SPECTRAL CLASSIFICATIONS FOR 112 VARIABLE STARS*

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ABSTRACT

The spectral types of 87 miscellaneous variable stars and of 25 stars belonging to the RW Aurigae class are presented. The variables assigned to the RW Aurigae class on photometric grounds alone scatter over a wide range of spectral class and luminosity and hence do not constitute a homogeneous group, nor do they include a significant fraction of variables having the physical characteristics of the type star.

Over the past decade, exploratory spectrograms have been obtained at this Observatory of a considerable number of variable stars of all types. Many of these stars proved to be of no further interest, but their spectral classifications are presented here on the chance that they may be useful to others. The results for 87 miscellaneous variables are given in Table 1. The spectral classifications of 25 variables that have been assigned to the "RW Aurigae class" are listed in Table 2.

In these tables the type of light-variation and spectral type are usually as given in the second (1958) edition of the *General Catalogue of Variable Stars*. In the fourth column are listed the number and the dispersion of the spectrograms available. The dispersion code, following a practice initiated by the Mount Wilson observers, is as follows: b = 75 A/mm at Hγ: 2-prism spectrograph and 6-inch camera, 36-inch refractor; c = 130 A/mm at Hγ: same spectrograph as b, with 3.5-inch camera; e = 430 A/mm at Hγ: nebular spectrograph, Crossley reflector. Following the U.T. date when the spectrograms were taken, the spectral classification is given on the MK system except for the late M-type giants, where the Mount Wilson system is used. A colon indicates that the quantity just preceding it is uncertain; thus "A7 V:" indicates that the luminosity class, not the spectral type, is of lower weight than usual. Similarly, a luminosity class of "IV, V" means IV *or* V, *not* an intermediate between IV and V.

Some of the present assignments differ slightly from those given elsewhere by the writer; in case of conflict, the new types take precedence.

The spectral classifications of RW Aurigae–type variables, which resulted from a special program to observe as many of these objects as possible because of their implied relationship to the T Tauri stars, are collected in Table 2. The conclusion drawn some years ago (Herbig 1954) on the basis of less extensive material still holds: the photometric characteristics used to define the RW Aurigae class do not result in a group of variables that is homogeneous with respect to either spectral type or luminosity. Furthermore, those photometric criteria by themselves are not adequate to segregate a significant fraction of stars having the physical characteristics of RW Aurigae itself.

