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Letter to the Editor

The early stages of NOVA Oph 2003 (V2573 Oph)*

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Abstract. Intermediate resolution spectroscopy of NOVA Oph 2003 (V2573 Oph), which was first detected March 21th 2003 but reported July 19th 2003, obtained 19th to 23rd of July is presented here. The photometry during the early phases of the object is shortly discussed. We also retrieved very accurate astrometry of the target in this crowded field. This is needed to be able to do further observations of the post-nova during the next years. The inspection of the sky survey plates gives a possible progenitor candidate and allows to derive a lower limit for the outburst magnitude of about $10\overset{\mathrm{m}}{.}0$. The spectrum shows an overall expansion of 2200 km s^{-1} and has clearly complex outflow substructures. The spectroscopy identifies this object as classical nova, "Fe II" subclass.

Key words. stars: novae – stars: individual: NOVA Oph2003 = V2573 Oph

1. Introduction

NOVA Oph 2003 was discovered July 10th 2003 as an $11\overset{\mathrm{m}}{.}4$ object (Takao et al. 2003). They point out that Tabur detected this variable on CCD images already March 21th 2003 and that *"he initially dismissed the object as a less-urgent variable star due to its long presence on his past images"*. There is some ongoing discussion on the validity of this detection (Kato 2003). This late report reminds us on the situation of the report of the Nova V1178 Sco (Hasada et al. 2001; Andersen & Kimeswenger 2001). Thus the first spectroscopic data with higher resolution was only obtained July 18th (Della Valle et al. 2003) showing the nova to be caught during its early decline. The variable star name given to the object is V2573 Oph (Samus 2003).

We obtained spectra using the ESO NTT telescope at La Silla (July 19th to 22nd) with the multi mode instrument EMMI mounted. Also V filter images were obtained there. This allowed a precise astrometry.

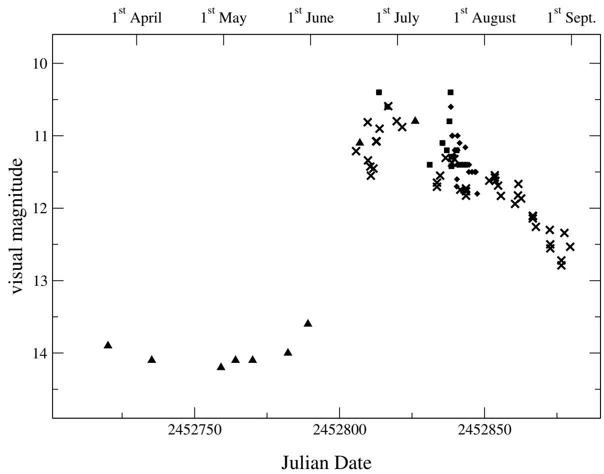

Fig. 1. The photometry collected from different resources; from IAUCs: triangles – V. Tabur (possibly spurious detections – see text), diamonds – AAVSO, squares – others in IAUCs; crosses: ASAS-3. The R band CCD values of Tabur were shifted down by $1\overset{\mathrm{m}}{.}0$ to correspond to the visual and V band measurements.

2. Photometric classification

For the light curve different resources from literature and network were combined (Takao et al. 2003; Liller et al. 2003; `http://archive.princeton.edu/~asas`). The data of Tabur, labelled as unfiltered CCD images in the IAUC seem to be taken in fact with an R band filter. The photometry before May 10th are suspected to be spurious detections (Kato 2003). It is beyond the scope and the possibilities of the authors to verify this here. They were shifted by $1\overset{\mathrm{m}}{.}0$ to fit the visual light curve and the upper limits given by Liller et al. (2003) for June. This might be a major source of uncertainty, as the target surely will have changed its color during the early phases. The resulting light curve is shown in Fig. 1. The shape is similar to the ones of V1548 Aql and V723 Cas, which are joined to a subclass by Kato & Takamizawa (2001). Although the increase from the plateau phase to the final peak of about $3\overset{\mathrm{m}}{.}0$ is double that of these two older novae, they seem to have a lot in common. Using the decline phase data from the maximum (JD = 2 452 816) in the ASAS-3 data only, we derive a $t_2 \approx 62$ days. This is very similar to that of the slow FeII class

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* Based on observations made at ESO, La Silla Chile.

