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The spectral variations of AC Herculis

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Summary. — Low dispersion spectra were taken in order to study the spectral variations of the RV Tau star AC Her. They cover a complete cycle of light variations.
The results are discussed also in connection with the visual light variations.
As the spectra of AC Her are very entangled, the multivariate data analysis method of correspondences has been applied to them. This method has proved to be very effective in extracting information from data that are affected by several factors and that generally have a low signal to noise ratio.

Key words : RV Tau stars — spectral variations — multivariate data analysis.

1. Introduction.

AC Her is the brightest RV Tau star after R Sct and U Mon. Thus it is one of the most studied objects within a class of variable stars rather neglected by astronomers.

It has a $75^{d}.4$ period between successive primary minima.

Even though its light variations are among the most regular in its class, it shows during most of its period rather strong bands of CH and CN, so that Rosino (1951) was induced to classify it, during these phases, as Rp.

Other works on the spectral variations of AC Her, at low or intermediate dispersions, came from Sanford (1931, 1955) and Preston *et al.* (1963).

A coarse abundance-analysis was made by Yoshioka (1979) and a fine one by Baird (1981). The latter tells us that AC Her is very poor in metals with respect to the Sun ($Z_* = 0.06\, Z_\odot$), but not so poor in carbon ($C_* = 0.2\, C_\odot$).

In a very recent paper, Baird (1982) has studied the kinematic behaviour of the atmosphere of AC Her. According to this paper, the main velocity curve can be explained in terms of radial pulsation. However, there is a secondary activity which Baird thinks could be due to a partial reflection of the outward pulsation and/or to the presence of a companion (first detected by Sanford, 1955).

Photoelectric observations of this star were carried out by Preston *et al.* (1963), Du Puy (1973) and Nakagiri and Yamashita (1979). Some photometric measurements in the DDO system were made by Dawson (1979).

AC Her also has a circumstellar dust shell (Gehrz, 1972).

2. Observations and data processing.

Observations of AC Her were made at the Merate Observatory from July 4, to September 29, 1980, with the Boller and Chivens mod. 31523 grating spectrograph attached to the 137 cm reflector. A total of 26 spectrograms at 115 Å/mm were obtained on II-a-F or 103-a-F photographic plates. Each spectrum covers the region between 3500 and 7000 Å, and each has been individually calibrated with a 12 step sensitometer.

The journal of observations is reported in table I, with the number of the spectrum, its Julian Date, phase, exposure time and photographic emulsion. The phases were computed with respect to the epoch of the deep minimum as it was obtained from the visual light curve (see below) : $J.D._{min\,I} = 2444478$. Taking into account the uncertainties about this epoch and the length of the period, the phases are accurate within 0.015.

All the spectra are of good quality since an exposure-meter was used during the observations.

Moreover, 34 spectra of 10 standard stars, with spectral types between F2 and K5 and of luminosity classes Ib and II, were obtained for spectral classification purposes.

All the material was digitized on the PDS 1010A microdensitometer of Napoli Observatory with a sampling step of 10 μ. The spectra were then processed on the PDP 11/34 computer of the Merate Observatory. The data tape was read with a program written by Santin (1980), and then abscissae and densities of the spectra were transformed into wavelengths and intensities with some programs written by the author.

Several attempts were made to find an automatic criterion to define the continuum, but the results were not satisfactory owing to the complexity of the spectra of AC Her, whose spectra have emissions and absorption features with very large changes in width and depth from one spectrum to another. Finally the continuum was hand-drawn on plots of the spectra.

3. Results.

The central depths of the lines which appear in most of the spectra were measured taking the continuum as a unit. The depths of the hydrogen lines (multiplied by

1000) and the equivalent widths (in Å) of the CaII K line are listed in table IIa. A minus sign means that the line is in emission; a small « e » means that an emission peak is visible inside the line.

The values of all other metallic lines and molecular bands are in table IIb, where the first column gives the wavelength, the following 26 columns the central depths (multiplied by 1000), and the last one the element (or elements) which is the main contributor to the line. These element identifications were taken from Moore (1945), Dunham (1920), Wright *et al.* (1964) and Rosen (1970). The λ4325 line was first attributed to CH by Rosino (1951). It must be taken into account that because of the dispersion of the spectra, all the measured features are blends of several lines.

The values of the Ca H line are not given since this line is heavily contaminated by the emissions of H7. Neither are the values of the Na I D lines given, since in some spectra they are polluted by city light emissions.

Where a value is missing in table IIb, it means that the feature has not been identified with certainty.

The data concerning some of the most outstanding features are plotted in figure 1.

The light variations of AC Her, observed during the two cycles in which the spectra fall, are represented at the top of this figure. The dots represent the visual observations of the AAVSO members, while the crosses are observations by an Italian amateur, Mr. Pampaloni.