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TABLE 1

SPECTRAL TYPES OF VARIABLE STARS

STAR	GENERAL CATALOGUE		TYPE, NO. OF SPECTRO-GRAMS	DATE	SPECTRAL TYPE	NOTES
	Type	Spectrum				
Anon.	.....	.....	c	49 Sept. 23	K2 III	1
V Psc.	?	.....	e	55 Sept. 22	M1 V	
W Scl.	cst	.....	e	55 Sept. 22	F5	2
HS Cas.	I*b*?	M3	c	47 Dec. 14	M3 I	
RZ Psc.	EA?	G8 V	c	56 Nov. 9	K0 IV	3
GG Cas.	EA	Comp.	b	50 Sept. 28	Comp.	4
SW Cet.	I	Mb	3b	45–52	gM7	
SVS 344.	Nl	.....	b	54 July 16	B8	
TZ Per.	Z	pec	2e	49, 50	Cont.	5
SZ Cas.	CW	F6–G4	b	52 Sept. 29	F8 I*b*	6
TW Cam.	RV*a*	F8–G8 I*b*	5b	44, 45	G0–G5 I*b*	7
TW Tau.	I*b*	K0	b	45 Sept. 6	K0	8
SVS 844.	.....	A0	8b	44–45	A0 V	
Y Lep.	SR*b*	M4 III	2b	50, 52	gM4	
Anon.	.....	.....	c	49 Sept. 14	F0	9
V346 Ori.	I*a*	A	b	52 Sept. 15	A5 III:	
EX Ori.	I	.....	b	46 Apr. 10	gM7	
+21°981.	.....	.....	2b	51	A2 IV, V	10
UV Ori.	I	.....	b	46 Jan. 11	Late M	
CO Aur.	RV?	F5	b	51 Nov. 17	F5 I*b*	
SS Aur.	UG	pec	e	51 Jan. 5	pec	11
DE Gem.	I*b*	M4	2b	44 Jan. 22	g:M6	
U Gem.	UG	G?ep	2e	49, 50	pec	12
UU Cnc.	EB	K4 III	4b	55–56	K4 III	13
SU UMa.	UG	pec	2e	50	pec	14
UZ UMa.	I?	.....	e	56 Mar. 8	A5	
SW UMa.	UG	pec	e	50 Feb. 13	pec	15
FV Hya.	I	.....	e	59 Mar. 4	G8	
AL Hya.	E	.....	e	56 Feb. 7	A7	
VX Hya.	RR	.....	2b	50	F I*b*	16
CE Vel.	RCB?	.....	c	51 Mar. 12	M4	
X Leo.	UG	pec	e	50 Feb. 18	Cont.	17
UY Leo.	I	.....	2b	44	gM7	
SZ UMa.	cst?	M1 V	b	51 June 10	M1 V	
X Vir.	?	.....	b	44 Mar. 27	Fp	18
Y Crv.	?]	.....	b	45 May 3	A	
RW CVn.	SR*b*	M7	b	44 Mar. 27	gM7	
Y Boo.	cst?	K0 III	2b	50, 51	K0 III	
UV Boo.	I*a*	F5	17b	44–46	F5 V	19
RY CrB.	SR*b*	M10	b	44 Apr. 1	gM8+	
TZ Oph.	?	.....	e	46 July 27	F6	
GN Her.	I*b*	M4	b	45 May 1	gM4	
HV 10856.	I	.....	b	54 July 7	Bnne	20
V447 Oph.	I*b*?	M6e	2b, 3c	46–55	gM4e	21
AO Dra.	SR	.....	c, e	58	g:Me	22

TABLE 1—*Continued*

Star	General Catalogue		Type, No. of Spectrograms	Date	Spectral Type	Notes
	Type	Spectrum				
V771 Sgr	I*a*	B0ne	3b	50–54	Bne	23
AV Oph	I	.....	c	54 Apr. 13	M8	
AZ Sgr	RV?	F	c	57 July 26	F5 V:	24
TZ Dra	EA	.....	b, c	46, 50	A7 V:	
BP Sct	I*b*	M3	e	49 July 24	S4, 9:	25
HK Aql	I*b*	K5 III	2b	50, 55	K5 III	
AB Aql	I*b*?	M5	c	46 May 3	gM5	
AP Her	CW	F5–G0	b	56 May 26	F5 I*b*, II	
VW Aql	I*b*	M5	c	46 May 7	gM5	
CM Aql	Ne	pec	e	57 July 28	pec	26
RT Vul	cst	A0	b	55 June 8	B8	
X Lyr	I*b*	M2	b	45 June 15	gM3.5	
HN Lyr	M	M4e	e	58 Dec. 8	gM7e	27
MS Aql	I*b*	M1	b	55 Aug. 7	gM4	
CV Sge	I*b*	K	c	54 Apr. 20	gM4	
RZ Vul	RCB	.....	2c	49, 51	G2 IV, V:	28
124.1935 Vul	.....	.....	b	47 July 16	Comp.	29
Z Sge	I*b*	M3:	e	59 July 5	gM6	30
AB Dra	Z	pec	e	49 July 25	pec	31
SVS 876	.....	.....	e	44 Sept. 20	F6	
V 425 Cyg	I*a*	F5	4b	50, 57	pec	32
V 395 Cyg	I*a*	F8 I*b*	b	52 July 6	F8 I	
KT Cyg	I	.....	b, e	54, 55	B5eβ	
SVS 805	.....	.....	2b	45	B8	
V 407 Cyg	Ne	Mep	e	52 Oct. 10	Me	33
V 408 Cyg	I*b*	M6	b	45 July 4	gM6	
Z Mic	RR*a*	F0–F5	c	51 July 11	F5 II	34
SVS 886	.....	.....	b	45 Apr. 18	G8 I*b*, II	
SVS 763	.....	.....	2b	45	B8–A2	35
AK Cyg	cst?	.....	.....	45	.....	36
SVS 808	.....	G3	4b	44, 45	G1 V	
BG Cep	RCB	.....	e	59 Dec. 2	B8:	37
AZ Cep	I*b*	M0	b	46 Aug. 2	gM1	
EE Cep	RCB?	.....	c	57 July 26	B5:neβ	38
SY Cep	RCB?	.....	c	45 Nov. 21	A3:	
BT Lac	RV*b*	.....	e	59 Oct. 2	G8	
BH Lac	RCB	.....	b	51 Oct. 17	A0s	39
RZ Lac	cst?	B9e	b	46 Aug. 6	B7e	40
BC And	I*b*	M7	b	45 Jan. 23	gM7	
CE CasA	Cδ	.....	b	51 Aug. 23	F9 I*b*	
CE CasB	Cδ	.....	2b	.....	F8–G0 I*b*	41
CF Cas	Cδ	.....	b	51 Sept. 12	F8 I*b*	

