

Lick's deed required that it should be, "the most powerful in the world." We have but just begun to use it regularly. In many details it is as yet incomplete, but its performance up to this time has proved to us that, if it is rightly used under suitable conditions, it will produce superb results. The chief object of this note is, as I have said, not so much to add any fact of scientific value to what is known, as to enable a judgment to be made of the power of this latest addition to the family of great telescopes.

*Lick Observatory, University of California,
Mount Hamilton : 1888, July 15.*

Observations of Nebulæ at the Lick Observatory. By Edward S. Holden, Foreign Associate of the R.A.S., and J. M. Schæberle.

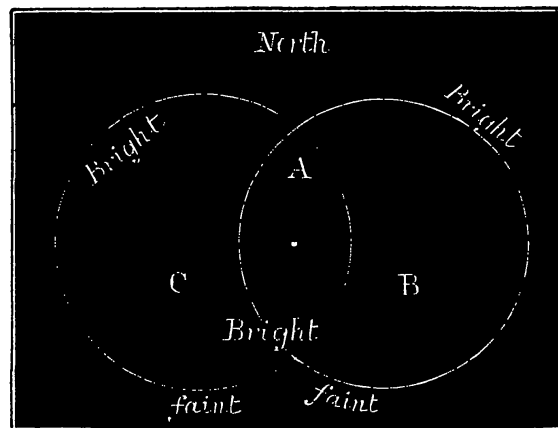
In the intervals of other work the great equatorial has been turned upon some of the more interesting nebulæ. Our observations of the annular nebula in *Lyra* have already been communicated to the Royal Astronomical Society. We beg to communicate herewith further observations upon nebulæ of the planetary class, one of which (37 H. iv., *Draconis*) has proved to be a highly complex and interesting object of a new class.

Helical-Nebula, 37 H. iv., Draconis = G. C. 4373.

This nebula (of which a drawing is given) was first viewed here on July 27, 1888.

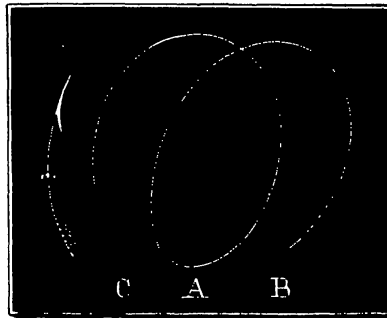
Its bright blue colour and elliptic shape make it one of the most interesting of the class of planetary nebulæ with central stars. It was examined with powers from 270 to 2000 and even higher, and bears magnifying well, losing only its characteristic and remarkable colour with the higher powers.

The nebula is apparently composed of rings overlying each other, and it is difficult to resist the conviction that these are arranged in space in the form of a true helix. The following diagram will illustrate this.



At the first glance the nebula appears to consist of two circles, C and B, which intersect so as to form the space A which surrounds the central star. At the south point of intersection the brightness is approximately twice the average brightness of the circumference; at the north point it is less bright relatively than this. A little attention, however, seems to show that these rings are so arranged that the complete ring C (360°) lies on the hither side (nearer the eye) of the complete ring B (360°); or, if we consider the helix to be generated by the motion of a luminous point in the direction of the arrow, the circumference B is last described.

A then appears to be a part of both B and C. This appearance is perfectly well seen with the central star in exact focus, and it is entirely unmistakable under these conditions with all the eyepieces. It is, however, much better seen with the eyepieces outside of the best focus for the central star. The aspect of the nebula is not changed in this way, but the brighter portions become relatively brighter, narrower, and more sharply defined.



With an eyepiece magnifying 700 diameters one of the observers (E. S. H.) focussed carefully on *Mars*, $\delta = -15^\circ$, and the focussing scale read 2.77 inches; on *Jupiter*, $\delta = -19^\circ$, the reading was 2.75 inches; on the central star of the nebula $\delta = +67^\circ$, 2.76 inches. The nebula itself was well seen with the setting 2.76, but was much better seen when the focus was lengthened by $\frac{44}{100}$ of an inch (reading of scale 3.20 inches): $\frac{44}{100}$ of an inch is about $\frac{1}{1500}$ of the focal length of the objective. A suggestion of Mr. Keeler's that the longer focal adjustment on the nebula was necessary because the central star was essentially red or yellow, while the nebula was unmistakably blue, was tested on August 6, and found to be correct by means of a small pocket spectroscope by Browning. The light of the nebula with a wide slit was monochromatic and blue. The image of the nebula, under these circumstances, was crossed by the continuous spectrum of the central star in which the colours, red and yellow, were plainly visible. With a narrow slit the spectrum of the nebula was seen to consist of three lines.

The places of these lines were first determined by Dr.

Huggins, in his celebrated paper on the "Spectra of Some of the Nebulae" (*Philosophical Transactions*, 1864, p. 438).

After viewing this object under the circumstances in which it is seen blue here, it is difficult to escape the conviction that in this instance we have the first example of a nebula whose brighter parts are arranged in a true helix. The disposition of the fainter parts has nothing to discredit this conception. In fact it is perfectly easy to conceive the true form of the whole nebula to be that of a cylinder, with the helix of the brighter portions wound upon its outer surface.

We have, therefore, ventured to designate this object as a *helical nebula*—the first of its class—because its brighter portions unquestionably *appear to the eye* in a helical and not simply in a spiral form; and also because it seems to us at least probable that the real disposition of the brighter parts in space *may be* in the form of a helix.