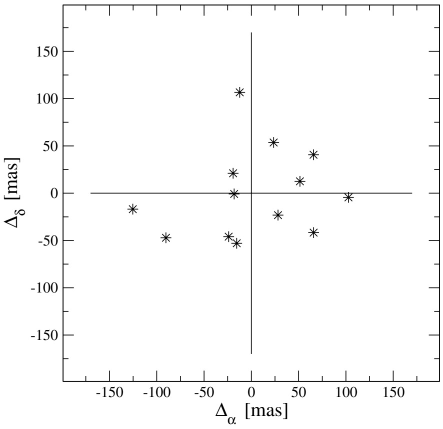

Fig. 2. The scatter diagram of the astrometric calibration sources around the target.

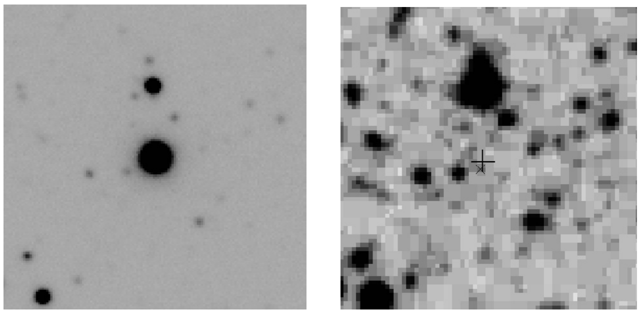

Fig. 3. The finding chart for the target from our ESO NTT observations (left) and from SuperCOSMOS scans of the UKIST *B* plate. The coordinates from the astrometry are centered (fineline +). There is a faint ($B \geq 20^{\mathrm{m}}.5$, $R > 19^{\mathrm{m}}.5$) star (×) which might be the progenitor (see text).

novae like DQ Her and V868 Cen with 67 and 55 days respectively (Della Valle & Livio 1998).

3. Astrometry and cross-identification

To obtain a very accurate astrometry of the target a set of *V* band images were taken. The EMMI red arm is currently equipped with a mosaic of two 2k × 4k CCDs giving, according to the manual, a resolution of $0''.333$ per pixel. In fact we measure $0''.33459$. The *FWHM* on the images used for the astrometry were within the range of $0''.68$ to $0''.81$. Only the chip covering the optical center of the field of view was used to avoid additional free parameters like rotation between the chips or different scales due to inclination. We used only the central distortion free part of the image, $2'.7 \times 3'.5$ in size around the target. As the target was taken near the zenith there should be no differential refraction. Astrometric calibrators were taken from *USNO CCD Astrometric Catalogue* (UCAC) (Zacharias et al. 2000). 13 stars surrounding the target were used to obtain the astrometry. The next nearby TYCHO-2 source has a distance of more than $6'.0$ and is known to have a high proper motion. Thus an additional TYCHO reference system, as in Andersen & Kimeswenger (2001), was not applied here.

The source extraction was obtained by using SExtractor v2.1.6 (Bertin & Arnouts 1996). The rms of the positions was 31 mas (Fig. 2). The largest residuals are found for the faintest sources. As our S/N was very high even for those sources, we assume that part of this error originates from the UCAC. As the target is very bright, the internal accuracy of the target coordinates was even better (5 mas rms). Assuming some systematic effects an error estimate of 20 mas is very conservative:

$$\alpha_{\rm J2000.0} = 17^{\rm h}19^{\rm m}14^{\rm s}.0913 \pm 0^{\rm s}.0014$$

$$\delta_{\rm J2000.0} = -27°22'35''.315 \pm 0''.020.$$

These coordinates are more accurate than those given by McNaught & Garradd (2003). Their larger error bars do overlap to the results here. An inspection of the sky survey plates SERC V and 2nd ed. ER shows a source at the plate limits very near to this position. The SuperCOSMOS scans (Hambly et al. 2001) give an estimate of $B \geq 20^{\mathrm{m}}.5$ and $R > 19^{\mathrm{m}}.5$ (Fig. 3) when using the PSF fitting for deblending and photometric calibration as described in Kimeswenger & Weinberger (2001). There is no brighter source in the field which is a candidate for the progenitor. This allows to derive a lower limit for the amplitude of the outburst of about $10^{\mathrm{m}}.0$.