NOTES TO TABLE 1

1. *Anon.*—This rapidly irregular variable was discovered by B. S. Whitney (unpublished); the position is 0^h07^m7, $+52°05'$ (1900).

2. *W Scl.*—The H lines and G band are of normal strength; the spectrum does not support the suggestion that the star belongs to the R CrB type (Pingsdorf 1950).

3. *RZ Psc.*—This classification replaces that quoted in the *General Catalogue*, which was a provisional estimate from the same spectrogram.

4. *GG Cas.*—The type given in the *General Catalogue* is that of Popper (1956). On the Lick plate, the later-type star is definitely earlier than K0; it looks most like an F8 or G0 giant.

5. *TZ Per.*—Two unwidened spectrograms (Nov. 23, 1949, $m_v = 13.9$, and Nov. 7, 1950, $m_v = 13.8$) show a hot continuum with no absorption or emission lines.

6. *SZ Cas.*—The strength of the H lines corresponds to a slightly earlier type.

7. *TW Cam.*—The type was G0 I*b* on Feb. 6, 1944, and Jan. 23, 1945; G2:I*b* on Oct. 17, 1944; and G5 I*b* on Oct. 6, 1944.

8. *TW Tau.*—The luminosity class is uncertain but is probably IV or V.

9. *Anon.*—This variable was discovered by B. S. Whitney (unpublished); the position is 5^h07^m0, $-4°29'$ (1900).

10. *+21°981.*—Slow, irregular variations were found by Sandig (1950), and a curious color change was described by J. R. Hind (1851). The spectrum is quite unexceptional.

11. *SS Aur.*—At $m_v = 14.8$, there were strong, rather wide emission lines of H and Ca II and possibly He I λ 4471, on a continuum of only moderate extension into the ultraviolet.

12. *U Gem.*—On Dec. 21, 1949 ($m_v = 14.0$), and Apr. 11, 1950 ($m_v = 14.4$), strong, wide H emission lines, a weak, bright K line, and possibly a faint emission He II λ 4686 were present (the latter only on the second plate).

13. *UU Cnc.*—As noted by Popper (1956), the H lines are too strong for the remainder of the spectrum. On the best plate, of Nov. 30, 1955, the strength of Hγ and Hδ is about as in type G2.

14. *SU UMa.*—On Feb. 13, 1950, not far from maximum ($m_v = 11.9$), an absorption spectrum is visible with very broad H lines, which run together following H9. The K line is also present; its ratio to the Balmer lines corresponds to type A5 or A7, but He I λ 4471 is probably present also. At minimum light (Apr. 11, 1950, $m_v = 14.4$), wide emission lines of H (and probably He I as well) were observed on a weak continuous spectrum.

15. *SW UMa.*—The star was near minimum light ($m_v \sim 16$) when this plate was taken; only wide emission at Hγ and Hδ is visible, and a weak continuous spectrum.

16. *VX Hya.*—On Apr. 4, 1950, 6^h08^m U.T., the type was F2 I*b*. The plate of Feb. 26, 1950, 7^h46^m U.T., is poorer, but the type is about F8.

17. *X Leo.*—The star was at minimum ($m_v = 15.7:$); no emission lines are visible on a rather blue continuum.

