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PHOTOMETRIC EVOLUTION OF NOVA Del 2013 (V339 Del) DURING THE OPTICALLY THICK PHASE

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The FeII-class Nova Del 2013 (=V339 Del) was discovered on 2013 Aug 14.584 UT by K. Itagaki when it was already visible at unfiltered 6.8 magnitude (cf. CBET 3628). The progenitor seems to be the blue star USNO B-1 1107-0509795 with $B\sim$17.2, $R_{\rm C}\sim$17.4. The observation by Denisenko et al. (cf. CBET 3628) reporting the nova still in quiescence at $\sim$17.1 mag on Aug 13.998 UT (14 hours before the discovery), would indicate a very fast rise to maximum. The very convenient placement in the evening sky and the naked-eye brightness attained by the nova favored a full suite of all-out observing efforts, which have produced a flurry of circulars and telegrams. Among others, descriptions of nova spectra have been provided by Shore et al. (2013a,b,c,d), Munari et al. (2013a,b,c,d), Tomov et al. (2013), Darnley & Bode (2013), Tarasova & Shakhovskoi (2013), Woodward et al. (2013); infrared observations have been reported by Gehrz et al. (2013), Cass et al. (2013a,b,c,d), Banerjee et al. (2013a,b), Shenavrin et al. (2013); development of X-ray emission has been monitored by Nelson et al. (2013) and Page et al. (2013a,b); and radio detections have been described by Dutta et al. (2013), Roy et al. (2013), Chomiuk et al. (2013), and Anderson et al. (2013). There also seems to be a 5σ detection of the nova in γ-rays (Hays et al. 2013).

No comprehensive description of the optical photometric evolution of Nova Del 2013 has been provided to date. In this paper we present our $BVR_{\rm C}I_{\rm C}$ light curve of Nova Del 2013 covering the evolution from discovery to day +77 past optical maximum, corresponding to the end of the optically thick phase of the ejecta and their transition to the nebular, optically thin regime. The light and color curves are presented in Figure 1, while Figure 2 highlights the phase of maximum brightness. The data are given in Table 1, available electronic only. To observe the nova we used eight different robotic or remotely controlled telescopes, equipped with photometric filters from various vendors (Schuler, Omega, Astrodon). Close to maximum brightness we used six small-diameter refractors: four 6-cm Bright Star Monitor instruments (part of AAVSOnet; located at AAVSO headquarters, Australia, California, New Mexico and identified in Figures 1 and 2 as BSM HQ, AU, CA and NM, respectively), and two operated by ANS Collaboration (a 6cm and a 15cm, with ANS identifiers 011 and 032. At the time of maximum nova brightness their aperture was reduced to 3 cm). At later times, when the nova had faded several magnitudes below maximum, two 30cm instruments joined the monitoring effort:

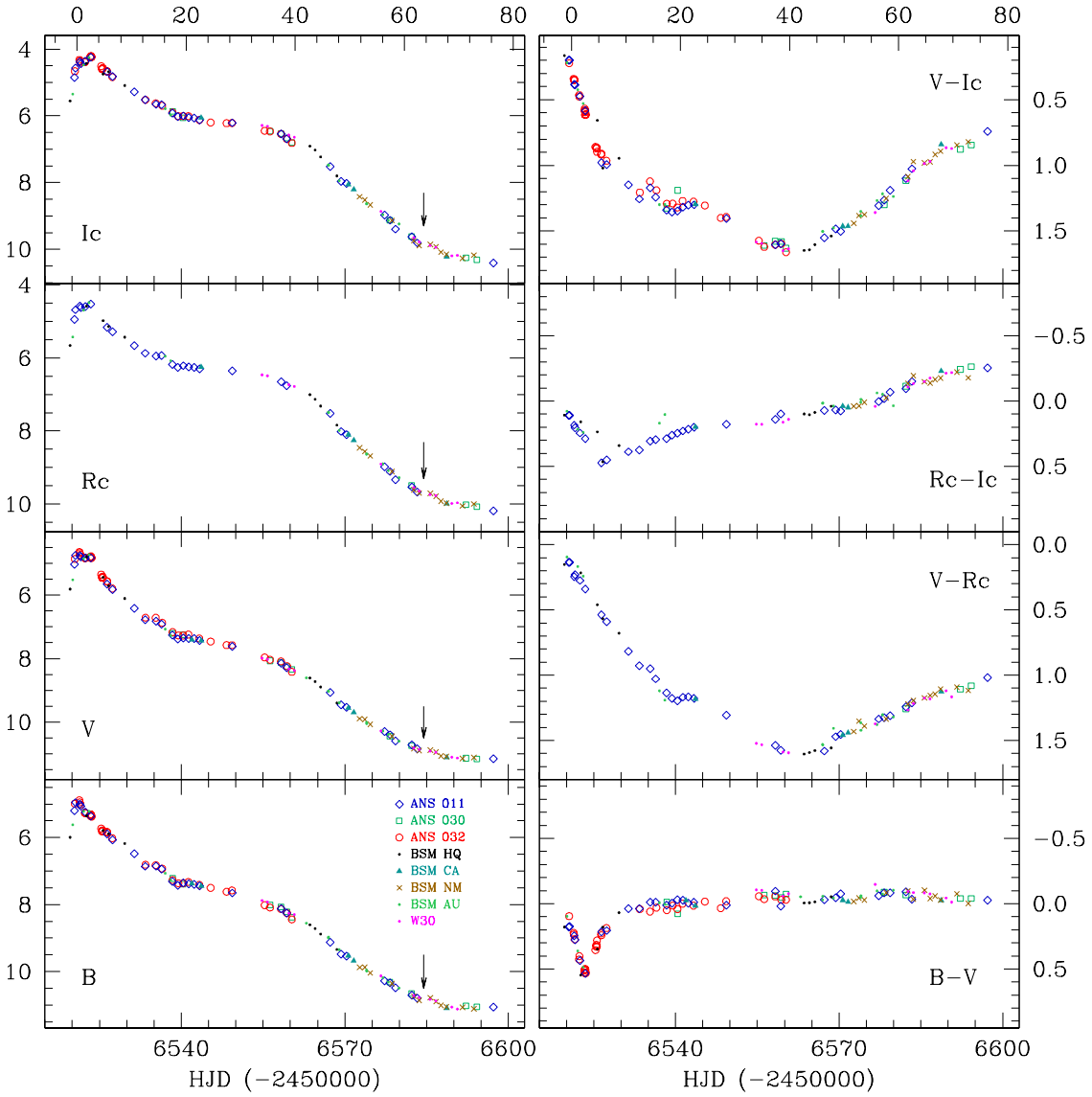

Figure 1. Our BVR_CI_C light and color curves of Nova Del 2013 extending to day +77 past maximum, covering the optically thick phase and the transition to nebular, optically thin conditions. The abscissae at the top of the graph are days counted from maximum brightness in V band. The arrows mark the time (Oct 17) when the flux of [OIII] 5007 Å emission lines equalled that of Hβ.

W30 from AAVSOnet and 030 from ANS Collaboration. The data collected at all these eight telescopes were reduced against the same local photometric sequence calibrated during photometric nights against Landolt (2009) equatorial standards. During data reduction, magnitude and colors were obtained separately and were not derived one from the other. The very strong emission lines displayed by Nova Del 2013 introduce some systematic deviation and offset (at the level of several hundredths of magnitude) between the light curves obtained with different instruments, which cannot be compensated for by the application of standard color equations. To rectify these small systematic offsets we have applied the light curve merging method (LMM) described by Munari et al. (2013e).