In figure 1 the ordinates show :

a) for the hydrogen lines, the central intensities with respect to the continuum (i.e. values larger than one correspond to emissions),

b) for the CaII K line, the equivalent width,

c) for the other features, the central depths expressed as a fraction of the continuum intensity.

It may be remarked that all these measurements refer to the same cycle of light variations of the star, and that they are not phased with respect to the period, as in other works on spectral variations in AC Her (e.g. Sanford, 1931, 1955). The phasing procedure, because of the non-perfect constancy of the period and of the shape of the light curve, can give only a rough picture of the phenomena.

Examining the data we can perceive the following :

i) the hydrogen lines have two emission maxima during the phases of rising light from the minima. The Hα line is always in emission;

ii) the maximum intensities of the CN and CH bands are reached during the decline from maxima. For a few days preceding the light minima, the λ4737 bands of C_2 are faintly visible (this fact had also been observed by Joy (1952));

iii) the metallic lines show different types of behaviour : some have variations similar to those of the bands, but reach their maximum intensity a little later (e.g. CaII K, λ4384(FeI), λ6497(BaII)), while others change very little (e.g. λ4444(TiII), λ6516(FeII) and to a limited extent λ4227(CaI)).

The classification of the spectra of AC Her is a very difficult task. Yet at first sight these spectra seem very different from those of standard ones. There are three major problems involved in the classification :

a) the hydrogen lines are useless because they are heavily contaminated by emissions;

b) the usual ratios of intensities between different metallic lines are useless too, because most of these lines are polluted at certain phases by CN or CH bands, and according to Baird (1981) the band spectrum must be ascribed to the circumstellar shell;

c) the metallic lines are weaker than those of standard stars of the same temperature (because of the abnormally low metallic abundances, Baird, 1981), and so a classification founded on the intensities of these lines tends to give earlier types than would be consistent with the temperature.

An example of the spectral types, that can be obtained from the intensities is given in table III. In general we see, as we would expect, that the metallic lines indicate earlier types than those of molecular bands. As general behaviour, the earliest types are reached during the rising from the minima, while the latest are observed when the light falls toward the deep minimum.

In conclusion, because of the peculiarities of these spectra, it would be inaccurate or even incorrect to assign a precise spectral type to them. All we can say is that it seems as if the star underlying the shell is in some respects similar to the F-type stars.

4. Correspondence analysis.

In order to achieve a better understanding of the spectral variations the data have been subjected to a « correspondence analysis » (Benzécri, 1980).

To do this each spectrum has been defined through the intensities of the lines marked with an asterisk in table IIb (i.e. through the lines with the more reliable measurements). Thus we considered 26 spectra, each one defined by 45 lines. Then we obtained the « profiles » of spectra and of spectral lines by dividing each term of a spectrum, or of a line, by the respective mass. The « mass » of a line is the sum of the intensities it has in all the spectra, and the « mass » of a spectrum is the sum of the intensities of all its lines. Such a procedure is equivalent to giving greatest weight to the most intense lines. This is correct, because the relative error is inversely proportional to the intensities of the measurements.

The 26 spectral profiles constitute a cloud in the space of the line profiles, while the 45 line profiles form a cloud in the space of the spectral profiles. The maximum dimension of the two clouds is 25, but, as all the measured elements are not completely independent and taking into account the errors in the measurements, a much smaller number of orthogonal axes is sufficient to give a satisfactory description of the clouds.

Each point in its space has an « inertia », which is the product of the mass of the point by the square of its distance from the cloud barycentre. The « inertia of the cloud » is the sum of the inertiae of all its points.

The problem to be solved involves finding, one after the other, the orthogonal axes that explain the largest amount of inertia of the clouds. In our case we found, for example, that the first three axes explain 39.5 %, 10 %, and 9 % of the cloud inertiae respectively. The other axes give information of decreasing importance, e.g. the 4th axis of 6.5 %, the 5th of 5 % and so on. Taking into account the errors in the measurements, it is wise to consider only the first three axes as meaningful. It can be shown that the two clouds, the one with spectral profiles and the one with line profiles, can be described by the same set of axes, on the basis of which the passage from the coordinates of one cloud to those of the other is only a matter of a scale transform.

The sections of the two clouds defined by the axes 1,2 and 1,3 are represented in figures 2 and 3 respectively. These figures may be interpreted as follows : when a spectral line falls near a spectrum, the line is strong in that spectrum; when it falls at a distance, the line is weak in that spectrum.

In addition to the 45 lines used to determine the axes, three more lines have been considered as « supplementary elements », i.e. their coordinates have been computed with respect to the axes. They were : Hα, CaII K, λ3883(CN). The intensities of Hα and CaII K have been arbitrarily normalized, as they were measured in units not homogeneous with those of the other lines. The measurements of λ3883(CN) were not very accurate, and this was due to the difficulty in defining its continuum in some spectra.

