Astron. Astrophys. Suppl. Ser. **133**, 1–6 (1998)

New variable chemically peculiar stars identified in the Hipparcos archive*,**

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Received March 19; accepted May 13, 1998

Abstract. Since variability of chemically peculiar (CP) stars plays an important role for the astrophysical explanation of their outstanding behaviour, we have identified new variable CP stars listed in Renson's catalogue using the extensive Hipparcos Variability Annex. From the 293 objects found, 33 were excluded because they are no CP stars and/or have no period listed, half of the remaining stars are newly identified and half had been already included in the catalogue of variable CP stars by Catalano & Renson (1997).

Most of the newly identified variability is due to an apparent magnetic field coupled with stellar rotation (oblique rotator model). The constraints of this model are fulfilled for all but three CP2 stars.

Variations of bona fide Am-Fm stars are exclusively explained by eclipses of binary systems. Furthermore eight candidates of the γ Doradus group (pulsating Am-Fm stars) were detected.

Key words: stars: chemically peculiar — stars: early type — stars: variable

1. Introduction

Variability of "classical" Ap stars (= magnetic chemically peculiar stars of the upper main sequence) is a common phenomenon. Ludendorff (1906) already reported line variations in the spectrum of the "prototype" Ap star α^2 CVn. The (asymmetrical) light curve of this star was first measured by Guthnick & Prager (1914).

It took almost 50 years to find the physical background for this variability. Babcock (1947) and Stibbs (1950) developed the oblique rotator model for these stars in which their magnetic field is inclined at a certain angle to the rotation axis. The observed variations are therefore coupled with the apparent magnetic field as the star rotates. This theory was highly successful in explaining magnetic field variations together with photometric as well as spectral line variations. It was used to develop the technique of "Doppler-imaging" (Deutsch 1970) in order to map the abundances of elements on the stellar surface.

The second kind of variability of CP stars is due to binarity causing light variations. All type of eclipsing systems were detected and play an especially important role concerning the Am-Fm phenomenon (Budaj 1997).

We have used the extensive Hipparcos Variability Annex (HVA hereafter) in order to search for peculiar stars included in the catalogue of Ap and Am stars by Renson (1991). 293 stars were found in both catalogues (33 were excluded, see next section), half of these stars had been already known as variable, whereas 130 stars are newly identified variable CP stars (Table 1). Concerning the rotational photometric variability it has to be emphasized that the photometric band operated by Hipparcos is by no means the most suitable to detect this kind of variations: for blue magnetic (CP2) stars the amplitude decreases from the UV towards longer wavelengths, for the cooler CP2 stars the largest variability has been found to occur in the Strömgren v band. On the other hand the large number of Hipparcos measurements appearing in the HVA compensate for this intrinsic disadvantage. This situation naturally calls for future ground based observations at shorter wavelengths both for confirming the periods determined and in order to establish the run of the light curve structure with wavelength.

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* Based on data from the ESA Hipparcos astrometry satellite.
** Table 1 is also available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

