

ON A GREAT NEBULOUS REGION AND ON THE QUESTION OF ABSORBING MATTER IN SPACE AND THE TRANSPARENCY OF THE NEBULAE

By E. E. BARNARD

While photographing the region of the great nebula of ρ *Ophiuchi* (which I had found with the Willard lens) at the Lick Observatory in 1893, the plates with the small lantern lens ($1\frac{1}{2}$ inches diameter, also attached to the Willard mounting) showed a remarkable nebula involving the 4.5 magnitude star ν *Scorpii* (Plate I). It had not been noticed on the Willard lens photograph, where it was very faint and near the edge of the plate. The discovery of this object therefore is due to the small lantern lens.

Roughly this nebula is bounded by the figure formed by the following places (for 1855.0):

	^a	^{δ}
15 ^h 59 ^m		-18° 20'
16 4		-18 0
and		
16 10		-21 00
16 16		-18 50

In its fainter portions it involves to the southeast the stars *B. D.*

19°4357, -19°4359, and -19°4361. The last two are in a dense nebulous mass in which on the north following side close to the stars are a thin dark lane and a narrow strip of brighter nebulosity. These two stars are joined to -19°4357, which is itself nebulous, by a thin thread of nebulosity which is well shown in Plate II A. North and following these objects are dark regions where there are apparently very few stars. The extensions of this great nebula reach to, and in a feeble manner connect with, the great nebula of ρ *Ophiuchi*.

The greatest interest in this nebula, however, lies in the fact that it seems to show a veiling of the stars in certain of its portions. Especially is this noticeable at its northern and western end, near the stars -17°4511, -17°4502, and -18°4240. It is quite evident that the thinning out or dimming of the stars in this region, that are apparently in the nebula, is not due to a chance vacancy. The line of demarka-

PLATE I

N



E

W

GREAT NEBULA OF NU SCORPII
10-Inch Lens. 1905, April 4, 19^h 25^m to 24^h 20^m G. M. T. Scale: 1° = 37 mm
The plate covers 3° 9' X 3° 1'

tion between the rich and poor portions of the sky here is too definitely and suddenly drawn by the edges of the nebula to assume the appearance due to an actual thinning out of the stars. It looks, where this part of the nebula spreads out, as if the fainter stars were lost, and the brightness of the others reduced at least a magnitude or more. This remarkable feature of the nebula is very important to a proper understanding of the region of the great nebula of ρ *Ophiuchi*, which is five degrees south of ν *Scorpii*. In the region of ρ *Ophiuchi* there is every appearance of a blotting-out of the stars by the fainter portions of the nebula, but from its complicated and irregular form the hiding of the stars is not so clearly evident as in the case of the ν *Scorpii* nebula. At present we have no means of determining whether a nebula is transparent or not. The assumption has always been that they are transparent like the comets. The proof of the transparency of comets is easy, but for obvious reasons there can be no similar proof with respect to the nebulae. I think in the present case, however, that the nebula of ν *Scorpii* is shown to be at least partially transparent, but the absorption of the light of the stars behind it must be considerable. The picture is quite conclusive evidence that the nebula is nearer to us than the general background of stars at this point. This fact, unfortunately, is not so evident in the reproduction as it is in the original, an inspection of which would at once lead to the above conclusion.

In connection with the present subject I would call attention to a paper of mine in *Astrophysical Journal*, 23, 144, March 1906, which describes a very intricate and straggling nebula in this region, connecting the stars π and δ *Scorpii*. I believe this object will ultimately be found, with more sensitive plates and longer exposures, to be connected with the ν *Scorpii* and ρ *Ophiuchi* nebulosities. The accompanying chart, which covers parts of the constellations *Ophiuchus*, *Scorpio*, *Libra*, and *Lupus*, is intended to show the relation of these various nebulosities to each other. There is strong evidence that they are but the brighter parts of one enormous nebula that covers all this region. I have indicated only the brighter portions of these nebulosities, especially in the case of ρ *Ophiuchi*, for that nebula extends in a strongly marked manner for some distance to the east and can be traced for at least 5° in α and $6\frac{1}{2}^\circ$ in δ . Indeed I am

convinced that all this region as far east as θ *Ophiuchi* and beyond is affected with this diffused nebulosity.

