

AN OBSERVATIONAL STUDY OF THE HERBIG Ae STAR VV SERPENTIS,
AND OF R-STARS ASSOCIATED WITH ITS DARK CLOUD

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In this work we give a revised distance (250 ± 20 pc) to the star VV Serpentis and its associated dark cloud complex, redetermine its spectral type (= A2e, see also Herbig, 1960, ApJ Suppl. 4, 337), and report on observations of previously unknown associated emission line stars, and of stars with associated reflection nebulosity (R-stars) belonging to the same region.

We have obtained uvby- $H\beta$ and JHKLM photometry of VV Serpentis, and of 12 selected R-stars with the 1.5 and 2.1m telescopes of the Sierra San Pedro Mártir National Observatory (México), respectively. Most of the stars were also observed at intermediate resolution ($R \approx 4000$) with the Waltz 72 cm reflector of the LSW, and/or with the 2.2 m at ESO, La Silla (Chile). VV Serpentis has also been observed at both high and low resolutions ($600 < R < 40.000$) by using the IDS and the Hamilton echelle spectrograph of the Lick Observatory (USA). For the present study $\alpha(16)$, $\Lambda(9)$ photometric colours of VV Serpentis were also available. The summarized observational data and results are listed in table 1.

The low resolution spectroscopic data of VV Serpentis indicate a spectral type A2, based on the lower Balmer lines, and the presence of lines of neutral and once ionized metals, mainly Ca II, Fe I and II, Ti I and II, Cr II (cf. Figure 1). The observed Balmer discontinuity is accordingly. Likewise two high resolution spectrograms clearly show Fe II (42) $\lambda\lambda 4923$ and 5018 in absorption. These lines are typical of early A type stars. Both $H\alpha$ and Na I-D lines are highly variable. The presence of He I $\lambda 5876$ Å ($W_\lambda = 0.86$ Å, asymmetric to the red) should be regarded as indicative of stellar activity and/or of an extended atmosphere rather than

traces of an early spectral type (see Finkenzeller and Mundt, 1984, *Astron. Astrophys. Suppl.* **55**, 109). The large $\Lambda(9)$ colour index observed for the star gives support to this.

The combined data yielded $A_V/E(B-V) = 4.0 \pm 0.1$ and $d = 250 \pm 20$ pc for the dark cloud complex. Hence the luminosity of VV Serpentis is $\approx 36 L_\odot$, with $L_{\text{IR}}/L_{\text{opt}} > 5$, and $M \approx 2.5 M_\odot$. Furthermore, the star is a photometric variable in the optical and infrared ($\Delta m \lesssim 0.4^m$), in time scales of 1^d or less. Its location in the H-R diagram is shared with the stars T Ori, HK Ori, BD +46°3471, all being evolved low mass Herbig Ae stars.

In order to check the R-stars for possible H_α emission, the plates taken by Iriarte and Chavira (1956, *Bol. Tonantzintla Tacubaya* **14**, 31) were reinspected by us, and 7 new H_α emission stars in the field were found. Our final results will be published elsewhere.

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TABLE I. R-stars associated with VV Serpentis' dark cloud

Nr.	other	coordinates 1950				V	K	sp.t.	n	A_V	R	dist
		h	m	s	°	'	"				pc	
1	BD-2°4607	18 18 57	-2 4 2		10.36	-	A2V:	1	1.92		259	
3	VV Ser	18 26 15	+0 6 34		12.54V	5.55V	A2e	1	4.6	6.6	pmas	
5		18 27 0	+1 6 13		-	9.8	<K2	1				
6		18 27 1	+1 6 20		-	8.3	AOV	1				
7		18 27 24	+1 1 48		12.25	-	<AOV:	1	6.3			
9		18 27 35	+1 1 7		11.74	-	<K2	1	3.5			
10	BD+1°3694	18 27 52	+1 11 26		9.87	7.5	A1V	1	2.53	3.8	185	
12	SAO123590	18 28 17	+1 21 22		8.46	6.40	B4V	1	2.97	4.1	239	
13	SAO123595	18 28 37	+1 25 14		8.54	6.90	B3V	1	2.62	4.1	319	
14		18 28 40	-2 22.9		13.9 V	-	Be	1	5.4		Pmas	
15	SAO123661	18 32 35	+0 0 3		8.05	-	B3V	1	2.7		259	
16		18 34 24	+0 17 36		10.65	-	<AOV	1	3.7			

Remarks to table 1

spectral type based on spectral data

luminosity class from spectrum or H_β index

