

# HARVARD COLLEGE OBSERVATORY.

CIRCULAR 176.

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## NOVA GEMINORUM, No. 2.

THE new star which appeared in the constellation Gemini in March, 1912, is one of the most interesting objects of its kind, since its prompt discovery has permitted us to learn more of the early history of these objects, than ever before. It was discovered by Enebo, at Dombaas, Norway, on Tuesday evening, March 12, 1912, and immediately announced so that astronomers throughout the world were enabled to observe it on the following night. An examination of the photographs of the Harvard Observatory showed no sign of it on Sunday, March 10, at 13<sup>h</sup> 22<sup>m</sup> G. M. T., although stars as faint as the eleventh magnitude appear, as shown in Figure 1. The scale is 60'' = 1 mm. The instrument employed was a Cooke Anastigmat, the exposure was 60<sup>m</sup>, and the scale of the original negative was about 600'' = 1 mm. This result was confirmed by a second photograph taken the same night with a Ross Zeiss lens. An examination of other earlier photographs showed a star of the fourteenth photographic magnitude, near, but apparently not identical with the Nova. A photograph taken the following night, Monday, March 11, 12<sup>h</sup> 13<sup>m</sup> G.M.T., shows the Nova as a star of the photographic magnitude 4.5. It is reproduced in Figure 2. This result is confirmed by a second photograph taken the same night with the Ross Zeiss lens. It therefore follows that the star appeared in the course of twenty-three hours and that during this interval the light increased at least two hundred fold and probably ten thousand fold. The star about 3 mm. to the right of the Nova is of the tenth magnitude. A number of photographs of the spectrum of the Nova were obtained on March 13, the night following the discovery, and a succession of clear evenings permitted the remarkable changes in the spectrum to be followed closely. Seventy-four photographs of the spectrum of this star have been obtained with the 8-inch Telescopes at Cambridge and Arequipa between March 13 and June 5, 1912. The following discussion of these has been made by Miss Cannon.

March 13. Seven photographs were taken, the middle of the times of exposure expressed in decimals of the day following Greenwich Mean Noon, being 0.644, 0.671, 0.687, 0.702, 0.721, 0.743, and 0.754, respectively. The spectrum at this time was totally unlike that of any other Nova so far observed, and resembled that of the Sun, except that the hydrogen lines were stronger. It appeared, therefore, to belong to Class F5, having also several of the dark lines unusually well marked. This is only the second instance in which the spectrum of a new star has been photographed while it was still increasing in light. The other case was the bright new star of 1901, Nova Persei, No. 2, whose spectrum at first resembled that of Class B8. See H.C. 56. In both of these cases, the spectrum characteristic of new stars did not appear until the maximum light was reached. Spectra of Nova Geminorum on several dates are shown in Figure 3. They were taken on isochromatic plates and are here enlarged ten times. These prints are negatives, so that bright lines appear dark. The first spectrum of Figure 3 is that of  $\alpha$  Canis Minoris, which is given here for purposes of comparison. It was taken with the same dispersion and under the same conditions as the spectra of the Nova. The second spectrum of Figure 3 was taken on March 13.702, exposure 21<sup>m</sup>. A dark line or band at the approximate wave length 4739 is present in the spectrum of the Nova, but not in that of  $\alpha$  Canis Minoris. Lines near the wave length 4175 are also stronger in the Nova, and there are probably other differences in individual lines, not affecting, however, the general type of the spectrum. On this, and other nights, no change was noticed in the spectrum during the evening.

March 14. Seven photographs were taken, the decimals of the day being 0.513, 0.534, 0.567, 0.594, 0.629, 0.658, and 0.681, respectively. The third spectrum of Figure 3 was taken on March 14.658, exposure 31<sup>m</sup>. A change had taken place, and the type is transitional between the spectrum of March 13, resembling the Sun, and the characteristic Nova type. In some respects, its general appearance resembles that of March 13, but the dark lines H $\beta$ , H $\gamma$ , H $\delta$ , H $\epsilon$ , and K now have broad, bright bands on the edge of greater wave length. On the ordinary plates, the bright band accompanying H $\beta$  is seen to be slightly more intense than the other bands, although it nearly disappears in Figure 3, owing to the absorption of the isochromatic plate. Other bright bands or spaces appear, three being clearly seen between H $\gamma$  and H $\delta$ . A trace of the bright lines, 4922 and 5016, is seen.

