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PHOTOMETRY OF THE PROGENITOR OF NOVA DEL 2013 (V339 DEL) AND CALIBRATION OF A DEEP BVRI PHOTOMETRIC COMPARISON SEQUENCE

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Nova Del 2013 (=V339 Del) was discovered on 2013 Aug 14.584 UT by K. Itagaki when it was already shining at unfiltered 6.8 magnitude (cf. CBET 3628). The observation by Denisenko et al. (cf CBET 3628) reporting the nova still in quiescence at ∼17.1 mag on Aug 13.998 UT (14 hours before the discovery), would indicate a very fast rise to maximum. The photometric evolution of the nova during the optically thick phase has been presented by Munari et al. (2013a).

The nova appeared at a position coincident with the blue star USNO B-1 1107-0509795, reported at B∼17.20, $R_{\rm C}$∼17.45 on the first Palomar Sky Survey plates (exposed on 7 July 1951), and at B∼17.39, $R_{\rm C}$∼17.74 on the second Palomar Sky Survey plates (exposed on 18 July and 15 September 1990, respectively). The progenitor is bright enough to have been recorded on patrol plates taken with the Asiago Schmidt telescopes, in particular the 67/92 cm instrument. We searched the Asiago plate archive and found 25 plates imaging the area of the sky where the nova later appeared (16 in B band, 7 in V, and 2 in $I_{\rm C}$).

Prior to measuring these plates, it was necessary to establish an accurate and reliable photometric sequence around the nova. Given the huge interest this nova has received because of its peak brightness(V=4.46, B=4.70), it may be presumed that its remnant will be studied for long after the system has returned to quiescence. To ensure proper comparison of the pre-outburst photometric data with the post-outburst ones, a well calibrated and common photometric sequence must be adopted. To this aim we obtained deep exposures in $BVR_{\rm C}I_{\rm C}$ bands of the field surrounding the nova on three separate photometric nights with the TMO61 telescope (part of the AAVSOnet robotic network) in New Mexico (USA). The data for each night were independently calibrated against the equatorial Landolt (2009) standard stars, and the results averaged.

From the common data set, we have extracted two sets of standards, presented in Tables 1 and 2. These standards are on the same photometric scale of the brighter ones used by Munari et al. (2013a) to derive the photometric evolution of the nova around maximum and early decline. The standards in Table 1 are optimized for CCD observations and are grouped within 5 arcmin of the nova. They were selected at three different