Analyzing the figures we note the following facts :

i) The first axis is connected to the intensities of the molecular bands. They are strongest in the spectra on the left and weakest in those on the right. We can see that the variations of most of the metallic lines are independent of band variations or they have opposite behaviour (i.e. some of the metallic lines are weak when the bands are strong and *vice versa*). The only metallic lines which we can see on the negative side of the 1st axis are those polluted by CN bands (e.g. λ4206(CN, FeI, EuII), λ4178(CN, YII), λ4172(CN, TiII, FeII), λ4154(CN, FeI), etc.). From the relative positions of lines and spectra we see, moreover, that the bands are weakest near secondary minimum and during the rising from the deeper one.

ii) The second axis is connected to the intensities of the lines which have TiII as main contributor (i.e. λ4395, 4468, 4444, 4501). These lines have their maximum intensities in the spectra at the top of figure 2; these values are reached a few days after the main light maximum, while their minimum intensities are reached during the light minima. Some lines which have FeI as main contributor show behaviour opposite to this (i.e. λ5108, 6231, 4064, 4260, 4071). The line λ4172, which is contaminated both by CN and TiII, is a good example of the efficiency of the analysis method in separating the two contributions (see Fig. 2).

iii) The third axis reflects the appearance of the spectra in the phases which follow the deep minimum immediately. We see, on the negative side of this axis, the spectra BCL 647, 648, 650, 658 (which have respective phases : 0.05, 0.06, 0.07 and 0.10). In these spectra the lines λ4405(FeI), λ6497(BaII), λ4260(FeI), λ4071(FeI), λ4250(FeI), are enhanced while the lines λ5052(FeI), λ4078(SrII), λ5018(FeI), λ5184(MgI), λ6371(SiII), are dimmed. Moreover the hydrogen lines have their strongest emissions (we can see how the Hα falls clearly below the lower edge of Fig. 3). As is known from Baird (1982), during these phases the star behaves in a very complex way, showing three major absorption systems and one major emission system of metallic lines, in addition to hydrogen emissions. The low resolution of the present spectra does not allow us to see these features, but obviously they affect the present spectra too, in some macroscopic way. Two spectra have a behaviour which is nearly symmetric with respect to the axes of figure 3, i.e. BCL 583 and 594 (phases : 0.39, 0.51, corresponding to the descent to secondary minimum and to the secondary minimum). We see from Baird's paper (1982) that in these phases the spectra are largely dominated by one absorption system, so that they are among the simplest. It is also remarkable that the spectra BCL 690 and 692, which have almost the same phases (0.38, 0.42), but belong to the following light cycle, behave differently, although the light curve is very similar in the two cycles.

Finally, we can observe how the correspondence analysis has been able to furnish much more information on the behaviour of the metallic lines than the approximate analysis of the data, which are blurred by noise. Similarly one can say this analysis method can extract information by considering the data in their totality.

5. Conclusions.

The spectral variations in AC Her have been observed and discussed, and their connections with the light variations have been emphasized.

The data analysis method of correspondences has proved to be a powerful tool in accomplishing this task, since it gives a concise, general and objective view of the matter, permitting deductions from the whole set of data, and hence the exploitation of the total information contained in them.

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TABLE I.

Spectrum	J.D.	Phase	Exposure min.	Emulsion
BCC 577	424.5	.29	53	II-a-F
" 581	429.5	.35	63	"
" 583	432.4	.39	53	"
" 594	441.4	.51	50	"
" 614	444.4	.55	84	"
" 619	445.4	.57	180	"
" 622	455.4	.70	176	"
" 628	456.4	.71	158	"
" 630	460.4	.77	80	"
" 634	461.4	.78	144	"
" 636	464.4	.82	92	103-a-F
" 639	465.4	.83	135	"
" 641	468.4	.87	123	"
" 643	472.4	.93	210	"
" 644	473.4	.94	225	"
" 647	481.4	.05	194	II-a-F
" 648	482.4	.06	135	"
" 650	483.4	.07	120	"
" 658	485.4	.10	114	"
" 664	488.3	.14	152	"
" 665	489.3	.15	115	"
" 667	492.3	.19	103	"
" 670	495.3	.23	132	"
" 671	496.3	.24	72	"
" 690	506.3	.38	180	"
" 692	509.3	.42	180	"

TABLE III.

Feature	Spectral types
K CaII	FO - F6
Ca I 4227	FO - F6
G Band	F5 - KO
CN Bands	GO - G8
MnI 4033	FO - G5
FeI 4384	FO - G1
4173-79	FO - G2

TABLE IIa.

