

NOTES FROM OBSERVATORIES

NOVA SAGITTARII 1919

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Nova Sagittarii (No. 5) 1919 was discovered on Harvard plates by Miss Ida Woods.¹ The published notice gave only the following general details: the star was normally about fourteenth magnitude; it was about seventh magnitude on April 24, 1919; it had faded to about the twelfth magnitude by September 13; a previous increase of three magnitudes had occurred in 1901. This last fact is of special interest, in view of the known existence of only three recurrent novae. The notice did not make it clear whether the brightening in 1901 was interpretable as an incompletely observed outburst, similar to that in 1919, or was actually limited in its range. While engaged in war work in Cambridge, I made use of the opportunity to investigate this object on Harvard photographs.

The nova is only about 15" west of the star Córdoba DM—29°15053. On the patrol plates the two images are completely blended. On plates of larger scale, the stars appear well separated except when the images are in the regions of poorer definition near the edges of plates, or when the images trailed. When blending occurred, the observed magnitude was corrected, on the assumption that the companion has a constant photographic magnitude of 11.6, which is very well determined relative to the sequence of comparison stars.

A chart of the field is in Figure 1, on which the comparison stars are marked. Magnitudes of the comparison stars were determined from patrol plates, by reference to a Carte du Ciel sequence at α 19^h 0^m, δ —31° 30'. The adopted magnitudes are in Table I. The observations of the nova are in Table II; they have been corrected for the effect of the near-by star DM—29°15053. These observations include all available plates

¹ *Harv. Bull.*, No. 693, 1919.

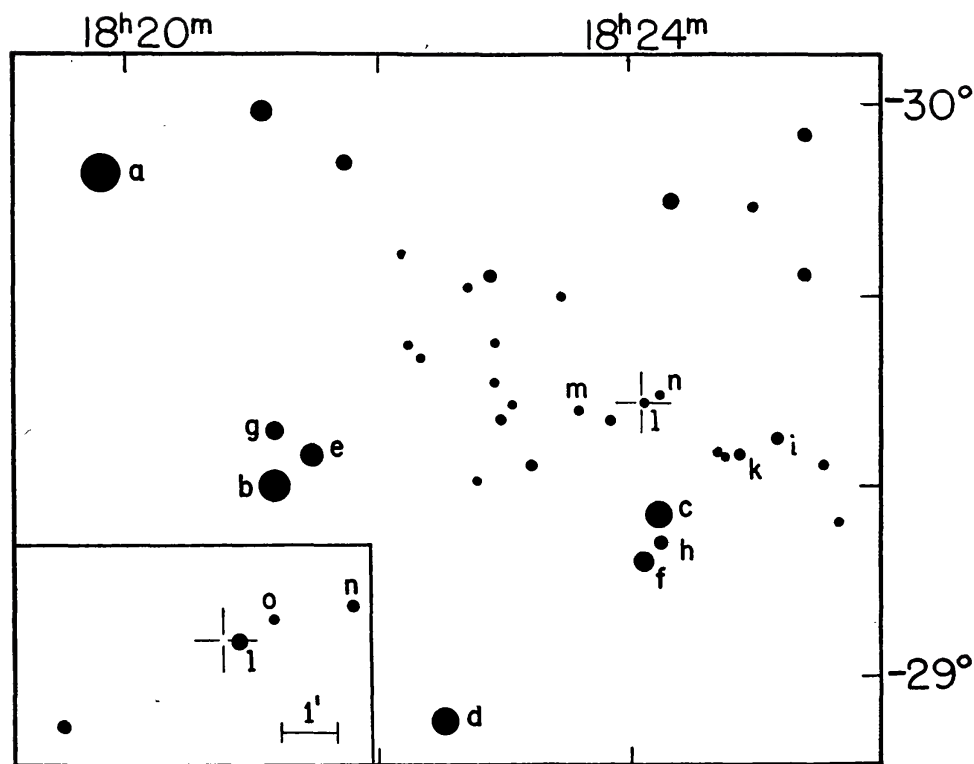


FIG. 1.—Chart of the field of Nova Sagittarii 1919 (inverted). A cross marks the position of the nova. Comparison star *o* is shown only on the large-scale insert at the lower left. Positions are referred to the equinox of 1875.

