

INFRARED SPECTRAL CLASSIFICATION OF HETZLER STARS

Using the 10-inch Bruce telescope of the Yerkes Observatory with infrared-sensitive emulsions, Hetzler (1937) made a survey for stars that were very red. He published identifications for 168 stars for which the infrared index, defined as the magnitude at 5600 Å minus the magnitude at 8500 Å, was greater than 2 mag. The largest infrared index he found was 10 mag. More recently an infrared survey has been in progress at the California Institute of Technology using an array of PbS detectors with a 62-inch reflector. This survey resulted in the discovery of several red objects (Neugebauer, Martz, and Leighton 1965; Ulrich, Neugebauer, McCammon, Leighton, Hughes, and Becklin 1966) at least one of which had already been noted by Hetzler. Multicolor data for a number of infrared stars discovered by various investigators have been reported by Johnson, Mendoza V., and Wiśniewski (1965).

The first spectroscopic study of these "infrared stars" was made by Rust (1938), who obtained spectra of the brightest Hetzler stars and showed that they were mainly of type M. The spectra of some of the stars identified by Neugebauer *et al.* have been observed by Münch and Scargle (1965), Ford and Rubin (1965), and Wing, Spinrad, and Kuhl (1967). Pesch (1967) has determined spectral types of thirteen of these very red stars. In view of the interest in these infrared stars and the general lack of spectral classifications available for them, some material obtained at the Warner and Swasey Observatory several years ago for the purpose of classifying the Hetzler stars has been re-examined, and the results are presented below.

A series of objective-prism plates was taken using I-N emulsion and a Wratten No. 89 filter to cover most of the regions surveyed by Hetzler. With these plates, classifications could be made to the magnitude limit of the original survey except for some variable stars that had become too faint. A total of 120 of the Hetzler stars were classified. The classifications were based on the strength of the TiO and VO bands in the near infrared as described by Nassau and van Albada (1949) and Cameron and Nassau (1955). The stars were identified by marking their position on *BD* charts enlarged to the scale of the Schmidt plates. No difficulties were encountered in the identification of the stars.

The assigned spectral classes are given in the second column of Table 1; the numbers in the first column are those assigned by Hetzler. A colon indicates a doubtful classification. Variable star data are given in the third, fourth, and fifth columns, which contain the star name, the spectral class, and the type of variability taken from the *General Catalogue of Variable Stars* (Kukarkin, Parenago, Efremov, and Kholopov 1958) or the *Catalogue of Stars Suspected of Variability* (Kukarkin, Parenago, Efremov, and Kholopov 1951). The final column contains spectral classifications from other sources when they differ from those given in the *GCVS*. In this column a letter is used to designate the source (sources are listed after the table), and the number is the star number from the source. The agreement between the classifications is good, especially considering that a large number of the stars are variable. For completeness data are given for some of the Hetzler stars that were not classified in the writer's survey.

The majority of the stars are late M stars; a few carbon and S stars are also present. The few early M stars are mainly supergiants. At the dispersion used in this survey, about 3400 Å/mm, the spectra of the late M stars show no peculiarities to distinguish them from other late M stars found in surveys and classified at Warner and Swasey Observatory.

TABLE 1
SPECTRAL TYPES FOR HETZLER STARS

STAR	SPECTRAL TYPE	VARIABLE STAR DATA			OTHER CLASSIFICATIONS
		Name	Spectrum	Class	
<u>Area I</u>					
1	M8	5494			
2	M8				
3	M7	5501			M6 (b,348);K5 (g,40649)
4	M8:				
5	M7				M7 (a);M6 (g,40723)
6	M7				
7	M7				M7 (b,333)
8	M5	CU Cep	M4	M	M6 (b,357);M6 (g,40921)
9	M5				M7(a);M6(b,341);M5(g,40389)
10	M6.5	5454			
11	M6	AA Cep	M7	I?	
12	M6				M6 (b,339)
13	M7				
14	M5				M6 (b,346)
15	M6				M7 (a);M4 (g,40171)
16	M7				
17	M7				
18	M4:				
19	M6				
20	M5				
21	M8:	DM Lac	M7	M	
22		5486			M0 (g,40351)
23	M7				
24	M5				M6 (b,362)
+54°2511	M6				M6 (e);M6 (g,39414)
+54°2517	M4.5				M4 (e)
+53°2684	M6	RU Cyg	M7e	SRa	M6.5: (d);M6 (e)
+54°2603	M6				M5 (b,111);M6 (e)
+58°2316	M2	μ Cep	M2e Ia	SRc	
+55°2737		RW Cep	M0: Ia-0	Ic	M1: (d);M2 (d)
+51°3117					M5 (b,109);M5 (e)
+53°2736	C	V413 Cyg	N	Ib	
+51°3188	M5				M5 (b,112);M4 (e)
		SU Lac	M5e:	M	
	M8	AB Cep	M8e	M	
	M6:	WZ Lac	M6	SRa	
		BQ Cyg	M7	M	
	M8	DQ Cyg		M	

