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ABSOLUTE SPECTROPHOTOMETRY AND LIGHT CURVE OF NOVA PUPPIS 2004 (= V574 Pup)

SIVIERO, A.[1]; MUNARI, U.[1]; JONES, A. F.[2]

[1] INAF Astronomical Observatory of Padova, I-36012 Asiago (VI), Italy; siviero@pd.astro.it, munari@pd.astro.it

[2] 31 Ranui Road, Stoke, Nelson, New Zealand; afjones@ts.co.nz

Only scanty information are available on Nova Puppis 2004 (α=07$^{\rm h}$41$^{\rm m}$53$^{\rm s}$.76, δ=−27°06′36″.9 [2000]; l=243°, b=−2°). It was discovered in outburst by A. Tago and Y. Sakurai on Nov. 20.8 (2004 cf IAUC 8443), and spectroscopically confirmed as a nova by Ayani (2004), who reported for Nov 21.75 (4.3 days before maximum) Balmer and FeII lines in emission, P-Cyg profiles for hydrogen lines, $\sim$ 650 km/s as the FWHM of Hα emission component (uncorrected for instrumental PSF) and the P-Cyg absorption component blue-shifted by 860 km/s with respect to the emission peak. A near-IR spectrum by Ashok and Banerjee (2004) secured five days later on Nov. 26.9, showed strong hydrogen emission lines of Paschen β and γ, Brackett γ and Brackett 11 to 17, and in addition emission lines of OI, NI and CI.

Soon after the announcement of the discovery we began obtaining visual estimates of Nova Puppis 2004 from Nelson (NZ) with a 0.32m reflector and the comparison sequence prepared for RASNZ-VSS by M. Morel (electonically available as 5638-f3). The estimates are collected in Table 1 and the resulting light curve is plotted in Figure 1. According to data from AAVSO website (`http://www.aavso.org`), the maximum optical brightness was reached by the nova on t_0 ~2453335.6 at V~8.0 (represented by the open circle in Figure 1). Our first estimate was collected before the optical maximum, all others were uniformly distributed along the decline phase until seasonal conjunction with the Sun prevented further observations. From the light curve in Figure 1 it results that a decline of 2 mag required t_2=13 days, which qualifies Nova Puppis 2004 as a quite fast nova (cf Warner 1995), of absolute magnitude M_V=−8.5 following t_2-M_V relation by Della Valle (2002) or M_V=−8.0 according to Cohen (1988) calibration. The following decline was slowed down by a plateau phase that lasted ~20 days in late December/early January, so that the decline by 3 mag from maximum took t_3=58 days. The light curve in Figure 1 shows that Nova Pup 2004 did not go through a dust condensation phase, contrary to several fast novae that displayed such a phase which generally starts when the nova has declined by 3.5 mag from maximum.

We obtained absolute fluxed spectra of Nova Pup 2004 on Nov 26.17 UT (within a few hours of maximum optical brightness of the outburst) and on Dec 12.15, 2004 UT (when the nova had declined by ΔV~2.1 mag) with the B&C spectrograph attached to the 1.22m telescope of the Asiago Astrophysical Observatory of the University of Padova. The detector was a 4-stage Peltier cooled Wright Instruments camera with a TK512CB1-1 CCD, 512×512 pixels of 27 μm size. The adopted 300 ln/mm grating blazed at 5000 Å, provided a scale of 4.5 Å/pix. To cover the 3500-7000 Å wavelength range, two exposures with different instrument set-ups where necessary. Flux standards located on the sky close to Nova Pup 2004 were selected from the Asiago Database of Spectroscopic Databases (ADSD, Sordo and Munari 2003). Given the latitude of the Asiago Observatory (+45°52′), Nova Pup 2004 reached at culmination an elevation over the geometrical horizon not exceeding 17°. To calibrate the spectra into good absolute fluxes, such low an elevation required excellent sky photometric conditions, orientation of the slit along the instantaneous parallactic angle and observation of spectrophotometric standards close on the sky to Nova Pup 2004 and well distributed in elevation in the range 15°to 25°so as to derive accurate local extinction coefficients. The data reduction was carried out with IRAF software and involved standard corrections for bias, flat and dark frames obtained each night and separately for both the blue and red wavelength set-ups required to cover the whole 3500-7000 Å wavelength range.