TABLE I
COMPARISON STARS FOR NOVA SAGITTARII 1919

Designation	Photographic Magnitude	Cape P.D.	Córdoba DM
<i>a</i>	7.2	—29°5565	—29°14965
<i>b</i>	8.0	—29°5574	—29°14995
<i>c</i>	8.4	—29°5593	—29°15058
<i>d</i>	8.5	—28°6576	—28°14648
<i>e</i>	8.75	—29°5576	—29°14999
<i>f</i>	9.35	—29°5590	—29°15052
<i>g</i>	9.75	—29°5573	—29°14994
<i>h</i>	10.4	—29°5594	—29°15059
<i>i</i>	10.7	—29°5598	—29°15072
<i>k</i>	10.9	—29°5596	—29°15066
<i>l</i>	11.6		—29°15053
<i>m</i>	11.8		—29°15041
<i>n</i>	12.8		—29°15056
<i>o</i>	13.8		

TABLE II

PHOTOGRAPHIC MAGNITUDES OF NOVA SAGITTARII 1919

Date	Magni- tude	Date	Magni- tude	Date	Magni- tude
1891 May 29	14.0	1903 May 5	[14.0	1919 Aug. 21	11.1
1893 July 22	[14.0	1903 Aug. 18	14.0:	1919 Aug. 23	11.1
1894 Aug. 7	[13.8	1903 Aug. 20	14.2:	1919 Aug. 24	11.3
1895 July 9	14.3	1903 Sept. 17	14.1	1919 Aug. 25	11.1
1896 July 1	[13.8	1904 Apr. 12	[13.8	1919 Aug. 28	11.3
1897 June 3	14.1:	1904 June 11	14.3:	1919 Sept. 13	11.9
1897 June 18	14.3	1904 July 1	14.0:	1919 Sept. 14	11.1:
1898 Apr. 26	[13.5	1905 July 10	14.0	1919 Sept. 23	11.5
1899 Apr. 6	14.1:	1909 June 26	[13.8	1919 Oct. 12	[10.8
1899 Aug. 4	14.2:	1910 June 26	14.1	1920 July 18	13.8:
1899 Aug. 7	14.3	1911 May 19	13.9	1920 July 22	13.6
1900 May 22	[13.9	1911 Oct. 3	13.9	1920 Sept. 9	13.6
1900 Oct. 25	[13	1913 June 14	[14.0	1920 Sept. 12	13.4
1901 Apr. 15	[13	1914 June 29	14.0	1920 Sept. 14	13.6
1901 May 13	*	1915 Aug. 28	[14.0	1920 Sept. 14	13.6
1901 May 21	[13	1916 May 9	14.2	1921 June 9	14.0:
1901 May 27	[13	1918 July 31	[13	1921 Aug. 31	13.8
1901 July 19	[13	1919 Mar. 11	7.2	1922 Nov. 1	[13.8
1901 July 25	12.3	1919 Apr. 24	8.2	1924 Aug. 22	14.0
1901 Aug. 2	[12.0	1919 May 4	8.6	1925 Apr. 28	13.9
1901 Aug. 5	[12.0	1919 May 5	8.4	1925 May 16	14.1
1901 Aug. 7	11.5	1919 June 4	9.5	1925 June 25	14.0
1901 Aug. 14	11.7	1919 June 12	9.3	1926 June 11	13.9
1901 Aug. 21	11.1	1919 June 23	9.1	1926 June 17	14.1
1901 Aug. 23	11.7	1919 June 25	9.1	1928 May 14	14.0
1901 Sept. 4	11.5	1919 June 30	9.2	1928 May 15	13.9
1901 Sept. 13	10.8	1919 July 8	9.5	1929 Sept. 9	14.1
1901 Oct. 1	11.1	1919 July 19	10.3:	1930 Apr. 28	14.0
1901 Oct. 3	10.8	1919 July 19	10.3	1931 Sept. 30	14.1
1901 Oct. 7	[10.8	1919 July 25	10.8	1932 July 10	14.0
1901 Oct. 8	[11.3	1919 July 26	10.4	1932 Aug. 5	14.0
1901 Oct. 10	11.3	1919 Aug. 1	10.4	1934 Apr. 25	14.0:
1902 Apr. 28	13.8:	1919 Aug. 14	[10.7	1935 May 15	14.0
1902 July 9	13.8	1919 Aug. 20	11.3	1937 Aug. 8	13.9

*An apparent image in the position of the nova, which is different from that of other stars, is, in all probability, a defect.

that showed the nova during the times of active variation and those on which it was invisible only if they made a positive contribution to the light-curve. Most of the observations at mini-

num represent selected plates that showed the nova most clearly separated from the companion.

