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Spectral classifications in the near infrared of stars with composite spectra

III. Study of a sample of 137 objects with the Aurelie spectrograph⋆

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Abstract. We provide spectral classifications for a sample of 137 stars mentioned as having composite spectra. The classifications were carried out on 33 Å/mm spectra in the region 8370 − 8870 Å. Of these 137 objects, 115 correspond in the infrared to cool stars (G, K or M) of luminosity classes III, II and I; for 22 stars, we find only hot spectra of types B, A, F or Am, so that they do not fulfil our definition of composite spectra. We detect four new Am stars, and one Am star (HD 70826) turns out to be a composite spectrum object.

As in Paper II, the cool components of composite spectra show a strong concentration in the vicinity of G8III.

Key words: stars: fundamental parameters — stars: infrared — binaries: spectroscopic

1. Introduction

The two preceding papers (Paper I: Ginestet et al. 1994; Paper II: Ginestet et al. 1997) provided:

• A study of MK standards in the region 8370 − 8780 Å, which established the validity in this region of the MK classification and provided the criteria which could be used. We showed also the interest of the near infrared spectral region for the classification of the cool companions of composite spectra (CS).

Let us remind briefly that in our studies we consider as composite spectra all those in which a hot dwarf (of spectral type B or A) spectrum appears with that of a cool subgiant, giant or supergiant (of spectral types G, K or M).

• An application of our criteria to a sample of 180 known or suspected to be CS: 60 stars present a hot spectrum of spectral types B, A, Am or F in the near infrared, whereas 120 present a cool spectrum of spectral type G, K or M.

These two papers are based on 33 Å/mm spectra obtained with the CARELEC spectrograph mounted on the 193 cm telescope of the OHP. We call attention to the fact that this instrument was used also to establish an Atlas of MK standards in the near infrared (Carquillat et al. 1997).

Most unfortunately in 1995 we encountered difficulties, since the spectrograph became reserved for extragalactic work and we had to change to the spectrograph AURELIE, mounted on the 152 cm telescope. Such a change had various implications for our work:
– we had to make a new calibration of MK standards and to reobserve a certain number of stars already classified to verify the joint with the previous system
– to prolongate the exposure times, with the resulting loss of limiting magnitude. As an advantage we have now a larger spectral region accessible, which includes the lines MgI 8806 and FeI 8824.

In the present paper we establish the spectral classifications of 137 objects from the near infrared, observed with the AURELIE spectrograph.

Let us mention in passing that numerous studies have been devoted in the last years to the near infrared region, from both the stellar and the extragalactic point of view. The interested reader will find the majority of these papers quoted in our Papers I and II, so that there is no need to repeat them here.

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⋆ Based upon observations carried out at Observatoire de Haute-Provence (OHP).

2. Samples, observations, calibrations and classification criteria

• *Samples*
We have studied the behavior of 57 MK standards and of 137 stars signaled as having composite spectra, on the basis of equivalent widths.

– Composite spectra
The sample of CS stars was selected, as for Paper II, from the list of Hynek (1938); some additional objects were taken from Markowitz (1969); Cowley (1973, 1976), Hoffleit & Jaschek (1982) and Stickland (1988).

We did observe 86 stars designed as or suspected to be CS; we have also reobserved 51 CS already taken with CARELEC, both to ensure a perfect fit and to supplement the material for some stars of Paper II which present problems.

– MK standards
We observed 57 standards stars; 40 of these had already been studied in Paper I and were reobserved to permit the calibration of AURELIE with respect to CARELEC. Seventeen new stars were included to study the lines MgI 8806 and FeI 8824. This complete sample is representative of stars of spectral types G, K and M and luminosity classes I, II, III and V.

The observational limits of our samples are $V < 9.5$ and $\delta > -25°$.

• *Observations*
The observations were made at the 152 cm telescope with the AURELIE spectrograph (Gillet et al. 1994) at a dispersion of 33 Å/mm. Five observational runs were made in 1995 and 1996 and permitted to secure 194 objects (standards plus CS), usually with two spectra for each star.

At this dispersion one has access to 880 Å, instead of the 400 Å available at the CARELEC spectrograph. We have used a region of 500 Å extending between 8370 and 8870 Å, because for $\lambda < 8370$ Å the spectra are dominated by strong telluric lines. The receiver for the AURELIE spectrograph is a Thomson double bar (TH 7832) constituted by two lines of 2048 photodiodes of $750 \times 13\,\mu$m, each line (even and uneven pixels) being read by two lateral CCD's.

The treatment of spectra is here definitely simplified respect to CARELEC, since we have to deal only with unidimensional images. As with CARELEC a tungsten lamp has been used for flat field, and a neon spectrum for calibrations in wavelength. The normalisation of the spectra and the measurement of the equivalent widths has been made in a similar way to those made with CARELEC (see Paper I) with the help of the IHAP software available at the OHP.

• *Calibrations CARELEC/AURELIE*
To calibrate the spectra obtained with Aurelie with regard to those obtained with Carelec, we have measured the equivalent widths of some blends and lines selected over the length of the spectrum for the 40 MK standards. We have chosen the blend 8468 Å, the CaII triplet (8498, 8542, 8662 Å), FeI 8688 Å and the total absorption between 8390 and 8775 Å (TA).

The measurements carried out with the two spectrographs are given in Figs. 1-4; on these graphs we have also plotted the equivalent width's of the CS measured.

We find that for the shorter wavelengths (blend 8468 and CaII triplet) the equivalent widths obtained with Aurelie are, in the mean, weaker than those measured with Carelec, whereas for the longer wavelengths (FeI 8688) and for the total absorption TA there is no significant difference.

A careful comparison of the spectra show effectively that the lines observed with Aurelie are less deep than when observed with Carelec. This translates into a correction of the sum of the three equivalent widths of the CaII lines by an average correction of 0.5 Å, i.e. a 3 to 7% correction of the equivalent width. On the other side, the continuous background of the spectrum is sligthly inferior to the pseudocontinuum at the longer wavelengths (essentially for $\lambda > 8662$ Å) because we had to adjust it over a longer wavelength range than for the Carelec spectra and these two effects seem to compensate for TA and FeI 8688.

