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BVI photometry and the spectroscopy of Nova Scuti 2005 N.2⋆ *(Research Note)*

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ABSTRACT

Our CCD photometry of Nova Scuti 2005 N.2 (=V477 Sct) shows it to be a very fast nova, which is characterized by $t_2 = 3$ and $t_3 =$ 6 days, affected by a $E_{B-V} \geq 1.3$ mag reddening, and which peaked at $V \sim 9.8$ mag on ∼Oct. 12.0 UT. The nova was probably entering a dust condensation episode or brightness oscillations during the transition phase when it became unobservable for the seasonal conjunction with the Sun. Absolute spectrophotometry shows it to belong to the He/N class. The emission line width at half intensity is 2600 km s^{-1}. At least five ripples are identified in the high resolution emission lines profiles at radial velocities ranging from −980 to +700 km s^{-1}. The nova erupted at a large distance from the Sun and at an appreciable height above the Galactic plane, suggesting an association with the Galactic bulge (unusual for a He/N nova). The progenitor was too faint to be recorded on DSS1/2 survey plates, when setting the outburst amplitude to $\Delta V \geq 11$ mag.

Key words. stars: novae, cataclysmic variables

1. Introduction

Nova Scuti 2005 N.2 (=V477 Sct) was discovered by Pojmanski (2005) on ASAS[1] patrol images, shining at $V = 12.0$ on Oct. 11.026 and at $V = 10.4$ on Oct. 13.066 (UT) indicating that the nova was first caught during the rise to maximum. The nova was independently discovered by Haseda (2005). An accurate astrometric position was derived by Puckett (2005) as $\alpha =$ 18 38 42.93, $\delta = -12$ 16 15.6 (corresponding to galactic coordinates $l = 20.57$, $b = -2.79$). No field star is visible at this position on DSS1 and DSS2 survey plates, indicating an outburst amplitude $\Delta V \geq 11$ mag. The absence of the progenitor on the 2MASS survey excludes its belonging to the class of recurrent novae with a cool giant donor star (like T CrB or RS Oph).

Very little is known about this nova that was discovered shortly before becoming lost in the seasonal conjunction with the Sun. Das et al. (2005) report that on Oct. 15.75 (UT) the nova displayed prominent H I emission lines of the Paschen and Brackett series on infrared spectra (1.08–2.35 μm range), indicating an FWZI of 6000 km s^{-1}, while an optical spectrum on 16.43 (UT) by Fujii (2005) shows a reddish continuum with broad emission lines including Hα, Hβ, and O I 7773 Å characterized by an *FWHM* of 2900 km s^{-1}.

2. Observations

Low and medium resolution spectra of Nova Scuti 2005 N.2 were secured on Oct. 27.7 with the AFOSC imager+spectrograph mounted on the 1.82 m telescope operated in Asiago by INAF Astronomical Observatory of Padova. We obtained absolutely fluxed low-resolution spectrophotometry covering the range 3505−7815 Å with a dispersion of 4.2 Å/pix. The spectrum is presented in Fig. 1, with line identification superimposed. Higher resolution emission line profiles were obtained with holographic grisms over short wavelength intervals covering Hα and OI 8447 Å lines (6390−7045 Å at 0.6 Å/pix, and 8265−9165 Å at 0.9 Å/pix, respectively). The velocity profile of both lines is presented and compared in Fig. 2. The spectra can be obtained in electronic form from http://ulisse.pd.astro.it/novasct2005n2/ and from the CDS.

The CCD B, V, I_C photometry on Nova Scuti 2005 N.2 was secured from a private observatory near Cembra (Trento), Italy, housing a 28 cm Schmidt-Cassegrain telescope. The data reduction was performed in a standard fashion in IRAF. The photometric data are reported in Table 1, and the photometric evolution of the nova is presented in Fig. 3. The photometric data are calibrated on nearby TYC 5700-812-1 used as a comparison star (being present in the same frames as the nova) for which we adopted $B_J = 10.96$, $V_J = 10.27$, $I_C = 9.50$. Johnson's B_J and V_J are derived from Tycho-2's B_T and V_T following Bessell (2000) transformations. I_C is derived from Johnson's B_J and V_J following Caldwell et al. (1993) transformations.