SPECT.	577	581	583	594	614	619	622	628	630	634	636	639	641
PHASE	.29	.35	.39	.51	.55	.57	.70	.71	.77	.78	.82	.83	.87
H ALPHA	−32	−29	−40	−213	−311	−171	−94	−68	−58	−25	−64	−33	−42
H BETA	410	382	468	346	332	244	268	264	276	354	390e	370e	427e
H GAMMA	340	434	518	424	378	336	298	346	300	348	426	460	404
H DELTA	332	360	552	406	424	422	396	384	396	428	408	496	484
K CAII	6.5	5.0	5.3	4.8	4.2	5.1	7.8	6.9	9.0	8.8	8.8	10.3	10.8

SPECT.	643	644	647	648	650	658	664	665	667	670	671	690	692
PHASE	.93	.94	.05	.06	.07	.10	.14	.15	.19	.23	.24	.38	.42
H ALPHA	−163	−150	−1075	−1025	−1114	−748	−717	−625	−483	−267	−183	−17	−0
H BETA	282	216	−470	−625	−752	−558	−329	−323	−98	36e	110e	376	418
H GAMMA	336	270	−413	−475	−546	−367	−193	−167	−43	108e	156e	330	396
H DELTA	502	340	−338	−340	−344	−150	−110	−75	0	198	204	376	502
K CAII	11.0	9.8	9.5	5.6	7.0	5.2	5.5	4.8	4.4	4.8	4.3	8.0	8.0

TABLE IIb.

