

DARK REGIONS IN THE SKY SUGGESTING AN OBSCURATION OF LIGHT

By E. E. BARNARD

The so-called "black holes" in the Milky Way are of very great interest. Some of them are so definite that, possibly, they suggest not vacancies, but rather some kind of obscuring body lying in the Milky Way, or between us and it, which cuts out the light from the stars. This explanation seems to become more and more plausible the more we know of these objects. In previous papers I have called attention to this possible obscuring matter, splendid examples of which are connected with the great nebulosities about the stars ρ *Ophiuchi* and ν *Scorpii*. See *Astrophysical Journal*, 31, 8, 1910, for an article bearing on this subject.

One of the most remarkable of these spots—remarkable because of its smallness and definite form—is in one of the dense star-clouds, in the position:

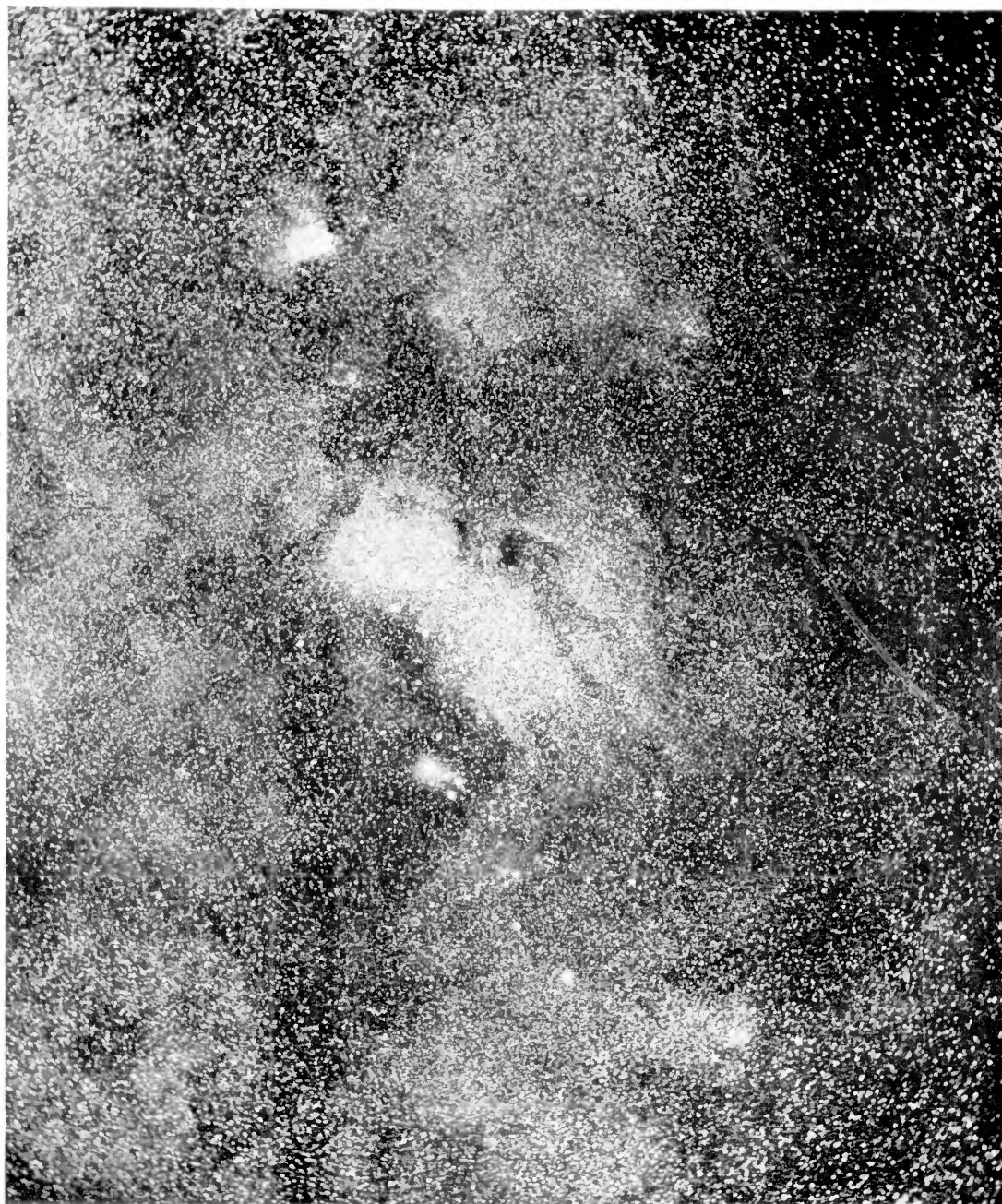
$$1855.0 \quad \alpha = 18^{\text{h}}7^{\text{m}} \quad \delta = -18^{\circ}15'.$$

Photographs taken with portrait lenses show it to be about 15' in diameter, north and south, with its following side very sharply defined. The preceding side is diffused and sprinkled with small stars. Near the center is a considerable star, with one or two smaller ones near it. To show the location of this object in the sky, a photograph taken by the writer at Mount Wilson, California, on July 31, 1905, with the 10-inch Bruce lens of the Yerkes Observatory, with an exposure of 4^h30^m is given (Plate XIX). Its true form, however, is more clearly shown in the fourfold enlargement (Plate XX, Fig. 2).

