           | 22.35 | 3.77  | ...    | ...   | ... |
| 6093     | 16 11.1       | -22 44        | ...   | ...   | ...    | ...   | C   | 6853     | 19 55.3        | +22 27        | ...   | ...   | 9.69   | .33   | ... |
| 6144     | 16 21.2       | -25 49        | ...   | ...   | ...    | ...   | c   | "        | " "            | " "           | ...   | ...   | 10.47  | .06   | ... |
| 6210     | 16 40.3       | +23 59        | 11.95 | .66   | 5.58   | .82   | Gc  | "        | " "            | " "           | ...   | ...   | 9.60   | 1.04  | ... |
| 6229     | 16 44.2       | +47 42        | ...   | ...   | 7.77   | .46   | C   | "        | " "            | " "           | ...   | ...   | 11.63  | ...   | ... |
| 6369     | 17 23.2       | -23 41        | ...   | ...   | 9.05   | .26   | G   | 6894     | 20 12.4        | +30 16        | ...   | ...   | 11.23  | .27   | G   |
| 6514     | 17 56.3       | -23 2         | ...   | ...   | ...    | ...   | c   | 6905     | 20 17.9        | +19 47        | 36.65 | 2.15  | 8.94   | .44   | G   |
| 6523     | 17 57.6       | -24 23        | ...   | ...   | ...    | ...   | c   | 6956     | 20 39.2        | +12 9         | ...   | ...   | ...    | ...   | C   |
| 6543     | 17 58.6       | +66 38        | 21.92 | .93   | 5.26   | .62   | Gc  | 7009     | 20 58.7        | -11 46        | 23.40 | 1.36  | 4.89   | .79   | Gc  |
| "        | " "           | " "           | 18.56 | 1.02  | ...    | ...   | "   | " "      | " "            | 18.56         | .60   | ...   | ...    | ...   | ... |
| 6553     | 18 3.2        | -25 56        | ...   | ...   | 9.55   | .12   | d   | 7023     | 21 0.4         | +67 46        | ...   | ...   | ...    | ...   | Cd  |
| 6563     | 18 5.4        | -33 54        | ...   | ...   | 9.82   | .26   | G   | 7026     | 21 2.9         | +47 27        | ...   | ...   | 9.45   | .49   | ... |
| 6565     | 18 5.4        | -28 12        | ...   | ...   | ...    | ...   | G   | 7027     | 21 3.3         | +41 50        | 11.84 | .37   | 4.39   | .42   | Gc  |
| 6572     | 18 6.2        | + 6 50        | ...   | ...   | 2.88   | .74   | Gc  | "        | " "            | " "           | 8.24  | .28   | ...    | ...   | ... |
| 6629     | 18 19.6       | -23 15        | ...   | ...   | 7.22   | .16   | Gc  | 7078     | 21 25.2        | +11 44        | ...   | ...   | ...    | ...   | C   |
| 6643     | 18 22.6       | +74 31        | ...   | ...   | 12.18  | .29   | ge  | 7129     | 21 40.7        | +65 39        | ...   | ...   | ...    | ...   | d   |
| 6720     | 18 49.9       | +32 54        | ...   | ...   | 7.73   | .21   | G   | 7208     | 22 1.7         | -29 32        | ...   | ...   | ...    | ...   | c   |
| 6772     | 19 9.4        | - 2 53        | ...   | ...   | 12.46  | .35   | G   | 7302     | 22 27.0        | -14 38        | ...   | ...   | 11.18  | .46   | c   |
| 6781     | 19 13.6       | + 6 21        | ...   | ...   | 11.10  | .24   | G   | 7662     | 23 21.1        | +41 59        | 24.54 | .60   | 6.63   | .43   | Gc  |
| 6818     | 19 38.3       | -14 24        | 23.92 | .48   | 6.81   | .31   | Gc  |          |                |               |       |       |        |       |     |

The following remarks comprise such portions of the original records as could not conveniently be reduced to a tabular form, while they still appeared of sufficient interest for publication. Remarks confirmatory of the descriptions of the nebulae previously published have been omitted, as well as many others considered deficient in precision or in importance. Each remark is preceded by the number of the nebula in Dreyer's New General Catalogue, the last four figures of the Julian Day denoting the date of observation, and the initial of the observer.