The ρ *Ophiuchi* nebula is far more remarkable than that of ν *Scorpii*. Indeed I do not think there is a finer nebula in the entire sky. Even in comparison with the great nebula of *Orion* in some

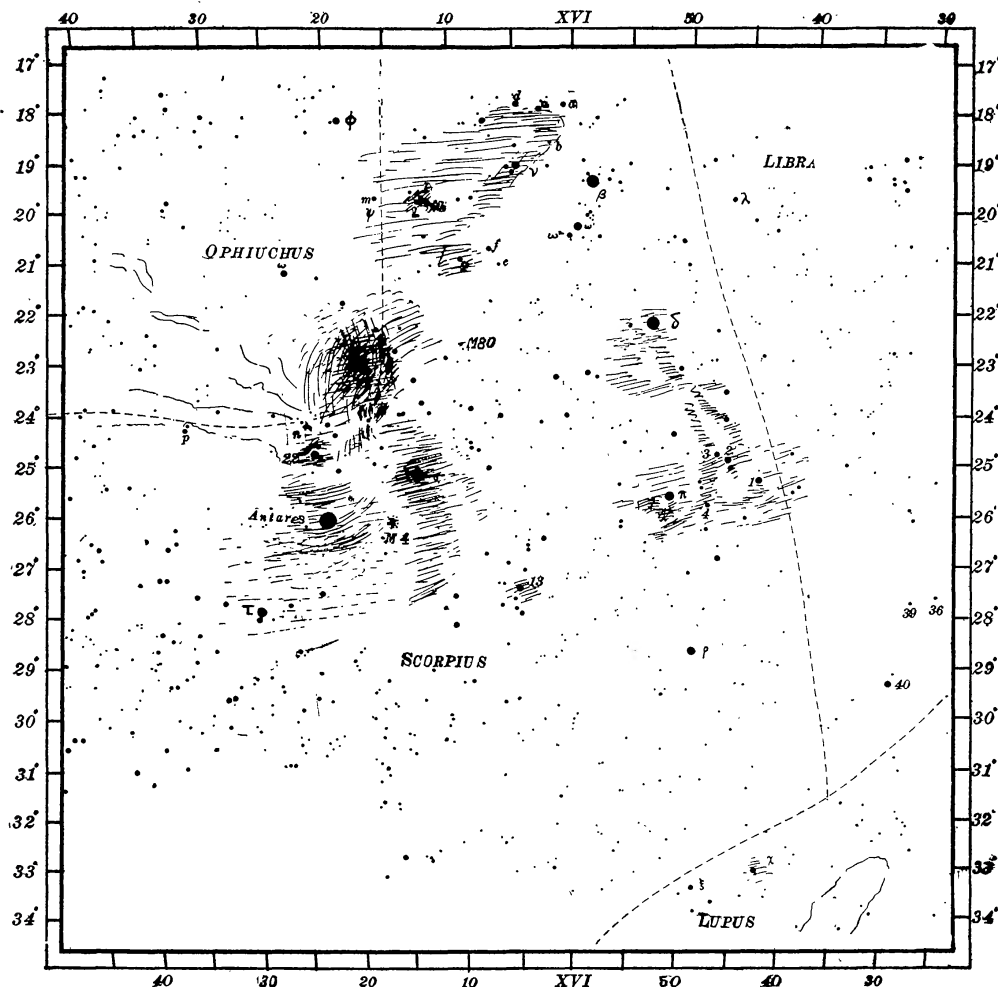
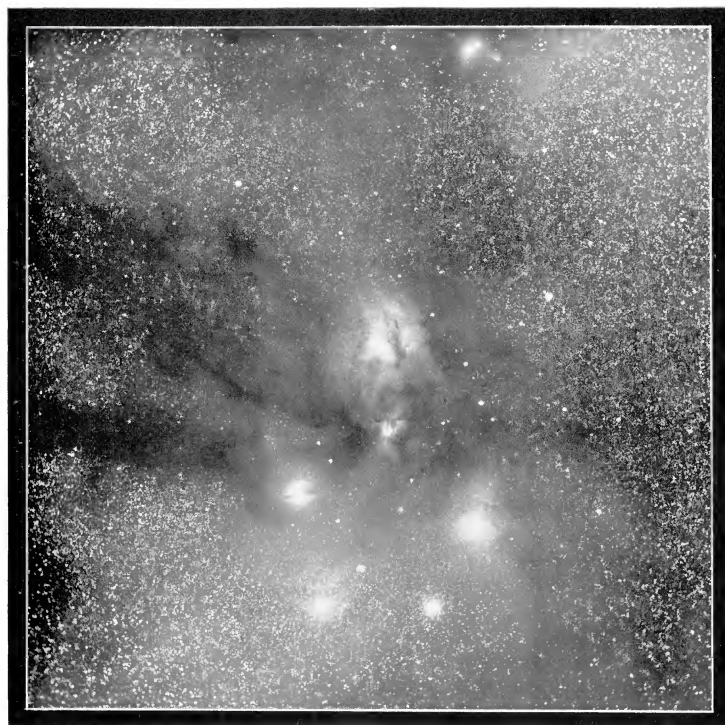