The observations are plotted in Figure 2, which consists of

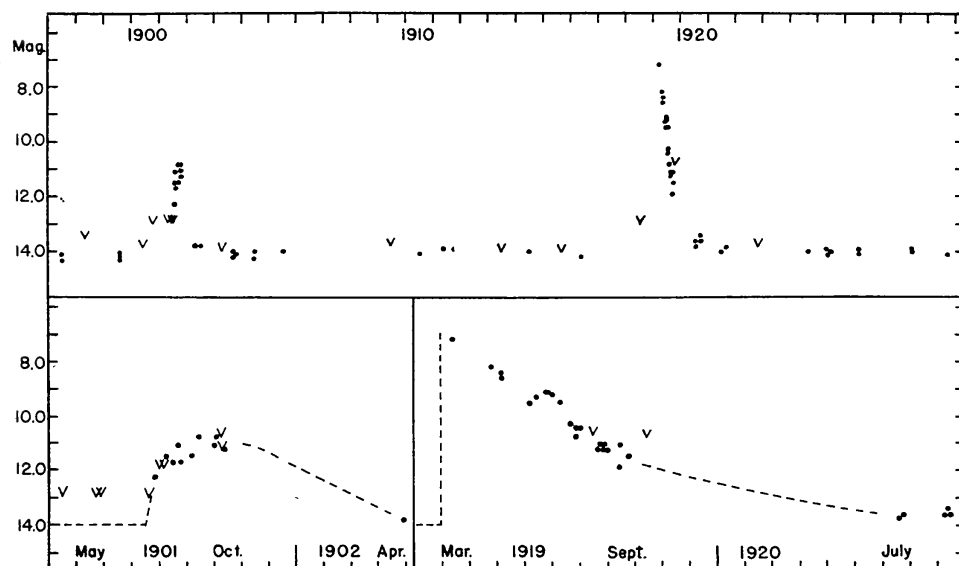


FIG. 2.—Light-curve of Nova Sagittarii 1919. Above, complete curve for the interval 1897-1929; lower left, the maximum of 1901; lower right, the maximum of 1919.

three parts. The upper part is the complete light-curve except for the oldest and the most recent observations, which merely show the nova at minimum. The lower left part gives details of the brightening in 1901, and the lower right is the light-curve of the outburst in 1919.

The nova was visible as a star of photographic magnitude 14.0 before and after both outbursts. It was perhaps slightly variable; the few observed magnitudes that are distinctly different from the mean are not convincing. That this minimum brightness is the true magnitude of the nova itself, and not that of an unresolved companion, is proven beyond reasonable doubt by M. L. Humason's observation of the spectrum,² which he found to be perfectly continuous and strong in the shorter wave lengths. It thus resembled several other old novae at minimum.

² *Ap. J.*, **88**, 237, 1938.

The outburst in 1919 was evidently that of a typical nova, although the total range and the time of rise remain uncertain because the star was brightest on the first plate of the season. In 1920 it was still slightly above minimum, but by 1921 the decline was certainly complete. The duration of decline was therefore much less than that of any nova of large range. Table III gives approximate durations of decline for a few typical novae of known range;³ for two recurrent novae, RS Ophiuchi and T Pyxidis; and for SS Cygni.

TABLE III
RANGE IN MAGNITUDE AND DURATION OF DECLINE

Star	Range in Magnitude	Duration of Decline
Nova Aquilae 1918.....	11.9	7 years
Nova Sagittarii 1898.....	12	9 years
Nova Lacertae 1910.....	9.8	4 years
Nova Sagittarii 1899.....	7.9	4 years
RS Ophiuchi.....	7	80 days
T Pyxidis	6.5	200: days
SS Cygni.....	3.5	20 days

If the range of Nova Sagittarii 1919 was much greater than 7 magnitudes, its duration of decline would certainly be abnormally short. It is estimated that its range was not greater than 8 magnitudes. The hypothesis that it is a recurrent nova appears consistent with all available data.