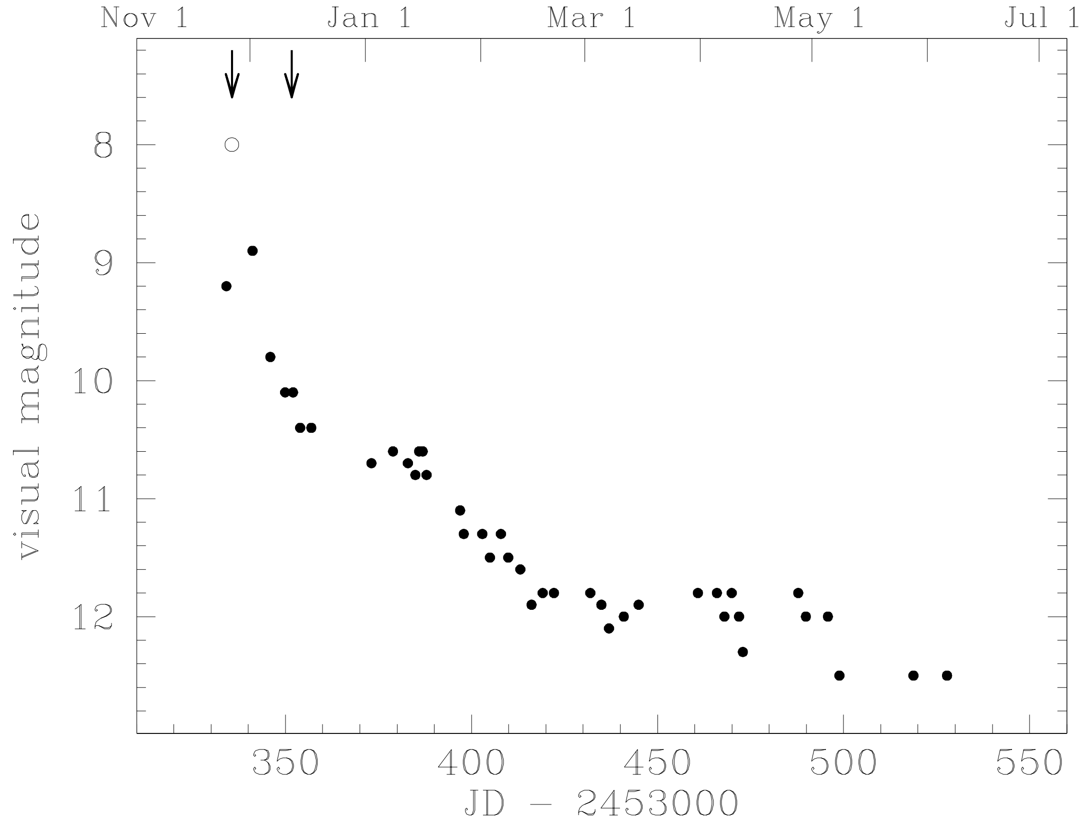

Figure 1. Light curve of Nova Pup 2004 (= V574 Pup) from the visual estimates reported in Table 1. The open circle represents the light curve maximum according to AAVSO database. The arrows points to the dates of the spectra presented in Figure 2.

The spectra are characterized by a high S/N for $\lambda \geq 4200$ Å and are presented in Figure 2, with logarithmic ordinates to emphasize visibility of weaker features. The spectra are available in electronic form from the IBVS web site as `5638-t4.txt` and 5638-t5.txt. Integrating the B and V magnitudes over the fluxed spectra – adopting the Buser (1978) band transmission profiles – results in B=8.30, V=8.03 for the Nov 26 spectrum, and B=9.84 and V=9.83 for the Dec 12 spectrum. The expected accuracy of the broad-band magnitudes derived from the spectra is ∼0.03 mag. The spectral resolution can be assessed directly on the spectra from the width of the telluric O_2 absorption B band at

6875 Å, which is 7.29 Å (1.6 pixels) in both spectra.

