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LIGHT AND COLOR CURVES OF THE 1967 SUPERNOVA IN NGC 3389*

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Photographic and photoelectric observations of SN 1967 in NGC 3389 from March 7 to June 9, 1967 define a branch of the light curve very similar to those of the Type 1 supernovae of 1937 in IC 4182 and NGC 1003 between 7 and 100 days past maximum. It must have been close to maximum light ($m\simeq13$) at the time of its discovery by Chuadze on February 28, 1967. For the adopted modulus $\mu=31.3$ ($\Delta=16.6~Mpc$) of NGC 3389 the absolute magnitude of the supernova at maximum was $M(\max)\simeq-18.3$.

The supernova should remain observable (20 < m < 22) through the 1968 opposition.

1. Observations and comparison stars. At the request of Dr. F. Zwicky the 1967 supernova in NGC 3389 discovered by Chuadze [1] on February 28, 1967, was observed from March to June, 1967 with the 36 and 83-inch reflectors of McDonald Observatory. Photoelectric observations in the U, B, V, systems were made in March, April and May with a two-channel pulse counting photometer [2] through two 2 mm apertures spaced by 38 mm equivalent to 32" and 10' at the Cassegrain focus of the 36-inch (March) and to 15" and 5' at the corresponding focus of the 82-inch. Photographic observations in B only were made in May and June with a new f/5 reducing camera attached at the Cassegrain foci of the same telescopes and giving plates scales of $44" mm^{-1}$ (35-in.) and $22""mm^{-1}$ (82-in.). No filter was needed because the glass optics of the reducing camera effectively cuts off the spectrum near 3850 Å. In addition several plates were kindly taken for us in June by H. D. Ables with

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the 61-inch reflector of the U. S. Naval Observatory station at Flagstaff. Except on the last night no filter was used, but since the supernova had then nearly the same color as the comparison stars it should make little or no difference.

Fig. 1 is a finding chart reproduced from the Sky Survey red print with the comparison stars marked. The adopted magnitudes are given in Table 1. Star A is the local standard; stars C and F are the main comparison stars used for the photographic calibration. The plates were measured in Austin by H. C. Corwin with 2 different fixed apertures of a Schilt-type densitometer and reductions were made graphically in a coordinates system that leads to a linear characteristic curve over the magnitude range of interest. The mean magnitudes of the comparison stars derived by photographic interpolations (or a short extrapolation for star G) are given in the last two columns of Table 1. The average deviation (pe-pg) is ± 0.12 mag.

Star	В	B-V	U—B	Nights	Pg	Plates	
A	12.03	+0.67	+0.11	7	(11.91)	4	
a	14.55	+0.87	?	. 2	14.64	9	
С	14.20	+0.65	0.00	9	14.36	9	
D	15.0:	+0,8:	+0.2:	1	14.86	9	
Е	14.9:	+0.65:	0.0:	1	14.80	7	
F	16.5:	+0.8:	-+-0.3:	7	(16.39)	10	
G	•	-		-	16.69	9	

COMPARISON STARS

Table 1

• Star G is between F and the center of NGC 3389 and could not be measured with the rather large field apertures used.

Because of the location of the supernova at the edge of the spiral pattern (see Fig. 2) the background was measured East and West of the star and very close to it. Occasional readings North and South were also used. The background corrections ranged from 30 per cent in March to 70 per cent in May of the observed pulse count on the supernova. This local background count was itself 1.5 to 2 times the blank sky count far from the galaxy. Integration times ranged from 10 sec in March to 30 sec in May and each observation consisted of at least 4 exposures on the supernova (2 in each channel) and 4 on the nearby background (2E, 2W) in each color, plus corresponding readings on at least two comparison stars. All other necessary cor-

566



Fig. 1. Comparison stars for SN 1967 in NGC 3389 marked on enlarged copy of Palomar-NGS Sky Survey red print.



Fig.2. SN 1967 in NGC 3389 photographed with reducing camera at Cassegrain focus of 82-inch Struve reflector McDonald Observatory. 1967 May 3; 103a-0; 30 min. rections such as the ratio of the spectral responses of the two channels or (on one occasion) the time variation of the blank sky level due to lunar twilight were applied.

The net count rate or sensitivity of the photometer system may be characterized by the magnitude m_0 of a star that would give 1 pulse per second through the B filter at the zenith; this was about 20.5 with the 36-inch and 21.5 with the 82-inch for the adopted gain and discriminator settings of the amplifiers. Allowing for the different telescope sizes and foci and for the additional optics in a two-channe system these figures are consistent with a value of about 24.0 for a single-channel photometer at the prime focus of the 200-in. telescope [3].

2. Light and color curves. Table 2 lists the observed magnitudes and colors of the supernova. The successive columns give the U. T. date, Julian date, telescope, plate and exposure time, V, B-V, U-B and B or $m_{\rm PK}$. The light and color curves are plotted in Fig. 3.