## REMARKS.

- |  |   |
|--|---|
| 16, 7636, P. Nebula much brighter in the middle, border hazy.  | 5247, 7876, W. Spectrum of central portion continuous; remainder doubtful.                              |
| 1535, 7746, W., P. The photometric observations relate to the central part of the nebula, near the nucleus.                          | 5574, 7510, S. Comparison star perhaps H. P. 2398, magn. 4.23, instead of H. P. 2373, magn. 4.36.       |
| 2438, 8131, W., P. This nebula is annular.   | 5576, 7510, S. See N. G. C. 5574.   |
| 2440, 7783, W. The photometric observations relate to the central part of the nebula.  | 5577, 7510, S. See N. G. C. 5574.   |
| 2440, 7812, W. The photometric observations relate to the brighter part of the nebula.   | 6210, 7563, S. Aperture reduced to 12.7 cm.; field of prism much brighter than that of large telescope. |
| 2387, 7816, W. The south preceding and north following portions of the nebula are the brightest, with a darker channel between them. | 6210, 7563, P. Aperture reduced to 12.7 cm.   |
|  | 6210, 7612, P., W. Spectrum shows a second image towards the more refrangible end.                      |

- 6210, 7612, P. In second photometric observation, aperture reduced to 12.6 cm.
- 6210, 7612, S. Aperture reduced to 12.6 cm. In second observation, images brought nearer together.
- 6210, 7847, S., W. Spectrum shows a second image towards the more refrangible end.
- 6229, 7619, P. Borders hazy; not planetary.
- 6369, 7910, P. Light of ring, not of centre, observed.
- 6543, 7722, P. S. With power of 400, and direct vision prism, a second image is visible towards the more refrangible end of the spectrum. The continuous spectrum also seen appears to be that of the nucleus only.
- 6543, 7853, W. Double gaseous spectrum seen with high power and suspected with low power.
- 6572, 7911, W., S., P. With direct vision prism, second image suspected towards more refrangible end of spectrum.
- 6572, 7916, W. Moonlight bright, but traces of second image certainly seen.
- 6572, 7925, W., S. Second image much fainter than chief image, and close to it on the more refrangible side.
- 6572, 7927, W. Second image plainly visible.
- 6572, 7928, P. Second image seen distinctly.
- 6629, 7951, W. A second image suspected on the more refrangible side of the chief image.
- 6720, 7562, S. The central part of the nebula, within the ring, is no brighter, in moonlight, than the sky surrounding the nebula.
- 6720, 7594, P. The comparison star,  $\alpha$  Lyræ, is bluer than the nebula.
- 6720, 7853, P. Brightest part of the nebula observed. S. Nebula yellow, and star,  $\alpha$  Lyræ, bluish.
- 6826, 7631, S. Star surrounded by small nebula. The photometric observations relate to the nebula, but are impeded by the presence of the star.
- 6826, 7723, P. With direct vision prism, second image suspected. The photometric observations relate to the nebula, not to the nucleus. Diameter measured not recorded.
- 6826, 7725, P. With direct vision prism, second image suspected towards the more refrangible end of the spectrum.
- 6826, 7725, S. Second image not seen. Nebula elongated, with or without prism. The photometric observations relate to the bright central part of the nebula, but not to the nucleus.
- 6853, 7990, 7995, P., W. The first observation by each observer relates to the southern part of the nebula, the second to the central part, and the third to the northern part. The fourth observation by W. relates to the south following tapering end. P. remarked that the southern part was brighter to the eye than the northern, although the photometric observation gave a different result.
- 6905, 7605, W. North following edge the brightest.
- 6905, 7618, P. Moonlight too strong for so faint a nebula as this.
- 7009, 7613, P. Ratio of axes 2 to 3. Position angle of longer axis about  $70^\circ$ .
- 7009, 7617. Position angle of major axis, from measurements by P.,  $78^\circ 3$ ; by W.,  $66^\circ 1$ ; by S.,  $78^\circ 6$ .
- 7009, 7627. Position angle of major axis, from measurements by W.,  $71^\circ 9$ ; by P.,  $77^\circ 2$ .
- 7009, 7630, P. In the photometric observations, the image outside of the focus looks larger than that inside.
- 7027, 7728. No remark on elongation of nebula made by either observer. The measurement of diameter by P. seems, however, to relate to the major, and that by S. to the minor axis.
- 7027, 7729, S. With high power, and without prism, the nebula was seen to be elongated. With the prism, it appeared elongated in the direction of the spectrum, but not brighter at one end than at the other. Hence it was thought that there might be two images not very different in brightness.
- 7027, 7736, S. With the prism, the nebula is somewhat elongated, the elongation not exactly coinciding with that of the continuous spectrum of the nucleus. It is brightest and most sharply defined towards the red end of the spectrum and a little to the left.
- 7662, 7643, P., S. With the prism, a second and fainter image is visible towards the more refrangible end of the spectrum. Without the prism, the nebula looks somewhat annular; that is, the central portion is a little darker than the region surrounding it.
- 7662, 7702, P. Edges hazy.
- 7662, 7722, P., S. In the last two sets of photometric observations, the aperture was reduced to 12.7 cm.
- 7662, 8045, P. With the prism, a third image suspected beyond the more refrangible end of the continuous spectrum. The continuous spectrum is more marked on the less refrangible side.