Attempts to observe the spectrum during the outburst in 1919 were not successful, although traces were recorded on two plates. A plate taken on September 25 shows a faint continuous spectrum of the companion and, beside it, a single faint hazy emission band of the nova in a position very close to λ 4640. On September 27, faint traces of two bands appear. One is at λ 4640; the other, nearly as bright, is at the redward end of the photographic spectrum. Probably it is a blend of $H\beta$ and the nebular emissions of [O III]. On September 13, a direct photograph taken with the 16-inch Metcalf telescope shows a sharp image

³ McLaughlin, *Pop. Astr.*, 47, 537, 1939.

of the companion star and a hazy one of the nova with a sharp nucleus. That the hazy portion of the image is out-of-focus emission near the extremities of the spectrum, either $[O\text{ III}] \lambda 4959$, $\lambda 5007$, or $[Ne\text{ III}] \lambda 3869$, $\lambda 3968$, appears to me more reasonable than that it is nebulosity about the nova at such an early stage. The extent of the "flare" at the ends of spectra photographed with the same instrument is favorable to this view.

On the other hand, the possibility that the nebulosity was real, and of the same nature as that observed about Nova Persei 1901 six months after maximum, must not be ignored. The radius of the apparent nebula about Nova Sagittarii was roughly $10''$, the interval after maximum about six months. If it represented a "light-shell" with the radius of the nebula perpendicular to the line of sight, the parallax of the nova would be $0''.0003$. The nova at maximum would then have been brighter than absolute magnitude -5.3 , the value depending on the amount of absorption of light in space (probably about 1.2 magnitudes⁴) and the extent of the unobserved portion of the light-curve near maximum. The corrected absolute magnitude is about -7 , in agreement with that of a number of other novae.⁵

The brightening of Nova Sagittarii in 1901 was obviously very abnormal. The observations, which are closely spaced, leave little doubt that the rise was slow (witness an observation at 12.3 mag. about a month before maximum) and no doubt at all that the maximum was broad, rather flat, and only three magnitudes above the minimum. Such variation some years *previous* to a major nova outburst is unique among recorded light-curves. It is true that some typical novae of large range (notably Nova Persei 1901) have shown variability before the explosion, but three magnitudes far exceeds the observed range of any of these.

A recurrent nova with a range of 7 to 8 magnitudes would be expected to have an interval of the order of 20 years between

⁴ McLaughlin, *A. J.*, 51, 140, 1945.

⁵ McLaughlin, *Pop. Astr.*, 50, 233, 1942; *Pub. A.S.P.*, 57, 69, 1945.

outbursts, according to the meager statistics furnished by the known objects of this type. The 1901 maximum of Nova Sagittarii 1919, therefore, suggests a possible abortive "attempt."

So far as the form of the curve is concerned, Nova T Coronae furnishes a partial parallel. This star showed a marked brightening in 1938, about 72 years after its major outburst. The total range cannot be stated precisely, because the nova at minimum is considerably fainter than its class M companion. From the lack of dilution of the class M spectrum by continuous spectrum of the nova at minimum,⁶ and from the character and extent of the dilution in 1938,⁷ it is estimated that the range was at least two magnitudes.

We note also the suggestion of similarity—except for the time scale—between the abnormal behavior of Nova Sagittarii and the occasional anomalous maxima of SS Cygni and other stars of the U Geminorum class. We are left with a general impression that almost every conceivable gradation may exist between recurrent variables on the one hand and typical violent novae on the other, with recurrent novae and such objects as Z Andromedae and CI Cygni in the middle ground. It is becoming increasingly difficult to defend any theory of novae that involves an accidental cause operating from outside the star. There remains a strong suspicion that Nova Sagittarii 1919 is a typical recurrent nova, and if so, an examination of it a few times each year may be worth while.

Grateful acknowledgment is made to Dr. Harlow Shapley, director of the Harvard College Observatory, for the privilege of using the Harvard photographs.

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⁶ Adams and Joy, *Pub. A.S.P.*, 33, 263, 1921; Humason, *Ap. J.*, 88, 233, 1938.

⁷ A. H. Joy, *Pub. A.S.P.*, 50, 300, 1938; Minkowski, *ibid.*, 51, 54, 1939.