Light and Color Curves of the Unusual Slow Nova LMC 2005

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Abstract Nova LMC 2005 was discovered on November 26, 2005, at approximate magnitude 11.5. Fainter photographic images were detected four nights earlier, and the ASAS-3 sky survey recorded it at $V = 11.695$ one night before discovery. Its evolution thereafter was closely followed in V, B, and R by the four of us, and the decline found to be slow with sizeable fluctuations. We present herewith the observational data and comment on their significance.

1. Introduction

According to Shida (2007), thirty-four classical novae have now been discovered in the Large Magellanic Cloud (LMC), although it is probable that the ones discovered in 1937 and 2004 and in 1968 and 1990b are two recurrent novae. Few have detailed light and color curves owing to their relatively faint magnitudes, the scarcity of photometric equipment in the Southern Hemisphere before the mid-20th century, and often because of the crowded fields in which the novae were discovered. Liller *et al.* (2004) published the light curves of seven recent LMC (and two SMC) novae, but no color data were included. Other light curves and some color data have been compiled by Della Valle (1991) and by van den Bergh and Younger (1987). At least eight additional nova-like stars, three in the LMC, were found by the MACHO, EROS2, and OGLEII gravitational lensing surveys.

N LMC 2005 was discovered by one of us (Liller *et al.* 2005) on November 26; its position measured by Peter Nelson (Waagen *et al.* 2005) is R.A. = $05^h\ 10^m\ 32.68^s$, Dec. = –69° 12' 35.7" (eq. 2000) puts it on the southwestern edge of the LMC "bar." Walter *et al.* (2005) quickly established spectroscopically that this was a classical nova near maximum. Located at the edge of the bar, the nova is in a crowded field, but only one star brighter than ~20th magnitude is within 30" of the nova. This star, dubbed by us "the little beastie," is located 4.8" to the WNW. It is shown in Figure 1. According to Massey (2002), its $V = 16.48$, $B–V = +0.99$, and $V–R = 0.57$, in good agreement with our own measurements (see next section).

Because at the time of discovery the nova was well-placed in the morning sky to permit photometric monitoring over an extended time period, the four of us decided to make a concerted effort to follow its decline in detail.

2. The magnitudes and colors

All the magnitudes and colors presented here were made with CCDs. One of us (Di Scala) used Landolt standard stars chosen at approximately the same altitude as, and with colors similar to, the nova. The rest of us relied on previously measured colors and magnitudes of stars found in the same CCD field, thereby assuring that the extinction corrections would be similar for all stars. Morel (2005) provided a convenient map of the region with pertinent stellar data tabulated. The calculated differential extinction values never exceeded a few hundredths of a magnitude and were applied as appropriate.

Some of our measurements have appeared in AAVSO reports; all our data can be found in the recently established AAVSO public dataset site: ftp://ftp.aavso.org/public/datasets/jlillw352.txt.

As for the nearby "little beastie," in early February after the nova had faded considerably, we measured its magnitude and color to be $V = 16.67$, $B–V = +1.03$, $V–R = +0.62$ (± 0.02). This star was often included in the CCD aperture used to isolate the nova, and when it was, its contribution to the total light was subtracted. The light and color curves of the nova appear in Figure 2 and the full CCD data listing is given in Table 1.

3. Discussion

Faint images of N LMC 2005 with an estimated V magnitude of 12.8 ± 0.2 were found on a pair of photographs taken on November 22, four nights before the discovery photographs. Also, in an e-mail message, Morel (2005) reported to us that he found one observation of the nova in the ASAS-3 database, as follows: JD 2453699.67545 = Nov. 25.175 UT, $V = 11.695$. The estimated V magnitude of the nova at time of discovery, Nov. 26.16 UT, was 11.5, indicating that the peak brightness came very close, perhaps ±0.5 day, to this date.

The small, positive values of $B–V$ and $V–R$, especially during the early stages of the development, strongly suggest that the nova was, at most, only slightly reddened. Further support for this conclusion results from noting that thirteen days after peak brightness, the smoothed V magnitude was 12.5 ± 0.2, in good agreement with the average found for thirteen generally unreddened LMC novae, namely 12.58 ±0.16 (Liller and Shida 2005).