As the nebula in Orion was too extensive to allow any determination of its general brightness, particular regions in it were selected for observation. Table V. gives the details of these observations in the same form employed in Table II., except that in the first column a letter designating the region observed, replaces the number from Dreyer's New General Catalogue. Table VI. gives the letters designating the regions in the first column, the right ascensions and declinations of the regions for 1900 in the second and third columns, the mean result for the stellar magnitude corresponding to the light of each region in the fourth column, and the probable error of one observation of the light in the last column.

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TABLE V.

LIGHT OF REGIONS IN NEBULA OF ORION.

| Reg. | J. D. | H. P. | Magn. |      | Obs. | Reg. | J. D. | H. P. | Magn. |       | Obs. | Reg. | J. D. | H. P. | Magn. |       | Obs. |
|------|-------|-------|-------|------|------|------|-------|-------|-------|-------|------|------|-------|-------|-------|-------|------|
|      |       |       | Star. | Neb. |      |      |       |       | Star. | Neb.  |      |      |       |       | Star. | Neb.  |      |
| a    | 7754  | 1045  | 1.89  | 7.87 | P.   | e    | 8166  | 1045  | 1.89  | 8.43  | S.   | p    | 7754  | 1039  | 3.74  | 8.75  | P.   |
| "    | "     | "     | "     | 8.70 | P.   | "    | 8168  | "     | "     | 8.68  | W.   | "    | 7755  | "     | "     | 9.14  | W.   |
| "    | 7755  | "     | "     | 9.01 | W.   | f    | 7754  | 1045  | 1.89  | 6.90  | P.   | "    | 7763  | "     | "     | 9.07  | W.   |
| "    | "     | "     | "     | 8.26 | W.   | "    | 7755  | "     | "     | 9.02  | W.   | "    | 7785  | "     | "     | 8.63  | W.   |
| "    | 7763  | "     | "     | 8.45 | W.   | "    | 7763  | "     | "     | 8.46  | W.   | "    | 8166  | "     | "     | 8.86  | S.   |
| "    | 7785  | "     | "     | 8.06 | W.   | "    | 7785  | "     | "     | 7.24  | W.   | "    | 8168  | "     | "     | 9.02  | W.   |
| "    | "     | "     | "     | 7.56 | W.   | "    | 8166  | "     | "     | 8.13  | S.   | q    | 7754  | 1039  | 3.74  | 10.11 | P.   |
| "    | "     | "     | "     | 7.70 | W.   | "    | 8168  | "     | "     | 8.03  | W.   | "    | 7755  | "     | "     | 10.03 | W.   |
| "    | "     | "     | "     | 7.45 | W.   | g    | 7754  | 1039  | 3.74  | 9.09  | P.   | "    | 8166  | "     | "     | 8.97  | S.   |
| "    | 8166  | "     | "     | 7.43 | S.   | "    | 7755  | "     | "     | 9.86  | W.   | "    | 8168  | "     | "     | 9.59  | W.   |
| "    | "     | "     | "     | 8.50 | S.   | "    | 7763  | "     | "     | 9.23  | W.   | r    | 7754  | 1039  | 3.74  | 10.08 | P.   |
| "    | "     | "     | "     | 8.66 | S.   | "    | 7785  | "     | "     | 10.27 | W.   | "    | 7755  | "     | "     | 9.39  | W.   |
| "    | 8168  | "     | "     | 7.89 | W.   | "    | 8166  | "     | "     | 9.67  | S.   | "    | 7785  | "     | "     | 9.74  | W.   |
| "    | "     | "     | "     | 7.68 | W.   | "    | 8168  | "     | "     | 10.00 | W.   | "    | 8168  | "     | "     | 9.21  | W.   |
| "    | "     | "     | "     | 7.87 | W.   | h    | 7754  | 1039  | 3.74  | 10.08 | P.   | "    | 8173  | "     | "     | 9.39  | S.   |