We still compare in Sect. 3 the classifications made with material from the two spectrographs to see if with all corrections made there remains still a systematic effect.

• *Classification criteria*
The classification of the 115 objects which present a cool stellar spectrum (G, K or M) in the near infrared has been carried out using the same criteria defined in Paper I and using the same technique as described in Paper II. But since the zone observable with Aurelie is larger than the zone observable with Carelec, we have been able to study with the help of the 57 MK standards the behavior of two supplementary intense lines, MgI 8806 and FeI 8824.

We have found in Paper I that a relation exists between the spectral type and the ratio of the central depths (R) of the neighbouring lines TiI 8683 and FeI 8679.
The mean relation was as follows:

Spectral Type	G0	G2	G5	G8	K0	K3	K5
R (classes V, III, II)	0.32	0.40	0.50	0.70	0.85	1.30	1.85
R (classe Ib)	0.40	0.52	0.80	1.06	1.26	1.60	1.85.

We have therefore used this ratio R instead of the spectral type (assumed unknown for the CS) for the study of the behaviour of the lines MgI 8806 and FeI 8824: both lines present a positive luminosity effect (see Fig. 2). We have also considered the ratio of the equivalent widths of MgI 8806 and FeI 8688, as well as the ratio MgI 8806/FeI 8824. These two relations present a negative luminosity effect and permit a separation of giants and supergiants (Fig. 3). Dwarfs figure also on these graphs, in spite of their small number; they seem to behave like giants.

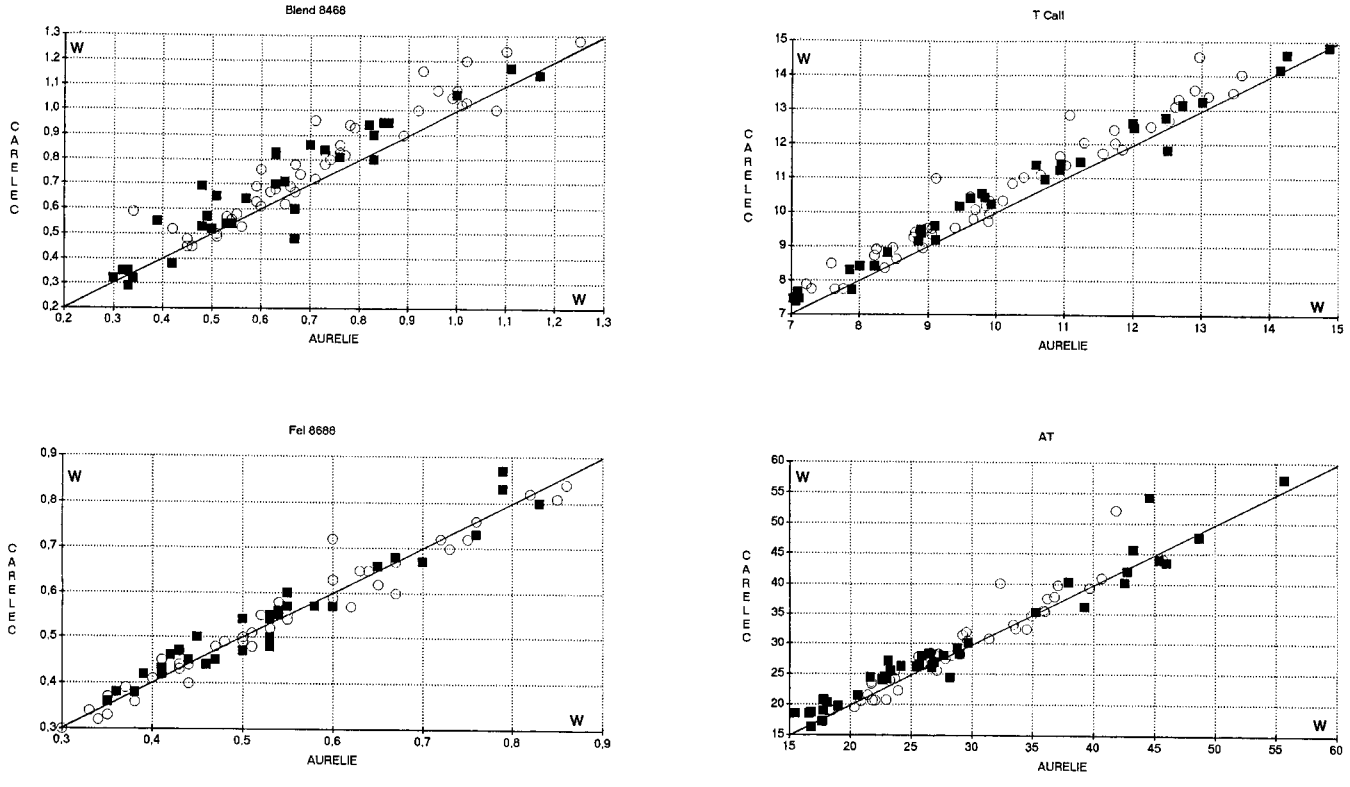

Fig. 1. Comparison of equivalent widths measured from CARELEC and AURELIE spectrographs for the 8468 Å blend, the Triplet of CaII, the FeI 8688 line and the Total Absorption between 8390 Å and 8775 Å. Filled squares: MK standards; open circles: composite spectra

