COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5850

Konkoly Observatory
Budapest
26 September 2008

HU ISSN 0374 – 0676

EARLY SPECTROSCOPY AND PHOTOMETRY OF THE NEW OUTBURST OF V1647 Ori

KUN, M.

Konkoly Observatory, H-1525 Budapest, P.O.Box 67, Hungary, e-mail: kun@konkoly.hu

V1647 Ori is a young eruptive variable star, illuminating a variable reflection nebula (McNeil's Nebula). The previous outburst of the star between 2004 January and 2005 October has been extensively documented in the literature (e.g. Briceño et al. 2004, Ojha et al. 2006, Acosta-Pulido et al. 2007, Fedele et al. 2007). Optical, near-, and mid-infrared observations of the star during the quiescent period following the outburst (Aspin et al. 2008) suggested a spectral type of M0$\pm$0.2, mass 0.8$\pm$0.2 $M_{\odot}$, and age < 0.5 Myr for V1647 Ori. The observed properties of the outburst of V1647 Ori are different in several respects from both the EXor and FUor type outbursts, and suggest that this star probably represents a new type of eruptive young stars, younger and more deeply embedded than EXors, and exhibiting variations on shorter time scales than FUors.

A new outburst of the star was announced on 27th August 2008. Itagaki et al. (2008) detected the apparent brightening of V1647 Ori on 26 August. The flux-calibrated optical spectrum of the star, obtained by Aspin (2008) on Aug 30, showed strong Hα emission line with P Cygni profile, the CaII triplet lines in emission, and suggested a Johnson R magnitude of 17.3, corresponding to a brightening of some 6 mag in the R-band with respect to the quiescent phase.

In order to compare the present brightness and emission line strengths of the star with those observed at the beginning of the outburst in 2004 I observed V1647 Ori between 28 August and 1 September 2008, using the CAFOS instrument on the 2.2-m telescope of Calar Alto Observatory (Spain). Spectra covering the wavelength region of 4800–7800 Å were obtained on Aug 29 and 31, using the grism G–100 whose dispersion is 2.12 Å/pix. Grism R–100, having a dispersion of 2.04 Å/pix, was used for observing the spectral region 5800–9000 Å on Aug 28, 30, and Sep 1. The exposure time was 1800 s for each spectrum. The spectrum of a He–Hg–Rb lamp was observed for wavelength calibration. Direct images, each with an exposure time of 60 s, were taken immediately after the spectroscopic observations, utilizing the central 1024$\times$1024 pixel region of the SITe 2048$\times$2048 chip. The image scale was 0.53$''$/pix. The 9-arcmin field of view included seven secondary standard stars published by Semkov (2004). Two $I_{\rm C}$-band images were obtained on both August 28 and 29, and two images both in the $I_{\rm C}$ and $R_{\rm C}$ bands were taken on the remaining three nights. Data reduction and analysis were performed in IRAF. One-dimensional spectra were extracted from the spectroscopic images using the 'apextract' package of IRAF. The spectrum of the nebula was also extracted from the images obtained through grism G–100. The resulting spectra were wavelength-calibrated and analysed in the ‘onedspec’ package of IRAF. The direct images, obtained through the same filter on each night, were coadded after bias subtraction and flatfield correction, using dome flat field images. The instrumental magnitudes of V1647 Ori and the comparison stars were determined on the coadded images by PSF-photometry using the ‘daophot’ package in IRAF. The preliminary aperture photometry, used for scaling the PSF magnitudes was obtained using 1.5 arcsec apertures in each image. The instrumental magnitudes were transformed into the standard photometric system as described by Acosta-Pulido et al. (2007).

The upper panel of Fig. 1 shows the spectrum of the star (thick line) and the nebula (thin line) in the green spectral region, normalized to the continuum. The most conspicuous feature of this spectral region, is the strong Hα emission with P Cygni type absorption. Both spectra indicate a weak Hβ and NaI D absorption. The lower panel shows the red spectral region with strong Hα and CaII triplet emissions. In addition to the strong atmospheric absorption bands around 6860, 7600, and 8280 Å the OI line at 7773 Å is clearly seen in absorption in each red spectrum. The left panel of Fig. 2 shows an I-band image, centred on V1647 Ori, obtained on 1 September. The right panel shows the Hα line observed on three different nights.

The R_C and I_C magnitudes, as well as the equivalent widths of the Hα, CaII, and OI lines are listed in Table 1. Values for both the emission and absorption components of the Hα line are shown. The UT, given in Column 2, refers to the start of the spectroscopic exposure. The photometric uncertainties were computed as the quadratic sum of the formal errors of the instrumental magnitudes provided by IRAF and the uncertainties of the standard transformation. The uncertainties of the equivalent widths are around 6%, estimated from repeated measurements.