SPECT.	577	581	583	594	614	619	622	628	630	634	636	639	641	643	644	647	648	650	658	664	665	667	670	671	690	692	MAIN
PHASE	.29	.35	.39	.51	.55	.57	.70	.71	.77	.78	.82	.83	.87	.93	.94	.05	.06	.07	.10	.14	.15	.19	.23	.24	.38	.42	CONTR.
3883	526	390	344	142	222	422	522	672	824	834	738	740	738	510	606	630	514	598	444	530	352	396	402	324	666	666	CN
3944	202	48	184	78	114	154	---	264	---	208	162	---	342	232	162	---	168	196	138	136	74	108	100	---	---	---	AL I
3997	132	52	56	70	118	130	144	---	174	142	136	180	192	368	166	142	78	102	---	104	78	112	42	72	130	158	FE I
4005	144	90	150	146	136	120	144	---	176	142	52	172	186	368	154	166	---	168	156	142	130	120	92	114	132	236	FE I
4012	84	38	122	100	114	90	48	---	46	72	---	48	48	23	22	50	72	30	46	128	56	48	82	90	78	302	TI II
* 4033	130	132	198	120	174	150	222	246	164	184	174	242	222	326	236	288	158	192	166	202	108	168	202	150	240	300	MN I
4045	63	69	108	53	81	---	---	---	53	---	69	27	105	127	---	---	55	---	---	---	44	77	36	83	19	---	FE I
* 4064	161	128	166	119	129	119	92	180	54	108	73	138	139	329	113	168	124	102	98	75	102	114	91	78	101	177	FE I
* 4071	142	93	92	103	166	79	75	104	108	74	121	46	96	180	204	140	86	170	109	154	126	83	80	103	107	212	FE I
* 4078	148	139	259	202	142	145	98	114	138	168	174	183	159	326	170	78	88	108	61	154	132	181	132	78	156	151	SR II
* 4144	96	102	121	67	93	62	126	79	128	151	166	208	244	260	235	182	148	129	43	123	140	98	38	71	134	168	CN-FE I
4152	---	45	---	---	70	21	---	64	155	204	245	286	299	439	---	198	97	60	92	84	---	61	---	41	95	---	CN-LA II-CE II
* 4154	110	38	77	130	77	37	120	191	162	189	251	286	290	451	311	139	75	66	89	39	80	57	91	54	134	171	CN-FE I
4161	73	58	44	---	84	83	105	128	---	132	---	---	---	285	207	82	69	60	47	125	73	31	38	41	110	93	CN-TI II-ZR II
4167	---	---	---	---	---	71	---	---	133	106	220	247	269	359	233	156	29	23	---	117	---	---	32	47	95	80	CN-MG I
* 4172	70	169	194	168	174	110	220	181	208	304	362	398	432	46	330	239	140	96	109	106	191	146	100	156	156	220	CN-TI II-FE II
* 4178	101	145	230	144	121	107	183	227	257	282	366	424	406	498	374	270	180	105	1 5	139	159	164	136	138	210	234	CN-Y II
* 4196	140	91	118	80	122	91	139	162	189	288	325	344	310	482	304	283	133	40	85	108	92	103	122	50	133	98	CN-FE I-(LA II)
4202	109	69	97	98	110	108	136	---	---	---	---	---	229	331	---	247	114	---	101	59	107	---	---	63	138	192	CN-FE I
* 4206	66	46	123	70	44	50	133	158	161	174	234	272	226	309	261	256	125	87	79	67	49	78	104	73	165	280	CN-FE I-(EU II)
* 4216	192	185	190	152	172	143	180	184	250	267	335	361	377	392	362	285	131	128	107	95	110	131	108	117	167	180	CN-(SR II)
* 4227	129	146	164	146	210	186	161	149	130	122	131	144	137	245	193	148	98	145	151	183	149	145	113	126	146	138	CA I
* 4236	63	68	169	57	108	141	140	103	116	112	125	121	146	244	162	206	113	137	76	97	100	103	102	98	121	164	FE I
* 4250	71	157	111	136	135	163	127	185	165	148	187	218	128	229	258	270	153	160	81	83	152	145	121	105	202	115	FE I
4254	63	55	60	---	106	---	112	---	101	64	110	76	---	176	144	175	155	103	59	---	100	---	---	34	---	103	CR I
* 4260	89	74	89	71	139	127	99	106	105	86	80	141	142	265	183	233	121	117	87	66	110	92	86	79	143	118	FE I
* 4272	201	141	159	156	182	143	181	238	179	183	227	256	262	320	247	288	138	181	123	115	188	183	145	164	158	283	FE I
* 4289	193	173	184	149	126	167	209	248	202	200	252	300	307	402	297	316	200	164	102	109	149	146	186	166	155	285	CH-CR I-TI II
* 4300	342	280	296	260	229	243	410	422	402	468	511	542	560	636	503	344	228	256	176	216	253	286	254	233	373	402	CH-(TI II-FE I)
* 4308	242	242	223	185	156	212	425	450	408	494	508	512	581	585	528	394	230	226	156	177	206	231	220	230	362	485	CH-(TI II-FE I)
* 4314	234	306	278	146	120	150	425	462	432	494	548	562	602	522	512	394	246	146	170	214	222	246	216	232	402	485	CH-(SC II-TI II)