4. Spectroscopy

The spectra were obtained at the ESO NTT + EMMI. We used grism #2 (resolution of 0.35 nm/pixel; 390 to 980 nm) and grism#6 (resolution of 0.14 nm/pix; 500 to 880 nm). There were taken at least two spectra with each grism during four nights, starting 19./20. July. The observations always were obtained between 23:20 and 0:40 UT. The calibration (bias, flatfield, wavelength calibration and response curve) was done using usual procedures in MIDAS.

The spectra had a S/N of >200 in the continuum over the whole region (Fig. 4). The intensity of most of the lines slowly decreased (Table 1) during the observation period. In the night 19./20. July the H_α and the Ca IR triplet were overexposed.

Lines of the Balmer series (Fig. 5), OI (Fig. 6) and NaI (Fig. 7) show significant P-Cygni profiles giving expansions of up to 1800, 2200 and 1600 km s^{-1} respectively. This is somewhat higher but within the same range than the values measured July 18th by Della Valle et al. (2003). Remarkably, the iron lines are stronger than e.g. reported in CI Aql (Kiss et al. 2001), while $[\mathrm{NII}]_{575}$ hardly is visible. The Na-D line is very prominent too. Normally blended by HeI_{588}, this line appears here only as a weak absorption feature at the blue end. This part of the spectrum is very much like that of Nova Sco 2001 (Andersen & Kimeswenger 2001).

The Ca II IR triplet does not show P-Cygni profiles, but a pronounced saddle like profile (Fig. 8). This may originate from a tilted equatorial expanding ring or bipolar ejected clumps. Although assuming spheroidicity, this also can be explained by a transition of the object from photosphere to shell type spectra as shown in Williams (1992) for Nova LMC 1988 No. 2 for the hydrogen lines. As Ca II has the lowest excitation of the optical lines here, the object was maybe

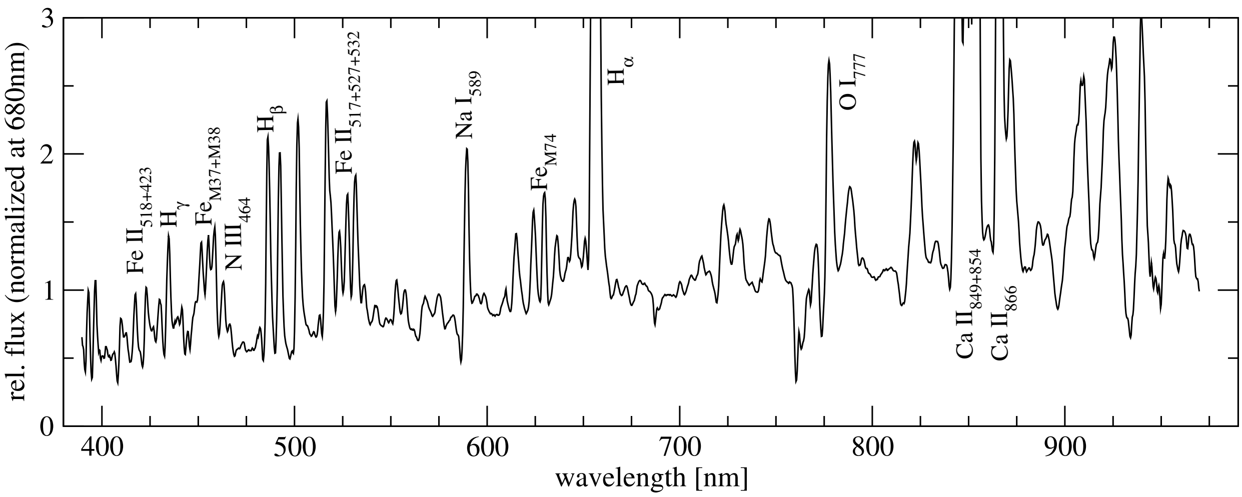

Fig. 4. The overall spectrum of V2573 Oph. H_α and $CaII_{849+854+866}$ are displaced exceeding the box in order to see all the weaker features. All P-Cygni profiles show more or less the same global expansion, but with different substructures. The maximum expansion velocity is about 2200 km s^{-1}. Most of the lines at the red end are blends of OI, NI and metal lines. They are thus not labelled individually.

