

values different from those determined from the brighter stars (§ 11 and Table IV.).

(4) Results are given in Tables I.–IV. for two distinct systems of measurement. Up to a certain point the two methods do not differ much in accuracy. The defect of the first (described in § 5) lies in the uncertainty with which measures can be reproduced after an interval or under different circumstances (§ 9 and Table II). The simple bisection method is much easier, but has the defect that it indicates a change of scale value with star magnitude, this anomaly being conspicuous in the abscissæ, but not in the ordinates (§ 11).

University Observatory, Oxford:
1902 Nov. 8.

William Herschel's observed Nebulous Regions, 52 in number, compared with Isaac Roberts' Photographs of the same Regions, taken simultaneously with the 20-inch reflector and the 5-inch Cooke lens. By Isaac Roberts, D.Sc., F.R.S.

William Herschel communicated a paper to the Royal Society which was published in the *Philosophical Transactions* in the year 1811, vol. 74, pp. 269 to 336, under the title of "The Construction of the Heavens"; and in a part of it is a section with the title: "Extensive Diffused Nebulosity" and "Observations of Nebulosities that have not been published before." Fifty-two regions in the sky are stated to be thus affected, and their coordinates of position and the approximate extent of the nebulosity are given in tabular form.

A century nearly has elapsed since these important statements were made, and astronomers still theorise and speculate concerning these nebulous regions in reliance upon the deservedly high eminence and conscientious care with which Herschel executed all his work. The aggregate extent of the diffused nebulosity in these fifty-two regions he estimated to cover about 151.7 square degrees, and he suggested that these represented only a small portion of the total areas in the sky that are similarly affected with nebulosity.

It occurred to me, several years ago, that it would be useful scientific work to photograph, with my 20-inch reflector, the fifty-two regions of diffused nebulosity which had been recorded by Herschel, and thus either verify, or correct, his observations in case of the absence of nebulosity. The photographs would also furnish data, that would be free from human bias and error, in the settlement of the questions, or inferences, which have been founded upon Herschel's records of these nebulous regions.

The work was commenced by me in 1896 and was completed

in 1902. The photographs have been taken, in duplicate, with the 20-inch reflector and a special lens of 5-inch aperture, made by Cooke & Sons, of York, known as Taylor's patent triplet lens. The exposures of the plate with the two instruments were made, in all cases, simultaneously and during equal times; the plates were selected and tested to be practically equal in sensitiveness; the duration of each dual exposure was ninety minutes, which my long previous experience in photographing the stars and nebulae enabled me to judge that nebulosity of the faintness of stars of 16th to 17th magnitude would leave images upon the photographic plates exposed in the 20-inch reflector, and images of the 14th to 15th magnitude on those exposed in the 5-inch lens camera.

The results which I expected to obtain by these methods were that stars and nebulosity of at least the degree of faintness seen by Herschel would be shown on the reflector plates, and be, therefore, evidence that would be accepted with full confidence by astronomers.

The lapse of so many years since the publication of Herschel's paper, and the consequent difficulty in obtaining copies of it for study, suggested to me the desirability of quoting in my present communication to this Society, so much of it as would explain the view he then entertained concerning these nebulous regions as initial parts in "The Construction of the Heavens." The tabular method adopted by Herschel in publishing the results of his telescopic observations enables me to give the photographic results in a concise and intelligible form, coinciding line by line with his, by comparing the headings and reading the descriptive matter attached to each object respectively.

I shall now quote from Herschel's paper in the *Philosophical Transactions* above referred to.

1. "Extensive diffused Nebulosity.
2. "Observations of Nebulosities that have not been published before.

"It may be easily supposed that in my sweeps in the heavens I was not inattentive to extensive diffusions of nebulosity, which occasionally fell under my observation. They can only be seen when the air is perfectly clear, and when the observer has been in the dark long enough for the eye to recover from the impression of having been in the light.

"I have collected fifty-two such observations in a table, and have arranged them in the order of right ascension; in the first column they are numbered; in the second and third columns are the right ascension and north polar distance of a place, which is the central point of a parallelogram comprehending the space which the nebulosity was observed to fill. They are calculated for the year 1800.