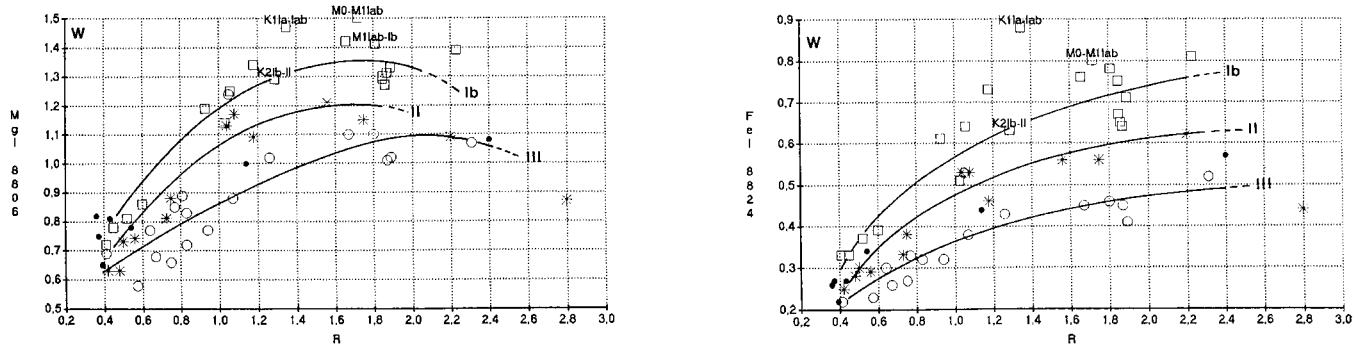

Fig. 2. Behaviour of the equivalent widths of the MgI 8806 and FeI 8824 lines versus R (correlated with the spectral type, see text) for MK standards. Open squares: supergiants; asterisks: bright giants; open circles: giants; dots: dwarfs

3. Results and discussion

As said before we have observed 137 stars designated as CS or candidates. A first examination permits to separate 22 stars which have a spectrum of a hot star of type B, A, Am or F in the near infrared. These stars are listed in Table 1. The other 115 stars have a cool spectrum of types G, K or M. These are listed in Table 2, except 20 stars for which the classification from Aurelie and from Carelec coincide totally (see part 3a). In the two tables the data V and $B-V$ were taken from the Hipparcos and Tycho catalogues (1997). If they are not contained in these catalogues, the data come from the Centre de Données Stellaires (CDS) or from Hynek (1938). An asterisk implies a note at the end of the table. In the column "references", for reasons of space economy, figures only the name of the first author of the paper.

We next will validate our classifications obtained from Aurelie with proceeding from Carelec. Then we shall confront our classifications with those of the "standard" CS, that is, stars which possess a classification which we consider trustworthy (see Paper II, 4.1). And finally we shall

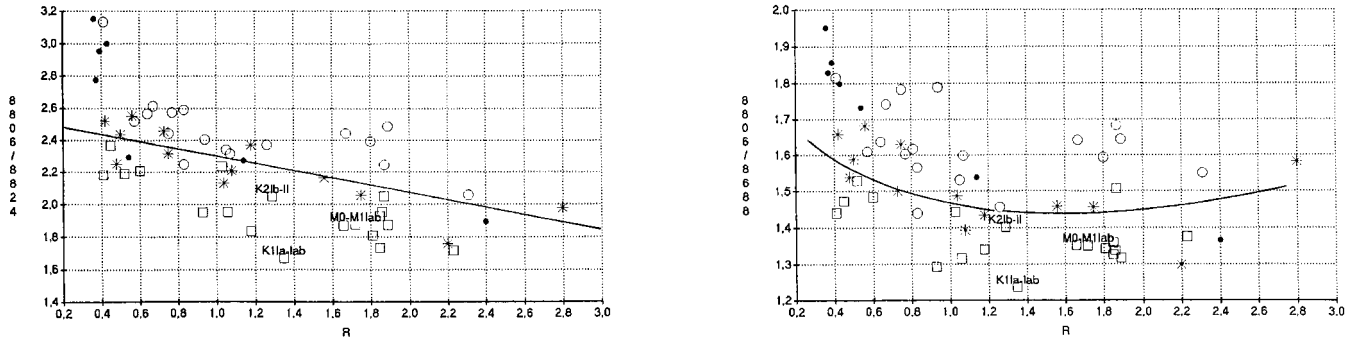

Fig. 3. Behaviour of the MgI 8806/FeI 8824 and MgI 8806/FeI 8688 equivalent width ratios versus R (correlated with the spectral type, see text) for MK standards. Open squares: supergiants; asterisks: bright giants; open circles: giants; dots: dwarfs

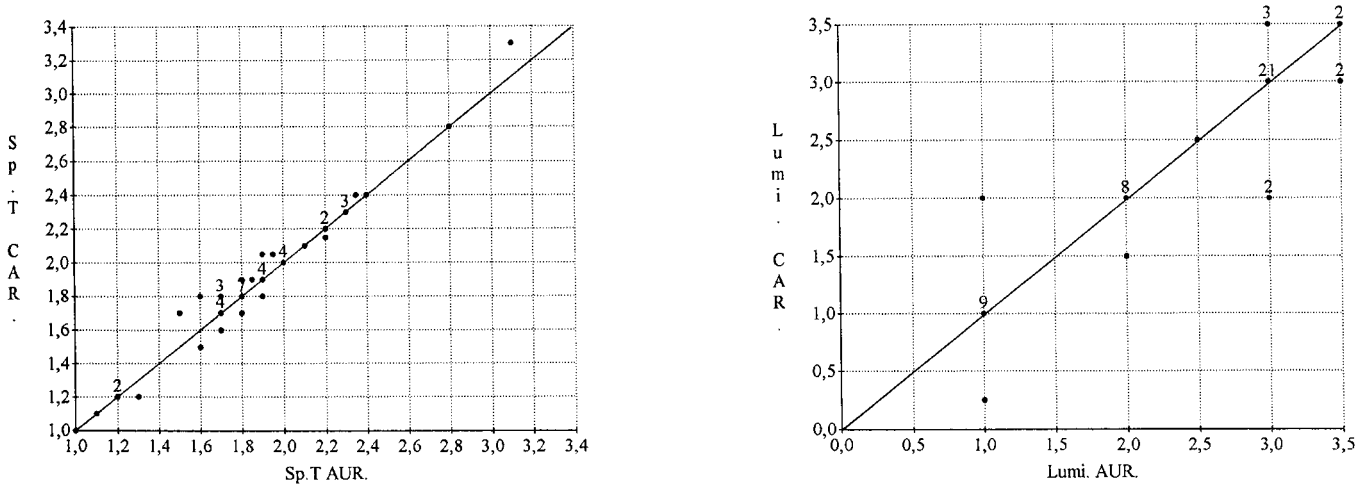

Fig. 4. Comparison of the Spectral Types (Sp T) and Luminosity Classes (Lumi.) for 51 composite spectra classified with both the CARELEC and AURELIE spectrographs. Sp T: G...1, K...2, M...3; Lumi.: Ia...0, Ib...1, II...2, III...3; numbers of the plots are weights

confront, for a small sample, our results with those published in the Michigan catalogues (Houk 1982; Houk & Smith-Moore 1988).