3. Photometric evolution

The lightcurve in Fig. 3 is clearly that of a very fast nova. The exact maximum is somewhat uncertain, there being no data between Oct. 11.026, when the nova was discovered on the rising branch at $V = 12.0$, and Oct. 13.066 when it was at $V = 10.4$ and fading already. A reasonable hand-drawn fit of the early light-curve in Fig. 3 suggests that the maximum was reached

⋆ Spectra are available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/452/567

[1] http://archive.princeton.edu/~asas/

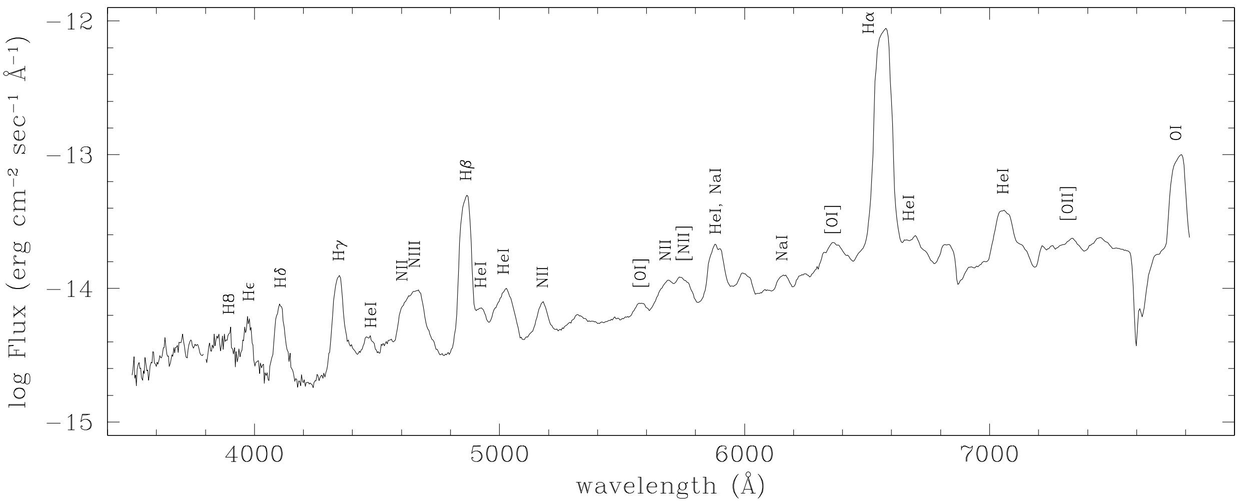

Fig. 1. The absolutely fluxed 3500–7800 Å low resolution spectrum of Nova Scuti 2005 N.2 observed on 2005 Oct. 27.76 UT. Most probable identification for the emission lines is given. The ordinate scale is logarithmic to emphasize the visibility of weaker features.

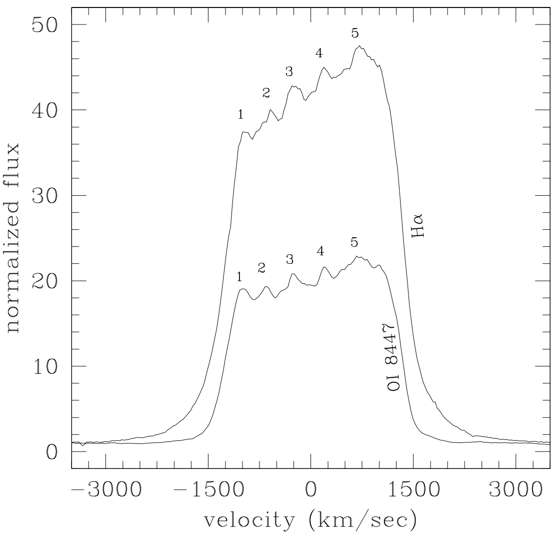

Fig. 2. Resolved Hα and OI 8446 Å emission profiles of Nova Scuti 2005 N.2 observed on 2005 Oct. 27.74 UT. The continuum is normalized to 1.0. The numbers identify the ripples in the profiles whose radial velocity is given in Table 2.

