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SPECTROSCOPY OF THE FAINT DWARF NOVAE DV UMa AND AR Cnc

HAEFNER, R.

Universitäts-Sternwarte München, Scheinerstr. 1, D-81679 München, Germany

Results of time-resolved spectroscopy of the faint dwarf novae DV UMa and AR Cnc are reported. Both objects have attracted little observational attention so far. The present observations were performed using the Low Resolution Spectrograph (LRS) at the 9.2-m Hobby-Eberly Telescope (HET) and the FORS2 instrument at the ESO Very Large Telescope (VLT) Unit No. 2. Table 1 lists the observing log for each object. All spectra were reduced with IRAF† standard tools. Radial velocities were measured using the IRAF 'splot (k)' routine.

Table 1: Journal of observations. UT times refer to the start of the first and last exposure, respectively. The VLT runs were consistently interrupted to observe other targets

Object	Date	First exp. (UT)	Last exp. (UT)	Indiv. exp. time (s)	No. exp.	Res. (Å/pix)	Tel.
DV UMa	2002 Jan. 25	10:31:32	11:28:22	500	7	5	HET[1]
AR Cnc	2001 Feb. 26	01:38:50	03:38:50	480/600	4	1.2	VLT[2]
	2001 Feb. 27	01:49:40	03:08:02	900	2	1.2	VLT[2]
	2002 Feb. 20	09:00:23	09:19:29	800	2	5	HET[1]

1: wavelength range $\lambda\lambda$4400–9200 Å, 2: wavelength range $\lambda\lambda$3700–5900 Å

Table 2: System parameters for DV UMa

i (°)	$M_2/M_\odot$	$M_1/M_\odot$	Type	Reference
72	0.23	0.43	spec.	Szkody & Howell (1993)
71.5–73	0.17	0.31	phot.	Howell & Blanton (1993)
84	0.15	0.90	phot.	Patterson et al. (2000)
84	0.16/0.17	1.14/1.04	phot.	Feline et al. (2004)

DV UMa is known to be a faint ($V \approx 19$) eclipsing ($\Delta V \approx 2$) dwarf nova of SU UMa type. The orbital period amounts to $2^h3^m38^s$. Spectroscopic work on this object is scarce in the literature: Mukai et al. (1990) detected the spectral signature of the secondary in a low resolution spectrum and determined its spectral type to be M4.5. This finding

†IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

was later confirmed by Smith et al. (1997). Szkody & Howell (1993) demonstrated H_β to feature the typical double-peaked line structure of a high inclination system. Based on nine spectra they also derived radial velocities by fitting Gaussians to each of the two peaks of this line with the final velocity being the midpoint of the two Gaussians, respectively. The resulting radial velocity curve ($\gamma = -61 \pm 13$ km/s, $K_1 = 140 \pm 18$ km/s) shows a phase lag of 36° compared to the eclipse thus indicating that the H_β velocities do not exactly reflect the motion of the white dwarf. Therefore, the derived mass estimates given in Table 2 may be less reliable. Table 2 also lists inclinations and masses obtained by several authors using eclipse analyses.

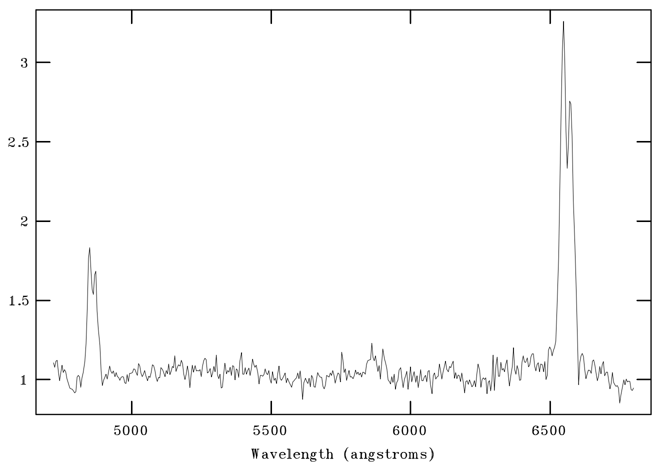

Figure 1. The normalised average spectrum of DV UMa showing the double-peaked lines of H_α and H_β. The He I λ5876 line may also be present

The individual HET spectra of DV UMa (Fig. 1 presents the average spectrum) proved to be suitable to determine the H_α and the H_β velocities in part using the same procedure as Szkody & Howell (1993). Results are shown in Fig. 2. The data points cover roughly half a period and indicate an amplitude $K_1 \approx 115 \pm 20$ km/s as well as a moderate phase lag of about 20°. Assuming $i = 84°$ and $M_2 = 0.16\ M_\odot$ (mass-period relation) one then arrives at $M_1 = 0.39(+0.24/-0.08)\ M_\odot$. Even if the range of dispersion is high and one is aware of the problems in determining the true K_1, the derived range of M_1 is distinctly smaller than the values obtained by recent eclipse analyses. This small mass would be in line with the finding by Webbink (1990) that the mean white dwarf mass for dwarf novae with periods below the gap amounts to $0.5 \pm 0.1\ M_\odot$, which does not, however, exclude a higher value for the individual system DV UMa.

AR Cnc is a faint ($V \approx 19$) dwarf nova which shows deep eclipses (≥ 3 mag) repeating with a period of $5^{\rm h}9^{\rm m}$ (Howell et al. 1990). Spectroscopic confirmation was based on three spectra obtained by Bruch (1989), Mukai et al. (1990) and Szkody & Howell (1992), respectively.