a) Comparison Carelec-Aurelie

A comparison of the 51 stars observed with both spectrographs permits to isolate 22 stars for which the results are identical. These are: HD 4775 (G7III) - 17878 (G7III) - 21771 (K3II) - 23089 (G2Ib) - 25555 (K1II) - 26630 (G0Ib) - 26673 (G9II) - 29094 (G7Ib) - 39118 (K0II) - 66094 (G9III-IV) - 74395 (G1Ib) - 88021 (G8III) - 166479 (G8III) - 169985 (G9III) - 184759 (G8III) - 187259 (G8III) - 193410 (K0III) - 193495 (G9II) - 197177 (G8II) - 200428 (K0III) - 205114 (G2Ib) - 213310 (K6-M0I). These objects do not figure in Table 2, except HD 4775 and HD 25555 for which recent classifications exist, obtained on the basis of the method of substraction of spectra (Griffin R&R 1986). For the other 29 stars one perceives small differences in spectral type and luminosity classes (Fig. 4), but without a systematic trend. The average scatter around the linear relations corresponds to about 0.7 tenth of a spectral type and 0.3 luminosity class. Both errors are within the normal precision of spectral types (Jaschek & Jaschek 1987).

b) Comparison with the so called "standards" CS

We have made the inventory of CS stars for which a satisfactory classification exists (see Paper II). The complete list is as follows: HD 4775, 17878, 25555, 26630, 29094, 57146, 74395, 88021, 169689, 173764, 184759, 187076, 187259, 187299, 190161, 192713, 200428, 200905, 201270, 205114.

Of this list 13 have classifications obtained by R&R Griffin by the so called method of substraction of spectra and six others are MK standards. In Fig. 5 we compare our Aurelie classifications with those of the "standards" for spectral types and for luminosity classes respectively. From the dispersions around the average relation we find again values which are normal for the errors of classification (one tenth of spectral type and 0.25 luminosity class). Also there does not exist a systematic effect.

c) Comparison with the classification of the Michigan catalogues

Our complete sample (Papers II and III) contains 25

Table 1. Stars of the sample which exhibit a hot spectrum

HD / BD	A2000	D2000	*V*	*B-V*	SP	Références	SP (IR)
	h m s	° ′ ″					
1952	00 24 05.2	+44 15 53	6.66	0.413	F6III+A4V	Markowitz (1969)	**F2III**
					F3III	Bidelman (1988)	
					F5V	Sato (1990)	
5621	01 03 37.7	+84 36 26	6.74	0.246	F5p	Cat. HD	**A8IV**
					A8V+G0II-III	Markowitz (1969)	
13728	02 13 42.1	-03 01 54	7.33	0.338	Am	Olsen (1979)	**Am**
					Am	Griffin (1993)	
29354	04 37 37.3	+04 58 58	7.62	0.344	F0	Cat. HD	**F0IV**
39569	04 54 12.1	+16 20 40	8.20		A3	Cat. HD	**F1V**
60092	07 32 16.3	-18 31 03	7.34	0.411	Fm delta Del	Houk (1988)	**Am**
70318	08 21 53.9	+17 36 05	8.23	0.349	A3	Cat. HD	**Am**
97336	11 12 30.1	+24 39 06	8.15	0.357	F5A5	Cat. HD	**F5wl**
103885	11 57 60.0	+73 46 54	8.80	0.445	F2	Cat. HD	**F5V**
108283	12 26 24.0	+27 16 06	4.92	0.277	F0IIInp	Cowley (1969)	**A9p**
					F0III sh	Slettebak (1982)	
					A9 sh	Jaschek (1991)	
					A9 Sr	Malanushenko (1994)	
					A9Vp lamb. Boo	Abt (1995)	
111844-5	12 51 54.6	+19 10 05	7.29	0.569	Am ; F8-G0III	Berger (1962)	**Am ; F9III- ***
					A8IVp ; F8IV	Cowley (1967)	
					Am ; F8V	Abt (1981)	
121800	13 55 15.4	+66 07 00	9.04	-0.093	Gp	Cat. HD	**B shell ***
					B1,5V	Dworetsky (1982)	
					G7	CDS	
135631	15 14 56.7	+38 18 02	7.11	0.359	F0p	Cat. HD	**F0V**
					F1V	Abt (1981)	
140283	15 43 07.2	-10 55 45	7.20	0.484	A8V var.	Keenan (1953)	**F9wl**
					F3VI	Evans (1966)	
					G0IV-V m-5	Gray (1989)	
141652	15 39 39.2	+79 58 58	6.89	0.392	F2V	Abt (1981)	**F1V**
142846	15 56 14.9	+14 45 04	8.28	0.400	F2IV	Bidelman (1951)	**F2V**
147275	16 19 14.5	+41 39 32	8.01	0.363	A5G	Cat. HD	**F0V ***
154225	17 02 21.0	+40 04 25	7.99	0.439	A5	Cat. HD	**Am**
224738	00 00 18.4	+65 56 41	8.50		F	Cat. HD	**Am**
232625	02 16 15.0	+52 17 24	9.4:		F	Cat. HD	**F4V**
					F5	CDS	
232767-8	03 15 30.4	+51 31 05	9.74	0.633	K5A	Cat. HD	**Am**
234729-30	18 51 39.1	+51 15 50	9.28	1.000	G5A0	Cat. HD	**F3III:**

Notes:
. HD 111844-5: ADS 8690; the spectra of the components are obtained separately (Sep. 16").
. HD 121800: one spectrum in the blue region leads to B2 shell.
. HD 147275: could be a marginal Am.