"The length and breadth of the parallelograms are set down in the fourth and fifth columns in degrees and minutes of a great circle, the time taken up in the transit of each parallelo-

gram having been properly reduced to space by the polar distance given in the third column, in order to make it agree with the space contained in the breadth of the zone described by the telescope. The dimensions of the former space, therefore, is in the parallel, and that of the latter in the meridian. My field of view being fifteen minutes in diameter, its extent has been properly considered in the assigned dimensions of the parallelograms. It is, however, evident that the limits of the sweeping zone leave the extent of the nebulosity in the meridian unascertained. The beginning of it is equally uncertain, since the nebulous state of the heavens could only be noticed when its appearance became remarkable enough to attract attention. The ending is always left undetermined; for, as the right ascension was only taken once, I have allowed but a single minute of time for the extent of the nebulosity in that direction, except where the time was repeatedly taken with a view to ascertain how far it went in the parallel; or when the circumstances of its brightness pointed out a longer duration.

"The sixth column of the table contains the size of the observed nebulosity reduced to square degrees and decimals, computed from the two preceding columns; and in the last I have given the account of these nebulosities as recorded in my sweeps at the time they were made, namely, within a period of nineteen years, beginning in 1783 and ending in 1802.

"When this account says 'Affected,' it is intended to mean that the ground upon which, or through which, we see or may see stars is affected with nebulosity.

"In looking over this table it may be noticed that I have inserted several nebulosities that were only suspected. Had I been less scrupulous at the time of observation the word suspected would generally have been omitted; for with this nebulosity, as well as with the great number of nebulae that in my catalogues are marked suspected, I have, almost without exception, found in a second review that the entertained suspicion was either fully confirmed, or that, without having had any previous notice of the former observation, the same suspicion was renewed when I came to the same place again.

"When these observations are examined with a view to improve our knowledge of the construction of the heavens, we see in the first place that extensive diffused nebulosity is exceedingly great indeed; for the account of it, as stated in the table, is 151.7 square degrees; but this, it must be remembered, gives us by no means the real limits of it, neither in the parallel nor in the meridian; moreover, the dimensions in the table give only its superficial extent; the depth or third dimension of it may be far beyond the reach of our telescopes; and when these considerations together are added to what has been said in the foregoing article, it will be evident that the abundance of nebulous matter diffused through such an expansion of the heavens must exceed all imagination.

"By nebulous matter I mean to denote that substance, or rather those substances which give out light, whatsoever may be their nature, or of whatever different powers they may be possessed.

"Another remark of equal importance arises from the consideration of the observed nebulosities. By the account of the table we find that extreme faintness is predominant in most of them ; which renders it probable that our best instruments will not reach so far into the profundity of space as to see more distant diffusions of it. In No. 44 of the table we have an instance of faint milky nebulosity, which, though pretty bright in some places, was completely lost from faintness in others ; and No. 46 confirms the same remark. It has also been mentioned in the first article that the nebulosity in V. 14 was brighter in three or four places than in the rest. The stars also of the Milky Way which were scattered over it, and were generally very small, appeared with a brilliancy that will admit of no comparison with the dimness of the brightest nebulosity. In consequence of this we may already surmise that the range of the visibility of the nebulous matter is confined to very moderate limits."

The photographs were taken with an exposure of the plates during 90^m in duplicate simultaneously with the 20-inch reflector and with the 5-inch Cooke lens. In all cases the objects were photographed when on or near the meridian. The reflector plates measure 2° by 2°, and the stars upon them are shown to the faintness of the 16th or 17th magnitude. On the 5 inch camera plates they are shown to the faintness of about the 14th or 15th magnitude.

Herschel's Nos.	R.A. 1900. h m s	Decl. 1900. ° ' "	Herschel's descriptions in the Phil. Trans. 1811.	Dates when photographs were taken.	Isaac Roberts's descriptions of his photographs.
1	0 10 8	9 26	Much affected with nebulosity.	1900 Nov. 22	Sky clear, stars small and faint and few in number ; large areas void of stars ; no nebulosity on plate.
2	0 17 37	3 59	Much affected.	1899 Sept. 5	Sky clear ; stars small and faint and not very numerous ; large areas void of stars ; no nebulosity on plate ; film dark.
3	0 22 23	29 9	Affected.	1899 Sept. 9	Sky clear ; stars small and very, very numerous, one star of 5.9 mag. = D.M. 75, zone 28°, on plate ; small areas void of stars ; no nebulosity.
4	0 25 37	3 59	Much affected.	1900 Nov. 22	Sky clear ; stars few and faint, large areas void of stars ; no nebulosity on plate.
5	0 30 11	23 25	Much affected.	1900 Oct. 27	Sky clear ; stars faint and numerous ; nebulae H III. 476 and N.G.C. 169, d'Arrest and Ld. R. together with other fainter ones on plate ; many areas void of stars ; no diffused nebulosity.