JD	V	JD	V	JD	V	JD	V	JD	V
334.117	9.2	382.922	10.7	407.909	11.3	440.937	12.0	489.872	12.0
341.139	8.9	384.907	10.8	409.889	11.5	444.919	11.9	495.805	12.0
345.941	9.8	385.926	10.6	413.122	11.6	460.863	11.8	498.903	12.5
349.931	10.1	386.904	10.6	416.152	11.9	465.970	11.8	518.791	12.5
352.058	10.1	387.914	10.8	419.137	11.8	467.971	12.0	527.813	12.5
353.958	10.4	396.935	11.1	422.165	11.8	469.942	11.8		
356.943	10.4	397.924	11.3	431.938	11.8	471.903	12.0		
373.117	10.7	402.910	11.3	434.923	11.9	472.939	12.3		
378.908	10.6	404.950	11.5	436.954	12.1	487.818	11.8		

Table 1: Visual estimates of Nova Pup 2004 obtained by A.F.J. with a 0.32m reflector from Nelson (NZ).

JD	Date	Hα				Hβ			
	2004	Flux	Em (km/s)	P-Cyg (km/s)	Abs (km/s)	Flux	Em (km/s)	P-Cyg (km/s)	Abs (km/s)
2453335.664	Nov 26.17	5.0(−10)	2830	−1910	840	2.0(−10)	2180	−1650	710
2453351.648	Dec 12.15	7.5(−10)	2810	−1930	830	2.0(−10)	2170	−1650	720

Table 2: Hα and Hβ on the spectra of Figure 2. *flux* is the flux in erg cm^{-1} s^{-1} integrated on the whole profile of the emission component. *em* is the FWHM of the emission component. *P-Cyg* is the blue-shift of the center of the P-Cyg absorption component with respect to the flux barycenter of the emission component. *abs* is the FWHM of the absorption component.

The continuum slope on the spectra indicate a marked bluing of the nova, with a large increase in the emission line contrast on the background continuum, while their integrated flux remained essentially constant (cf. Table 2). The spectra at both epochs are dominated by Balmer hydrogen and FeII emission lines. The basic Hα and Hβ parameters are summarized in Table 2. At the time of Dec 12 spectrum, no nebular lines had yet appeared.

At time t_2 the mean intrinsic color of novae is $(B-V)_0$=-0.02 ± 0.04 with a dispersion on σ=0.12 mag (Warner 1995). When the Dec 12 spectrum was secured, the nova had declined by ~2.1 mag, and the color integrated over the spectrum is $B-V$=+0.01, which argue in favor of a negligible reddening affecting the nova, of the order of a mere E_{B-V}~0.03. Typical color of novae at maximum is $(B-V)_0$=$+0.23\pm0.06$ with a dispersion on σ=0.16 mag (Warner 1995). The color of the nova on the Nov 26 spectrum – secured right at maximum brightness – is $B-V$=+0.27, again supporting a negligible reddening of the order of a mere E_{B-V}~0.04. There is a high convergence of both methods to indicate that the nova is essentially un-reddened ($E_{B-V}\leq$0.05 mag). This is however in sharp contrast with the high reddening expected from the large distance to the nova and its low galactic latitude (b=2°). With V=8.0 at maximum and M_V=-8.6 estimated above from t_2, the distance to the nova is d=20 kpc with a height above the galactic plane of z=0.7 kpc, reducing to d=15 kpc and z=0.5 kpc for M_V=-8.0. In both cases, the reddening maps of Neckel and Klare (1980) would support a $E_{B-V}\geq$1.0 for distances $\geq$3 kpc. A high resolution spectrum in the NaI and KI resonance line wavelength regions would have greatly helped in measuring the extinction objectively and free of assumptions using the Munari and Zwitter (1997) calibration into reddening of the equivalent widths of these strong interstellar lines. A E_{B-V}=0.5 reddening would have produced an equivalent width for an unblended interstellar NaI doublet of 1.2 Å. On both our low resolution spectra the equivalent width of the absorption feature located at the expected NaI D spectra is far lower (~0.5 Å), to which could furthermore contribute the absorption component of the P-Cyg profile of the NaI from the nova expanding ejecta.