| "    | 8173  | "     | "     | 7.01 | S.   | "    | 7755  | "     | "     | 10.78 | W.   | ad   | 7754  | 1039  | 3.74  | 10.93 | P.   |
| b    | 7754  | 1045  | 1.89  | 7.06 | P.   | "    | 7763  | "     | "     | 10.46 | W.   | "    | 7755  | "     | "     | 10.57 | W.   |
| "    | 7755  | "     | "     | 8.82 | W.   | "    | 7785  | "     | "     | 10.37 | W.   | "    | 7763  | "     | "     | 9.69  | W.   |
| "    | 7763  | "     | "     | 8.10 | W.   | "    | 8168  | "     | "     | 9.88  | W.   | "    | 7785  | "     | "     | 10.16 | W.   |
| "    | 7785  | "     | "     | 7.01 | W.   | k    | 7754  | 1039  | 3.74  | 9.67  | P.   | "    | 8166  | "     | "     | 9.04  | S.   |
| "    | "     | 1039  | 3.74  | 9.65 | W.   | "    | 7755  | "     | "     | 10.69 | W.   | "    | 8168  | "     | "     | 8.94  | W.   |
| "    | 8166  | 1045  | 1.89  | 6.90 | S.   | "    | 7763  | "     | "     | 10.14 | W.   | be   | 7754  | 1039  | 3.74  | 11.47 | P.   |
| "    | 8168  | "     | "     | 7.78 | W.   | "    | 8166  | "     | "     | 9.91  | S.   | "    | 7755  | "     | "     | 10.39 | W.   |
| c    | 7754  | 1045  | 1.89  | 7.50 | P.   | "    | 8168  | "     | "     | 9.85  | W.   | "    | 7763  | "     | "     | 9.55  | W.   |
| "    | 7755  | "     | "     | 8.57 | W.   | l    | 7754  | 1039  | 3.74  | 9.70  | P.   | "    | 7785  | "     | "     | 9.61  | W.   |
| "    | 7763  | "     | "     | 8.40 | W.   | "    | 7755  | "     | "     | 9.51  | W.   | "    | 8166  | "     | "     | 9.81  | S.   |
| "    | 7785  | "     | "     | 6.08 | W.   | "    | 7763  | "     | "     | 9.83  | W.   | "    | 8168  | "     | "     | 10.28 | W.   |
| "    | 8166  | "     | "     | 6.93 | S.   | "    | 7785  | "     | "     | 9.37  | W.   | bf   | 7754  | 1039  | 3.74  | 9.65  | P.   |
| "    | 8168  | "     | "     | 8.18 | W.   | "    | 8168  | "     | "     | 10.00 | W.   | "    | 7755  | "     | "     | 10.55 | W.   |
| d    | 7754  | 1045  | 1.89  | 9.12 | P.   | m    | 7754  | 1039  | 3.74  | 10.69 | P.   | "    | 7763  | "     | "     | 10.77 | W.   |
| "    | 7755  | "     | "     | 9.81 | W.   | "    | 7755  | "     | "     | 10.88 | W.   | "    | 8166  | "     | "     | 9.26  | S.   |
| "    | 7763  | "     | "     | 9.22 | W.   | "    | 7785  | "     | "     | 10.28 | W.   | "    | 8168  | "     | "     | 10.25 | W.   |
| "    | 7785  | "     | "     | 9.32 | W.   | "    | 8168  | "     | "     | 10.72 | W.   | kr   | 7754  | 1039  | 3.74  | 11.07 | P.   |
| "    | 8166  | "     | "     | 9.27 | S.   | "    | 8173  | "     | "     | 9.35  | S.   | "    | 7755  | "     | "     | 11.48 | W.   |
| "    | 8168  | "     | "     | 8.72 | W.   | o    | 7754  | 1039  | 3.74  | 8.62  | P.   | "    | 8166  | "     | "     | 10.18 | S.   |
| e    | 7754  | 1045  | 1.89  | 8.40 | P.   | "    | 7755  | "     | "     | 10.01 | W.   | "    | 8168  | "     | "     | 11.28 | W.   |
| "    | 7755  | "     | "     | 8.57 | W.   | "    | 7785  | "     | "     | 8.94  | W.   | oq   | 7754  | 1039  | 3.74  | 11.06 | P.   |
| "    | 7763  | "     | "     | 8.84 | W.   | "    | 8168  | "     | "     | 9.55  | W.   | "    | 7755  | "     | "     | 11.35 | W.   |
| "    | 7785  | "     | "     | 8.11 | W.   | "    | 8173  | "     | "     | 9.53  | S.   | "    | 8168  | "     | "     | 9.57  | W.   |

