COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 6162

Konkoly Observatory
Budapest
8 March 2016

HU ISSN 0374 – 0676

PHOTOMETRIC EVOLUTION OF THE 2016 OUTBURST OF RECURRENT NOVA LMC 1968: THE FIRST THREE WEEKS

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When Nova LMC 1968 (= LMCN 1968-12a = Nova Men 1968; Sievers 1970) erupted again in 1990 (as Nova LMC 1990 N.2 = LMCN 1990-02a = LMC V1341; Liller 1990), it became the first recurrent nova known in LMC (Shore et al. 1991). Further outbursts of Nova LMC 1968 were observed in 2002 (by the ASAS-3 survey, Pojmanski 2002), and in 2010 (by the OGLE survey, Mroz et al. 2014). A fifth eruption, detected in OGLE real-time data, has just been announced by Mroz and Udalski (2016). In this paper we present and discuss our extensive B,V,R_C,I_C photometry of the first three weeks of 2016 event, while further observations are in progress.

We have obtained optical photometry of the nova with the (*a*) SMARTS 1.3-m telescope + ANDICAM from CTIO (Chile), which data are reduced against nightly observations of all-sky standard stars (Walter et al. 2012), and with (*b*) a 0.4-m robotic telescope operated by ANS Collaboration in Atacama (Chile), which data are reduced against a local photometric sequence extracted from the all-sky APASS survey (Henden et al. 2012, Munari et al. 2014). Two faint field stars are located within $\sim$2 arcsec of the nova, a fact not appreciated in previous outbursts whose published photometry refers to the combined (non-deconvolved) light of the nova and of these two nearby field stars. The combined magnitude of the two field stars is B=18.79, V=18.26, R_C=17.86, and I_C=17.49. In Figure 1 we present our non-deconvolved B,V,R_C,I_C photometry of the 2016 outburst (measured through a 11-arcsec aperture on both telescopes), while deconvolved SMARTS photometry (PSF-fitting) is plotted in Figure 2, and both sets of data are listed in Table 1 (available electronically only). No deconvolution is possible for SMARTS JD=2457414.65 observation because of the $\sim$3 arcsec seeing affecting it. ANS photometry is not deconvolved because of the focal length too short for a meaningful PSF-fitting. In both figures, the continuous line is the deconvolved OGLE I_C-band photometry for the 2010 outburst, plotted for reference. A similar comparison with other outbursts and/or other wavelengths is not possible because the published photometry is very scanty, with only a few points being – at best – available per outburst.

The decline rates for the first week of the 2016 outburst are 0.57 mag day^{-1} in R_C, 0.53 in I_C, 0.50 in B, and 0.45 in V. The corresponding classical t_2 and t_3 decline times are 3.5 and 5.2 days in R_C, 3.8 and 5.7 in I_C, 4.0 and 5.9 in B, and 4.5 and 6.7 in V. The