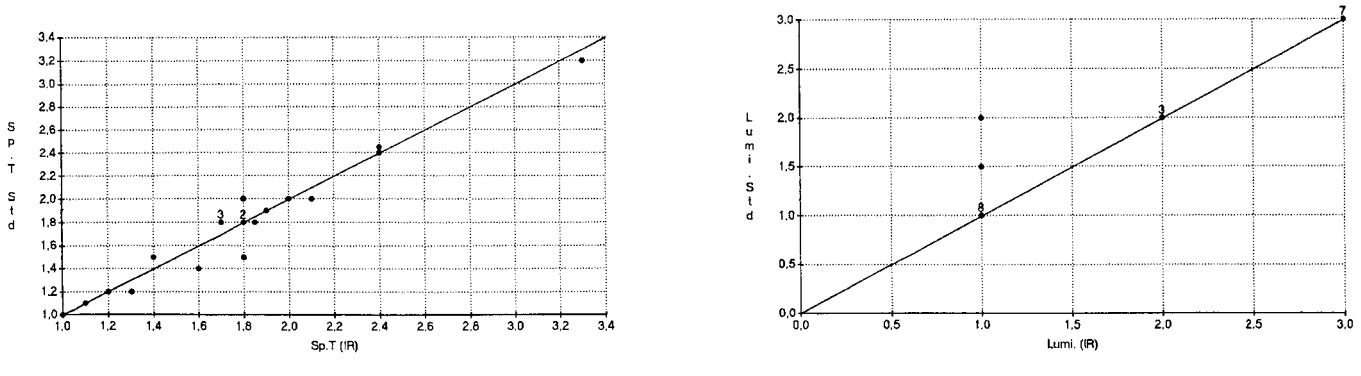

Fig. 5. Comparison of infrared MK classifications (spectral types and luminosity classes) with those of "standard composite spectra" (see text). Sp T: G...1, K...2, M...3; Lumi.: Ia...0, Ib...1, II...2, III...3; numbers on the plots are weights

Table 2. Classifications of the cool components, SP(IR), of stars with composites spectra

HD / BD	A2000	D2000	V	B - V	SP	Références	SP(IR)
	h m s	° ′ ″					
3125	00 34 29.4	-04 32 48	7.01	0.732	G4III-IV+F8IV	Stephenson (1969)	G7 III
					G1IV	Abt (1985)	
					gK+?	Bidelman (1988)	
3210	00 35 48.7	+49 01 16	7.00	0.615	B4V+K3:III	Abt (1985)	K4 II-III
4775	00 50 43.5	+64 14 52	5.35	0.528	G0III+A4V	Bahng (1958)	G7 III
					B9,5+G0III-IV	Markowitz (1969)	
					G8IIIa+B9V	Mason (1997)	
8036	01 19 48.2	-00 30 31	5.87	0.635	G8III:+A7V	Bidelman (1958)	G9 III-IV
					G5III-IV+A5V	Stephenson (1969)	
					A7V+KIII:	Cowley (1976)	
					A2:V+G4:III	Abt (1985)	
9352	01 33 25.6	+58 19 39	5.70	1.435	K3Ib-II+B9V	Markowitz (1969)	K3Ib-
					K0Ib+B9V	Hoffleit (1982)	
11154	01 50 08.4	+22 16 33	5.80	0.743	G0III+A	Roman (1949)	K0 III+
					K0III+A6V	Bidelman (1958)	
					A5+KIII:	Cowley (1976)	
					K1IIb	Levato (1978)	
					G3III+A3IV	Abt (1985)	
16082	02 36 48.1	+51 57 40	7.24	0.922	G5A5	Cat. HD	K0 II
17245	02 47 31.1	+44 16 21	6.45	0.637	A1V+G2III	Markowitz (1969)	G7 II-III
					A0V+F6III	Abt (1986)	
19091	03 05 46.1	+43 42 09	6.90	0.747	gK+late B	Bidelman (1985)	G8- III
19278	03 08 30.0	+56 39 03	8.00		K0A3	Cat. HD	K2 II
20084	03 32 17.8	+84 54 47	5.62	0.894	G8II-III	Roman (1955)	G8 III
					G0II+F0:V	Markowitz (1969)	
					G5IIa CH1 Fe-1	Keenan (1989)	
24480	03 57 08.2	+61 06 33	4.99	1.435	K3I-II comp.	Appenzeller (1967)	K3 II
					K3II+A3V:	Stephenson (1969)	
					K4III	CDS	
25555	04 04 21.6	+24 06 21	5.46	0.813	B9V+G1III	Markowitz (1969)	K1II
					A1:+GIII:	Cowley (1976)	
					A7V+G0:IV	Abt (1981)	
					K0II+B7V	Mason (1997)	
27395	04 21 45.4	+50 02 06	7.11	1.322	G3Ib+?	Bidelman (1988)	G9 II
27639	04 22 22.7	+20 49 17	5.91	1.660	M0IIIab	Hoffleit (1982)	K5: II
					B3V+K3II	Abt (1985)	
+40°1043	04 46 29.3	+40 54 12	9.40:		F5A5	Cat. HD	K1 III
					F8	CDS	
32068	05 02 28.6	+41 04 33	3.69	1.154	K4II+B7V	Wellmann (1951)	K4 II+
					K5II+B5V	Markowitz (1969)	
