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SPECTROSCOPIC ORBIT OF THE ECLIPSING BINARY V2031 Cyg IN THE FIELD OF THE OPEN CLUSTER NGC 6913≡M 29

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NGC 6913 is inserted in the list of young open clusters that are studied spectroscopically in high resolution from Asiago to the aim of investigating their internal kinematics, deriving their galactic motion and detecting and solving their binaries. This long term program is described in Munari (1992), and first results have been published by Tomasella and Munari (1998), Munari and Tomasella (1999), Milone et al. (2000).

Here we present the spectroscopic orbit of the eclipsing star V2031 Cyg (HD 194378) in the field of NGC 6913≡M 29. The membership of V2031 Cyg to NGC 6913 is astrometrically possible according to Sanders (1973). However, we derived for NGC 6913 a radial velocity RV=-17.1 ± 0.9 km sec^{-1}, with an internal dispersion of $\sigma = 2.7 \pm 0.1$ km sec^{-1}. The barycentric velocity of V2031 Cyg that we derive here is RV=$+8.65 \pm 0.48$ km sec^{-1}, apparently ruling out any physical partnership with the open cluster. The chance superposition of V2031 Cyg onto the line-of-sight to NGC 6913 is also supported by the proper motion of the star as measured by Hipparcos/Tycho that turned out to be significantly different from that of the cluster. Also the studies of NGC 6913 by Crawford et al. (1977) and Joshi et al. (1983) does not support the membership because in their color-magnitude diagrams V2031 Cyg falls off the expected position.

Hipparcos detected the star as a variable, with a range $8.66 \leq H_p \leq 8.76$ mag, but could not determine the type of variability and derive a period for it. Prompted by the alignment of V2031 Cyg with NGC 6913 and by the fact that a few radial velocity measurements by Liu et al. (1989) suggested a binary nature for it, Kim and Lee (1996) monitored V2031 Cyg in V band with a CCD camera and independently discovered the variable nature. Their data show a single *eclipse*–like event and did not allow the determination of any periodicity.

We have obtained 19 high resolution spectra of V2031 Cyg over the 1996-2001 period, using the 1.82 m telescope and its Echelle+CCD spectrograph operated by the Astronomical Observatory of Padova at Asiago (Cima Ekar). A journal of the observations is given in Table 1. The spectra have been extracted and calibrated in a standard fashion using the IRAF reduction package and the radial velocities were obtained from measurements of seven spectral lines (of FeI and MgI), fitted individually with Gaussian profiles. Reference wavelengths were taken from Moore (1959). The resulting radial velocities are listed in Table 1.

We determined the spectroscopic orbit by setting the eccentricity to zero, as a preliminary analysis with eccentricity as a free parameter did not support a different value. The orbital solution is given in Table 2 and in graphical form in Figure 1 (upper panel). To derive it, we used only our data in Table 1. In fact, inclusion of the lower precision four measurements by Liu et al. (1989) did not change the solution at the expense of increasing the errors. Liu's data however well fit our solution (see Figure 1).

Table 1. Journal of observations and measured radial velocities.

Date	HJD 2400000+	disp at H_α	λ range	$RV_\odot$ km s^{-1}
28 Jun 1996	50263.422	0.38 Å/pix	4100-6700 Å	-32.7 ± 1.3
1 Aug 1996	50297.502	0.38 Å/pix	4100-6700 Å	$+18.1 \pm 1.2$
3 Aug 1996	50299.476	0.38 Å/pix	4100-6700 Å	$+67.4 \pm 1.3$
21 Aug 1996	50316.557	0.38 Å/pix	4100-6700 Å	$- 1.5 \pm 1.1$
28 Aug 1996	50324.473	0.38 Å/pix	4100-6700 Å	$+24.3 \pm 1.1$
6 Sep 1996	50333.426	0.38 Å/pix	4100-6700 Å	-52.4 ± 1.2
25 Jul 1997	50655.486	0.38 Å/pix	4100-6700 Å	-43.6 ± 1.1
11 Aug 1997	50671.557	0.38 Å/pix	4100-6700 Å	-50.6 ± 1.0
13 Aug 1997	50674.404	0.38 Å/pix	4100-6700 Å	-44.8 ± 0.7
13 Aug 1997	50674.488	0.38 Å/pix	4100-6700 Å	-38.4 ± 0.7
14 Aug 1997	50674.565	0.38 Å/pix	4100-6700 Å	-30.6 ± 0.7
14 Aug 1997	50675.392	0.38 Å/pix	4100-6700 Å	$+64.6 \pm 1.2$
9 Sep 1998	51066.390	0.38 Å/pix	4100-6700 Å	-51.8 ± 1.1
17 Dec 2000	51896.245	0.38 Å/pix	4500-9500 Å	-19.0 ± 1.4
30 Jul 2001	52121.480	0.19 Å/pix	4500-9500 Å	-35.9 ± 0.7
9 Sep 2001	52162.368	0.19 Å/pix	4500-9500 Å	$- 1.3 \pm 2.0$
29 Oct 2001	52212.436	0.38 Å/pix	4500-9500 Å	$+15.0 \pm 1.2$
2 Nov 2001	52216.308	0.38 Å/pix	4500-9500 Å	-17.4 ± 0.9
30 Nov 2001	52244.251	0.19 Å/pix	4500-9500 Å	$+68.2 \pm 1.5$

We have then phase plotted the Hipparcos photometric data according to the 2.70465 day orbital period. A fine *eclipse*–like shape is evident, with a primary eclipse with a depth of 0.10 mag and a secondary eclipse with a depth of 0.05 mag., confirming the preliminary suggestion by Kim and Lee (1996) about the nature of V2031 Cyg. The lightcurve based on Hipparcos data is plotted in Figure 1 (middle panel). It looks noisy because of the low amplitude coupled with the fact that V2031 Cyg is close to the fainter limit of Hipparcos H_p sensitivity where observational errors are higher. The noisy nature of Hipparcos lightcurve prevented us from a combined spectro/photometric solution of V2031 Cyg with a Wilson-Devinney code.