CHART OF THE GREAT NEBULOUS REGION

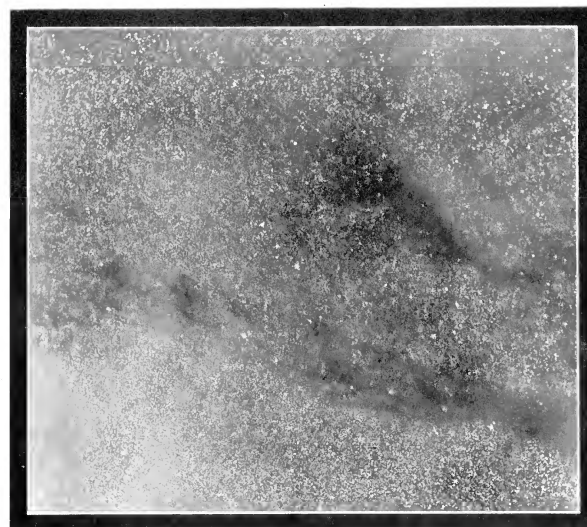
respects it has a deeper interest because of the aspect of the sky near it. It is impossible adequately to describe in detail its extraordinary nature and that of the surrounding region. The reproduction falls far short of doing justice to this subject, though it shows the brighter parts of the nebula fairly well. The dark lanes which run eastward

PLATE II A
N



GREAT NEBULOUS REGION OF RHO *OPHIUCHI*
10-Inch Lens. 1905, April 5, 19^h 45^m to 24^h 15^m G. M. T. Scale: 1°=16.7 mm
The plate covers 7°7'×7°7'

PLATE II B
N



EXTENSION OF VACANT LANES TOWARD THE EAST
Plates overlap slightly. Center of plate at $\alpha=16^h 45^m$, $\delta=22^\circ$ South
10-Inch Lens. 1905, June 3, 17^h 0^m to 21^h 0^m G. M. T. Scale: 1°=13.5 mm
The plate covers 7°6'×6°7'

from it contain very striking black markings, especially the northern one of the two. To me these singular dark features are of as much importance as the bright portions of the nebula, but it has been impossible to bring them out, in the half-tone. The picture shows, however, the striking absence of stars in the space occupied by the main portions of the nebula. To all appearance, the great nebula is located in a hole in a very dense part of the Milky Way, from which vacant lanes extend far to the east. Besides the two main condensations, σ *Scorpii* is involved in a very strong and irregular condensation which is marked by a considerable amount of detail and which spreads in a faint diffusion for several degrees to the south. In addition to the main great condensations there is another one, equally remarkable, 1° due south of ρ at the star *C.D.*— $24^\circ.12684$. This presents a very singular and striking appearance. From the star as a center issue four bright whorls of nebulosity, which are each about $20'$ or $30'$ long, the two running north and south being the longest. About $14'$ north and slightly east is a singular U-shaped dark marking that is so distinct as to appear almost like a defect. Immediately following this condensation is a dark whirlpool appearance which is formed by the beginning of the vacant lanes running to the east.