March 15. Two photographs were taken, the decimals of the day being

0.596 and 0.719, respectively. The first of these plates was taken at Arequipa, the second, at Cambridge, where the weather conditions were poor. The Arequipa plate shows that the transition to the Nova type was almost complete. The intensity and width of the bright hydrogen lines, have increased and the narrow dark lines present on March 13, have disappeared or been changed into wide bands with bright spaces between them.

March 16. Five photographs were taken, the decimals of the day being 0.519, 0.591, 0.652, 0.678, and 0.751, respectively. The transition to the Nova type appears to be complete. The dark lines of hydrogen are barely visible while the bright bands are very intense and broad with faint lines of reversal superposed. The dark bands H and K are still present. The entire spectrum appears to be composed of bright and dark bands or spaces.

March 17. Two photographs were taken, the decimals of the day being 0.537 and 0.571, respectively. The fourth spectrum of Figure 3 was taken on March 17.571, exposure 60<sup>m</sup>. The spectrum resembles that of March 16, except that the dark bands H and K have become fainter, and the maximum intensity of the bright lines, H $\beta$ , H $\gamma$ , and H $\delta$  has shifted towards the edge of greater wave length.

March 18. Four photographs were taken, the decimals of the day being 0.540, 0.582, 0.615, and 0.756, respectively. The continuous spectrum appears to be much fainter than on March 17. The dark bands, H $\delta$ , H $\epsilon$ , and K, are again well marked, and divided into two portions. The lines of reversal, superposed upon the bright H $\beta$ , H $\gamma$ , H $\delta$ , H $\epsilon$  and K, are stronger than on previous dates.

March 19. One photograph was taken, the decimal of the day being 0.525. This plate is not very good, and no change in the spectrum is detected since March 18.

March 20. Four photographs were taken, the decimals of the day being 0.519, 0.580, 0.584, and 0.641, respectively. The only noticeable change in the spectrum is that the bright band K, which on March 17 was about equal to band H in intensity, is now decidedly fainter than H.

March 22. Three photographs were taken, the decimals of the day being 0.525, 0.568, and 0.731, respectively. The fifth spectrum of Figure 3 was taken on March 22.525, exposure 50<sup>m</sup>. The dark hydrogen lines accompanying the bright bands are of well marked intensity, and are seen from H $\beta$  to H $\theta$ , inclusive. The bright band K, which was observed to be faint on March 20, has now disappeared, and only a narrow dark line remains.

March 23. One photograph was taken, the decimal of the day being 0.528. This plate is poor. The spectrum appears to be like that of March 22.

March 25. Two photographs were taken, the decimals of the day being 0.567, and 0.743, respectively. These plates do not show much detail and no certain changes are observed.

March 26. One photograph was taken, the decimal of the day being 0.573. This plate is poor, and shows only the bright bands.

March 27. Three plates were taken, the decimals of the day being 0.517, 0.541, and 0.574, respectively. An increase in brightness of the portion of the spectrum at about the wave length 4640, has occurred since March 22. The continuous spectrum is faint and the dark hydrogen lines are not clearly seen.

March 29. Two photographs were taken, the decimals of the day being 0.615, and 0.649, respectively. The spectrum appears to be similar to that of March 27.

March 30. Five photographs were taken, the decimals of the day being 0.511, 0.526, 0.547, 0.580, and 0.659, respectively. The continuous spectrum appears to be much more intense than on March 26, 27, or 29. The dark hydrogen lines are again present on the edge of shorter wave length of the bright bands and are distinctly double. The dark band K, which is present and fainter than band H, is also double. The spectrum in general resembles that of March 22, but differs in the portion between  $H\beta$  and  $H\gamma$ , owing chiefly to the increased intensity of the bright band 4640.