* 4325	206	212	162	88	156	100	202	264	228	280	306	300	276	288	275	248	132	150	130	144	190	180	140	180	224	208	CH-(FE I-SC II)
* 4375	163	124	109	63	80	56	108	196	175	125	198	235	181	195	211	241	112	136	65	81	126	77	82	121	97	181	SC II-Y II-FE I
* 4384	200	128	168	124	123	133	154	163	204	127	191	234	269	302	256	281	153	150	173	154	151	149	153	174	173	237	FE I
* 4395	102	178	184	92	102	100	78	126	92	72	150	202	144	172	114	114	80	36	56	102	128	92	130	158	98	114	TI II
* 4400	91	87	116	49	101	43	55	141	83	55	128	74	148	123	106	130	65	46	89	82	48	69	125	133	104	138	SC II-TI II-CR I
* 4405	91	58	74	33	87	56	47	99	68	53	100	107	96	155	159	161	61	105	113	79	42	54	49	131	103	100	FE I
* 4415	138	158	192	102	156	72	94	132	106	114	127	168	144	130	128	186	116	94	140	186	220	160	154	172	144	120	FE I-(SC II)
* 4444	100	184	160	84	162	90	78	126	108	114	158	174	100	96	134	150	154	88	118	92	155	132	112	144	120	168	TI II
* 4468	142	156	168	76	76	82	72	54	90	100	96	148	158	124	166	134	80	84	78	78	136	26	138	158	166	104	TI II
* 4501	124	108	120	48	60	62	60	60	36	0	48	84	42	14	54	84	14	66	43	48	108	48	84	102	62	138	TI II
4523	120	120	130	64	88	36	96	90	70	76	78	124	---	24	96	48	66	68	82	90	70	108	102	168	132	178	FE II
* 4554	234	212	156	106	118	84	78	110	94	106	154	136	158	180	144	146	97	116	148	162	180	162	164	194	156	168	BA II
4564	145	150	126	70	84	50	102	84	36	88	36	60	---	112	84	68	54	82	48	112	96	78	60	100	108	118	TI II
4572	134	90	148	72	78	72	78	94	74	66	132	84	---	118	144	108	84	38	108	72	82	118	78	150	74	184	TI II
4584	106	66	158	122	116	130	94	124	122	120	96	112	---	132	144	136	102	86	76	158	132	132	152	188	124	108	FE II
* 4670	72	122	70	116	132	76	90	144	132	106	120	62	130	150	134	128	102	82	84	86	84	72	114	82	132	98	SC II
4737	65	30	50	150	87	63	60	77	70	75	108	135	110	122	130	100	73	92	42	22	60	45	58	65	93	137	C2
4805	72	54	124	36	50	96	36	78	60	40	28	40	78	114	---	80	66	54	60	90	80	98	48	36	34	132	TI II
4884	---	50	0	36	168	90	122	136	84	52	66	90	190	134	48	34	---	82	70	84	58	102	50	---	86	186	Y II
* 4924	162	132	270	94	208	84	138	174	90	120	150	142	244	288	176	160	156	127	118	186	186	120	152	166	122	204	FE II
* 4934	172	138	192	120	116	112	134	106	56	160	108	126	156	73	112	191	104	182	152	108	130	118	124	136	130	264	BA II
* 4957	120	108	228	120	82	96	154	56	108	78	60	116	196	95	116	156	48	112	120	198	96	78	72	132	132	204	FE I
* 5018	222	200	330	268	280	114	152	124	112	76	144	104	192	228	138	146	108	120	156	202	168	175	132	130	158	320	FE II
* 5052	190	102	300	240	118	124	132	132	156	152	108	118	222	134	204	140	66	84	94	116	114	130	84	104	164	186	FE I
* 5108	166	84	160	182	104	60	76	120	144	194	112	136	228	222	242	168	204	164	64	156	90	68	84	30	168	282	FE I
* 5167	270	256	456	294	360	300	264	252	324	328	262	300	384	438	274	472	270	302	310	234	240	230	250	194	356	420	MG I-FE I
* 5184	262	124	300	216	226	162	126	138	186	0	106	104	144	186	102	0	96	166	138	202	164	134	132	124	160	264	MG I
5192	244	---	156	54	145	---	112	66	94	108	130	60	192	184	194	276	126	126	162	270	120	114	138	70	190	264	FE I
5406	108	132	336	180	252	96	92	130	132	98	114	58	204	150	198	---	---	114	84	108	78	114	100	---	132	---	FE I
6137	76	66	200	246	88	70	78	90	66	98	102	88	102	126	---	210	61	86	---	78	---	84	82	94	98	205	FE I
* 6142	190	42	154	102	94	68	0	44	90	102	90	130	126	166	156	187	77	130	108	54	114	120	42	86	114	148	BA II
* 6231	66	24	68	84	100	38	64	66	52	88	108	50	156	168	96	83	108	24	66	108	30	60	38	65	64	128	FE I
* 6371	62	60	162	94	64	28	82	42	60	78	90	80	108	50	58	79	60	62	54	94	78	98	72	95	96	88	SI II
* 6497	172	72	30	78	57	80	126	112	140	156	162	198	208	216	180	205	175	190	156	170	127	143	142	133	82	154	BA II
* 6516	150	92	192	102	168	88	166	132	84	126	130	168	126	258	90	140	100	90	119	74	148	104	132	124	118	118	FE II