Herschel's Nos.	R.A. 1900. h m s			Decl. 1900. ° ' "	Herschel's descrip- tions in the Phil. Trans. 1811.	Dates when photographs were taken.	Isaac Roberts's descriptions of his photographs.
6	0	36	28	0 29	Appeared to be affected with very faint nebulosity.	1899 Oct. 28	Sky very clear; stars small and very few in number; large areas void of stars; some small nebulae on plate; no diffused nebulosity.
7	0	38	0	41 10	Affected with nebulosity.	1895 Oct. 17	Sky very clear; stars crowded on plate; many small areas void of stars; several photographs have been taken of this region, which includes the great An- dromeda nebula M 31, part of the <i>n.f.</i> end of which would cross Herschel's field of view in this sweep.
8	0	39	27	39 16	Unequally affected.	1900 Oct. 17	Sky clear; stars crowded on plate; many small areas void of stars; part of <i>s.p.</i> end of M 31 on plate; no other diffused nebulosity.
9	0	41	19	43 30	Suspected faint nebulosity.	1900 Oct. 26	Sky clear; stars small and crowded on plate; many small areas void of stars; no diffused nebulosity.
10	0	48	38	43 35	Suspected faint nebulosity.	1900 Oct. 26	Sky clear; stars small and crowded on plate; numerous areas void of stars; nebula N.G.C. 317 on plate; no diffused nebulosity.
11	1	41	8	29 48	Suspected to be tinged with milky nebulosity.	1900 Nov. 27	Sky clear; stars small and numerous; large areas void of stars; no nebulosity.
12	2	27	55	19 0	Much affected with nebu- losity.	1900 Dec. 13	Sky clear; stars small and not very numerous; large areas void of stars; some very small and faint nebulae on plate; no diffused nebulosity.
13	4	2	14	25 11	Much affected.	1901 Feb. 13	Sky very clear; stars small and numerous; large areas void of stars; no nebulosity.
14	4	23	51	35 7	Suspected pretty strong nebulosity.	1901 Feb. 13	Sky very clear; stars small and crowded on <i>s.</i> and <i>s.p.</i> sides, but few on the rest of the plate; large areas void of stars; nebula H I. 217, and also a 10th mag. star surrounded by very faint nebulosity, H I. 217 on plate; no nebulous region.
15	4	24	51	35 8	Suspected nebulosity.		
16	4	26	29	-7 30	Strong milky nebulosity.	1901 Feb. 14	Sky clear; stars small and very few on plate; large areas void of stars; no nebulosity.

Nov. 1902.

Nebulous Regions etc.