April 3. Two photographs were taken, the decimals of the day being 0.611, and 0.636, respectively. The dark hydrogen lines are fainter than on March 30. The dark band K, is now more intense than the band H.

April 4. One photograph was taken, the decimal of the day being 0.636. The dark components of the hydrogen lines are not seen and the spectrum resembles that of March 27.

April 5. Two photographs were taken, the decimals of the day being 0.572 and 0.595, respectively. It has been stated that during March, there were striking variations in the dark hydrogen lines, and that they were sometimes absent and then appeared again with marked intensity. These changes were probably connected with the variations in the light. On the plates taken in April, there is a somewhat similar variation in a dark band situated on the edge of shorter wave length of the bright hydrogen band  $H\delta$ . This may be the dark band  $H\delta$ , and will be so designated for convenience of reference. This dark

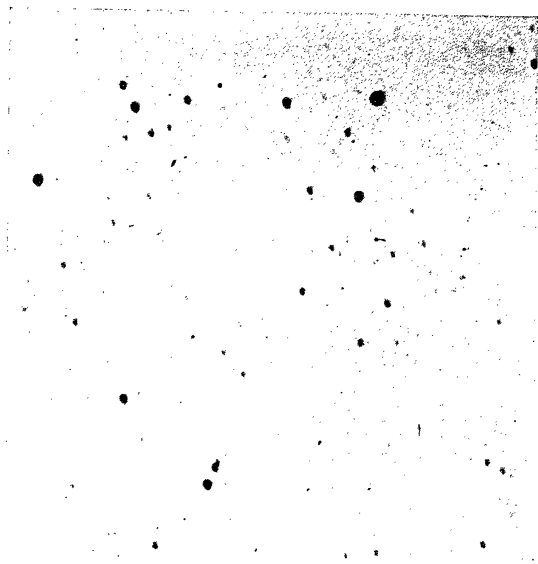


FIG. 1. MARCH 10, 1912.

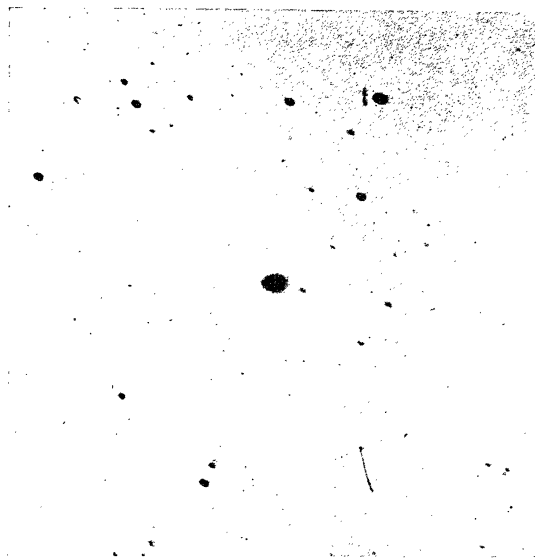


FIG. 2. MARCH 11, 1912.

 $\alpha$  CANIS MINORIS.

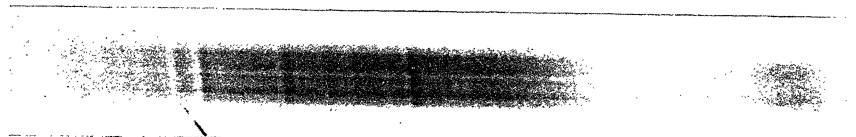
APRIL 20, 1912.

NOVA GEMIN., NO. 2.



MARCH 13, 1912.

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MARCH 14, 1912.

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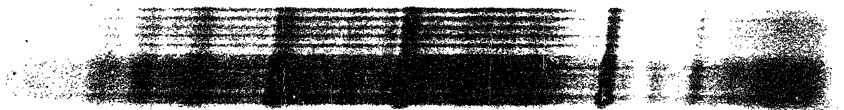
MARCH 17, 1912.

" " "



MARCH 22, 1912.

NOVA PERSEI, NO. 2.



MARCH 7, 1901.

FIG. 3. SPECTRA.

NOVA GEMINORUM, NO. 2.



band is seen on the plates taken on April 5, and the intensity is estimated to be 5.