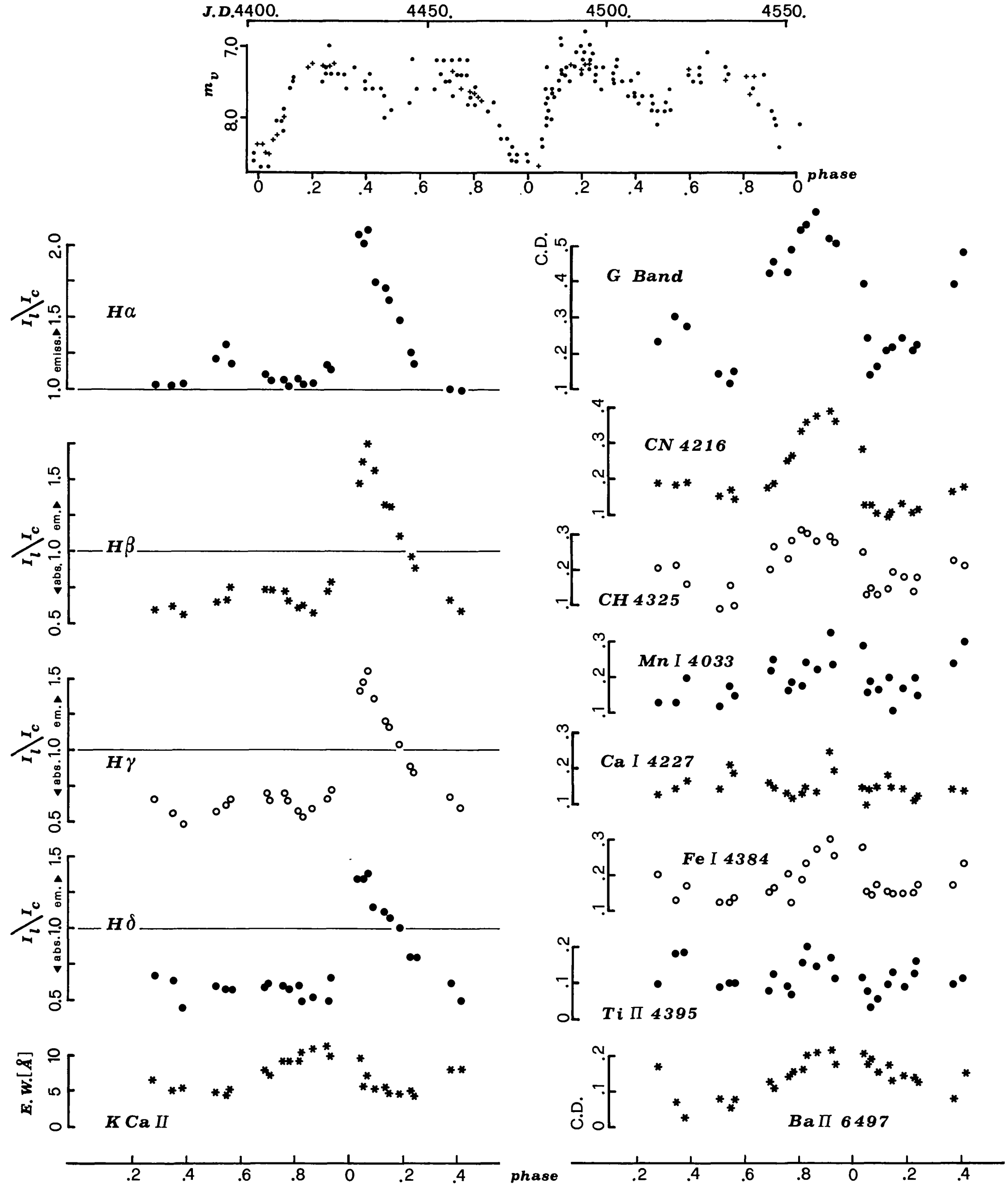

FIGURE 1. — Variations of some of the most relevant spectral features. At the top are represented the visual light variations. For details see text.

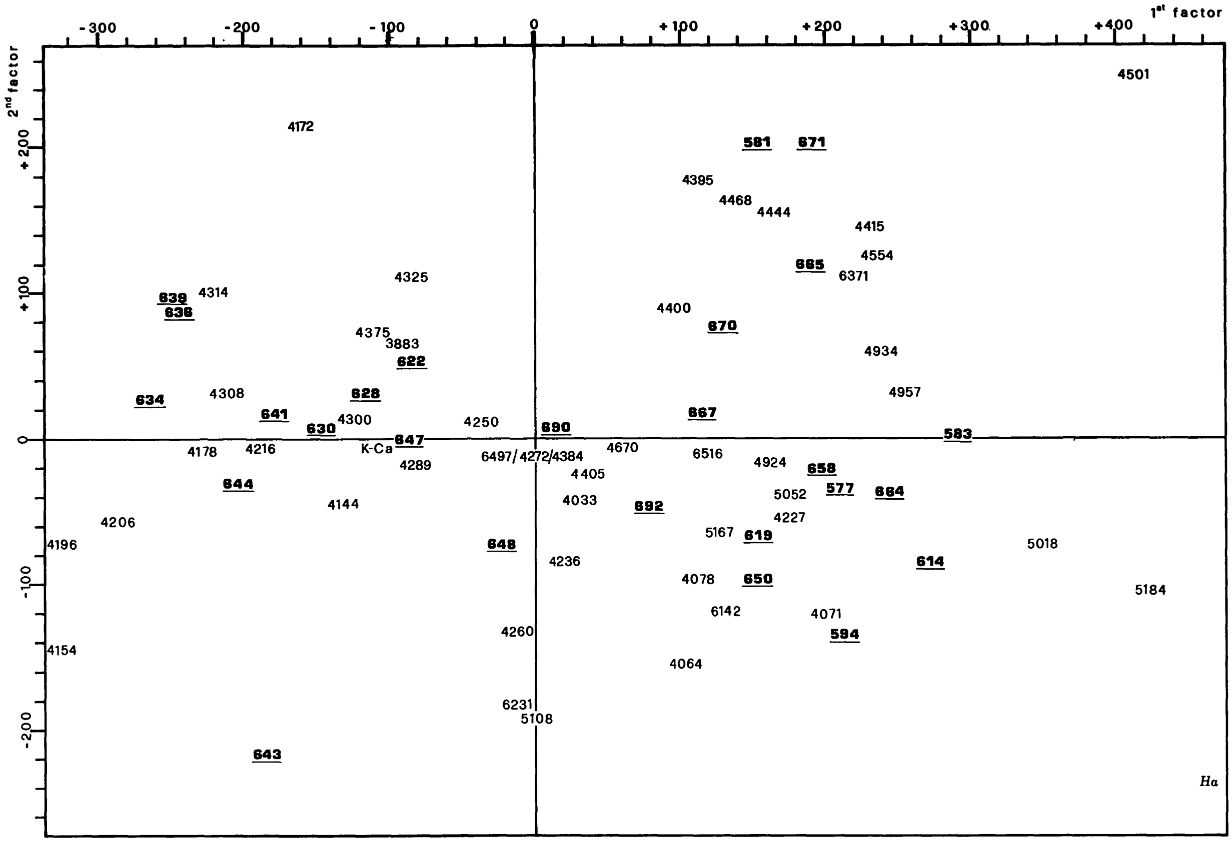

FIGURE 2. — Spectra (underlined numbers) and spectral lines are represented in the section defined by the 1st (horizontal) and 2nd (vertical) factorial axes.