					K4Ib+B6V	Wright (1970)	
					- - - +B6,5V *	Griffin (1990)	
33883	05 13 31.5	+01 58 04	6.08	0.421	F6III	Kuhi (1963)	G7 III-
33883	(suite)				A4V+A6V	Edwards (1976)	
36947	05 37 16.8	+44 04 15	7.24	1.200	A1V+G8:III	Abt (1986)	G8 Ib-
41162	06 05 02.6	+37 57 52	6.32	0.825	K0III:+A2:	Cowley (1973)	G8 III
					GIII:+late A	Cowley (1976)	
47579	06 38 23.0	-23 34 47	6.48	0.664	G8III	Kuhi (1963)	G8 III
					G5III+A3V	Markowitz (1969)	
					G8/K0III+A2V	Houk (1988)	
49618	06 53 05.0	+59 26 57	5.34	0.675	G4III+A2V	Bahng (1958)	G8 III
					G5III:+A2V	Stephenson (1969)	
50730	06 54 13.9	-06 01 07	7.54	1.101	K0A3	Cat. HD	K3 II
50820	06 54 42.0	-01 45 23	6.20	0.487	B3eV+K2II	Underhill (1954)	K3,5 III: Ca-
					B3eV+K	Markowitz (1969)	
00°1775	07 03 17.0	+00 30 36	9.30		F5A3	Cat. HD	G8: III-IV
55684	07 13 44.5	-05 09 21	7.19	0.848	A0+gK0	Wilson (1952)	K3 II
					F8III	Kuhi (1963)	
57146	07 18 51.2	-26 35 10	5.29	0.956	G1Iab-Ib	Morgan (1973)	G3 Ib *
					G0II	Malaroda (1975)	
					G2II	Houk (1982)	
					G2Ib+B9	Parsons (1982)	
					G2Ib	Keenan (1989)	
59067	07 27 51.6	-11 33 25	5.79	0.583	G8Ib-II+B	Bidelman (1958)	G4: Ib-
					G2Ib+B2V	Stickland (1988)	
59076	07 27 34.0	-21 08 46	7.55	0.757	G5III+A	Moore (1950)	G9 II-III:
					G8III+A0/2	Houk (1988)	
59604	07 30 56.6	+08 33 08	7.12	0.438	A2G	Cat. HD	G3 III-IV
59878	07 32 50.6	+22 53 15	6.54	0.998	G9III	Hallyday (1955)	G9 III+
					K0II-III+F8V	Stephenson (1960)	
60966	07 36 42.0	-10 38 00	8.24	0.548	F5A2	Cat. HD	G8 III
70826	08 24 49.1	20 09 11	7.34	0.644	Am	Abt (1984)	G7 III *
71466	08 26 50.3	-23 48 30	8.12	1.021	A0V+K5/M0III	Houk (1988)	K7-M0 III+:
74228	08 43 12.3	+12 40 51	5.62	0.435	F8V	Kuhi (1963)	G7 III-
					A3V+G0III	Markowitz (1969)	
					F3-5III+A5?V	Hendry (1981)	
102509	11 47 59.6	+20 13 08	4.50	0.547	A+G5III-IV	Slettebak (1955)	G5: III-IV
					G4III-IV+A7V	Markowitz (1969)	
					F2IV	Sato (1990)	
107700	12 22 30.2	+25 50 46	4.78	0.515	A2V+G0III-IV	Markowitz (1969)	G7: III-
					A4V+F6V	Abt (1977)	
					A2V+GIII	Cowley (1976)	
120901	13 52 38.9	-18 42 31	6.95	0.613	A2V+F9II-III	Markowitz (1969)	G8,5 III
					K0III+A1V	Houk (1988)	
137975	15 29 43.7	-16 50 28	8.56	0.722	K0III+A2V *	Houk (1988)	G8 III
157978	17 26 18.9	+07 35 45	6.01	0.592	G0III-IV+A3	Herbig (1953)	G9 III *