The two main and largest condensations lie, one, about the triple star ρ *Ophiuchi*, and the other, equally important, precedes it to the west about $30'$. This last does not seem to center at any particular star. These condensations are separated by an irregular dark rift $20'$ to $30'$ long, which runs north and south. North of ρ the nebula assumes a beautiful ribbed appearance which is but feebly represented in the half-tone. The star 22 *Ophiuchi* lies between two diverging strips of nebulosity, the northern and upper strip curving around the star. This star and the nebulous strips singularly resemble a human eye, from which fact I have called it "the eye." Waves of nebulosity extend to and beyond *Antares*, diffusing as far south as τ *Scorpii*. At its upper edge this plate (Plate II A) shows the three nebulous stars which are near the lower left-hand corner of Plate I. It also shows a portion of the nebula of ν *Scorpii* about $\frac{3}{4}$ inch or 19 mm ($1^\circ 8'$) to the west of these stars. Part of the illumination in the extreme upper right-hand corner of Plate II A is due to the

reproduction. The portion of the great ν *Scorpii* nebula which is shown at this point is readily made out (because of its great intensity) 0.9 inch from the right-hand outer edge of the block and 1.1 inches from the upper edge. The rest in this corner is unreal. The diffused nebulosity south of *Antares* is relatively too bright in the half-tone, though it is real.

The star n (which is *C. D.* --24° 12698) is 0.41 inch north and 0.25 inch east of 22 *Scorpii*. It has a narrow strip of nebulosity extending west and south from it for about 6'. This is noticeable on Plate II A.

Among the most remarkable features of this marvelous region are the vacant lanes or streams, previously referred to, extending to the east. The lower or southern of these, which is $\frac{1}{2}^\circ$ broad, is the strongest marked. Its full extent is beautifully shown in Plate II B, which overlaps Plate II A. Its edges are very clearly defined for about 7° , after which it becomes broken and shattered and ends 10° to the east in an irregular group of small holes. The northern and shorter of the two most conspicuous lanes is marked for about 2° with very black, irregular, and sharply defined rifts and perforations which unfortunately are lost in the reproduction. For a history of the discovery of this great nebulous region see *Popular Astronomy*, 5, 227, September 1897.

I have at other times called attention to the fact that the real connection of this great nebula with such bright stars as σ *Scorpii*, ρ *Ophiuchi*, and others, and its connection with the substratum of small stars of the Milky Way, in which the lanes occur, was a proof of the actual smallness of the stars forming the groundwork of the Milky Way at this point and elsewhere. This must necessarily be true, for the connection with the bright and small stars would imply that the small stars are roughly as near to us as the large ones in this part of the sky, and hence relatively small bodies. If, however, the connection with the small stars is only apparent and the lanes and holes are due to absorbing media between us and the Milky Way, the supposition of smallness would not hold true.

While speaking of these strange dark forms, such as are connected with the ρ *Ophiuchi* nebula, and which are so wonderfully shown on the photographs of the region of θ *Ophiuchi* (*Astrophysical Journal*,

9, 157, 1899, and *Popular Astronomy*, 14, 579, Dec. 1906), I would call special attention to an object of this class which has been shown on a number of my photographs for the past fifteen years or more. It is a small black hole in the sky, very much like a black planetary nebula. It is round and sharply defined. Its measured diameter on the negative is 2'.6. The position is closely:

$$1875.0 \text{ } \alpha = 18^{\text{h}}25^{\text{m}}31^{\text{s}}, \delta = -26^{\circ} 9'.$$

On account of its sharpness and smallness and its isolation, this is perhaps the most remarkable of all the black holes with which I am acquainted. It lies in an ordinary part of the Milky Way and is not due to the presence or absence of stars, but seems really to be a marking on the sky itself.

If these dark spaces of the sky are due to absorbing matter between us and the stars—and I must confess that their looks tempt one to this belief—such matter must, in many cases, be perfectly opaque, for in certain parts of the sky the stars are apparently entirely blotted out. It is hard to believe in the existence of such matter on such a tremendous scale as is implied by the photographs. As to its nature if it does exist, it must in some way be related to the nebulae, for we find them in most cases to be intimately connected. Is it an ultimate condition of nebulous matter or is it something wholly different from the ordinary nebulosity of the sky?