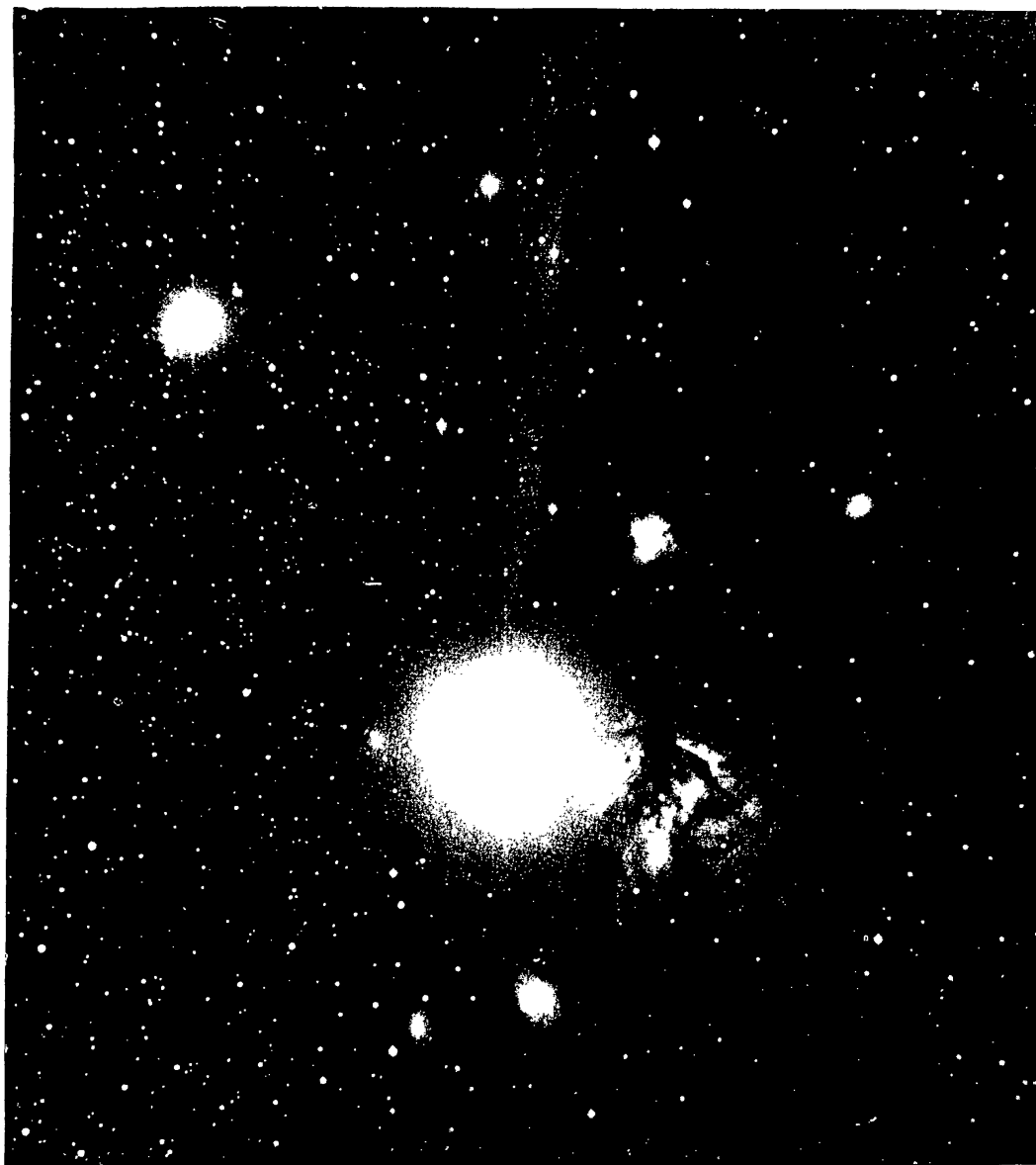
31

Herschel's Nos.	R.A. 1900. h m s	Decl. 1900. ° ' "	Herschel's descrip- tions in the Phil. Trans. 1811.	Dates when photographs were taken.	Isaac Roberts's descriptions of his photographs.
17	4 29 2	20 50	Much affected.	1901 Feb. 15	Sky very clear; stars small and very numerous; small areas void of stars; no nebulosity.
18	4 44 5	20 50	Much affected.	1901 Feb. 15	Sky very clear; stars small and crowded on plate; small areas void of stars; no nebulosity.
19	4 52 17	26 45	Strong suspi- cion of very faint milky nebulosity.	1901 Mar. 9	Sky clear; stars small and very few; large areas void of stars; no nebulosity.
20	5 15 50	25 1	Very much affected.	1901 Mar. 12	Sky clear; stars small and very few on plate; large areas void of stars; no nebulosity.
21	5 19 20	25 1	Affected.		
22	5 28 53	-6 56	Affected with milky nebu- losity.	1901 Mar. 13	Sky clear; stars not very numerous; large areas void of stars; H IV. 33 Orionis on plate; no nebulosity.
23	5 30 10	-2 43	Affected.	1901 Mar. 12	Sky clear; stars small and very few; large areas void of stars; no nebulosity.
24	5 31 56	-4 18	Visible and unequally bright nebu- losity. I am pretty sure that this joins to the great nebu- la in Orion.	1902 Mar. 5	Sky very clear; stars small and not very numerous; areas void of stars; no nebulosity on plate.
25	5 35 34	-2 31	Diffused milky nebulosity.	1900 Jan. 25	Sky very clear; stars very numerous on <i>p.</i> half of plate, but few on the <i>f.</i> half, where there are large areas void of stars; large cloud of nebulosity <i>n.f.</i>