Table 1. Observed emission line fluxes (unit: 10^{-14} W m^{-2} μm^{-1}) for the most prominent lines which are well separated (no blends). The fluxes were absolute calibrated with respect to the ASAS-3 photometry (m_V = 11.^{m}34) by folding standard filter curves. The main uncertainty originates from the "definition" of the continuum around the lines.

Line	July, 19th	20th	21th	22nd
H_α	2.1	2.1	2.0	1.8
H_β	6.3	5.9	5.5	5.5
H_γ	overexp.	58.5	66.0	63.4
Fe II 418 nm	1.8	1.7	1.5	1.6
Fe II 423 nm	1.5	1.5	1.2	1.1
Fe II 517 nm	7.7	7.0	7.6	7.2
Fe II 527 nm	2.6	2.2	2.5	2.5
Fe II 532 nm	3.7	3.2	3.7	3.4
N II 464nm	1.6	1.6	1.6	1.5
Na I 589nm	4.6	4.0	3.7	3.7
O I 777nm	7.5	7.7	7.7	7.4
Ca II 849+854nm	overexp.	56.3	54.6	48.9
Ca II 866 nm	overexp.	27.3	27.3	24.6

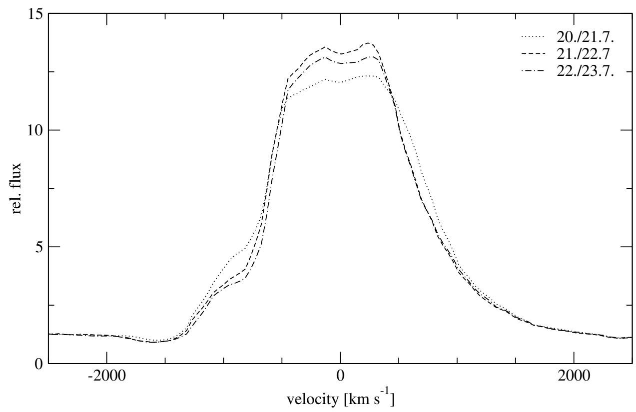

Fig. 5. The P-Cygni profile of the hydrogen Balmer line. The line peak grows significantly from day to day while it gets smaller. Especially the emission wing around −1000 km s^{-1} vanishes more and more.

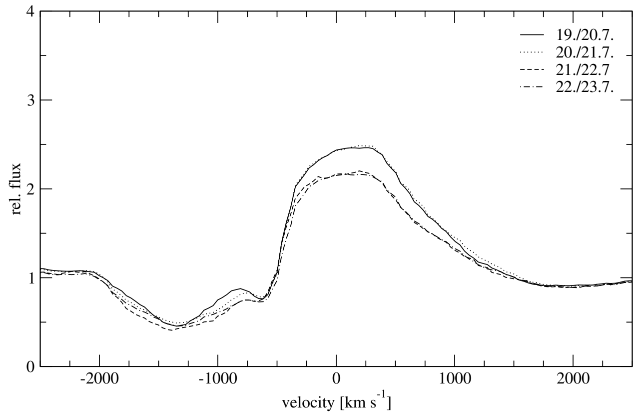

Fig. 6. The profile of the OI line at 777 nm shows the highest expansion (see text).

just starting this process at its outer cooler parts. The structure seems to be blueshifted with respect to the rest wavelength of the line by about 150 km s^{-1}.