Table 2. continued

HD / BD	A2000	D2000	V	$B-V$	SP	Références	SP(IR)
	h m s (suite)	° ′ ″					
157978					G2Ib	Kuhi (1963)	
					A1V+G0II	Markowitz (1969)	
					G0III+A1IVs+A2Vs	Abt (1995)	
159870	17 33 31.5	+57 33 32	6.15	0.602	G5III+A7V	Markowitz (1969)	G7 III- *
					F5V	Bertaud (1970)	
					A5V+GIII	Cowley (1971)	
					Fm	Cowley (1979)	
					F2m	Hendry (1981)	
164252	17 59 03.5	+30 02 56	7.17	0.958	G8II-III+A1V	Stephenson (1960)	G7 II-III *
					G5II	Abt (1985)	
167570	18 16 35.3	-20 32 40	6.89	1.027	G8III	Kuhi (1963)	G7 III
					G8/K0III+(A7)	Houk (1988)	
168348	18 19 37.0	-10 56 00	7.94	1.174	G5A5	Cat. HD	K1 III
168701	18 21 48.8	-16 19 28	7.64	1.116	K1III+B9(V)	Houk (1988)	K3 II
169652	18 26 26.4	-18 05 10	7.94	0.993	K0/1III+A0V	Houk (1988)	K0 III
169689	18 25 38.7	+08 01 55	5.64	0.884	G8IV	Kuhi (1963)	G9 II
					F8V+A	Hendry (1978)	
					G8III+A0V	Markowitz (1969)	
					G9II+B8V	Griffin (1986)	
172712	18 38 51.0	+52 20 39	6.92	0.432	A2V+F6-8III?	Hendry (1981)	G6: III-IV:
					Am	Abt (1985)	
173764	18 47 10.4	-04 44 53	4.22	1.087	G5II+B8,5	Stickland (1988)	G6 Ib- *
					G4IIa	Keenan (1989)	
173805	18 47 58.3	-18 13 44	7.29	0.901	K0(III)+B(2)IV/V	Houk (1988)	K1 II+
174016	18 44 21.1	+61 56 21	7.44	0.455	F5+A2	Olsen (1980)	G6: III-
					Am	Abt (1984)	
174191	18 50 02.3	-18 26 10	9.10		K0/1III+A0/1V	Houk (1988)	K2 III
175492	18 54 44.8	+22 38 42	4.57	0.782	G4III+A6V	Bahng (1958)	G8 III+:
					G5III+A2V	Markowitz (1969)	
					A8:+G8:III	Abt (1985)	
178452	19 08 14.4	+12 15 02	7.53	0.952	G5A2	Cat. HD	K1 III
					B9+K0	Stephenson (1961)	
181394	19 20 34.0	-06 44 52	8.00	1.357	K0A2	Cat. HD	K7-M0 II-III:
181657	19 19 52.1	+35 32 24	9.28	0.940	A0K	Cat. HD	K1 III
					K1IIp	Kuhi (1963)	
183912	19 30 43.2	+27 57 35	3.05	1.088	K0II+B9V	Bahng (1958)	K2 II
					K3II+B9,5V	Markowitz (1969)	
					K0III+A	Abt (1988)	
184398	19 31 13.5	+55 43 56	6.37	1.123	K2III	Kuhi (1963)	K2 II-III Ca-
					K2II-III+A0V	Markowitz (1969)	
186097	19 41 15.3	+30 43 17	7.09	0.693	B8+G2	Stephenson (1961)	G1: Ib-II
					A3V+F6:III	Abt (1985)	
186518	19 43 55.8	+27 08 08	6.27	1.015	K3II	Kuhi (1963)	K3 II+
	h m s (suite)	° ′ ″					
186518					G4III	Hoffleit (1982)	
					B7V+G1:III	Abt (1985)	
186570	19 44 50.7	+10 57 07	8.94	1.163	K0A	Cat. HD	G6: III:
187076	19 47 23.0	+18 32 03	3.68	1.313	M2Ib-II+A	Bidelman (1954)	M3 II
					M2Ib	Kuhi (1963)	
					M2II+A0V	Markowitz (1969)	
					M2+II+B9,5V	Griffin (1991)	
187299	19 48 21.6	+25 00 35	7.17	1.599	G5Iab-Ib	Bidelman (1957)	G8 Ib
					G5Ib+B7V	Griffin (1979)	
187321	19 48 43.5	+18 52 02	7.09	0.856	G5II-III+A,B	Bidelman (1957)	G5 Ib-II:
					B9V+G5II	Markowitz (1969)	
188262	19 53 45.9	+16 46 41	7.70	0.789	B7+G2	Stephenson (1961)	G8 II
					cG+A	Olsen (1980)	
+21°3983	19 57 00.7	+22 05 45	10.6:		G5A3	Cat. HD	K2 III
					B7+G0	Stephenson (1961)	
190361	20 03 51.8	+21 03 02	7.16	1.243	K4Ib+B4IV-V	Griffin (1997)	K4 Ib-
192577	20 13 37.8	+46 44 29	3.80	1.270	K2II+B3V	Bidelman (1954)	K2 Ib-
					K2II+B4V	Markowitz (1969)	
					K4Ib+B4V	Wright (1970)	
192713	20 15 30.1	+23 30 32	5.18	1.016	G3Ib-II+B9	Parsons (1985)	G4 Ib *
					G3Ib+B8V	Stickland (1988)	
					G3Ib-IIp comp.?	Keenan (1989)	
					G5Ib+B8V	Griffin (1993)	
192909	20 15 28.2	+47 42 51	3.96	1.451	K3Ib-II+B	Bidelman (1954)	K3 Ib-
					K3II+B9:V	Markowitz (1969)	
					K5Iab+B4IV-V	Wright (1970)	
193349	20 19 21.1	+14 22 14	6.74	0.362	A0G	Cat. HD	K0 III-
					B9,5V+FIII	Abt (1985)	
193469	20 18 57.6	+39 00 15	6.35	1.871	K4II	Abt (1985)	K4,5 Ib
					K5Ib+B8V	Stickland (1988)	
					K5Ib	Sato (1990)	
194359	20 24 25.6	+24 16 39	6.95	0.714	G0III+A3V	Markowitz (1969)	G7 III
					G1III	Sato (1990)	
196093	20 33 54.1	+35 15 03	4.61	1.593	K2Ib+B3V	Markowitz (1969)	K6: Ib+:
					K2Ib+B5V	Buscombe (1977)	
					K3Ib+B7	Hendry (1981)	
196753	20 38 35.0	+23 40 50	5.91	0.953	K0II	Cowley (1969)	K1 II
					K0II-III+A3V	Markowitz (1969)	
					G2III	Sato (1990)	
198810	20 52 21.8	+20 07 42	7.54	0.642	F8IV+A5V	Stephenson (1969)	G8- III
					gG+A	Bidelman (1985)	
199378	20 56 25.2	+14 48 58	7.28	0.921	K0A2	Cat. HD	K2 III+
					G0IVp *	Moore (1950)	

Table 2. continued

HD / BD	A2000	D2000	V	$B-V$	SP	Références	SP(IR)
	h m s	° ′ ″					
200905	21 04 55.7	+43 55 40	3.72	1.609	K5Ib+A2	Stickland (1988)	**K4: Ib- ***
					K4,5Ib-II	Keenan (1989)	
201270	21 06 52.4	+45 40 33	7.23	0.587	G5III	Kuhi (1963)	**G8,5 III**
					G8III+A2V	Griffin (1990)	
202447	21 15 49.3	+05 14 52	3.92	0.549	G0III+A5V	Bahng (1958)	**G8 III-**
					G0II	Kuhi (1963)	
					G2II-III+A4V	Markowitz (1969)	
203338	21 19 15.6	+58 37 25	5.51	1.114	M1eplb+B	Bidelman (1954)	**M1 Ib**
					M1eplb+B2V	Cowley (1969)	
					M1Ibep+B2pe	Markowitz (1969)	
203340	21 19 57.9	+48 38 05	7.89	0.927	G5	Cat. HD	**K0 III+**
206844	21 43 15.4	+51 00 12	8.23	0.844	G5A2	Cat. HD	**G8 III+**
207218	21 46 16.4	+43 03 38	6.52	0.278	Am	Walker (1966)	**G8: III-IV:**
					A4V+(GIII)	Cowley (1969)	
					A2V+G0:III	Markowitz (1969)	
					A3:V	Abt (1995)	
208816	21 56 39.1	+63 37 33	5.11	1.547	M2Iaep+B	Markowitz (1969)	**M1: I**