ζ Orionis with broad division void of stars, but with some nebulosity in *s.f.* to *n.p.* direction; other divisions break up the cloud into separate masses. To the *s.* of ζ is a stream of nebulosity 54 minutes of arc in length, with an embayment free from nebulosity dividing it in halves. Another faint nebulosity extends from ζ 27 minutes of arc towards the *s.*, *s.p.* and *n.p.* The star D.M. 1001, zone -1°, is in the midst of nebulosity, and it has a companion on the *s.p.* side. The star D.M. 1005, zone -1°, is involved in a large cloud of streaky nebulosity and it has a companion on *p.* side. The star D.M. 1345, zone -2°, is H IV. 24, N.G.C. 2023. It is in the midst of a large dense streaky cloud of nebulosity which has in it condensations and remarkable rifts free from nebulosity; near the *s.* end of one of these rifts is a 12th mag. star. The star D.M. 1350, zone -2°, is in the midst of a cloud of nebulosity with some faint structure in it; it has a faint companion on the *n.p.* side. The region here referred to, which covers 4 square degrees of the sky, has so many remarkable features that it is necessary, in order to make it intelligible to the reader, to present the photograph annexed along with the above description.

Herschel's Nos.	R.A. 1900.			Decl. 1900.	Herschel's descrip- tions in the Phil. Trans. 1811.	Dates when photographs were taken.	Isaac Roberts's descriptions of his photograph.
	h	m	s	°	'		
26	5	36	52	-6	57	A pretty strong suspicion of nebosity.	1901 Mar. 22 Sky clear; stars small and few; large areas void of stars; no nebosity.
27	5	43	11	+1	8	Affected with milky nebu- losity.	1901 Mar. 13 Sky clear; stars very few in number; large areas void of stars; no nebosity.
28	6	1	1	+3	44	Much affected.	1902 Jan. 29 Sky clear; stars crowded on <i>n.f.</i> and <i>s.p.</i> sides; areas void of stars; no nebosity.
29	6	0	54	-20	27	Affected.	1902 Mar. 6 Sky clear; stars small and very numerous; many areas void of stars; no nebosity.
30	6	40	7	41	16	Affected.	1901 Mar. 22 Sky clear; stars few in number; large areas void of stars; cluster H VIII. 71 on plate; no nebu- losity.
31	9	27	32	-18	27	Affected.	1902 Mar. 6 Sky clear; stars small and few in number; large areas void of stars; no nebosity.
32	9	36	43	71	13	Much affected with very faint whitish nebosity.	1901 Apr. 12 Sky clear; stars small and numerous; several large areas void of stars; no nebosity.
33	10	11	50	-9	3	Very faint whitish nebu- losity.	1901 Apr. 15 Sky clear; stars small and numerous; large areas void of stars; no nebosity.
34	10	22	25	51	32	Much affected.	1901 Apr. 13 Sky clear; stars small and not numerous; large areas void of stars; no nebosity.
35	10	40	59	62	45	Affected with very faint nebosity.	1901 Apr. 14 Sky clear; stars small and not very numerous; large areas void of stars; no nebosity.
36	11	4	30	62	44	Affected.	1901 Apr. 15 Sky clear; stars small and numerous; areas void of stars; several small faint nebulae on plate; no diffused nebosity.
37	12	2	5	30	37	Affected with whitish nebu- losity.	1901 Apr. 17 Sky clear; stars small and few in number; large areas void of stars; H II. 321 and H II. 802 on plate; no nebosity.
38	12	12	40	30	37	Affected with whitish nebu- losity.	1901 Apr. 18 Sky clear; stars few in number; large areas void of stars; four small prominent nebulae on plate; no diffused nebosity.
39	13	12	15	34	8	Much affected.	1901 Apr. 17 Sky clear; stars not very numerous; large areas void of stars; no nebosity.