Table 1. Results of the observations

Date	UT	R_C	I_C	W(Hα)		W_λ(CaII)			OI
				em.	abs.	(8498)	(8542)	(8662)	
		(mag)	(mag)	(Å)	(Å)	(Å)	(Å)	(Å)	(Å)
2008 Aug 28	04:17	···	14.64 (0.06)	−31.5	1.6	−7.46	−7.84	−6.24	1.6
2008 Aug 29	03:39	···	14.80 (0.07)	−41.5	3.4	···	···	···	
2008 Aug 30	03:48	17.02 (0.07)	14.64 (0.05)	−41.3	5.0	−8.45	−8.50	−6.79	2.2
2008 Aug 31	03:32	16.81 (0.07)	14.66 (0.07)	−41.5	6.0	···	···	···	
2008 Sep 01	03:51	17.11 (0.05)	14.69 (0.04)	−43.6	3.6	−7.97	−8.52	−6.36	2.0

Comparison of the image of McNeil’s Nebula, the main apparent features of the spectrum of V1647 Ori, and the data listed in Table 1 with similar data obtained in February–March 2004 suggests that the initial conditions of the present outburst are largely the same as were in 2004. Walter et al. (2004) and Ojha et al. (2006) measured similar Hα and CaII equivalent widths in February–March 2004, McGehee et al. (2004), Ojha et al. (2006), and Acosta-Pulido et al. (2007) report similar R_C and I_C magnitudes for the same period. The optical spectra obtained in February–March 2004 by Fedele et al. (2007) show P Cygni-type profile of the Hβ line with strong absorption and weak emission component, indicating that the source of the line is a strong stellar wind. Only the absorption component of the Hβ can be identified in the low S/N part of our spectra. The

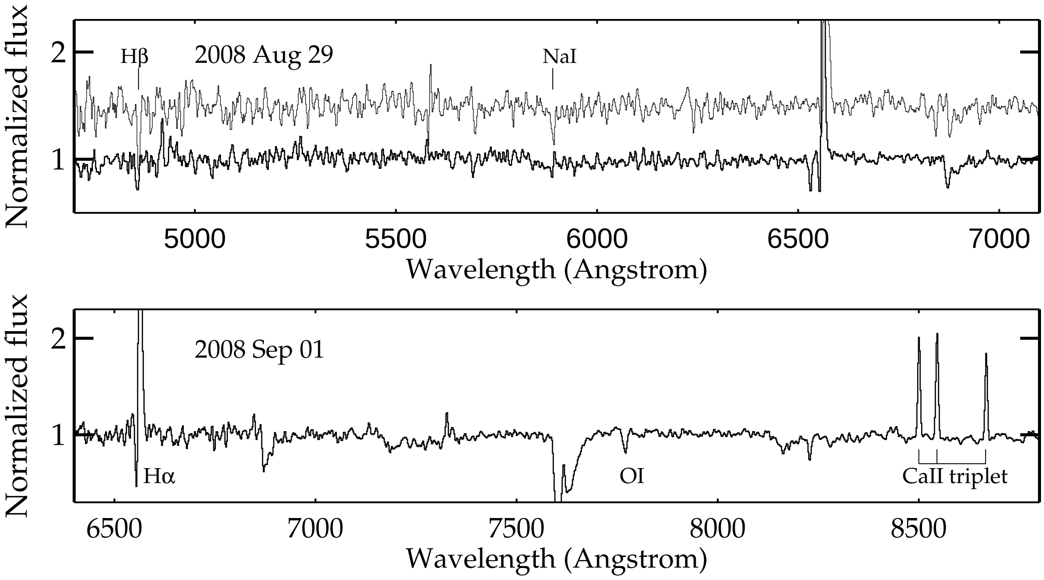

Figure 1. Upper panel: The spectrum of V1647 Ori (thick line) and McNeil's Nebula (thin line), on the wavelength interval 4700–7100 Å, obtained on Aug 29. Lower panel: The 6400–8800 Å region of the spectrum of V1647 Ori obtained on Sep 01 2008.