18. *X Vir.*—This star apparently was about mag. 8 in 1871, but has since remained near mag. 11 for approximately 70 years. The 1944 plate shows a metallic spectrum corresponding to type F8, with H lines of about F2. The luminosity class is IV or V. Two 430 A/mm and one 130 A/mm spectrograms taken by A. B. Wyse in 1935 show no obvious difference. X Vir has a twelfth-magnitude companion $2^s f$, 0!4 *n*; its type is dK4.

19. *UV Boo.*—The star varied between about $m_v = 7.1$ and 8.0 during this series of spectrograms. There is a minor variation in the strength of the H lines on these plates, but it does not appear to be correlated with the magnitude. The luminosity class is V or possibly IV–V, but certainly not as bright as IV.

20. *HV 10856.*—There is a sharp, fairly strong emission line at Hβ, but otherwise only very faint, wide depressions are visible at the positions of the H and possibly the He I lines.

21. *V447 Oph.*—Rather strong emission lines were visible at Hβ, Hγ, and Hδ on Mar. 26, 1946, June 16, 1951, and Apr. 12, 1954. They were weak on July 8, 1955, and very weak or absent on Aug. 9, 1949.

22. *AO Dra.*—On June 15, 1958, the type was M3 and Hγ, Hδ were in emission. On Aug. 2, 1958, the type was M4, and no emission was present.

23. *V771 Sgr.*—The type is intermediate B with very broad lines. There is strong narrow emission in Hβ, weak emission in Hγ, and a marginally visible bright line in Hδ.

24. *AZ Sgr.*—There may be weak emission in Hβ.

25. *BP Sct.*—The nebulosity reported by Miss Harwood (1938) as connected with the variable does not appear on the Palomar Sky Survey plates.

26. *CM Aql.*—The plate shows strong emission lines on a continuous spectrum of low color temperature. TiO bands are present faintly; the type is about M4. The relative intensities of the stronger emission lines are as follows: Hβ = 10, He II λ 4686 = 15, Hγ = 4, Hδ = 2. When observed by Humason in 1925 (Harwood 1925), λ 4686 was intermediate in intensity between Hβ and Hγ. The star is obviously a symbiotic object. I am indebted to Miss Harwood for an identification photograph of the field.

27. *HN Lyr.*—Hδ is strongly and Hγ faintly in emission, much as in the premaximum spectrum of a long-period variable.

28. *RZ Vul.*—The hydrogen lines are present, and the luminosity is not high; the spectrum therefore does not support an assignment to the R CrB class.

29. *124.1935 Vul* = HD 188037. The curious description of the spectrum in the *HD* is due to its composite nature: an A0 plus an M4 or M5. Although observed here as one star, HD 188037 is a visual binary (ADS 13055, 0″.8 in 273°); since one component is quite red as observed with the 36-inch refractor, it is likely that the two visual components are responsible for the composite spectrum. The reality of the variability has recently been questioned by Wenzel (1956).

NOTES TO TABLE 1—*Continued*

30. *Z Sge.*—This star lies near the edge of the cluster NGC 6838 (M71).

31. *AB Dra.*—The star was near minimum light (m_v = 15.3); strong, narrow emission lines of H, Ca II, and (faintly) He I are present on a hot continuous spectrum.

32. *V425 Cyg.*—MWC 628. Three plates taken in 1950 show wide strong He I absorption lines, as in a B5 star, but Hγ and Hδ are narrow, deep but wingless, as in a shell; there is diffuse emission at Hβ. The spectrum was filled with strong lines of Fe II, Ti II, and Si II, much as in an A5 supergiant, but Si II was abnormally strong, so that this spectrum cannot originate in a shell excited by dilute radiation. On a plate taken in 1957, the metallic absorption spectrum is much weaker, Si II and Mg II are not present, and narrow emission fringes have appeared shortward of the Balmer lines. Earlier observations have been reported by Merrill and Burwell (1943). This remarkable spectrum deserves detailed attention.

33. *V407 Cyg.*—Hδ is in emission on a late M-type absorption spectrum, but its presence without other hydrogen lines is quite normal for such a late-type object.