5. Conclusion

The spectrum classifies this object as of "Fe II" subtype (after Williams 1992). The astrometry presented here clearly indicates that the possible progenitors are at the plate limit of the sky surveys or beyond. This allows us to give a lower limit for the outburst magnitude of $\Delta M \geq 10.^m0$. The photometry classifies it as slow nova, with some signature of starting humps

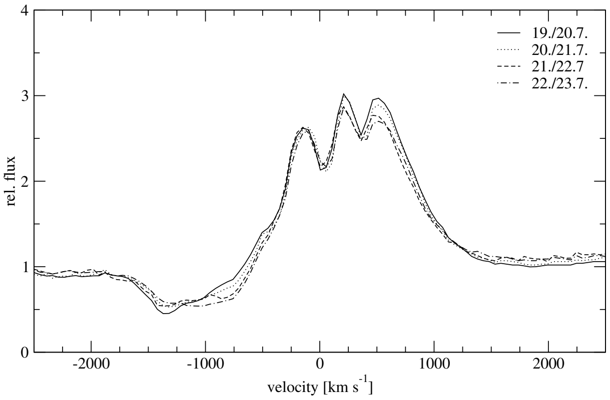

Fig. 7. The profile of the Na-D line shows nearly the same profile like the Balmer lines. The emission feature at -1000 km s^{-1} also faded during the observation period.

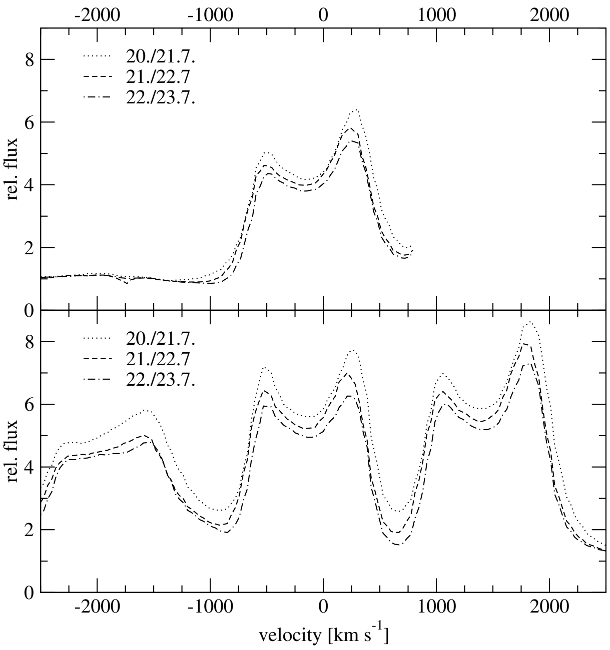

Fig. 8. The profile of the IR CA II lines at 866 nm (upper panel) and at 849+854 nm (lower panel). They show now P-Cygni type absorption but a nicely pronounced optically thin shell structure with an expansion of 550 km s^{-1}. The structure is blueshifted by about 150 km s^{-1}.

during decline as e.g. described in Kato et al. (2002). On the other hand the outburst magnitude is unusual high for a slow nova (Kato et al. 2002). Also the derived expansion is high for a typical slow nova: e.g. V356 Aql had 450 km s^{-1} (McLaughlin 1955) and RR Tel had not more than 600 km s^{-1} (Thackeray & Webster 1974). Thus the FeII-broad classification (Williams 1992) may be applied here. The pre max halt $3.^{m}5$ below maximum is very unusual at for a $t_2 \approx 62^{d}$.

Della Valle (2002) give $M_V = 7.^{m}2^{+1.^{m}2}_{-0.^{m}9}$ for such kind of slow novae. As there is no information about the interstellar reddening we estimate with the information of Della Valle et al. (2003) an extinction of $A_V < 5.^{m}0$. This leads to a crude estimate for the distance of 3.5–4.0 kpc. Future measurements (namely the expansion parallax of the post-nova shell) are needed to fix the distance and thus the absolute magnitude of the object.

The spectroscopy shows a complex structure of the outflow. The velocity field obtained by the hydrogen and helium lines suggests a two shell structure similar to the models for Supernova 1997A (Hanuschik et al. 1993) or strong aspherical components like expanding rings or bipolar outflows. The metal lines even indicate a more complex, most likely non-symmetric outflow with respect to the line of sight.

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