To those who may be interested in the subject of possible masses of dark absorbing matter in space in connection with visible nebulosities I would refer to a paper of mine, "On a Nebulous Groundwork in the Constellation *Taurus*," *Astrophysical Journal*, 25, 218, April 1907, where a system of dark lanes and holes in *Taurus* is shown to exist in the sky independently of the stars.

The accompanying photographs were made by me with the 10-inch Brashear lens of the Bruce photographic doublet which, through the courtesy of Professor Hale, was temporarily stationed at the Solar Observatory of the Carnegie Institution on Mount Wilson, California, in 1905.

As will be noticed in the photographs the great lane extending to the east from "the eye" on Plate II A and continued in Plate II B runs almost due east and west. While at the Lick Observatory,

I once showed a plate of this region to Professor Tucker, who had such a large part in the making of the *Cordoba Durchmusterung*. He said that this picture made clear an experience in his observing work at Cordoba that had always been a puzzle to him. One night he had set his telescope in the region a little north of *Antares* and prepared to record the transits of stars as they passed through the field. Presently no stars came into the field of his telescope. After watching for some time he finally concluded the sky had clouded over, but on looking out he found it perfectly clear. He returned and watched a long time before any stars appeared. His telescope had been pointed to this lane and nothing but blank sky had passed.

LIST OF STARS REFERRED TO ON THE CHART

Bonner Durchmusterung, EPOCH 1855.0

	No.	Mag.	α	δ	
<i>b</i>	-18° 4240	7.5	16 ^h 0 ^m 39. ^s 1	-18° 36'.4	
<i>c</i>	-17 4502	6.5	16 1 34.4	-17 57.1	
<i>v</i> <i>Scorpii</i>	-19 4333	4.5	16 3 33.9	-19 4.4	
<i>d</i>	-17 4511	7.3	16 3 40.6	-17 51.0	
<i>e</i>	-21 4305	7.0	16 5 9.4	-21 1.5	
<i>f</i>	-20 4444	6.8	16 5 56.9	-20 43.8	
<i>g</i>	-20 4454	6.8	16 8 26.8	-20 56.2	
<i>h</i>	-19 4357	6.0	16 10 38.3	-19 51.5	
<i>k</i>	-19 4359	7.7	16 11 36.3	-19 41.9	
<i>l</i>	-19 4361	7.3	16 12 0.8	-19 45.7	
ψ <i>Ophiuchi</i> = <i>m</i>	-19 4365	5.0	16 15 37.3	-19 4.6	

Cordoba Durchmusterung, EPOCH 1875.0

	No.	Mag.	α	δ	
χ <i>Lupi</i>	-33° 10754	4.2	15 ^h 43 ^m 1 ^s 8	-33° 14'.7	
π <i>Scorpii</i>	-25 11228	3.4	15 51 18.0	-25 45.3	
δ <i>Scorpii</i>	-22 11292	2.7	15 52 57.1	-22 16.2	
ι 3 <i>Scorpii</i>	-27 10841	5.3	16 4 36.6	-27 35.7	
σ <i>Scorpii</i>	-25 11484	3.4	16 13 37.2	-25 17.1	
	-24 12684	8.0	16 17 52.1	-24 10.3	} The star with the 4 whorls
ρ <i>Ophiuchi</i>	-23 12861	4.8	16 18 6.1	-23 9.2	
<i>Antares</i>	-25 11359	1.4	16 21 46.0	-26 8.9	
ζ 2 <i>Scorpii</i>	-24 12695	5.5	16 22 37.6	-24 50.5	
<i>n</i>	-24 12698	9.3	16 24 7.4	-24 8.8	
τ <i>Scorpii</i>	-27 11015	3.2	16 28 6.8	-27 57.2	
<i>p</i>	-24 12765	6.3	16 34 2.4	-24 13.5	

YERKES OBSERVATORY

November 30, 1909