There is no obvious pre-outburst counterpart to the nova, even if reported astrometry in IAUC 8443 could be stretched to agree with position of a 18 mag nearby field star visible on Palomar II plates. This sets the outburst amplitude to at least $\Delta V \geq 10$ mag, which is in agreement with a typical outburst amplitude of 11 to 14 mag – depending on the system orbital inclination – for novae characterized by t_2=13 days (Warner 1995).

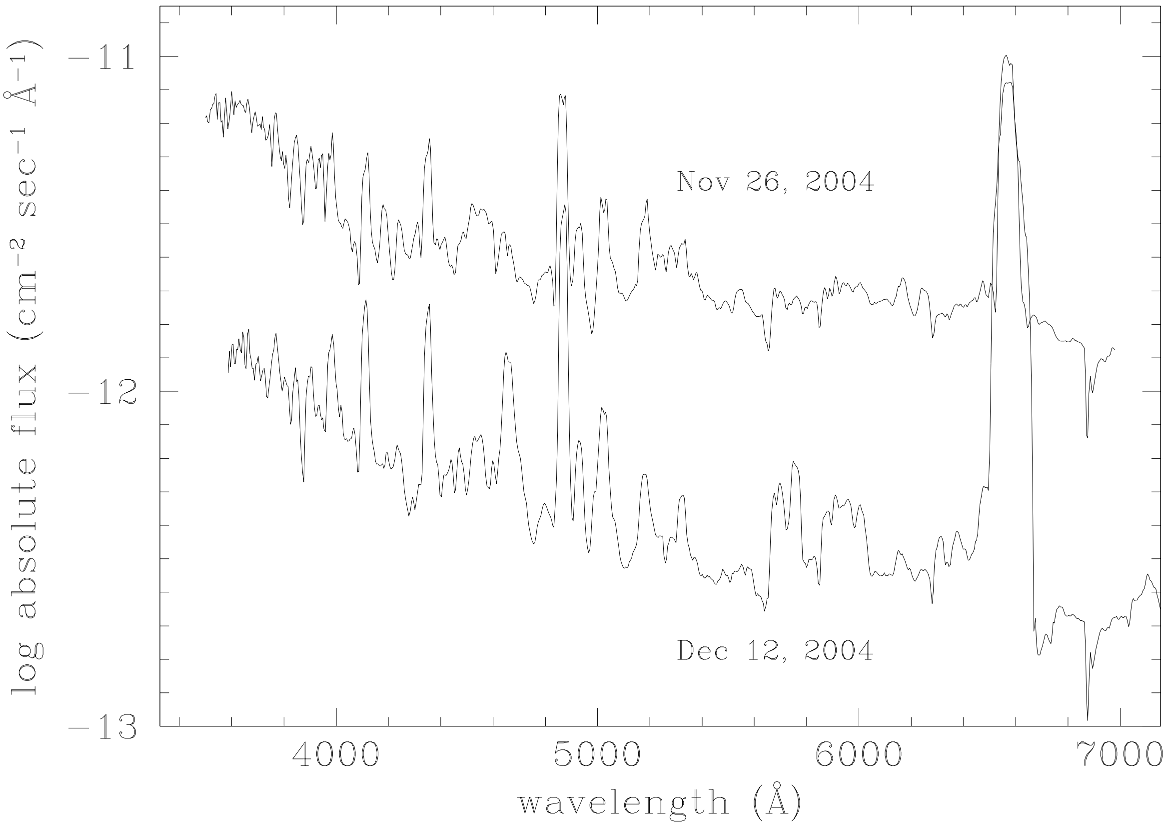

Figure 2. Absolute fluxed spectra of Nova Pup 2004 (= V574 Pup) for the two dates marked by arrows in Figure 1.

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