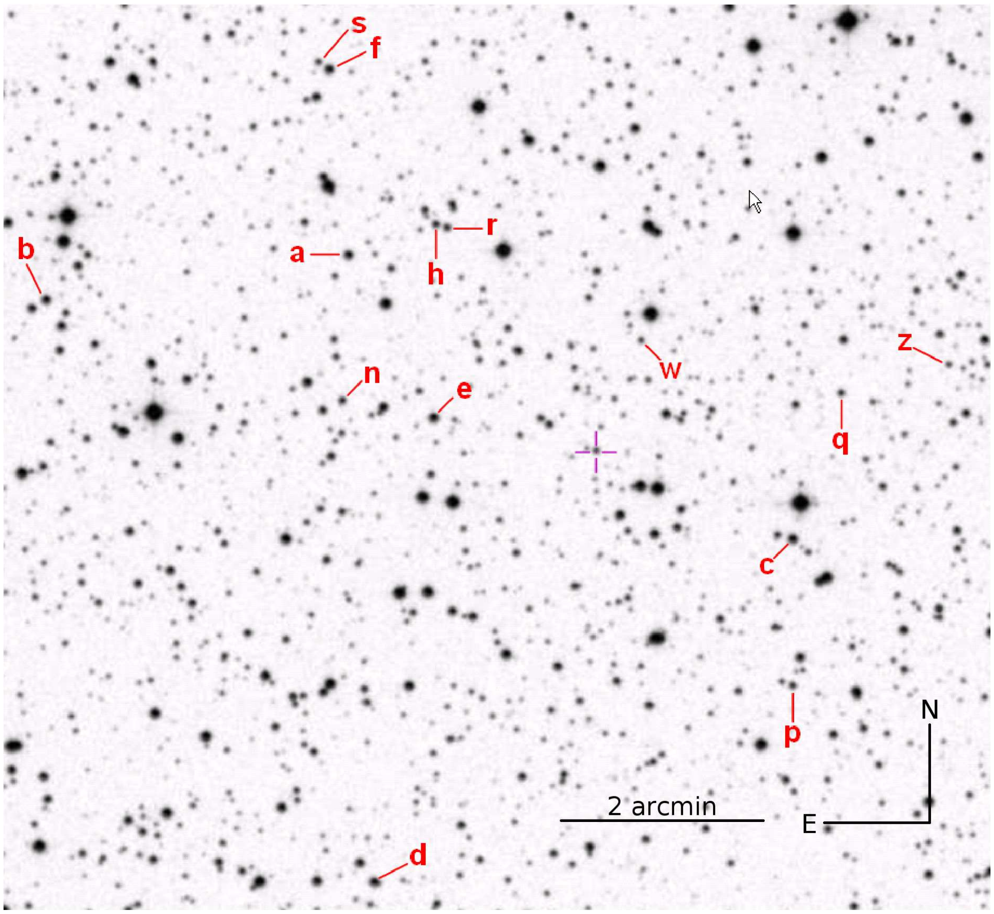

Figure 1. Finding chart for the BVR_CI_C photometric sequence in Table 1, optimized for CCD observations of Nova Del 2013 during the advanced decline and after its return to quiescence.

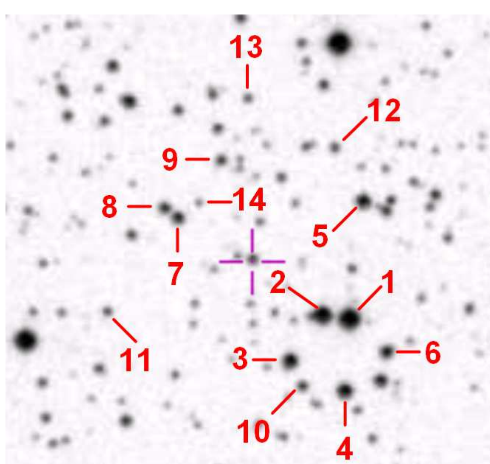

Figure 2. Finding chart for the BVR_CI_C photometric sequence in Table 2, optimized for measurement of the progenitor on archive photographic plates. The chart is 3.0 arcmin wide with North to the top and East to the left.

Table 1: $BVR_{\mathrm{C}}I_{\mathrm{C}}$ photometric sequence (plotted in Figure 1), optimized for CCD observations of Nova Del 2013 during the advanced decline and after its return to quiescence.

	α	$\pm$	δ	$\pm$	N	V	$\pm$	B-V	$\pm$	V-Rc	$\pm$	Rc-Ic	$\pm$	V-Ic	$\pm$
a	305.923000	0.257	20.800496	0.245	3	14.628	0.017	1.075	0.031	0.578	0.031	0.525	0.019	1.106	0.038
b	305.977735	0.042	20.792703	0.033	3	14.431	0.017	1.267	0.013	0.718	0.033	0.611	0.014	1.329	0.028
c	305.842211	0.049	20.752941	0.007	3	14.751	0.019	0.643	0.014	0.370	0.018	0.363	0.015	0.734	0.033
d	305.917730	0.073	20.694474	0.031	3	14.777	0.022	0.788	0.019	0.461	0.023	0.420	0.009	0.881	0.031
e	305.907336	0.053	20.773056	0.008	3	14.821	0.011	0.533	0.029	0.325	0.002	0.339	0.033	0.667	0.039
	.														
f	305.926635	0.063	20.831951	0.022	3	15.171	0.045	0.457	0.017	0.273	0.033	0.286	0.017	0.559	0.045
g	305.812010	0.096	20.797778	0.037	3	15.638	0.025	0.515	0.013	0.340	0.013	0.344	0.019	0.686	0.027
h	305.907143	0.086	20.805805	0.018	3	15.685	0.017	1.217	0.031	0.617	0.021	0.586	0.011	1.211	0.032
m	305.810946	0.042	20.774322	0.022	3	15.789	0.022	0.625	0.021	0.394	0.018	0.393	0.007	0.791	0.022
n	305.923894	0.015	20.775920	0.049	3	15.854	0.029	1.063	0.007	0.602	0.047	0.594	0.004	1.205	0.041
r	305.905116	0.051	20.805268	0.039	3	15.983	0.021	0.784	0.038	0.443	0.036	0.395	0.026	0.837	0.010
	.														
s	305.928668	0.021	20.833250	0.031	3	16.335	0.019	1.239	0.028	0.774	0.040	0.734	0.013	1.519	0.023
p	305.842054	0.065	20.728134	0.045	3	16.350	0.013	0.653	0.041	0.364	0.043	0.366	0.034	0.733	0.036
q	305.833547	0.073	20.777642	0.006	3	16.414	0.014	0.746	0.049	0.348	0.034	0.396	0.032	0.753	0.011
z	305.814090	0.044	20.782587	0.027	3	16.832	0.024	0.915	0.048	0.497	0.015	0.486	0.014	0.989	0.011
w	305.869829	0.015	20.786390	0.015	3	16.892	0.035	0.596	0.041	0.424	0.020	0.364	0.042	0.786	0.037