Our CCD monitoring was begun immediately after the discovery. The falloff in brightness was anything but steady, and we can only estimate approximately the time the nova took to fade by 2 and by 3 magnitudes, namely 63 days and 94 days, respectively. These rates of decline correspond to a "moderately fast" nova,

according to the classification of Payne-Gaposchkin (1964), but among the novae of the Magellanic Clouds only two of the forty-three known novae are slower, N SMC 1927 and N LMC 1949 (see Liller and Shida 2004). Whether or not a similar irregular falloff in brightness occurred in these two novae is impossible to know since the coverage was rather spotty and the magnitudes uncertain (Henize *et al.* 1954).

Quasi-periodic fluctuations in brightness are not uncommon in slow novae (Warner 1996), but large amplitude variations commencing almost immediately after maximum are rare. N LMC 2005 does not fit conveniently into the scheme of light curves described by Duerbeck (1981), but bears several close similarities to the recent Nova Scorpii 2004 #1 (Schwarz *et al.* 2007): the slow rise to maximum, a few irregularities shortly after maximum, and a moderately slow decline (a t_2 time of 20 days for Nova Sco 2004 #1).

Because the *B–V* color of N LMC 2005 changed little while the light fluctuations were going on it suggests that these variations must have been caused by irregular in-fall of material from the companion star and not by changing dust absorption which would have produced reddening. This conclusion is supported by the rough inverse correspondence to the light curve of the *V–R* color curve where the H-α emission dominates.

As to what caused the abrupt levelling off of the light curve some 125 days after maximum, note that the final sudden drop in *V* is accompanied by the *V–R* color becoming redder and the *B–V* color turning bluer, meaning that *B–R* changed little as *V* faded. It would seem then that in the *V* band, the expected falloff in continuum brightness was almost exactly compensated by the anticipated increase in strength of the nebular spectrum, especially the strong doubly ionized oxygen lines bracketing 500 nm. Since the Balmer emission lines of hydrogen dominate both the *B* and *R* bands, the *B–R* color remained effectively unchanged as the emission lines increased in strength. Partial confirmation of these conclusions comes from a well-timed spectrogram taken by Fred Walter on JD 2453835 = April 9 (Walter 2006).

A few *V* magnitude data points show abrupt changes over short time intervals. We are unable to say with certainty that these are real and not due to an instrumental problem or unusual weather condition, but in the interest of full disclosure (and honesty), we have included these points in both Table 1 and Figure 2.

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Table 1. CCD observations of Nova LMC 2005.

JD –2453000	*V*	*B–V*	*V–R*	*JD* –2453000	*V*	*B–V*	*V–R*	*JD* –2453000	*V*	*B–V*	*V–R*
701.90	12.84			729.96	13.39			758.91	13.35		
702.89	12.93			730.03	13.80	0.08	0.82	761.00	14.55	0.07	0.99
703.92	13.19			730.89	13.74			761.94	14.01		
705.92	12.73			732.13	13.50	0.12	0.65	762.00	14.34	0.00	0.73
708.20	12.56			735.02	14.09	0.17	0.72	762.95	13.79		
708.57	12.43			735.16	14.05			763.05	14.15	0.12	0.71
709.05	12.56	0.20	0.37	735.96	13.54	0.15	0.56	763.88	14.03		
709.56	12.29			735.98	13.47			764.01	14.23	0.04	0.72
710.57	12.18			737.90	13.28			764.06	14.16	0.09	0.70
711.59	12.44			738.00	13.36			764.87	13.87		
712.21	12.61		0.39	743.10	13.70	0.19	0.55	765.02	14.19	0.12	0.59
712.57	12.73			744.10	12.99	0.24	0.36	765.95	14.61	0.08	0.81
713.62	12.65			745.05	12.86	0.17	0.41	765.98	14.36		
714.01	12.61	0.22	0.44	745.98	12.60	0.22	0.41	767.98	14.93	0.00	0.94
714.10	12.54			747.10	12.95			770.89	14.37		
719.02	12.69		0.51	749.91	12.59			772.95	13.54	0.14	0.44
722.03	12.63	0.20	0.45	751.05	13.04	0.10	0.52	772.99	13.53	0.14	0.42
723.00	12.84	0.19	0.50	751.10	13.00	0.05	0.54	773.93	13.41	0.10	0.44
723.96	13.15	0.19	0.66	751.20	12.99	0.13	0.57	773.96	13.35	0.12	0.43
724.04	13.08			755.94	13.21	0.09	0.57	774.94	13.41	0.19	0.47
725.01	13.55	0.09	0.82	756.05	13.07			775.00	13.41	0.17	0.50
727.00	12.81		0.50	756.96	13.49			775.93	13.65	0.08	0.52
728.96	13.10			757.90	13.21			775.99	13.62	0.11	0.50
729.15	13.26	0.11	0.67	757.94	13.41	0.16	0.47	778.08	14.33	–0.10	0.80