on Oct. 12.0 (UT) at $V = 9.8$ mag, so for sake of discussion we adopt this in the following.

The nova decline times are $t_2 = 3$ and $t_3 = 6$ days, making it one of the fastest known novae. Among the very few known faster classical novae, there are Nova Her 1991 ($t_2 = 1.2$ and $t_3 = 3.2$ days) and Nova Ser 1983 ($t_2 = 2$ and $t_3 = 5$ days). Using the relation between t_2 and the outburst amplitude of Warner (1995), the nova progenitor should have shined at $V \geq 23$, so it is no surprise that it does not show up on DSS1 or DSS2 plates. The color of the nova remained stable at $B-V = 1.3$ for the first three weeks (cf. bottom panel of Fig. 3), which suggests a reddening amounting to $E_{B-V} = +1.3$ after adopting an intrinsic $(B - V)_0 = 0.0$ at time t_2 from Warner (1995). This agrees with the Neckel & Klare (1980) extinction maps that indicate $E_{B-V} \geq 1$ along the line of sight to the nova for any reasonable distance estimate. The equivalent width of the diffuse interstellar band at 6614 Å (barely noticeable at the compressed scale of Fig. 2 on the red wing of the Hα profile) is 0.16(±0.02) Å, much larger than the

Table 1. BVI_C CCD photometry of Nova Scuti 2005 N.2. MJD$_\odot$ = heliocentric JD − 2 450 000.

MJD$_\odot$	Date	B	σ_B	V	σ_V	I_C	σ_I
3 658.27	Oct. 14.77	12.91	0.08	11.64	0.04	8.69	0.03
3 660.28	16.78	13.74	0.09	12.48	0.05	9.30	0.02
3 666.27	22.77			13.55	0.08		
3 672.25	28.75					10.93	0.02
3 677.24	Nov. 02.74			14.60	0.10		
3 678.23	03.73			14.97	0.09	11.42	0.03

0.04 Å observed by Herbing (1995) in HD 183143, which is similarly reddened by $E_{B-V} = +1.3$, thus confirming a high reddening affecting Nova Sct 2005 N2, probably even larger than $E_{B-V} = +1.3$.

Using the Cohen (1988) relation between absolute magnitude and t_2 rate of decline, the nova absolute magnitude is $M_V = \sim\!-9.5$ (an identical value is found using the Schmidt (1957) relation for t_3), which corresponds to a distance of 11 kpc, and a height above the Galactic plane $z \sim 0.6$ kpc for $E_{B-V} = +1.3$ and $V_{max} = 9.8$ mag. Propagating the uncertainties involved with absolute and observed magnitude at maximum and with reddening, the error budget on distance and z is 33%, allowing an association of the nova with the Galactic bulge.

The drop in magnitude indicated by the last photometric point in Fig. 3 suggests that the nova was at that time entering a dust condensation episode in its ejecta or that it was beginning to experience the *oscillations* sometimes seen during the transition phase of fast novae. The color at that time $V - I_C = +3.6$ was significantly redder than the stable mean value $\langle V - I_C \rangle \sim +3.0$ characterizing the previous part of the lightcurve. However, this is not a conclusive argument in favor of a dust condensation episode because color changes have sometimes been observed to accompany oscillations, too. Quite unfortunately, bad weather and conjunction with the Sun prevented us from extending the observations in time to properly cover this interesting phase of the lightcurve.