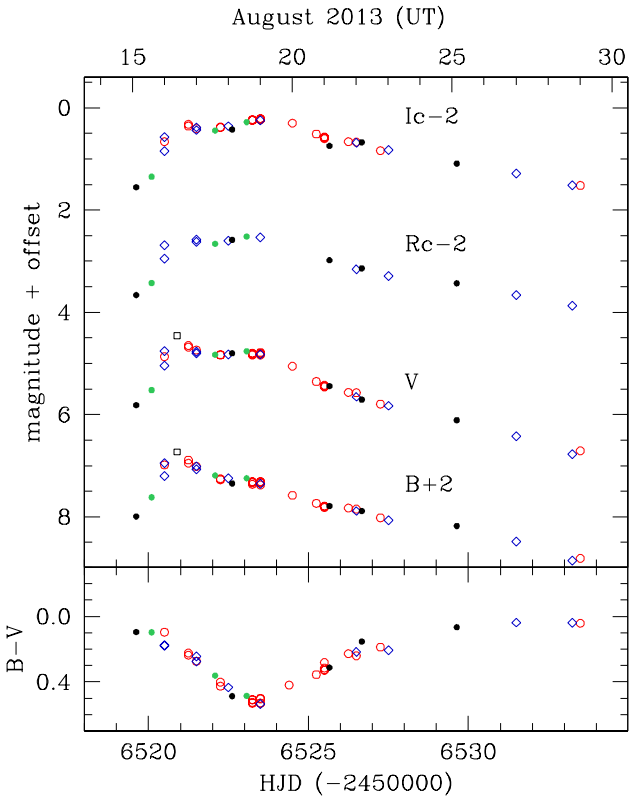

Figure 2. Zoomed view of Figure 1 around Nova Del 2013 maximum brightness.

The photometric evolution of Nova Del 2013 as illustrated in Figures 1 and 2 is characterized by: (1) a smooth behaviour, with short time scale variations – if any was actually present – not exceeding at any time a few hundredths of a magnitude; (2) a brief plateau appearing soon after maximum brightness and lasting ∼1.5 days; (3) a longer plateau extending from about day +20 to +37, that started when the nova had declined by ΔV=+2.8 mag from maximum brightness; (4) for both B and V bands, the rate of brightness decline before and after this long plateau remained the same: 0.125 mag/day. The R_C and I_C bands behaved similarly; (5) as typical of novae, a marked flattening of the decline rate occurred simultaneously with the transition of the ejecta from optically thick to nebular conditions. The time when the flux of [OIII] 5007 Å emission line equalled that of Hβ (October 17, from Munari et al. 2013e) is marked by an arrow in Figure 1. This transition to nebular conditions occurred when the nova had declined by ∼6 mag, much more than typically observed in other novae (where the transition occurs ∼3.5/4.0 mag below maximum brightness); and (6) a peculiar value and evolution for $B-V$ color, characterized by a nearly constant value apart from a brief excursion around the time of maximum brightness and the initial brief plateau. According to van den Bergh & Younger (1987), typical novae display $(B-V)_\circ = +0.23 \pm 0.06$ at B,V maximum brightness and $(B-V)_\circ = -0.02 \pm 0.04$ at t_2. The corresponding observed values for Nova Del 2013 were $B-V$=+0.14 and $B-V = +0.04$, that become $(B-V)_\circ = -0.04$ and $(B-V)_\circ = -0.14$ once corrected for the $E_{B-V} \simeq 0.18$ insterstellar reddening affecting the nova (cf. Tomov et al. 2013, Munari et al. 2013a).

Maximum light in B and V bands was attained by Nova Del 2013 during daytime in Italy on August 16, and during bad weather conditions at the AAVSOnet observing sites.

By interpolating data reported in CBET 3628, 3634 and by Burlak et al. (2013) it can be estimated that maximum brightness occurred around August 16.4 UT (JD 2456520.9), at $V \sim 4.46$ and $B \sim 4.70$. The outburst amplitude is therefore ΔB=12.5 mag, comparing with $B \sim 17.2$ for USNO B-1 1107-0509795 progenitor. This maximum is marked by an open black square in Figure 2. The evolution around maximum brightness looks different depending on the photometric band. In the B band, the maximum is sharp and the decline commenced immediately with characteristic times t_2^B=12 and t_3^B=30 days, that were t_2^V=10.5 and t_3^V=23.5 in V band, which place Nova Del 2013 in a borderline position between *fast* and *very fast* novae according to the Warner (1995) classification scheme. The brief plateau that the nova displayed in the V band soon after maximum and that lasted ∼1.5 days, corresponded to a prolonged flat maximum in the R_C band and to a delayed maximum in the I_C band, occurring ∼2.5 days after that in B.

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