The HET spectra of AR Cnc may resolve one of the puzzling results obtained for this system so far: the spectral features (TiO) to the red side of the A band (Fig. 3) indicate a spectral type around M1 for the secondary rather than M4–M5.5 as deduced by Mukai et al. (1990). This would be in line with the long orbital period of AR Cnc thus supporting a canonical value for the mass of the secondary of about 0.5 $M_\odot$. The unusual high mass

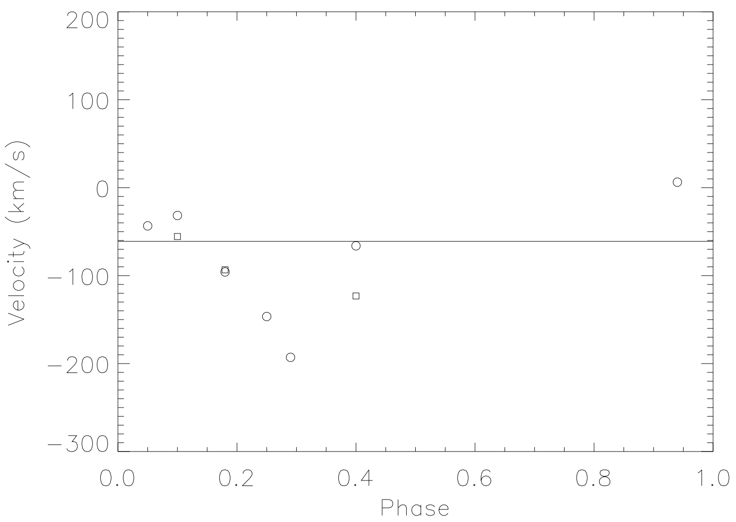

Figure 2. Radial velocities of DV UMa corrected for the motion of the earth (H_α: circles, H_β: squares). Phases are calculated using the precise ephemeris given by Feline et al. (2004). The straight line represents the γ-velocity determined by Szkody & Howell (1993)

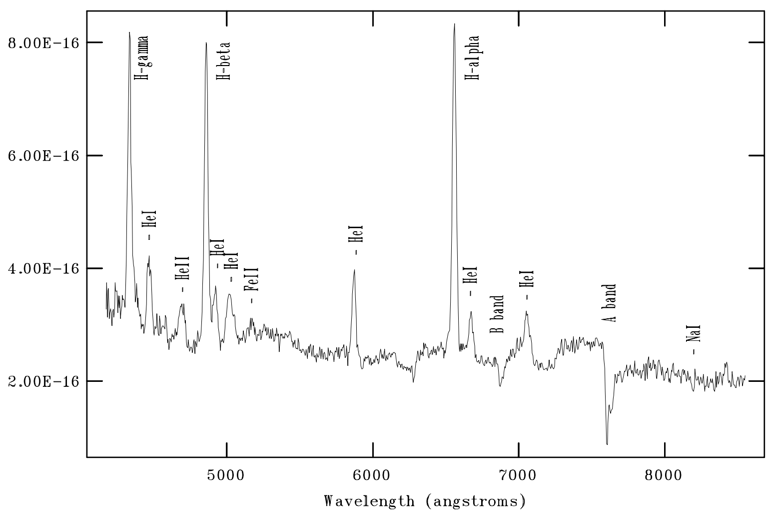

Figure 3. The average flux-calibrated HET spectrum of AR Cnc. It is dominated by Balmer and He I emission lines. Also present are the He II $\lambda4686$ and Fe II $\lambda5169$ emissions as well as the (unresolved) Na I doublet of the secondary at 8190 Å

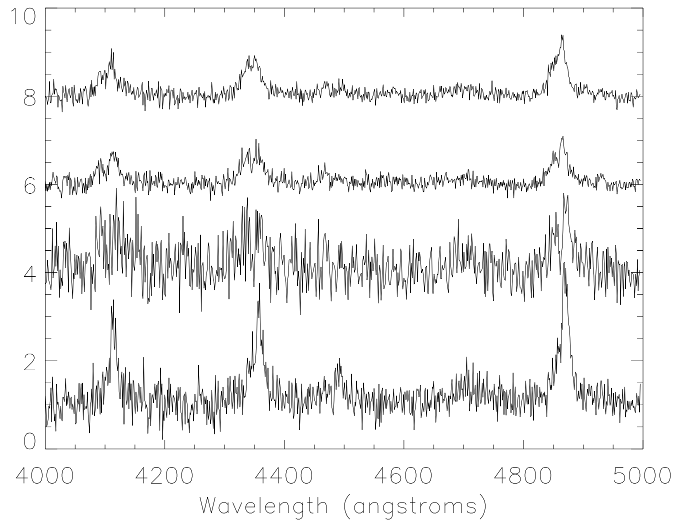

Figure 4. The best VLT spectra of AR Cnc, normalised and separated vertically by offsets (orbital phases from top to bottom: 0.0 (arbitrary), 0.10, 0.67 (bad seeing), 0.71). Note the changing relative intensities and profiles of the Balmer lines

for the primary ($\geq 2.45\ M_\odot$ for $i \geq 80°$) as derived by Howell & Blanton (1993) can only be decreased to a plausible value assuming an inclination $\leq 75°$, which would, however, contradict the large eclipse depth observed and the double-peaked emission lines found by Szkody & Howell (1992). The VLT spectra, though quite noisy (Fig. 4), nevertheless show that the emission lines do not exhibit a permanent double-peaked structure. The profiles vary considerably over the orbital period and may have a quite different appearance even at similar phases. The latter does not necessarily imply such severe variations on a short time scale, because the spectra obtained at phases 0.67 and 0.71 (Fig. 4) are separated by five orbital revolutions.

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