Including the discovery report of $m_{pg} = 13$ on Feb. 28 [1] the first part of the light curve indicates a decay of 2.5 to 3 mag. in one month, followed by a slower decay at the rate of about 0.7 mag. per month, perhaps with minor fluctuations. This is consistent with the light curves of Type I supernovae such as SN 1937 in IC 4182 and NGC 1003 [4] and confirms the spectral classification as Type I by Rubin and Ford [5]. If so the star must have been discovered close to maximum light. The dashed curve in Fig. 2 is a composite of the photographic light curves of SN 1937 in IC 4182 and of SN 1937 in NGC 1003 [4]. The agreement with the present observations is quite close. If, as might be expected, the agreement continues to hold the supernova should remain observable for a second season. The predicted magnitude for Feb.—March 1968, one year past maximum, is $m = m_m +$ $+ 8 \approx 21$.

The rapid reddening after maximum conforms to the typical behawior of many supernovae, but two-color data are not yet available for, a sufficient sample to make meaningful comparisons.

With the adopted modulus of NGC 3389 (see following paper [6]) $\mu = 31.3 \pm 0.2$, the absolute magnitude of the supernova at maximum was

 $M(\max) \simeq 13.0 - .31.3 = -18.3$; (pg)

which is 0.8 mag. fainter than the total magnitude of the galaxy and about average for Type I supernovae.

Table 2

568

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OBSERVATIONS OF SAPERNOVA 1967 IN NGC 3389

Date	U.T.	JD 2439+	Tel. (in.)	Plate	Exp. (min.)	v	B-V	U—B	B	Obs.
Mar	7.3	556.8	36	_	_	13.28	+0.27	0.19	13.55	GV, JES
_	10.2	559.7	36		-	13.48	+0.35	-0.10	13.83	**
	12.4	561.9	36	-		13.60	+0.37	0.05	13.97	u
-	13,3	562.8	36	-	_	13.62	+0.44	-0.03	14.06	19
-	15.3	564.8	36	-	-	13.69	+0.49	+0.11	14.18	
-	16.3	565.8	36		-	13.74	+0.60	+0.03	14.34	н
_	17.3	566.8	36		-	13.85	+0.65	+0.04	14.50	11
	20.4	569.9	36	-	-	14.10	+0.79	+0.30	14.89	
Apr	9.3	589.8	82	-	-	15.31	-+-0.80	+0.31	16.11	GV, SB
	11.2	591.7	82	-		15.33	-+0.90	-+0.07	16.23	17
-	14.1	594.6	82	-	-	15.43	+0.91	+0.11	16.33	
May	3.2	613.7	82*	103a—O	10	_		-	16,35	SB
-	3.2	613.7	82*	103a-O	30		_	-	16.43	91
	6.2	616.7	82*	Ila—O	10	-	-	-	16.65	GV
-	8.2	618.7	82*	Ia-O	15	-		-	16.45	
A.C	9.2	619.7	82*		10	_	-	-	16.85	
-	11.2	621.7	82*	laO	15	-	- 1	_	16.73	11
- 5	13.2	623.7	82*	-	-	16.33	+0.61	+0.34	16.94	JES
Jun	2.2	643.7	- 36 -	103a-O	16	_	-	-	17.50	SB
-	4.2	645.7	61	Ja—O	10	-	-	-	17.40	HDA
_	8.2	649.7	61	Ia-O	10	-	-	-	17.38	19
-	9.2	650.7	61	Ia-O	13	-		-	17.78:	η

* 77-inch diaphragm,

THE SUPERNOVA IN NGC 3389



Fig. 3. Light and color curves of SN 1967 in NGC 3389.

569

For comparison, if IC 4182 is a member of the CVnI Cloud (Group No 3, in [7]) for which $\Delta = 3.8 \ Mpc$ and $\mu = 28.1$, the absolute magnitude of SN 1937 at maximum was M = -19.5. If NGC 1003 is a member of the NGC 1023 group (No 7 [7]) for which $\Delta = 6.3 \ Mpc$ and $\mu = 29.5$, the 1937 Supernova ($m \approx 12.8$) reached only $M(\max) =$ = -16.7, but its location in the spiral pattern and the tilt of the plane of the galaxy to the line-of-sight suggest that internal absorption in the system could be significant.

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КРИВЫЕ ЯРКОСТИ И ЦВЕТА СВЕРХНОВОЙ 1967 В NGC 3389

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Отрезок кривой яркости сверхновой 1967 г. в NGC 3389 за период с 7 марта по 9 июня 1967 г. очень похожа на кривые яркости в интервале 7—100 дней после максимума сверхновых І типа 1937 г. в IC 4182 и NGC 1003. Во время обнаружения сверхновой со стороны Чуадзе 28 февраля 1967 г. она "была близка їк "максимуму яркости $(m \approx 13)$. При принятом модуле NGC 3389 $\mu = 31.3$ ($\Delta = 16.6 \ \text{мnc}$) абсолютная величина сверхновой в максимуме была $M (\max) = -18.3$. Сверхновая должна быть еще наблюдаема (20 < m < 22) в 1968 г.

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'570