34. *Z Mic.*—Sr II λ 4077 is unusually strong. The time of mid-exposure was 10^h18^m U.T.

35. *SVS 763 Cyg.*—Both spectrograms show a K line of type A2, but He I and Mg II are as in type B8.

36. *AK Cyg.*—The star identified as the variable by Kanda (1935) is double, with separation about 20″ in 85°. Spectrograms of both components taken in 1945 with 75 A/mm dispersion show the eastern component to be about type A7, while the western is F8, luminosity class I*b* or II. Judging from spectral class and luminosity alone, the western star could be a cepheid or RV Tauri variable.

37. *BG Cep.*—The spectral type does not support an assignment of this star to the R CrB class.

38. *EE Cep.*—There is weak double emission at Hβ. The spectrum is not that of an R CrB variable.

39. *BH Lac.*—The H lines are sharp and deep; the star may have a luminosity above the main sequence, but it is not a supergiant. It does not have the spectrum of an R CrB star.

40. *RZ Lac.*—There is weak central emission in Hβ and possibly also in Hγ and Hδ.

41. *CE Cas B.*—On Aug. 23, 1951, the type was F8 I*b*; on Oct. 3, 1950, it was G0, and of about the same luminosity class.

TABLE 2

SPECTRAL TYPES OF VARIABLE STARS ASSIGNED TO THE RW AURIGAE CLASS

Star	General Catalogue		Type, No. of Spectrograms	Date	Spectral Type	Note
	Type	Spectrum				
HQ Per	RW	.....	b, c	51, 52	F	
CQ Tau	RW	F2	3b	50, 51	F2 IV	
BN Ori	RW	A6	b	55 Mar. 6	Comp.?	1
HH Aur	RW	G5	b	55 Nov. 30	G5 IV	
V 350 Ori	RWn	.....	b	53 Jan. 11	A0	
V 351 Ori	RWn	A2	b	52 Dec. 15	A7 III	
EN Tau	RWn?	.....	2e	58 Dec.	G0	
CT Tau	RW	B5:n	b, e	50, 59	B2n	
SVS 1100	RW?	.....	e	59 Nov. 27	K2 III:	
CY Ori	RW	G0 V	c	50 Dec. 21	G0 V	
DO Mon	RW	M4–M5	e	47 Mar. 24	gM4	
ST Lyn	RW	.....	c	54 Dec. 18	K0 III	
AK Sco	RWn	F5 V	2b	50	F5p V	2
DU Sgr	RW	.....	e	46 July 24	F1:	
V 426 Oph	RW	pec	3c	52, 54	pec	3
BQ Ser	RW	F5 III	3c	50–54	F3 III:	4
V 733 Aql	RW	G0	2b	49, 51	F9 I*b*	5
AQ Dra	RW?	.....	e	51 July 5	F2	6
V 517 Cyg	RWn	A0–A5	2c	50, 52	A5:	
DR Cep	RW	.....	e	57 Nov. 17	F5p	7
V 530 Cyg	RW	.....	b	57 July 19	B5:	
BH Cep	RW	F5	2c	49, 51	F5 IV	
YZ Cep	RW	.....	2c	45, 56	G0 V	
BO Cep	RW	F0–F5	3c	49, 51	F2:	
SV Cep	RW	A	b, c	46, 53	A0	

NOTES TO TABLE 2

1. *BN Ori.*—The spectrum is peculiar and may be composite; if so, the spectral types are A and F8.
2. *AK Sco.*—The type from the metallic lines is F5 V, but the hydrogen lines are too strong: they correspond to type A7 or F0.
3. *V426 Oph.*—Moderately strong, diffuse emission lines of hydrogen, together with He I λ 4471, are present on a featureless continuum.
4. *BQ Ser.*—The luminosity is clearly above the main sequence, and class III is the best compromise, but λ 4077 is still abnormally strong.
5. *V733 Aql.*—The best plate, which essentially determined the assigned type, was obtained on Aug. 23, 1951.
6. *AQ Dra.*—Absorption Hβ is absent, as if filled in by emission.
7. *DR Cep.*—The H and Ca II lines indicate F5, but the strength of the G band corresponds to G0.