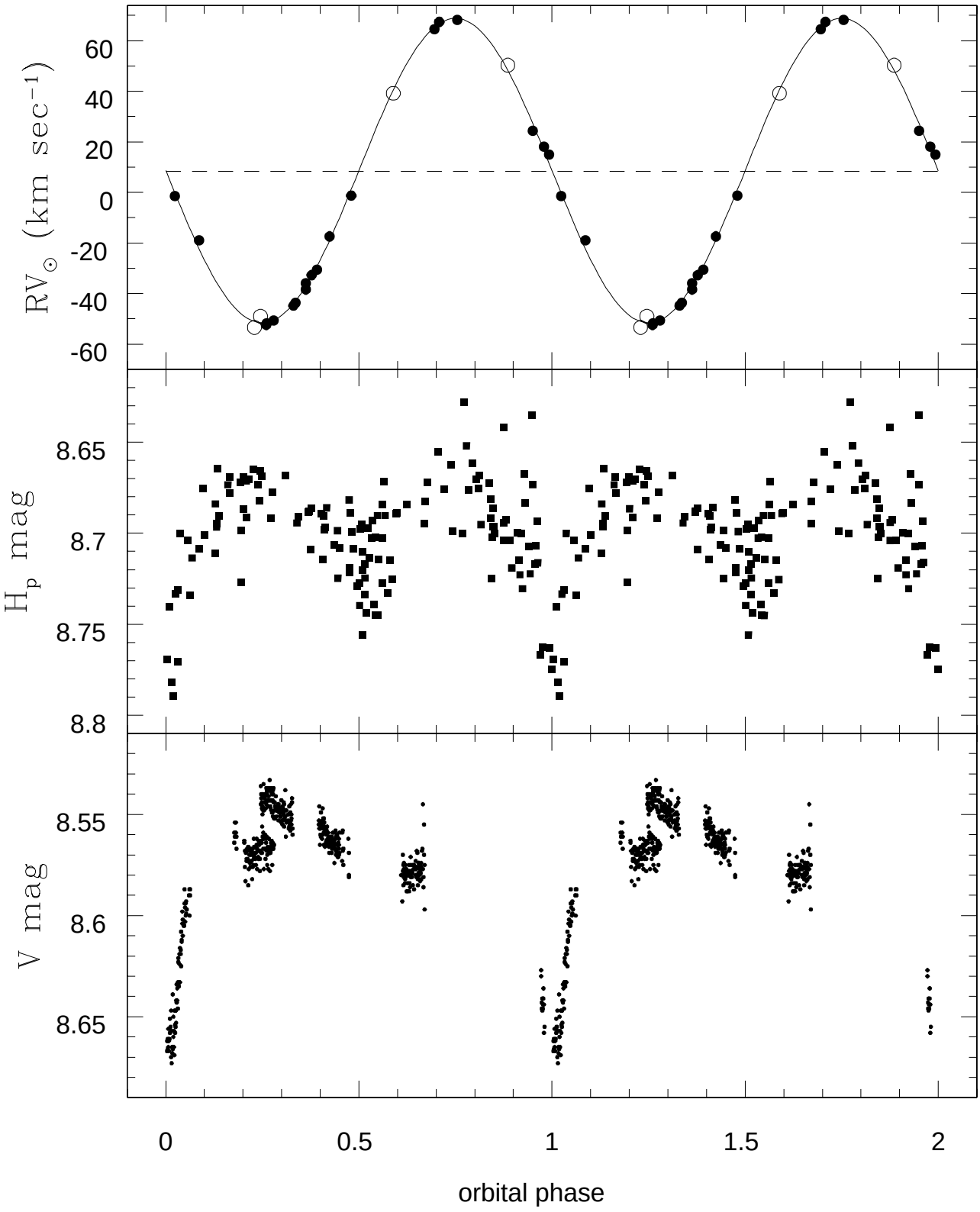

Figure 1. Radial velocity curve of V2031 Cyg (top). *Filled circles:* our measurements from Table 1. *Open circles:* Liu et al. (1989) data (four measurements on dates 25-11-1987, 26-11-1987, 30-09-1988, 01-10-1988). The dashed line gives the barycentric velocity. The middle and bottom panels are phase diagrams of the Hipparcos H_P data and the Kim and Lee (1996) V band photometry according to our orbital solution in Table 2.

Table 2. Orbital Elements for V2031 Cyg

Orbital Element		Value	error
P	(days)	2.70465	± 0.00001
e		0.000	
K	(km s^{-1})	60.19	± 0.71
γ	(km s^{-1})	+8.65	± 0.48
T_0	(HJD)	2451038.638	± 0.005
ω	(deg)	0.000	
$a \cdot \sin i$	(AU)	2.23	± 0.02
i	(deg)	≃90	
f(m)		0.061	± 0.002
RMS residual	(km s^{-1})	1.51	

In Figure 1 (bottom panel) the Kim and Lee (1996) data are phase plotted according to our orbital period of 2.70465 day (data kindly communicated privately by S.-L. Kim). They confirm the eclipsing nature of V2031 Cyg but they too do not allow a photometric solution because: (i) the out-of-eclipse data seems to suffer from variable zero-point problems, (ii) the primary eclipse is only partially covered and the secondary is entirely missed.

Given the object's brightness, position in the sky and already available spectroscopic data and orbital solution, V2031 Cyg well qualifies as an easy target for a devoted photometric investigation aimed to derive a combined spectro-photometric solution, that we encourage.

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