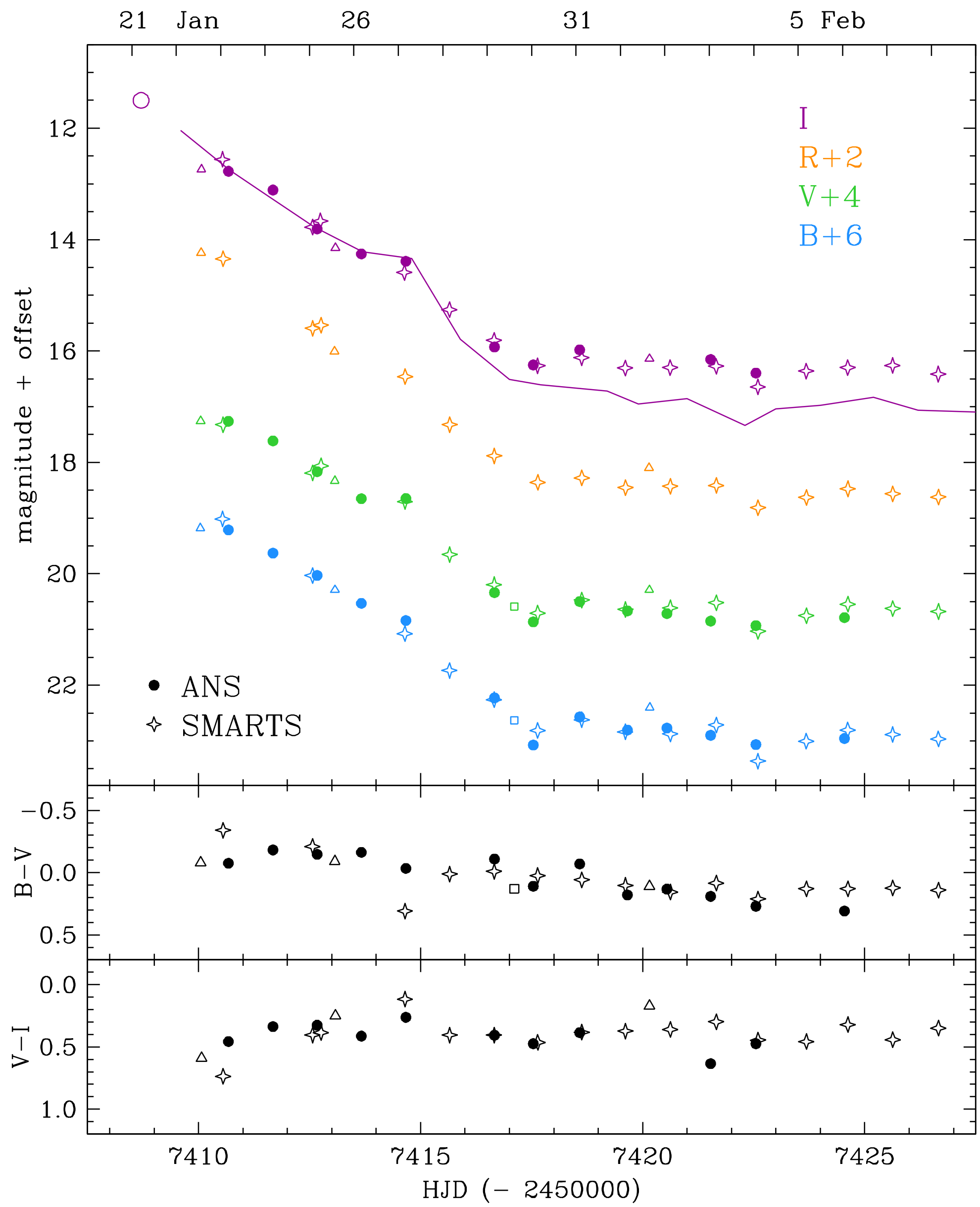

Figure 1. Non-deconvolved BVR_CI_C photometry of the 2016 outburst of Nova LMC 1968. The open circle is the I_C-band discovery observation by Mroz and Udalski (2016), and the line is the I_C-band light curve of the 2010 outburst (from Mroz et al. 2014). Triangles and squares are observations by Kaur et al. (2016) and Darnley and Williams (2016), respectively.

2016 outburst is characterized by a striking similarity to that of 2010, at least for the I_C light curve, as illustrated in Figures 1 and 2. In addition to the identical decline rates, the ∼1 day *plateau* the nova went through between 26 and 27 Jan 2016, is similarly present in the 2010 light curve, and coincides with the first appearance of super-soft X-ray emission in 2016 Swift observations of the nova (Page et al. 2016). The detection of emerging super-soft emission indicates the ejecta were turning optically thin and therefore exposed to the hard radiation field of the central white dwarf. The consequent input of ionizing photons spreading through the ejecta, counter-balanced for a short time the recombination and delayed by ∼1 day the resumption of the fast decline, which is driven by the dilution