S

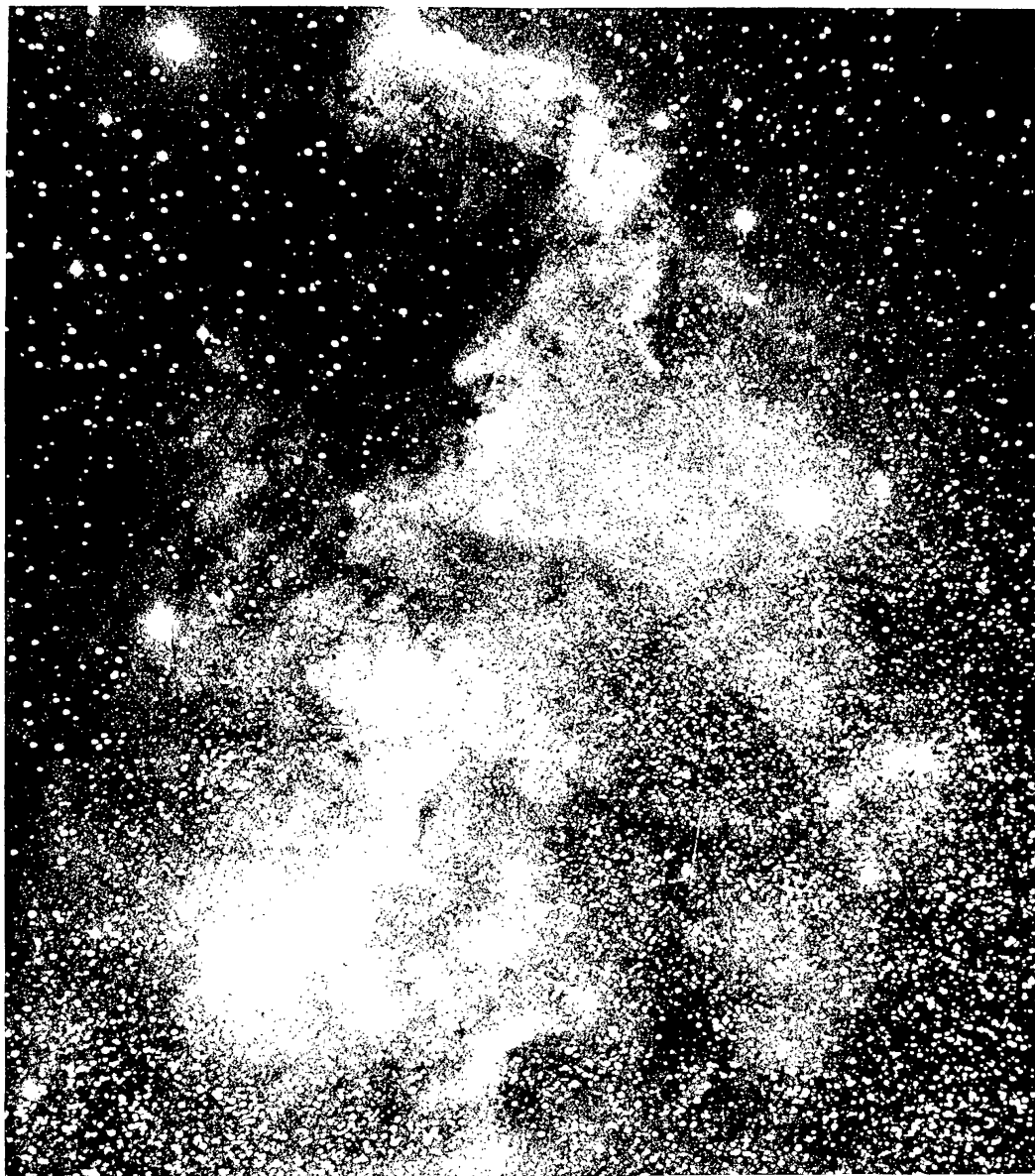


N

PHOTOGRAPH OF NEBULOSITY ROUND ζ ORIONIS

BY ISAAC ROBERTS, D.Sc., F.R.S.

S



N

PHOTOGRAPH OF NEBULOSITY HERSCHEL V. 37 CYGNI

BY ISAAC ROBERTS, D.Sc., F.R.S.

Nov. 1902.

Nebulous Regions etc.

