THE VARIABILITY OF THE λ5200 FEATURE IN CP2 STARS

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ABSTRACT. 32 stars have been checked for Δa variability, with the purpose to learn which factor(s) influence the strength of the λ 5200 continuum depression. One third of the stars appear to be constant within a range of 0.005 mag. The results on the remaining ones indicate that maximum strength is related to at least one of the magnetic poles, but spectral inhomogeneities are almost certainly responsible for the largest amplitudes.

1. OBSERVATIONAL DATA

Maitzen (1976) discussed the detectability of Ap stars by Δa photometry. 32 Ap stars in his sample were observed on at least seven epochs, and are studied now for variability. Table 1 summarizes the results. We refer to Maitzen (1976) for details on the observing runs. The external one-sigma error for observations within each particular run has been estimated from standard stars, Ap stars with apparently constant Δa, and from comparison of observations at nearby phases: $\sigma \leq 0.003$ mag (see also column 8 of Table 1).

2. OCCURRENCE OF VARIATIONS

Only two stars in our sample have a total range in Δ a exceeding 0.02 mag: EP Vir and CU Vir. Three other stars, not in our original sample, fall in this category: FF Vir (Hensberge et al., 1985), HD187474 (Hensberge et al., 1984) and HD133880 (Maitzen, unpubl.). They comprise the whole interval of photometric periods, from 0.5 days to over 6 years, but none of them is a cool Ap star.

The majority of the stars vary over a range of about 0.01 mag. (Fig. 2).

About one third of the stars (12/32) is constant within 0.005 mag.

C. R. Cowley et al (eds.), Upper Main Sequence Stars with Anomalous Abundances, 183–187.

TABLE 1. CP2 stars discussed in this paper. Columns give star identification (HD; name or HR); (rotation) period in days; number of Δa observations available; mean value of Δa and total range of variability (both as computed from sine-fit or, if necessary, from fit up to sin(2)). "<" means that the total range of variation is 6 or lower; shape of the Δa phase diagram; significance of the result: the first number given is the one-sigma of individual measurements around their mean value, the second one the one-sigma scatter of individual measurements around the best-fit curve. Unit = mmag. No fit was attempted when the original scatter did not exceed 3 mmag.

notation used for phase relations:

phase B_e, antiphase B_e indicates relation with absolute value of B_e when no (or very weak) polarity reversal is seen;

phase: weak (strong) extr. B_e indicates whether the weaker or stronger maximum of B_e corresponds to maximum Δa;

(prob) indicates an ill-defined phase dependence for one or some of the involved parameters.

HD	name	P(d)	N_{obs}	< a>, range		shape	signif.	phase relations; remarks
25823	41 Tau	7.23	10	30	9	narrow max.	4.0/2.2	phase: B_e (prob.), SrII, TiII antiphase: SiII
124224	CU Vir	0.52	9	20	22	see fig.	9.1/2.7	phase: strong extr. B_e, SiII antiphase: HeI
223640	ET Aqr	3.73	13	42	10	broad max.	4.5/2.1	P not accurate enough. SrII, TiII variable
37808	HR1957	1.10	10	24	8	sinusoidal	3.6/1.8	no data on magnetic field or spectrum variability
168733	HR6870		8	32	<		3.2/2.5	
74521	49 Cnc	4.24	8	73	<		2.7	
43819	HR2258	1.08	8	36	10:	sinusoidal	5.6/3.5	P suspect? R.sin(i)=0.26 seems to rule out variability
112413	α^2 CVn	5.47	8	42	11	sinusoidal	4.6/1.9	phase: weak extr. B_e, FeII, CrII antiphase: EuII, TiII
11503	γ_2 Ari	1.61?	7	39	<		2.8	
203585	θ^2 Mic	?	12	21	<		2.8	constant in light
192913	MW Vul	16.85	9	31	11:	double-0.9? inc. phase coverage	4.2/2.3	
10783	UZ Psc	4.13	13	46	12:	narrow max	7.7/5.4!	phase: B_e no spectrum variability
111133	EP Vir	16.3	9	57	27	sinusoidal	11.2/2.0	phase: B_e, CrI, CrII, FeI, FeII, SrII
72968	3 Hya	11.3 ?	9	47	<		2.3	
125248	CS Vir	9.30	7	46	<10:	incomplete phase coverage	2.5	phase: weak extr. B_e (prob.), Cr I (prob.), CrII (prob.) antiphase: EuII (prob.)
151525	45 Her	1.31	7	15	10:	double-0.8	3.6/0.8	Cr variable in strength, phase relation unknown
126515	FF Vir	130.0	42*	54	35	broad max.		phase: B_s, TiII, SiII, EuII, FeII, CrII observ. ApWG (Catalano, Pavlovski, Schneider, Vogt, Weiss) added
135297		?	7	32	<		3.2/ ?	inconclusive (too bad phase coverage Δa) CaII, SrII variable,
49976	HR2534	2.98	10	44	>11	incomplete phase coverage	4.8/ ?	B_e polarity reversal
220825	κ_1 Psc	0.59	13	32	<		2.4	
203006	θ^1 Mic	2.12	12	40	10	double-0.63	3.7/2.0	SrII max and min at <Δa> antiphase: Eu II
153882	HR6326	6.01	8	47	16:	broad max.	7.0/4.0!	phase: Be posit. extr. (symm. reversal)
130559	μ Lib	?	8	29	<		2.6	
221760	ι Phe	?	13	20	<		2.4	constant in light and spectrum
71866	TZ Lyn	6.80	9	47	<		2.8	B_e nearly symm. reversal, EuII and GdII double wave variab.
148898	ω Oph	2.99?	8	17	<8	double if var.	3.1/0.9	P not unambiguously established
30466		2.78	8	50	13	double-0.8	4.8/2.2	
22374		10.61	10	18	12	broad max.	5.5/3.5	
15144	AB Cet	3.00?	11	30	7	narrow max.?	3.3/1.5	Δa does not vary in 15.88d period proposed for B_e by Bonsack
134793		2.78	8	40	7	narrow max.	3.7/2.0	
3980	ξ Phe	3.95	10	38	<		3.0	
98088	SV Crt	5.91	9	34	12	double-0.5	4.9/2.3	phase: SrII, EuII; weak extr. B_e corresponds to primary max. Δa
137909	β CrB	18.5	8	23	<10:	incomplete phase coverage	2.4	phase: weak extr. B_e (prob.), B_s (prob.) no spectrum variability