Table 2: $BVR_{\mathrm{C}}I_{\mathrm{C}}$ photometric sequence (plotted in Figure 2), optimized for measurement of the progenitor on archive photographic plates.

	α	$\pm$	δ	$\pm$	N	V	$\pm$	B-V	$\pm$	V-Rc	$\pm$	Rc-Ic	$\pm$	V-Ic	$\pm$
1	305.866822	0.000	20.761365	0.009	3	12.956	0.020	0.663	0.016	0.368	0.027	0.335	0.011	0.701	0.036
2	305.869855	0.021	20.761706	0.007	3	13.974	0.020	0.441	0.010	0.257	0.028	0.275	0.014	0.533	0.039
3	305.873531	0.021	20.756879	0.032	3	14.923	0.019	0.644	0.010	0.352	0.033	0.387	0.009	0.745	0.041
4	305.867263	0.047	20.753647	0.004	3	14.434	0.014	1.186	0.005	0.623	0.022	0.564	0.007	1.191	0.027
5	305.865298	0.049	20.773975	0.004	3	14.837	0.016	1.040	0.023	0.580	0.015	0.545	0.018	1.130	0.032
6	305.862514	0.036	20.757837	0.037	3	15.624	0.037	0.713	0.068	0.425	0.030	0.391	0.003	0.816	0.031
7	305.886392	0.053	20.772088	0.025	3	16.020	0.017	0.478	0.051	0.319	0.008	0.349	0.021	0.672	0.032
8	305.887957	0.033	20.773124	0.015	3	16.104	0.023	0.930	0.048	0.540	0.039	0.479	0.032	1.019	0.026
9	305.881489	0.057	20.778284	0.044	3	16.907	0.037	0.543	0.086	0.298	0.020	0.373	0.037	0.682	0.055
10	305.872048	0.044	20.754137	0.013	3	16.422	0.040	1.251	0.096	0.715	0.045	0.573	0.078	1.285	0.048
11	305.894345	0.026	20.762005	0.025	3	17.284	0.067	0.765	0.096	0.638	0.132	0.653	0.078	1.305	0.040
12	305.868499	0.101	20.779694	0.080	3	17.376	0.068	0.862	0.093	0.475	0.107	0.452	0.084	0.929	0.068
13	305.878491	0.244	20.784939	0.056	3	17.597	0.040	0.686	0.042	0.493	0.060	0.469	0.013	0.965	0.067
14	305.884012	0.276	20.773748	0.000	2	18.497	0.058	0.600	0.068	0.564	0.037	0.468	0.105	1.030	0.083

magnitude levels ($V\sim$14.6, 15.6, and 16.6 mag) to support photometric investigation of both the advanced decline and the following return to quiescence of the nova. At each of the three different magnitude levels, at least five standards are provided that cover a broad range of colors so to allow the calibration of color equations to transform the measurements from the local to the standard system. The standards in Table 2 are instead optimized to derive the magnitude of the progenitor on old photographic plates, most of which were exposed in blue light or in B band. They are grouped within 1 arcmin of the nova.