33

Her- schel's Nos.	R.A. 1900. h m s	Decl. 1900. ° ' "	Herschel's descrip- tions in the Phil. Trans. 1811.	Dates when photographs were taken.	Isaac Roberts's descriptions of his photographs.
40	14 2 20	34 8	Very much af- fected, and many faint nebulae sus- pected.	1899 June 2	Sky clear; stars small and not numerous; areas void of stars; no nebulosity.
41	15 9 37	18 57	Affected with very faint nebulosity	1899 June 12	Sky clear; stars small and not very numerous; areas void of stars; no nebulosity.
42	21 3 26	-1 53	Much affected with whitish nebulosity.	1902 Nov. 4	Sky clear; stars very numerous; no nebulosity. Herschel's sweep 42, as given in the <i>Phil.</i> <i>Trans.</i> (R.A. 1800 = 20 ^h 58 ^m 20 ^s , N.P.D. 1800 = 92° 17') is not in sequence; as this may be due to a typographical error in one of the coordinates, a plate corresponding to (R.A. 1800 = 20 ^h 38 ^m 20 ^s , N.P.D. 1800 = 92° 17') was taken on 1897 Aug. 28 as follows:
				1897 Aug. 28	Sky very clear; stars crowded on plate; no nebulosity.
43	20 53 15	16 44	A good deal affected.	1897 Oct. 20	Sky clear; stars crowded on plate; no nebulosity.
44	20 54 34	43 32	Faint milky nebulosity scattered over this space, in some places pretty bright.	1896 Oct. 10	Sky very clear; stars crowded on parts of plate; large areas void of stars on others; nebula H.V.37, N.G.C. 7000, forms part of this region; the photograph shows it as a magnificent object. I have published a photograph of this region in Vol. II. of <i>Stars, Star-Clusters and Nebulae</i> , Pl. 24, p. 155, and also in <i>Knowledge</i> , 1898 Nov. 1. A copy is also annexed to this paper.
45	20 57 34	-1 34	Much affected with whitish nebulosity.	1897 Sept. 21	Sky clear; stars small and numerous; no nebulosity.
46	20 56 55	43 16	Suspected nebulosity joining to plainly visi- ble diffused nebulosity.	1896 Oct. 10	Regions 44 and 46 are on the same plate; see description given above, No. 44.
47	21 5 8	14 21	Affected.	1899 Aug. 6	Sky clear; stars small and crowded on plate; no nebulosity.
48	21 34 15	10 19	Much affected.	1898 Oct. 12	Sky clear; stars small and numerous; areas void of stars; no nebulosity.

D

Herschel's Nos.	R.A. 1900. h m s	Decl. 1900. ° ' "	Herschel's descriptions in the Phil. Trans. 1811.	Dates when photographs were taken.	Isaac Roberts's descriptions of his photographs.
49	21 46 52	21 31	Affected.	1899 Aug. 9	Sky clear; stars small and crowded; areas void of stars; no nebulosity.
50	22 57 24	25 45	Much affected.	1898 Sept. 20	{ Sky clear; stars very numerous; areas void of stars; no nebulosity.
51	22 57 54	25 45	Affected.		
52	23 0 17	29 17	A little affected.	1900 Oct. 27	Sky clear; stars small and very numerous; areas void of stars; $\frac{1}{2}$ II. 212 on plate; no diffused nebulosity.

Conclusions.

The final results of the correlation of Herschel's fifty-two nebulous regions and my photographs can be given in a few words, as follows :

Of the fifty-two nebulous regions described by Herschel, the photographs show diffused nebulosity on four of them only ; there is no visible trace of diffused nebulosity on forty-eight of the areas, but on the remaining four, which are Nos. 7, 25, 44, and 46 respectively in the table, there is nebulosity with remarkable characteristic features, and these are delineated upon three of the photographs, regions Nos. 44 and 46 being on one plate.

Two photographs have been enlarged as paper prints, and are reproduced on Plates 1 and 2, an examination of which will convey a more accurate knowledge of the objects than is possible by any descriptive matter.

Note on Photographs of Comet b 1902 (Perrine), taken at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

Photographs of Comet b 1902 (Perrine) were obtained on twenty-seven nights, between September 6 and October 29. With the exception of one or two photographs at the beginning, the 30-inch reflector was used. Twenty-nine of the photographs of short exposure showing a well-defined nucleus have been selected for measurement for the position of the comet, and the results deduced from them will be communicated to the Society later. The exposures with the 30-inch reflector ranged from 5^m to $\frac{1}{2}^m$, according to the brightness of the comet. Besides these, seven photographs with long exposures, ranging from 13^m to 70^m , were also taken, those obtained on September 26 and September 29 (the latter reproduced on Plate 3) being of special interest. On these days the exposures were 53^m and 62^m



COMET *b* 1902, SEPT. 29

From the photograph of the comet (Fig. 10, p. 10)