TABLE VI.  
DESIGNATION OF REGIONS.

| Region. | R. A.<br>1900. | Dec.<br>1900. | Light. | P. E. | Region. | R. A.<br>1900. | Dec.<br>1900. | Light. | P. E. |
|---------|----------------|---------------|--------|-------|---------|----------------|---------------|--------|-------|
|         | h.<br>m.       | °<br>'        |        |       |         | h.<br>m.       | °<br>'        |        |       |
| a       | 5 30.4         | -5 29.4       | 8.01   | .39   | m       | 5 30.6         | -5 17.7       | 10.38  | .43   |
| b       | 5 30.5         | -5 27.6       | 7.61   | .57   | o       | 5 30.0         | -5 21.1       | 9.33   | .42   |
| c       | 5 30.3         | -5 27.3       | 7.61   | .71   | p       | 5 30.5         | -5 26.6       | 8.91   | .15   |
| d       | 5 30.3         | -5 29.7       | 9.24   | .20   | q       | 5 30.0         | -5 26.6       | 9.68   | .38   |
| e       | 5 30.5         | -5 25.6       | 8.51   | .18   | r       | 5 30.4         | -5 32.0       | 9.56   | .26   |
| f       | 5 30.4         | -5 26.1       | 7.96   | .55   | ad      | 5 30.3         | -5 29.5       | 9.72   | .63   |
| g       | 5 30.8         | -5 28.1       | 9.67   | .33   | be      | 5 30.5         | -5 26.6       | 10.18  | .49   |
| h       | 5 30.9         | -5 36.0       | 10.31  | .26   | bf      | 5 30.4         | -5 26.9       | 10.10  | .48   |
| k       | 5 30.9         | -5 32.0       | 10.05  | .27   | kr      | 5 30.6         | -5 32.0       | 11.00  | .40   |
| l       | 5 30.6         | -5 19.9       | 9.68   | .18   | oq      | 5 30.0         | -5 23.8       | 10.66  | .75   |