The magnitude of the progenitor of Nova Del 2013 on Asiago photographic plates was

Table 3: The brightness of the progenitor of Nova Del 2013 as measured on Asiago photographic plates.

plate	tel.	date	UT	epxt.	emulsion	filter	band	mag
10005	67/92	1979 04 23	00:06	5	103 a-O	GG 13	B	>13.6
10033	67/92	1979 05 20	00:03	15	103 a-O	GG 13	B	>14.5
10034	67/92	1979 05 20	00:31	20	I-N Sen.	RG 5	I	>15.3
10055	67/92	1979 05 23	00:09	20	103 a-O	GG 13	B	17.2
10056	67/92	1979 05 23	00:42	30	I-N Sen.	RG 5	I	>15.3
10240	67/92	1979 10 24	21:21	20	103 a-D	GG 14	V	>17.3
10262	67/92	1979 11 20	20:20	20	103 a-O	GG 13	B	>17.5
10303	67/92	1979 12 11	19:57	15	103 a-O	GG 13	B	>16.5
10484	67/92	1980 05 12	23:26	15	103 a-D	GG 14	V	>16.1
10530	67/92	1980 07 09	20:50	15	103 a-O	GG 13	B	>17.5
10531	67/92	1980 07 09	21:16	15	103 a-D	GG 14	V	>16.4
10546	67/92	1980 07 16	00:03	15	103 a-O	GG 13	B	17.2
10547	67/92	1980 07 16	00:25	15	103 a-D	GG 14	V	>16.9
10624	67/92	1980 09 30	20:01	15	103 a-D	GG 14	V	>16.4
10646	67/92	1980 10 13	21:34	15	103 a-O	GG 13	B	17.8
11035	67/92	1981 07 26	22:55	20	103 a-D	GG 14	V	17.4
11076	67/92	1981 08 23	23:47	30	103 a-O	GG 13	B	17.2
11100	67/92	1981 09 06	22:20	20	103 a-O	GG 13	B	17.2
11122	67/92	1981 10 23	21:10	20	103 a-O	GG 13	B	17.2
11178	67/92	1981 11 16	18:11	20	103 a-O	GG 13	B	17.1
11231	67/92	1981 11 22	19:35	30	103 a-O	GG 13	B	17.4
11568	67/92	1982 06 28	01:18	20	103 a-O	GG 13	B	17.5
11578	67/92	1982 07 16	01:00	20	103 a-O	GG 13	B	16.9
11716	67/92	1982 10 20	20:45	30	103 a-D	GG 14	V	17.8
15355	40/50	1983 04 09	21:43	15	103 a-O	GG 13	B	>17.5

estimated by eye through a high quality Zeiss microscope. The plates were independently re-measured a few days later and the results were found to be the same within 0.1 mag, which is therefore taken as the error associated to the measurements. The results are presented in Table 3. The mean brightness of the progenitor on these plates is $<B>$=17.27 and $<V>$=17.6, for a mean color $(B-V)$=−0.33. The recorded total amplitude of variation in B band is 0.9 mag. Color and variability are in agreement with a progenitor dominated by the emission from an accretion disc. The reddening toward Nova Del 2013 is low (E_{B-V}=0.18, e.g. Munari et al. 2013b) given its high galactic latitude (b=$-9\overset{\circ}{.}4$). Brightness level and color are in excellent agreement with the USNO-B1 values from Palomar surveys 1 and 2, arguing for a long term stability before the 2013 eruption.

The progenitor was marginally detected also by the APASS all sky survey, when it visited the field on 2012 April 21, 24 and 25, thus about 18 months before the nova eruption. We have stacked the CCD images from these three visits and measured the progenitor at B=17.33±0.09 and V=17.06±0.10.

References:

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Munari, U. et al. 2013b, ATel 5297