April 6. One photograph was taken, the decimal of the day being 0.538. The dark band  $H\delta$  is not seen and the spectrum is like that of April 4.

April 7. One photograph was taken, the decimal of the day being 0.519. The spectrum is like that of April 4.

April 8. Two photographs were taken, the decimals of the day being 0.528 and 0.624, respectively. The dark band,  $H\delta$ , is seen, but it is faint, intensity 1.

April 9. One photograph was taken at Arequipa, the decimal of the day being 0.541. The spectrum differs from that of April 8, only in the increased intensity of the dark band  $H\delta$ , which now has intensity 10.

April 10. One photograph was taken at Cambridge, the decimal of the day being 0.569. The spectrum is like that of April 8, and the dark band  $H\delta$  is faint, having intensity 1.

April 12. One photograph was taken at Arequipa, the decimal of the day being 0.516. The spectrum is like that of April 9. The continuous spectrum is fainter than on April 10, and the dark band  $H\delta$  is present, having intensity 10.

April 13. One photograph was taken at Arequipa, the decimal of the day being 0.513. The spectrum in general resembles that of April 8. The dark band  $H\delta$ , however, is wider than on April 8, and its intensity is estimated to be 5.

April 14. One photograph was taken, the decimal of the day being 0.545. The plate is not very good, and only the bright bands are seen.

April 16. One photograph was taken, the decimal of the day being 0.522. The spectrum is stronger than on April 14. The dark band  $H\delta$  is seen, and the spectrum appears to resemble that of April 9.

April 17. One photograph was taken, the decimal of the day being 0.506. The definition is poor, perhaps owing to the low altitude. No certain change is observed.

April 18. One photograph was taken, the decimal of the day being 0.523. The definition is poor, perhaps owing to the low altitude. No certain change is observed.

April 19. One photograph was taken, the decimal of the day being 0.499. The dark band  $H\delta$  is present, with intensity 10. The spectrum appears to be very nearly like that of April 9.

April 20. Two photographs were taken, the decimals of the day being 0.508, and 0.540, respectively. This spectrum resembles that of April 19, in the presence and intensity of the dark band  $H\delta$ . However, several of the dark bands appear narrower than on April 19, and a wide, dark band between  $H\delta$  and  $H\epsilon$  has a shorter wave length than on April 19.

April 21. One photograph was taken, the decimal of the day being 0.506. The lines appear broader than on April 20, but this may be due to atmospheric conditions.

April 30. One photograph was taken, the decimal of the day being 0.547. No certain change is observed since April 21.

May 10. One photograph was taken, the decimal of the day being 0.582. The continuous spectrum has become very faint, and several changes have occurred since April 30. The most important are the increased intensities of bands 4640 and 5016. Band 4640 is narrower than on previous dates, but is now slightly more intense than  $H\beta$ . Band 5016, which on previous plates is slightly fainter than 4922, is now a strong band, while band 4922 is barely seen. This increased intensity of 5016 may be due to the presence or increased brightness of the nebular line, 5008, which would be superposed on the helium line 5016, with this dispersion. A bright band has also appeared near  $H\gamma$ , towards the edge of greater wave length.

June 3. One photograph was taken, the decimal of the day being 0.580. The plate is poor and shows no certain change since May 10.

June 5. One photograph was taken, the decimal of the day being, 0.577. The plate is poor and shows no certain change since May 10.

The last spectrum of Figure 3 is that of Nova Persei, No. 2, on March 7, 1901, which is given here for purposes of comparison with the spectra of Nova Geminorum, No. 2.

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### THE VARIABLE STAR, 87.1911.

ANNOUNCEMENT was made by Mr. C. R. D'Esterre in the Astron. Nach. 190, 163, of a "Nova or new variable star" whose position for 1900 is R. A. =  $2^h 3^m 16^s.3$ , Dec. =  $+56^\circ 42'.8$ . The designation 87.1911 has been assigned to this object. The star was conspicuous on plates taken by D'Esterre on November 13 and 21, 1911, but was not seen on plates taken on three previous dates. Professor Wolf, Astron. Nach. 192, 7, on a plate taken