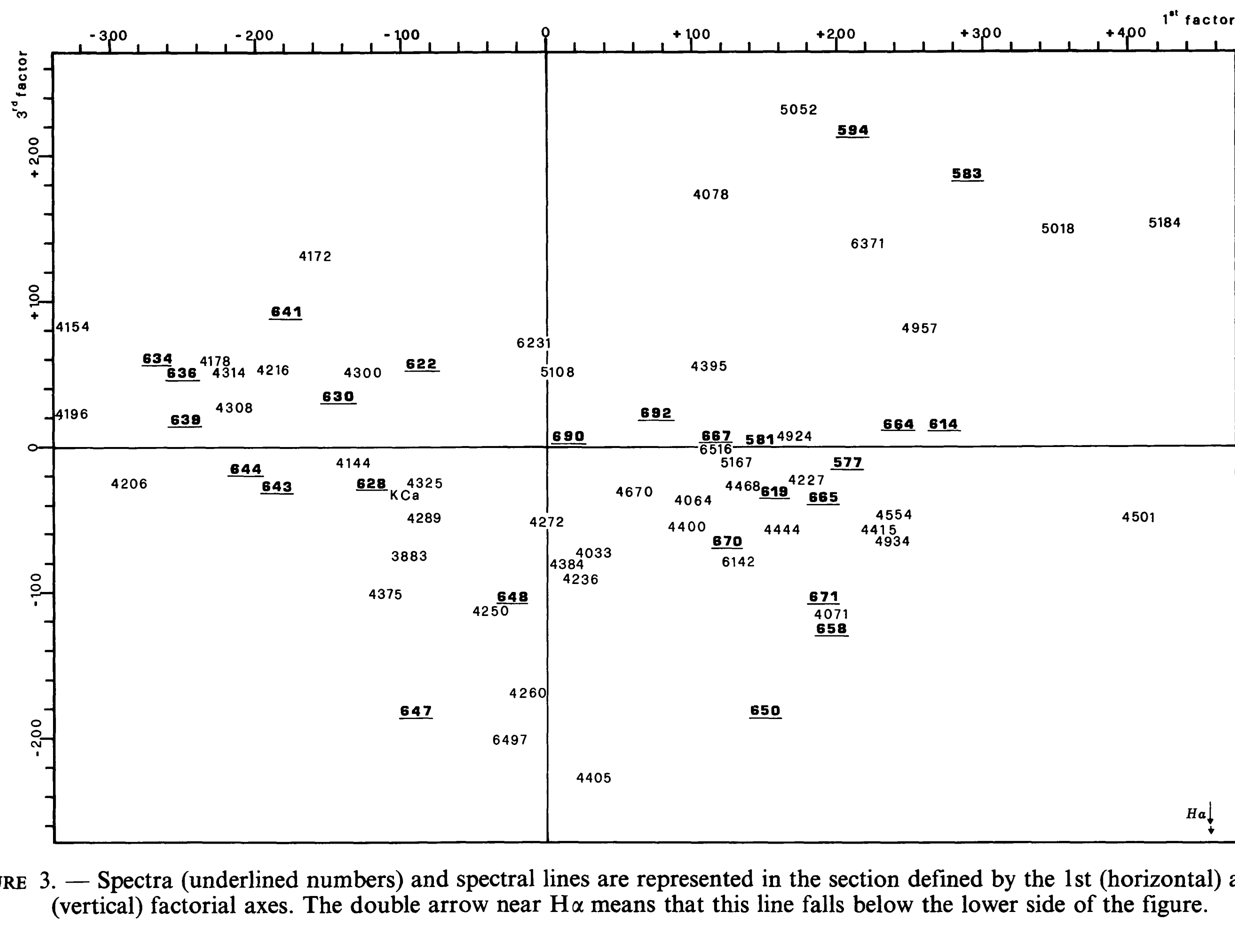

FIGURE 3. — Spectra (underlined numbers) and spectral lines are represented in the section defined by the 1st (horizontal) and 3rd (vertical) factorial axes. The double arrow near Hα means that this line falls below the lower side of the figure.