4. Spectroscopy

Integrating the B and V magnitudes on the spectrum of Fig. 1 using Buser (1978) transmission profiles provides $B = 15.36(\pm0.05)$ and $V = 14.04(\pm0.04)$ mag, which fit the photometric evolution in Fig. 3 well (where they are represented by

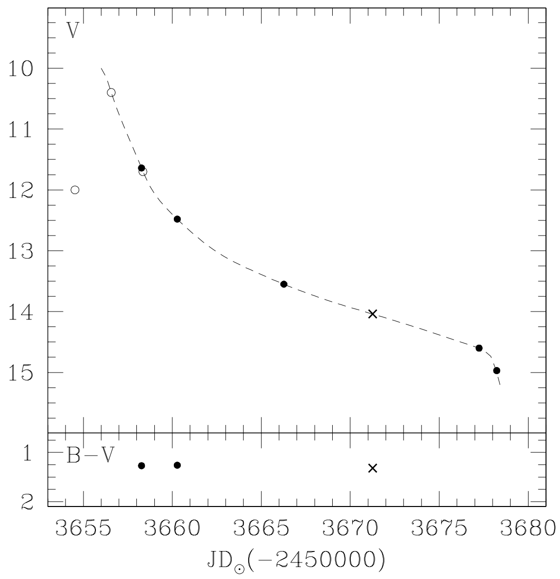

Fig. 3. The photometric evolution of Nova Scuti 2005 N.2. The dots mark our CCD observations in Table 1, the crosses correspond to *B*, *V* band integration over the absolutely fluxed spectrum of Fig. 1, and the open circles are values published in IAUC 8617. The dashed line is hand drawn.

Table 2. Radial velocity of the ripples numbered on the Hα and OI 8447 Å emission line profiles of Fig. 2.

	Component velocity (km s^{-1})				
	1	*2*	*3*	*4*	*5*
Hα	–970	–595	–260	+180	+705
OI 8446 Å	–990	–655	–250	+200	+695

the cross symbol), thus enforcing confidence in the accuracy of the calibration into absolute fluxes of the spectrum.

The spectrum in Fig. 1 shows that the nova had not yet entered the nebular phase at the time of observation (+16 days from maximum). The spectrum lacks significant FeII lines and is instead rich in He and N lines, allowing us to associate Nova Scuti 2005 N.2 with the He/N class defined by Williams (1992), which is consistent with the very fast speed class of the nova. It is worth noticing that Della Valle & Livio (1998) found a typical scale height of He/N novae above the Galactic plane of ≤100 pc, significantly less than the $z \sim 0.6 \pm 0.2$ kpc we have derived above for this nova. The spectrum in Fig. 1 bears some resemblance to the spectrum of Nova LMC 1990 N.1 presented by Williams et al. (1991), which at later stages evolved into a Neon nova.

The high resolution profiles of Hα and OI 8446 Å in Fig. 2 display a width at half intensity of 2645(±15) and 2590(±15) km s^{-1}, respectively, within the observed spread of the McLaughlin (1960) relations between expansion velocity and t_2, t_3 decline rates. These velocities are about 10% slower than found by Fujii (2005) for observations secured 11 days earlier, in agreement with the expected velocity decrease with time (e.g. Warner 1989).

Both the profiles in Fig. 2 display a series of ripples. Their radial velocities are given in Table 2. There is good correspondence in the radial velocity of the same ripple observed in the two distinct profiles, supporting a real kinematic identity. Such ripples can be ascribed to large, distinct blobs of material ejected by the nova at different angles with respect to the line of sight (beautifully visible in the HST images of Nova Cyg 1992 and T Pyx). Alternatively, they can be caused by projection effects of equatorial and polar rings of enhanced brightness in the expanding ejecta as shown in the atlas of computed lines profiles by Gill & O'Brien (1999).

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