The accompanying figure (Plate 4, fig. 1) is the best representation which we could make. It is highly unsatisfactory at the best; and in order to present more data, extracts from our observing book of July 31, 1888, are given below.

"With power 270, focussed on a star. The central star of the nebula is also in good focus, and the helical shapes are perfectly well seen. They are also seen with the eyepiece inside of focus, and best of all with the eyepiece slightly outside.

"With power 670; the same.

"With other (higher) powers; the same. The higher the power the greater the advantage gained by viewing the nebula slightly out of focus.

"Near the *west* end of the minor axis of A is the darkest part of A; the *south* half of A is the next darkest. The *north* half of A is pretty well filled up with nebulosity.

"The whole of the interior of B is pretty dark; it is darkest towards the *north-west* edge.

"The interior of C is darkest on the *east* and *south* sides."

Circumferences.

"The brightest part of the nebula is about 20° at the *south* extremity of A. The next brightest is about 40° in the *north-west* edge of B. The third brightest part of the circumference begins at the *north* point of A, and extends about 70° towards the *north-east* (in C). Beyond that point the circumference of C is rapidly fainter."

"Starting from the point where C and A join, at the *south*, the first 30° of the circumference is faint; the next 40° fairly bright; then comes a fainter portion; and then the circumference is bright till it joins A at the *north*, where C seems to overlie A."

"The *east* half of the circumference of A is pretty bright as far *north* as the central star, and the rest of the way it is very

faint. The *west* half of the circumference of A is pretty faint for the first 30° or more, commencing at the north point; and then pretty bright down to the *south* point of A."

"The circumference of B is faint and diffused from the *south* point of A to the *west* end of the major axis of the nebula; from the latter point for 70° or so it is quite bright, and fainter again before it re-joins A at the *north*."

The outlying nebulosity is about as drawn, only that it is relatively too bright in the sketch.

The only thing specially noteworthy with regard to this outlying nebulosity is the dark space lying on the *north-east* side of the whole nebula which separates two spires of nebulous matter.

A star 14 magnitude, north of the nebula in the direction of the minor axis, has a nebulous appendage on its *west* side. The central star is 11 magnitude. Another star is shown in the sketch close *south-following* the circumference of B. A node of nebulosity or a faint star is obvious in the brightest part (the *north-west* part) of the circumference of B.

"The longest diameter of A makes an angle of about 25° with the minor axis of the whole nebula, and is inclined towards the *west* at its *north* extremity."

The foregoing notes, together with the sketch, will probably serve as a sufficient description of this most remarkable of Sir William Herschel's planetary nebulæ, which seems to be the first known example of an entirely new class of objects.

Ring Nebula, 1 H. iv., Aquarii, G. C. 4628.

The accompanying drawing (Plate 4, fig. 2) gives a fair idea of the shape of this truly wonderful object. One of the best general representations of this nebula may be found in Mr. Lassell's paper, *Memoirs of the Royal Astronomical Society*, vol. xxxvi., plate x., figure 37.

The colour is a pale blue. The form of the object is perfectly well seen with the central star in focus. It is a little better seen by moving the eyepiece outside of focus until the central star almost disappears.

None of the shapes are changed by this process, but the bright central ring becomes narrower, relatively brighter and better defined, and the circular mass in which the central ring seems to lie does not lose any of its characteristics.

The central oval is not bounded by a smooth curve. It looks like an elastic link which has been warped, so that the preceding one-quarter appears beyond the median plane (further away from the eye); the central one-half appears on the hither side of the median plane (nearer the eye); and the following one-quarter again appears to be beyond the median plane.

To use a very homely comparison, the appearance of this central ring is similar to that of a footprint left in the wet sand of a sea-beach.

The central ring lies upon an oval of much fainter nebulosity, somewhat as drawn. This outer nebulosity is fairly uniform in brightness, except that there is a defalcation of light at its *south-preceding* edge, and one at its *north-following* edge, as drawn. The latter is very remarkable as seen, but it is very imperfectly depicted in the sketch. A dark band lies just *north* of the bright central ring, and one not quite so dark lies just *south* of the same ring.

The two satellites preceding and following nearly in the major axis of the nebula appear to be faintly connected with the main nebula. They are nebulous patches with a faint central nucleus, which is probably not stellar.

The central ring is brightest in the *s.p.* quadrant, in the *s.f.* quadrant, and in the *n.f.* quadrant, somewhat as drawn. Just following the *south* end of the minor axis the bright circumference becomes suddenly much fainter, as drawn. This defect of light materially aids to give the warped appearance to the surface of the interior oval, and suggests a helical arrangement of the parts.

The interior of the central oval is filled with pretty bright nebulosity at its following end, with diffused nebulosity at its preceding end, and a dark circular space surrounds the central star (by contrast?). This circular space is prolonged in a triangular shape towards the west. The preceding end of the major axis of the central ring is open, somewhat as in the ring nebula in *Lyra*. Besides the central star (or nebulous nucleus?) there is a fainter star (or node of nebulosity?) near the north end of the minor axis of the whole nebula, and two nebulous nodes in the north portion of the brighter central ring. These two nodes form a nearly equilateral triangle with the central star. It is noteworthy that Mr. Lassell, one of the most scrupulously accurate observers, places the central star south of the major axis of the inner oval. We think there is no doubt that this nucleus is now slightly north of this line.

Careful inspection fails to show a decided helical form to the nebulous mass as a whole, yet the analogy of this nebula to 37 H. iv., *Draconis*, is sufficiently striking to deserve mention.

Lick Observatory, Mount Hamilton, 1888.