HD / BD	A2000	D2000	V	$B-V$	SP	Références	SP(IR)
	h m s	° ′ ″					
208816	*(suite)*				M2Ia-Ib+Be:	Wright (1970)	
					M2Iaep+B8Ve	Hoffleit (1982)	
213503	22 29 46.1	+68 13 16	7.85	0.988	G5A0	Cat. HD	**K2 III+**
218257	23 06 09.6	+41 47 24	7.09	0.801	G5A3	Cat. HD	**G7 III**
218640	23 09 54.7	-22 27 27	4.71	0.674	sgG2+A2	Markowitz (1969)	**G9 III**
					G2III+A2V	Stephenson (1969)	
					G6/8III+A3(IV)	Houk (1988)	
223047	23 46 01.9	+46 25 13	4.97	1.086	G5Ib+A0V	Markowitz (1969)	**G6 Ib**
					G5Ib+B9IV-V	Arellano (1986)	
					G3Ib-II	Keenan (1989)	
223932	23 53 45.8	-18 21 54	7.36	0.863	K0III+A5/7V	Houk (1988)	**G9,5 III**
224646	23 59 31.8	+54 41 19	7.73	0.525	F6III:+A2V:	Stephenson (1969)	**G7 III**
227947	20 05 12.0	+34 03 00	9.5		G5A2	Cat. HD	**G8 II**
227984	20 09 30.0	+34 43 00	10.1	1.17	K	Cat. HD	**K2,5 III Ca-**
234138	14 26 58.9	+52 29 10	9.52	0.927	K0p	Cat. HD	**K0 III-IV**
236115	23 24 15.9	+55 11 06	8.61	0.825	G5A5	Cat. HD	**G9 III**

Notes

HD 32068: Griffin gives B6.5V by substracting the spectrum of the cool component obtained during eclipse.
HD 57146: MK standard G1Iab-Ib (Garcia 1989).
HD 70826: truly composite spectrum, the hot component is evidenced by the P12 and P14 lines.
HD 137975: Houk (1988) gives also A2/3V+G8III.
HD 157978: triple system (Batten 1989).
HD 159870: the companion is probably an Am star.
HD 164252: the classified star is the primary of the visual system (Sep. near 20").
HD 173764: MK standard G4 Ia (Garcia 1989).
HD 192713: MK standard G3Ib-IIp (Garcia 1989).
HD 199378: the authors suspect the object to be composite (G5III+A).
HD 200905: MK standard K4.5Ib-II (Garcia 1989).

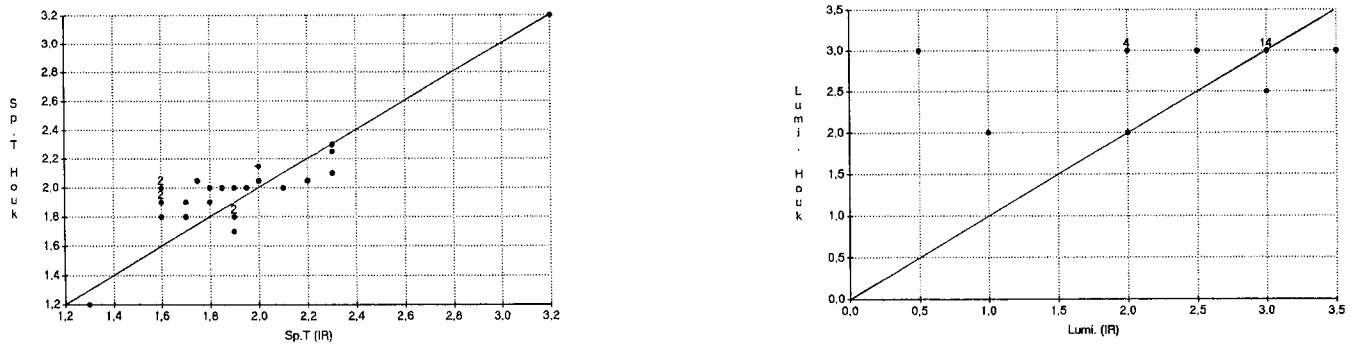

Fig. 6. Comparison of infrared MK classifications (spectral types and luminosity classes) with those of N. Houk (Michigan Catalogues). Sp T: G...1, K...2, M...3; Lumi.: Ia...0, Ib...1, II...2, III...3; numbers on the plots are weights

stars of the southern hemisphere which figure in the catalogues of Michigan: HD 29961, 35162, 47579, 51250, 57146, 59076, 60414, 70442, 74946, 75098, 79267, 84367, 95235, 102171, 120901, 137975, 167570, 168701, 169652, 173805, 174191, 193495, 209278, 218640, 223932.

In Fig. 6 we compare their and our classifications, for spectral types and luminosity classes respectively. We notice that for HD 209278 Houk does not provide the luminosity classification.

The spectra classed by Houk were obtained with the objective prism, on IIaO plates, dispersion 108 Å/mm at H_γ and a resolution near to 2 Å. If one takes into account the difficulties in classifying CS in this wavelength region (see Paper I), the agreement with our classifications is very good for the spectral types. On the average, the Michigan classifications are slightly later than ours for type G and slightly earlier for type K. For luminosity classes the agreement is excellent for class III, but in disagreement for classes I and II. From five stars classed II by us, four are classed III by Houk and two stars classed I by us are classed II and III by Houk.

4. Conclusions

Of the 86 stars classed for the first time in the near infrared, 27 had not MK classification to our knowledge. Of these 27, 4 are Am, 7 are F type classes V or IV, 11 are cool giants and 5 bright giants.

Let us also point out an example of confusion between Am and CS. Usually one finds Am stars called CS, but here we find an Am which is CS. The object is HD 70826 which figures as Am in Hauck (1986). We included it in our list of CS candidates because its correlation peak in the CORAVEL instrument for the measure of radial velocities did not correspond to an Am star.

We detect again, as Paper II, a large quantity of giants between types G7 and K2 with a maximum around G8 and an absence of early type G giants which predominated in the old classifications.

Our program of classification of cool components of CS stars is now complete (Papers II and III). From 266 stars observed as true CS or candidates, we found in the near infrared 184 spectral types of cool stars (G, K and M) and 82 corresponding to early type stars (B, A, Am, F).

We hope to continue this study in two directions. On one hand we wish to classify the hotter components in the blue region, since there exist a wide disparity of classifications for the same object. This would enable us to carry out a sound statistical study of the group. We notice that the majority of the radial velocities of these binaries are being studied by R. Griffin (Cambridge Observatory) and by ourselves with CORAVEL (OHP), so that for a certain number of objects the orbital elements are already known. The other direction is to confront the whole set of our classifications with the data from the Hipparcos-Tycho catalogues.

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