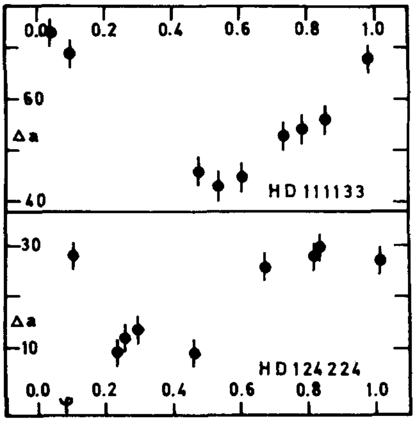

FIG. 1. Phase diagrams for EP Vir CU Vir. Phase zero corresponds to phase of maximum absolute value of effective field. The adopted periods are 16.304d and 0.520675d respectively.

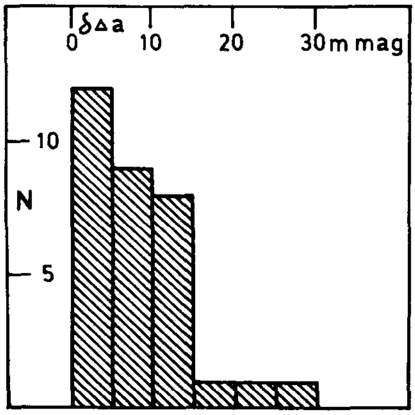

FIG. 2. Distribution of the range of Δa variability, δΔa, for our sample.

3. CORRELATION WITH SPECTRUM VARIATIONS

Δa variability correlates statistically with spectrum variability: 75% of the spectrum variables show a measurable variation, while this frequency is 50% for the other stars. This is most likely a moderate aspect effect.

Silicon shows in-phase variations in two stars with a very large Δa range (CU Vir, FF Vir), but the moderate variation of SiII in 41 Tau is definitely in antiphase. Chromium varies in-phase with Δa in the four stars where Cr variations were studied. Strontium varies in-phase, except for θ^1Mic where it varies 1/4 period out of phase with the double wave in Δa. Europium varies generally in antiphase with Δa, with the exception of SV Crt (Abt's star) and TZ Lyn. In the latter, the rare earts are variable, but Δa is constant, although the whole stellar surface is seen during the rotation cycle.

Although a statistical correlation between Si abundance and Δa, as found by Cowley (1981), cannot be ruled out, arguments against Si are: the antiphase variation in 41 Tau; Δa reaches only a secondary maximum at Si maximum in FF Vir; 3 Hya has very weak SiII (Babcock, 1958; Hensberge and De Loore, 1975), a rather weak magnetic field (B_s 2kG) but high Δa. It has very strong Cr and Sr. FF Vir, 3 Hya and the Cr spectrum variables in general lend support to a correlation Cr – Δa.

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4. CORRELATION WITH MAGNETIC FIELD

Several papers have discussed the relation between B_s and the strength of the λ5200 feature (see e.g. North, 1980).