(Table 1 continued on following page)

Table 1. CCD observations of Nova LMC 2005, continued.

JD –2453000	*V*	*B–V*	*V–R*	*JD* –2453000	*V*	*B–V*	*V–R*	*JD* –2453000	*V*	*B–V*	*V–R*
778.94	14.13	0.03	0.68	798.09	15.13	–0.09	0.80	831.94	16.21	–0.31	1.73
782.92	14.42	0.00	0.71	802.94	14.69	–0.20	0.54	833.90	15.92	0.14	1.19
782.98	14.45	–0.13	0.86	803.95	14.63	–0.06	0.54	834.91	15.94	0.03	1.28
783.96	14.55	–0.13	0.81	805.97	14.69	–0.06	0.49	836.92	16.22	–0.10	1.24
784.96	14.44			806.98	14.45		0.46	837.98	16.02	0.26	1.27
784.97	14.92	0.02	0.89	807.87	14.59			840.89	16.34	–0.35	1.32
785.89	14.44			808.83	14.69			846.90	16.31	–0.03	1.25
785.94	15.15	–0.03	1.16	808.95	14.67	–0.08	0.46	847.87	16.10	–0.03	1.06
786.86	14.38			810.95	14.97	–0.07	0.51	847.89	16.13	–0.01	1.08
787.86	14.43			813.00	15.12		0.51	852.05	16.08	0.02	1.21
788.86	13.96			813.00	15.12	0.04	0.49	859.90	16.02	–0.03	1.03
788.98	14.38	0.03	0.64	816.00	15.56	–0.13	0.86	868.87	16.11	–0.05	1.13
789.86	14.61			816.00	15.56	–0.09	0.81	870.94	15.91	0.16	0.87
789.93	15.38	–0.15	1.26	818.08	15.81	–0.32	1.02	875.97	15.95	0.17	0.82
790.97	14.89	–0.22	0.90	818.08	15.81	–0.27	0.96	876.87	16.38	–0.42	1.13
790.98	15.16	–0.14	1.04	819.96	15.97	–0.29	1.24	879.91	15.98	0.16	0.84
792.87	15.54			820.96	16.14	–0.52	1.50	882.89	15.94	0.24	0.78
794.97	14.72	–0.03	0.67	821.97	16.21	–0.54	1.51	889.89	15.86	0.31	0.62
795.02	14.76	–0.13	0.77	822.01	15.97	–0.51	1.36	893.88	15.77	0.41	0.43
795.08	14.75	0.01	0.72	822.97	16.21	–0.54	1.51	903.92	15.93	0.30	0.57
795.98	14.84	–0.04	0.75	824.95	15.97	–0.22	1.18	906.90	15.85	0.41	0.49
796.00	14.85	–0.03	0.71	826.98	16.06	–0.54	1.45				
797.02	14.97	–0.02	0.86	831.02	16.34	–0.20	1.68				