Known to me in my early days of comet-seeking, this object has always been of the deepest interest, and it was one of the first subjects that I sought to study with the Willard lens at the Lick Observatory. I have also examined it repeatedly with the great telescopes of the Lick and Yerkes observatories. In these visual

PLATE XIX

North



E. E. Barnard

BLACK SPOT IN STAR CLOUD IN SAGITTARIUS

1855.0 $\alpha = 18^{\text{h}}7^{\text{m}}$ $\delta = -18^{\circ}15'$

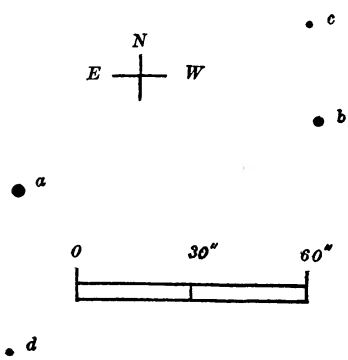
10-inch Bruce telescope 1905 July 31, Exposure 4^h30^m

Scale $\left\{ \begin{array}{l} 1 \text{ in.} = 77'.9 \\ 1 \text{ cm} = 30'.7 \end{array} \right.$

observations there has sometimes been a suspicion that I could see an actual object at this point. An observation of this kind, however, requires both good definition and good transparency. A little unsteadiness of the air blurs the light of the many near-by stars into a mistiness of the field, and a want of transparency cuts off any feebly luminous object and readily defeats any effort to see it. On the night of July 27 of the present year, the conditions were very favorable, both for transparency and for steadiness. Under these conditions the hole or spot was examined very carefully with the 40-inch telescope. With its following edge cutting across the middle of the field, which is some three times smaller than the spot, it was quite distinctly seen that the preceding half of the field, in which there were no stars, was very feebly luminous, while the following side showed a rich, dark sky with the few small stars on it. From the view, one would not question for a moment that a real object—dusky looking, but very feebly brighter than the sky—occupies the place of the spot. It would appear, therefore, that the object may be not a vacancy among the stars, but a more or less opaque body.

The photographs with a portrait lens show this object black against a luminous sky. The explanation of this apparent anomaly is that the sky about it is filled with innumerable small stars, both visible and invisible, with perhaps some nebulosity. The effect of these upon the plate is to counterbalance the feeble light from the matter forming the hole, and thus to produce by contrast the appearance of a vacant spot; or in other words, if the object were placed on the ordinary dark sky away from the Milky Way, it would be seen and photographed as a luminous spot, sharply defined on one side and diffused on the other; or, similar to a sun-spot, it is black only by contrast with its brighter surroundings. Perhaps this can be made clearer when we remember that the scale of the portrait lens is relatively very small, and that the stars crowd together here so thickly that their images on the photograph almost coalesce into a complete bright sheet, or continuous background, on which the spot stands out strongly. This of course accentuates the definiteness of the hole and the contrast it makes with the sky. If a sufficiently long exposure were

made with a long-focus instrument like the 40-inch telescope, to show the faintest stars on the portrait lens plate, the hole



would not be recognizable except from the want of stars at that point. This is essentially what happens, only it is more marked, in the visual observations of this object with the large telescope.

At the suggestion of Professor J. C. Kapteyn, I have measured the position of the small star in the hole with respect to stars outside of it, as there is a possibility that the star is on this side of the general back-

FIG. 1.—Chart of stars in black spot 1855.0: $\alpha = 18^h 7^m$; $\delta = -18^\circ 15'$.

ground. I have also measured the positions of several faint stars quite near with respect to it. See diagram, Fig 1.

THE CENTRAL STAR AND AN $8\frac{1}{2}$ MAGNITUDE STAR FOLLOWING
(=B.D. -18°4871 [8^m4])

Date	$\Delta\alpha \cos \delta$	$\Delta\delta$
1913.504 July 3	-301.91	+0' 40".3
.513 6	-301.57	+ 40.3
.529 12	-301.65	+ 40.3
1913.515	-301.71	+0 40.3

$\therefore \Delta\alpha = -0^m 21^s 18.$

On July 6, 1913, the $\Delta\alpha$ was also determined by transits:

$\Delta\alpha = -0^m 21^s 10$ (8 tr.).

On this last date also, I measured by transits the position of the small star relative to a 9th-magnitude star preceding it, =B.D. -18°4853 (9^m2) = Bordeaux A.G.C. 5313.