TABLE 1—Continued

STAR	SPECTRAL TYPE	VARIABLE STAR DATA			OTHER CLASSIFICATIONS
		Name	Spectrum	Class	
<u>Area II</u>					
1	M8	TX Cam		M	
2	M6				M6 (a)
3	M6				
4	M7	TT Cam	M0	M	
5	M7				
6	M6				
7	M6				
+53°882	M7	RV Cam	M4 II-III	SRb	
+55°934	M6	R Aur	M7e-M9e	M	
<u>Area III</u>					
1	M6				
2	M8				
3	C:				
	M5	TT Cep		SR	M6.5 (d);M7 (g,40727)
+62°2030	M5				
+60°2267	C	102116			N (HD 205777)
+61°2134	M5	SW Cep	M6	SRb	
+60°2217	M6				Mb (HD 203265)
+62°2028	M2	102144			18 Cep (gM5)
+62°2007	M2	VV Cep	M2ep Ia	EA	
+63°1770	M4				
+64°1583	M5				
+63°1740	M3				
+62°1924	M6.5				
+62°2079	M4:				M4 (e)
<u>Area IV</u>					
1	S	101863			S (c,17)
2	M7				M1 (g,17576)
3	S				S3 (a)
4	M7				
5	M8				M8: (a)
6	M7				S3 (a);S(h,4)
7	M5				M8 (a)
8	M8	CN Vul	M5	M	
9	M6.5				
10	M4				
+22°3659	M4				M6 (e)

TABLE 1—Continued

STAR	SPECTRAL TYPE	VARIABLE STAR DATA			OTHER CLASSIFICATIONS
		Name	Spectrum	Class	
<u>Area V</u>					
1	M8				M9 (a)
2					M7 (a)
3	C				R or N (a)
4	M7				
5	M7				M7: (a)
6	M7:				
7	M7:				
8	M7:				
10	M7:				
11	M6.5				
12	M6				
13	M4				S3± (a)
14	M7				M6 (a); M6 (g, 24682)
17	M6				
18	M5				M5 (a)
19	M4				M5 (a)
		TT Per	M5 II-III	SRb	
		AX Per	gM3ep + Q	Ne	M5 (g, 24517)
+53°413		U Per	M6e-M7e	M	M1 (a)
+55°290	M6	AA Cas	gM6	Ib	M8 (g, 25212)
+57°237	M5				M4 (e)
		BQ Cas	M6.5	Ib	
		BT Cas	M8	M	M9 (d)
		TY Cas	M6	M	
		T Per	M2 Iab	SRc	
		X Cas	Ne	M	
		XX Per	M3	Ib?	
<u>Area VI</u>					
+85°122					gM5 (f)
+85°256					g:M2 (f)
+86°175					gK5: (f)
		R Cam	S2,9e	M	
<u>Area VII</u>					
1b	M7	DN CMa	M9	M	
2	M7	908			
3	M6				
5	M7				
6	M7				
7	M7				
8	M7	845			

TABLE 1—Continued

STAR	SPECTRAL TYPE	VARIABLE STAR DATA			OTHER CLASSIFICATIONS
		Name	Spectrum	Class	
<u>Area VII—continued</u>					
9	C	100776			
12	M5				
13	M6				
14	S				
15	M6.5	900			
16	M6	936			
	M7	RV CMa	M6	Ib	
		W CMa	N	Ib	
<u>Area VIII</u>					
1*	M8	CG Gem	M6.5	SRa	
2	M8	CC Gem	M6	SRb	M6.5 (d)
3	M7				
4	M4				
5	M7	GS Gem	M5	SR	
6	M7				
8	M6.5				
9	M6	CL Gem	M6	SRa	M6.5 (d); M3 (g,12381)
10	M7				M3 (g,12262)
12					M5 (g,12018)
13	M7	EP Gem	M6.5	SR?	
14	M5				
15	M7				
	M8	AQ Gem	M6.5	Ib	
		DD Ori	M7	Ib?	M6.5 (d)
		AT Gem	M6	SRb	
	M6	AS Gem	M6	Ib	
	M6	BL Gem†	M6	Ib	
	C	BL Ori	C6 ₂	Ib	
		AX Gem	M5	Ib	M6 (g,12465)
	M7	AP Gem	M6.5	Ib	
	M7	UU Gem	M9	M	
+14°1350	M5	DY Gem	S8,5	SRa	M5 (e)
+15°1236	M6				M6 (e)
+16°1194	C	CR Gem	N	Ib	

* Misidentified as SX Gem by Hetzler.

† Misidentified as AZ Gem by Hetzler.

SOURCES FOR TABLE 1

a: Rust, C. F. 1938, *Ap. J.*, 88, 525.b: Nassau, J. J., and Blanco, V. M. 1954, *Ap. J.*, 120, 118.c: Nassau, J. J., Blanco, V. M., and Morgan, W. W. 1954, *Ap. J.*, 120, 478.d: Cameron, D., and Nassau, J. J. 1956, *Ap. J.*, 124, 346.e: Neckel, H. 1958, *Ap. J.*, 128, 510.f: Nassau, J. J., and Seyfert, C. K. 1946, *Ap. J.*, 103, 117.g: Lee, O. J., Baldwin, R. J., Hamblin, D. W., Bartlett, J. J., and Gore, G. D. 1947, *Ann. Dearborn Obs.*, Vol. 5.h: Nassau, J. J., and Stephenson, C. B. 1961, *Ap. J.*, 133, 920.

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