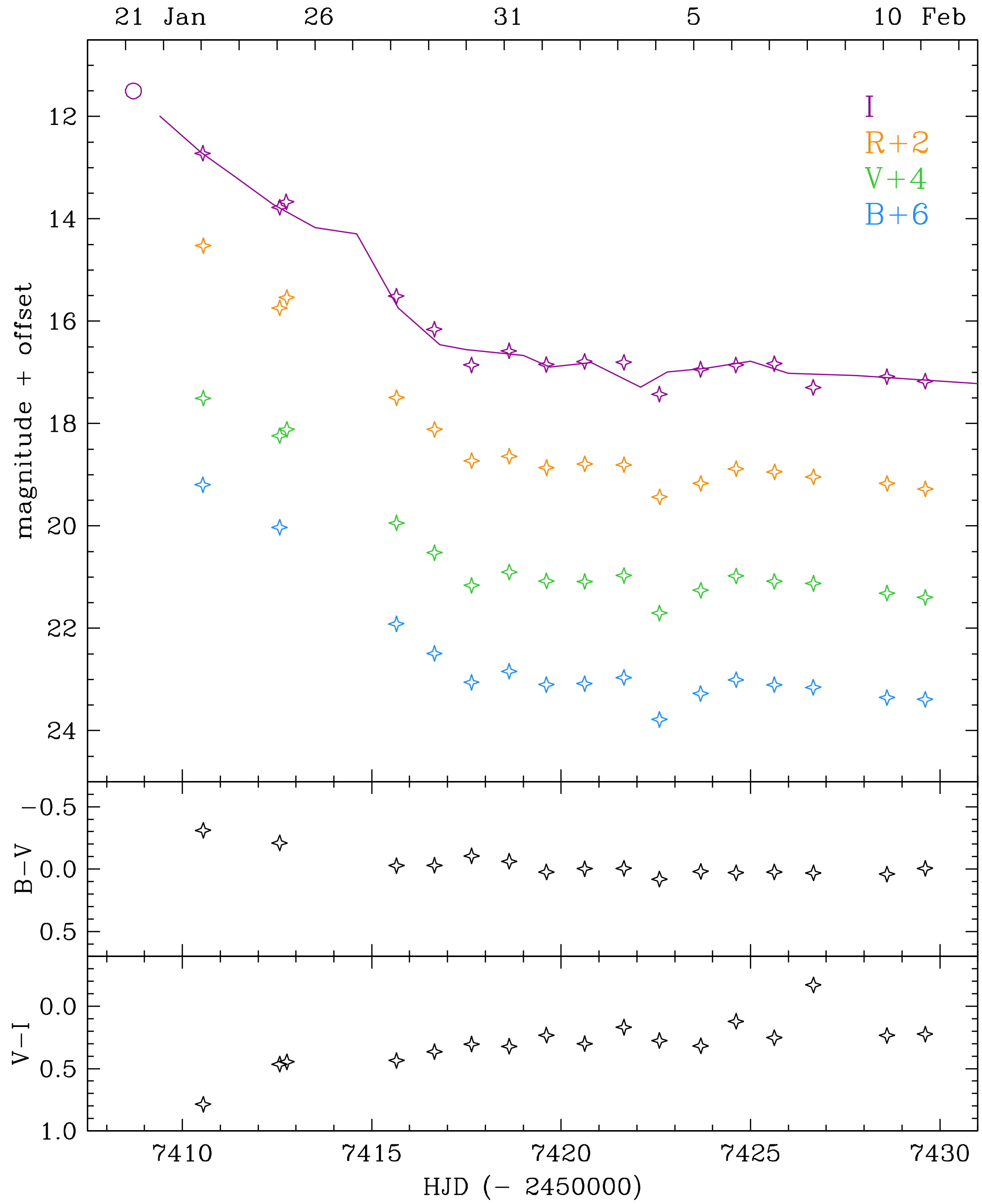

Figure 2. Deconvolved SMARTS $BVR_\mathrm{C}I_\mathrm{C}$ photometry of the 2016 outburst of Nova LMC 1968. The open circle and the line have the same meaning as in Figure 1.

of the rapidly expanding ejecta. The fast decline lasted for only a few more days, until the system brightness became sustained primarily by the direct emission from the central white dwarf. This phase corresponds to the marked flattening of the light curve after January 30. As illustrated in Figure 2, the brightness of the nova during this phase is identical in the 2016 and 2010 events, signifying identical conditions for the white dwarf and the ongoing nuclear burning at its surface. Intriguing is the dent visible in all bands between February 3 and 4, similarly present in the 2010 light curve.

For the 2010 eruption, Mroz et al. (2014) report the nova being at normal $I_\mathrm{C} \sim 19$ mag quiescent brightness on 19.2 November and at $I_\mathrm{C} \sim 12$ mag (possibly saturated) on the next observation two days later, on 21.2 November, and estimate in $I_\mathrm{C} \sim 11.5$ the peak magnitude supposedly reached around 20.2 November. Mroz and Udalski (2016) quote their $I_C = 11.5$ mag discovery observation on 21.2 January 2016 as saturated. Its position on the light curve of Figure 1 suggests however that the saturation is probaby only marginal. It is also at the same level of the peak brightness estimated by Mroz et al. (2014) for the 2010 event. Considering the identical 2010 and 2016 light curves, it seems reasonable to assume that the nova reached its maximum $I_C \sim 11.5$ brightness on 21.2 January 2016. Adopting for LMC a 18.5 mag distance modulus and a $E_{B-V} = 0.08$ mag reddening, the corresponding absolute magnitude is $M_I = -7.15$ mag. By low order extrapolation to 21.2 January of the color evolutions depicted in Figures 1 and 2, the peak brightness attained by the nova in the other bands can be estimated as $R_C \sim 11.3$, $B \sim 12.0$ and $V \sim 12.2$. As already noted by Sekiguchi et al. (1990) for the 1990 outburst, these magnitudes are much fainter than expected – for LMC distance and reddening – on the basis of magnitude-at-maximum/rate-of-decline (MMRD) relations, like the most recent one by Downes and Duerbeck (2000) that predicts an observed $V_{\rm peak} \sim 9$ mag.

Only small portions of the light curve were mapped during previous outbursts. Given the identical I_C light curve for 2010 and 2016 eruptions, we may assume that the light curves in other bands are similar from outburst to outburst, in particular their decline rates. The time intervals elapsed between the 2016, 2010, 2002, 1990, and 1968 events are then 1888.4, 2961.2, 4621.7, and 7728.3 days, respectively (uncertainties ± 0.6 days). Considering that (*i*) the 2010 outburst was missed altogether by the community, and it was recovered only by inspecting years later the archived OGLE data (Mroz et al. 2014), (*ii*) OGLE-IV is in operation only by a few years, and (*iii*) inter-season gaps in the OGLE monitoring of LMC last for ~ 100 days, we may conclude that several more outbursts of Nova LMC 1968 have probably gone missed. A recurrence period of ~ 955 days would decently fit both the OGLE inter-season gaps and the observed intervals between previous outbursts. If correct, this would place Nova LMC 1968 among those with the shortest known recurrence period, between M31N 2008-12a ($\sim$1 year) and M31N 1963-09c ($\sim$5 years; Shafter et al. 2015).

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