We computed estimates of $\langle B_s \rangle$ for as many programme stars as possible, using B_e data and information on oblique rotator geometry. Fig. 3 shows that the upper envelope of a (Δa,B2-G) graph is composed of stars with $B_s \geq 4$ kG.

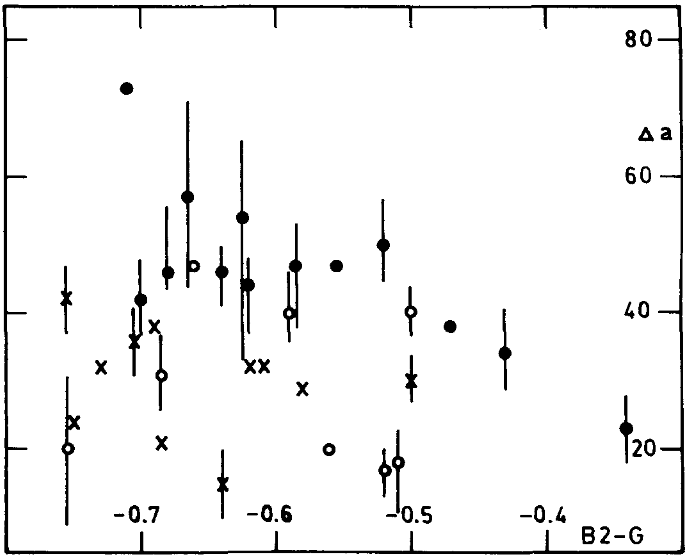

FIG. 3. Mean Δa values (time averaged over one cycle) and total variability range (=length of bars) against the temperature parameter B2-G (Geneva photometric system). Dots refer to stars with $B_s > 4$ kG, open circles to stars with $B_s < 4$ kG. Crosses are used when B_s could not be estimated.

Variability of Δa does not correlate with field strength. There is a strong tendency for Δa to show extrema when the field is longitudinal (Table 1, Fig. 3). If no clear polarity reversal occurs, then Δa varies in-phase with B_e. When both poles are clearly seen, high Δa may correspond as well to the stronger as to the weaker B_e extremum. This is not easily understood with a dipole model, but detailed calculations show that a relatively small quadrupole contribution (not larger than necessary to explain B_s in 53 Cam or FF Vir) suffices to create a "higher Δa = higher B_s" relation per star. In the case of α^2 CVn, the best-fit model of Borra and Landstreet (1977) predicts the measured antiphase relation.

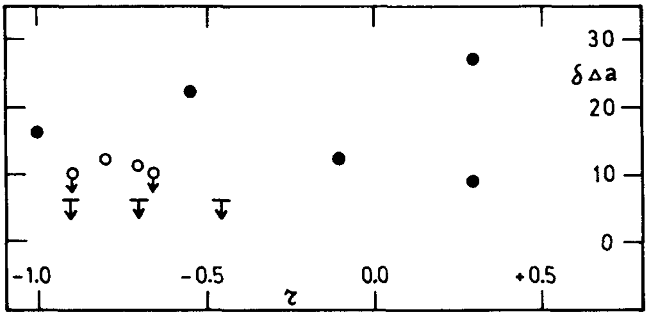

FIG. 4. Total variability range $\delta\Delta a$ against r, the ratio of the weak to the strong B_e extremum. Dots represent stars with Δa maximum coinciding approximately ($\Delta\phi < 0.1$) with maximum $|B_e|$. Open circles represent stars with high Δa corresponding to the weaker B_e extremum. Arrows indicate upper limits for $\delta\Delta a$.

The Δa range for stars without polarity reversal is as large as when both poles are seen. Thus, the total Δa range seem to occur between regions with longitudinal and transversal fields.

It is very unlikely that the largest variations of Δa are dominated by magnetic line intensification effects. Variations in spectral line density are likely to dominate in the spectrum variables. Nevertheless, some stars without spectrum variability show a moderate Δa variability (UZ Psc).

REFERENCES

Babcock, H. W.: 1958, Astrophys.J. Suppl. 30, 141.
Borra, E. F., Landstreet, J. D.: 1977, Astrophys.J. 212, 141.
Cowley, C. R.: 1981, Astrophys.J. 246, 238.
Hensberge, H., De Loore, C.: 1975, Astron.Astrophys. Suppl. 20, 183.
Hensberge, H., Maitzen, H. M., Catalano, F.A., Schneider, H., Pavlovski, K., Weiss, W.W.: 1985, submitted to Astron.Astrophys.
Hensberge, H., Manfroid, J., Schneider, H., Maitzen, H. M., Catalano, F. A., Renson, P., Weiss, W. W., Floquet, M.: 1984, Astron.Astrophys. 132, 291.
Maitzen, H. M.: 1976, Astron. Astrophys. 51, 223.
North, P.: 1980, Astron.Astrophys. 82, 230.

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