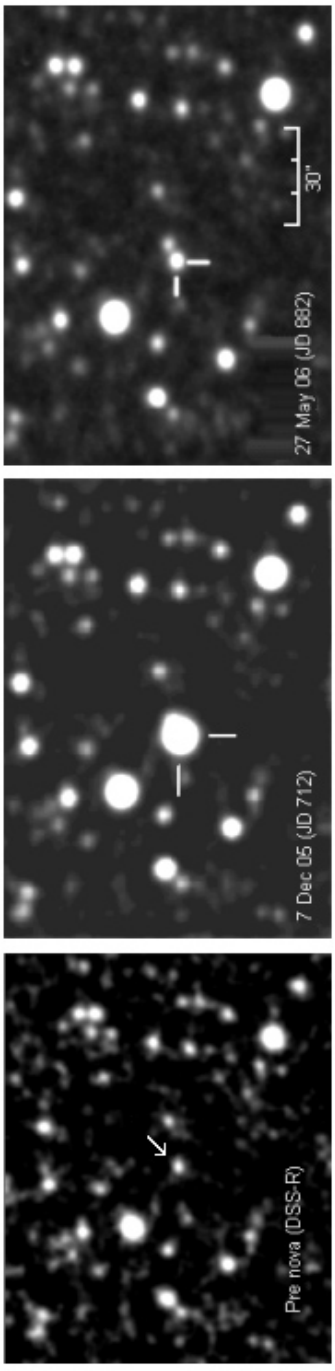

Figure1. The pre-nova field from a DSS plate and the nova development over a six-month period, with close companion star indicated by the arrow. The later two images were taken by one of us (Heathcote).

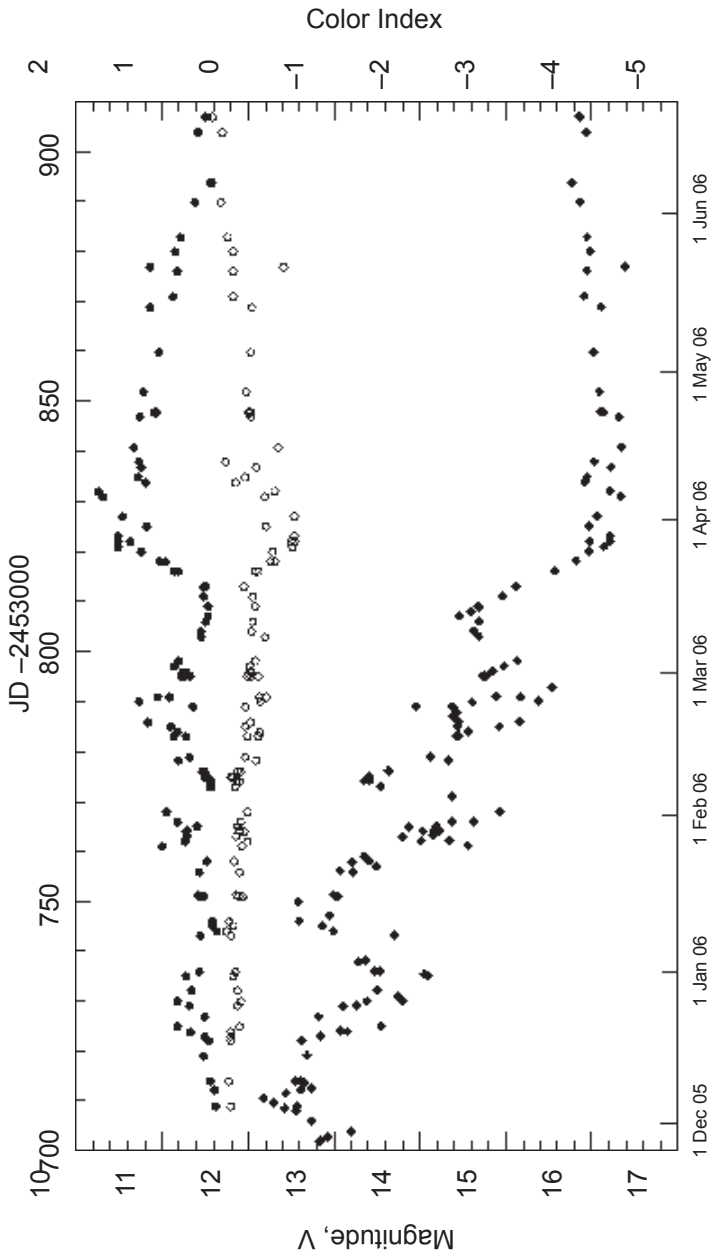

Figure 2. Nova LMC 2005 CCD light curve: *V* (lower plot, diamonds), and color indices *B*–*V* (middle plot, open circles), and *V*–*R* (upper plot, filled circles).