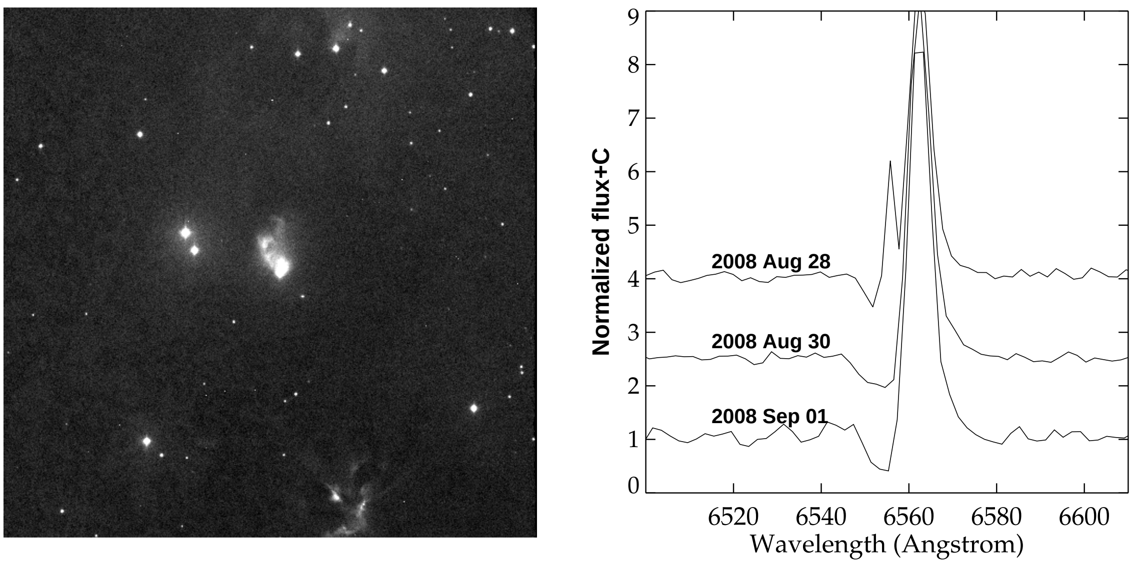

Figure 2. Left: I-band image of the field centered on V1647 Ori, observed on September 1. Right: Hα line profiles on three different nights.

OI λ 7773 Å absorption was also detected by Ojha et al. (2006) in the spectra obtained at the early phases of the outburst in 2004. The CaII line ratios $W_\lambda(8498)/W_\lambda(8542)$ and $W_\lambda(8662)/W_\lambda(8542)$ are useful tracers of the physical conditions at the origin of the emission (e.g. Hamann & Persson 1992). Our measured ratios, averaged for the three nights, are 0.95 and 0.78, whereas the same ratios obtained by Walter et al. (2004) in March–April 2004 are 1.10 and 0.63, respectively. Both measurements show that the λ 8662 Å line was the weakest component of the triplet. Ojha et al. (2006) reported on nearly equal equivalent widths of the triplet components in later phases of the outburst. The ratios measured in the quiescent phase by Aspin et al. (2008), 0.86 and 0.97, show a similar situation.

The simultaneous spectroscopic and photometric observations allow us to calculate line fluxes. The average observed fluxes of the Hα, CaII(λ8498), CaII(λ8542), and CaII(λ8662) emission lines are F(Hα)=1.4×10^{-17} Wm^{-2}, $F_\lambda(8498)=1.2\times10^{-17}$ Wm^{-2}, $F_\lambda(8542)=1.3\times10^{-17}$ Wm^{-2}, and $F_\lambda(8662)=1.0\times10^{-17}$ Wm^{-2}, respectively. These numbers indicate a 14-fold increment of the Hα flux with respect to the flux measured in 2007 February (Aspin et al. 2008). The observed emission line fluxes are affected by the increased accretion rate from the disk onto the star, the strong wind accompanying the enhanced accretion, and the decreasing circumstellar extinction associated with the outburst (Aspin et al. 2008). The contribution of these processes to the fluxes of various emission lines may be strongly different.

Acknowledgements: These results are based on observations obtained at the Centro Astronómico Hispano Alemán (CAHA) at Calar Alto, operated jointly by the Max-Planck-Institut für Astronomie and the Instituto de Astrofísica de Andalucía (CSIC). The observations were supported by the OPTICON project. OPTICON has received research funding from the European Community's Sixth Framework Programme under contract number RII3-CT-001566. Financial support from the Hungarian OTKA grant T49082 is acknowledged.

References:

Acosta-Pulido, J. A., Kun, M., Ábrahám, P. et al. 2007, *AJ*, **133**, 2020
Aspin, C. A. 2008, *IAUC*, **8969**
Aspin, C. A., Beck, T. L., Reipurth, B. 2008, *AJ*, **135**, 423
Briceño, C., Vivas, A. K., Hernández, J., et al. 2004, *ApJ*, **606**, L123
Fedele, D., van den Ancker, M. E., Petr-Gotzens, M. G., Rafanelli, P. 2007, *A&A*, **472**, 207
Hamann, F., & Persson, S. E. 1992, *ApJS*, **82**, 247
Itagaki, K., Nakano, S., Yamaoka, H. 2008, *IAUC*, **8968**
McGehee, P. M., Smith, J. A., Henden, A. A., et al. 2004, *ApJ*, **616**, 1058
Ojha, D.K., Ghosh, S. K., Tej, A. et al. 2006, *MNRAS*, **368**, 825
Semkov, E. H. 2004, *IBVS* **5578**
Walter, F. M., Stringfellow, G. S., Sherry, W. H., Field-Pollatou, A. 2004, *AJ*, **128**, 1872