1913 July 6 $\Delta\alpha$ (small star -9^m star) +1^m7^s11 (8 tr.)
 $\Delta\delta$ +2' 26".4 (4).

These last measures give the position of the small star (which we shall call *a*):

1913.0 $\alpha = 18^h 10^m 28^s 82$ $\delta = -18^\circ 15' 27".3$.

Singularly enough the star 4853 is in the *Bordeaux Catalogue* (No. 5313), while 4871, a much brighter star, is not.

Following are the measures of the smaller stars:

a and b

Date	P.A.	Dist.	Mags.
1911.391 May 23	285°25	80.67	11.0 13.0
.424 June 4	282.41	80.34	12.2 13.9
.429 6	282.32	80.37	
.462 18	282.14	80.59	
1913.504 July 3	282.30	80.33	
1911.842	282.88	80.46	11.9 13.6

b and c

1911.391 May 23	3°62	25".76	15.5
.424 June 4	3.56	25.38	16
.462 18	5.73	25.01	15
1911.426	4.30	25.38	15.5

a and d

1913.570 July 27	176°13	42".14	15½
.576 29	175.83	42.43	16½
1913.573	175.98	42.28	16

On June 18, 1911, *d* was estimated to be of the 16th magnitude. It is very faint and difficult to measure, and is shown very feebly on the original photograph. The star *c* is difficult to measure unless the seeing is good.

The plate also shows a narrow black marking some 20' following the one under discussion. This is very black in its north end, and is doubtless of a similar nature to the larger one.

Another black spot, which I came across some thirty-odd years ago,¹ is perhaps still more remarkable because it is even smaller (5' = in diameter). It is found in a dense part of the Milky Way, in about the position:

$$1875.0 \quad \alpha = 17^{\text{h}}55^{\text{m}}1 \quad \delta = -27^{\circ}59'.$$

¹ *Astronomische Nachrichten*, 108, 369, 1884.

It is a very striking object in a 5-inch telescope, where it looks like a drop of ink on the luminous sky. The photographs show it black, but with some faint stars in it. On the preceding border is a bright orange-colored star (perhaps *Argentine General Catalogue*, 24531 [$8\frac{1}{2}$ mag.])

$$1875.0 \quad \alpha = 17^{\text{h}}55^{\text{m}}32^{\text{s}}.04 \quad \delta = -27^{\circ}53'19''.8.$$

Near the hole, and preceding it, is a cluster of small stars.

There are many other small black spots in the Milky Way (which are shown on my photographs) in which I am interested, and of which it is hoped soon to make a catalogue. A considerable number of very small ones are found in the great star cloud whose center is in

$$1855.0 \quad \alpha = 18^{\text{h}}46^{\text{m}} \quad \delta = -7\frac{1}{2}^{\circ}.$$

With respect to the question of obscuration of light in space, there is one other object which strikingly shows this effect. In the east side of the well known nebulous stream that runs southward from ζ *Orionis* is a very conspicuous black notch which is very sharply defined. This striking feature is well shown on a photograph by Dr. Isaac Roberts which was printed in the *Astrophysical Journal*, 17, Plate IV. In the text of his article ("Herschel's Nebulous Regions") at p. 74, Dr. Roberts refers to the dark spot as an "embayment," and dismisses it with the following statement: "To the south of ζ is a stream of nebulosity, $54'$ of arc in length, with an embayment free from nebulosity dividing it in halves."

This object has not received the attention it deserves. It seems to be looked upon as a rift or hole in the nebulosity, as implied in the quotation from Dr. Roberts' paper. I have made numerous photographs of it, and in the past winter gave a long exposure with the expressed purpose of showing more definitely the true form of the object. This last photograph on February 7, 1913, with an exposure of $4^{\text{h}}33^{\text{m}}$, shows the nebulosity better than I have seen it before. Instead of an indentation, the almost complete outline of a dark object is shown projected against the bright nebulosity. The west side of it is very definite and sharp, while the eastern limit is scarcely discernible, and is entirely lost in the enlargement. The best description I can give of it is to

present the photograph of the object itself for inspection (Plate XX, Fig. 1). A glance at the original would show that this is not a perforation in the nebula. It is clearly a dark body projected against, and breaking the continuity of, the brighter nebulosity. Possibly this is a portion of the nebula itself nearer to us, but dark and opaque, that cuts out the light from the rest of the nebula against which it is projected.

On the night of November 4, 1913, with good conditions of seeing and fair transparency, I examined this object with the 40-inch telescope and a power of 460. The position was carefully located with the aid of the photograph. The outlines of the spot—so sharp and clear in photographs of this region—could not be made out with any definiteness. The view showed that the spot is certainly not clear sky, for the field was dull, apparently indicating the presence of some material substance at this point. To me the observation would confirm the supposition of an obscuring medium at this point.

The position of this remarkable object from the *B.D.* charts is

$$1855.0 \quad \alpha = 5^{\text{h}}33^{\text{m}}6 \quad \delta = -2^{\circ}35'.$$

YERKES OBSERVATORY
November 15, 1913