Table 1. a) Newly identified variable CP stars

HD	HIC	RNS	Type	Min	Max	Period	Epoch	Δa	Δp	$v \sin i$	Spec.
1826?	1799	410	ELL	6.993	7.024	1.43237	8501.2256		1.6		A3-
4058?	3414	1120		5.002	5.016	0.98211	8500.401		1.4	60	A4-
4161	3572	1140	EA/DM	5.673	6.06	4.4673	8500.883			25	A2-A4
16545*	12478	4120	ACV	7.319	7.369	1.61942	8500.6802				A0 Si
16769	12821	4240	ACV	5.990	6.007	1.26819	8501.052			35	A2-A6
18473	14049	4610	ACV	7.332	7.369	0.666832	8500.2845			75	B9 Si
18597	13937	4660	EA/DM	8.712	9.237	2.78157	8500.2963				A1-F0
18806	14087	4710	ACV	9.075	9.164	4.1030	8500.68		4.5		A1 Cr Eu Sr
21912	16591	5510	ELL	5.815	5.866	0.91718	8500.523		1.2	100	A3-A7
23848?	17886	6090	EB	5.149	5.206	1.76532	8501.4890		−0.2	80	A2-
24188	17543	6210	ACV	6.206	6.235	2.2301	8500.673			<30	A0 Si
26481	19380	6720	EA	8.560	8.870	2.38330	8500.9720				A2-F2
26591	19571	6790	EA	5.840	>6.130	3.6586	8502.817	11	5.5	45	A1-A6
26792	20004	6840		6.701	6.743	3.8031	8501.530				B8 Sr
26961?	20070	6880	ELL	4.600	4.657	1.52735	8501.2430			95	A2 Si
27404	20262	7030	ACV	7.971	8.024	2.77929	8502.4260		2.6		A0 Si
32145	23328	8190	ACV	7.180	7.216	2.42082	8501.3551	37			B8 Si
34719	24906	8850	ACV	6.632	6.665	1.63988	8501.516	44	4.4		A0 Hg Si Cr
294046	25394	9190	SPB	8.231	8.288	0.898544	8500.1830				B9 Si
39220	27971	10520	EB	5.18	5.343	2.93326	8502.56		−0.2	80	A0-
39575	27748	10600	ACV	7.824	7.867	3.1009	8501.85	55			A0 Si Cr Eu
42968	29455	11470	EA	8.460	8.707	2.87211	8500.9091				A0-F1
44691*	30651	11840	EA/DM	5.590	5.980	9.9451	8509.050		3.1	30	A3-F1
44953	30426	11930	ACV	6.550	6.579	5.0465	8501.74	17	0.9	<30	B8 He Fbl.
45439	30587	12040	ACV	7.830	7.892	1.10064	8500.6817	19	1.8		B9 Si
46462	31116	12430	ACV	7.466	7.534	10.3630	8506.734	25	0.8	<30	B9 Si
47144	31457	12660		5.541	5.557	2.21004	8500.6040	14	0.7		B9 Si
47802	31906	12860	ACV	8.493	8.550	1.031227	8500.3646	30			B9 Si
49484	32570	13390		8.240	8.288	7.039	8500.72				B9 Si
49713	32745	13480	ACV	7.276	7.339	2.13503	8501.9352		4.0		B9 Cr Eu Si
50304	32937	13774	ACV	7.556	7.596	7.884	8504.32				A0 Eu Cr
50341	33166	13780	ACV	8.165	8.222	2.50919	8500.4185				B9 Sr Cr Eu
52993	33864	14550	EB	6.527	6.583	1.29644	8501.1043	29		145	B9 Si
56336	35156	15350	ACV	8.992	9.078	1.64029	8501.312	32			B9 Si
56429	35187	15390	EA/DM	7.968	>8.520	4.8002	8502.482				A0-
57119	35407	15590	ACV	8.656	8.790	1.64376	8500.066				B9 Si
60559	36728	16550	EB	6.216	6.243	1.94270	8501.1401		0.2		B8 Si
61073	36971	16700	ACV	9.118	9.208	1.96001	8500.185				B9 Si
62640	37692	17220	ACV	7.995	8.083	0.73573	8500.403	19		45	B9 Si
64784	38416	17760	ACV	7.468	7.506	4.0081	8502.38			25	B9 Si
66546?	39225	18393	EA	6.080	6.200	2.51465	8501.3100		0.8	160	B7 Si
68161?	39919	18840	ACV	5.622	5.651	17.028	8513.10	22			B8
68292	40066	18860	ACV	7.465	7.530	5.7426	8741.69	35		<30	B9 Si
68561	39791	19010	ACV	7.973	8.023	4.2334	8500.085	14		<30	B9 Si
72175	41714	19940	ACV	9.071	9.127	4.494	8501.23				B9 Cr Eu Si
72303	41644	19990	ACV	6.387	6.417	3.7189	8500.830			<30	B9 Si
74067	42540	20630	ACV	5.152	5.196	3.11299	8502.0780	37	3.6	50	A0 Cr Si
74888	42819	20950	ACV	6.780	6.833	1.83807	8500.537	22		60	B9 Si
75202?	43071	21060		7.736	7.774	0.290669	8500.1320				A3-
77653	44337	21970	ACV	5.191	5.220	1.48782	8500.0669	26	0.5	45	B9 Si
79781	45693	22680	ACV	8.662	8.720	0.1348410	8500.1300				F0-F5
80282	45548	22830	ACV	7.537	7.566	2.0499	8501.502	30	1.6	45	A0 Si
81847	46295	23260	ACV	8.280	8.328	1.41299	8500.8380	47	3.5		B8 Si
82567	46452	23480	ACV	7.725	7.774	1.98442	8500.8138	26		<30	B9 Si
82692	46833	23560	ACV	9.310	9.377	4.8910	8504.41				A0 Si
85037	48054	24270	EA	6.560	6.720	2.72290	8501.2500		−0.1		A1-
87488?	49375	25100	ACV	6.932	6.989	18.201	8514.843				B9 Eu Cr

Table 1. b) Table 1a continued

HD	HIC	RNS	Type	Min	Max	Period	Epoch	Δa	Δp	$v \sin i$	Spec.
88158	49642	25240	ACV	6.402	6.422	3.8412	8500.48		0.9	60	B8 Si
88603	49940	25360	ACV	7.860	7.917	1.65776	8501.5360		0.4		B7 Si
91089	51412	26200	ACV	7.449	7.529	2.15060	8500.558			<30	B9 Si
92106	51632	26470	ACV	7.805	7.837	25.36	8515.89			<30	A0 Sr Eu Cr
93226	52634	26920	ACV	7.405	7.444	1.72901	8500.597				A0 Si
95321	53708	27480		9.039	9.090	0.213659	8500.0830				A3-A9
101724	57067	29330	ACV	8.000	8.047	1.40329	8500.019	16	0.4		B9 Si
104810	58835	30330	ACV	7.334	7.399	2.8718	8501.270	19	−0.3	120	B8 Si
105509	59229	30510	EA	5.812	6.011	4.9664	8502.225		2.6		A2-F2
105770	59404	30610		7.394	7.429	3.7163	8503.427	18		<30	B9 Si
106112	59504	30670	EA	5.212	5.244	1.27095	8501.232			78	A4-F3
111709	62774	32420		9.330	9.382	1.18567	8500.752				A4-A8
114125	64120	33030	EA	7.880	8.220	2.73233	8500.5700		3.1		F2-
117057	65776	33780	ACV	8.106	8.168	1.61678	8501.124	17			B9 Si
122314?	68692	35070	EA/DM	7.699	>8.200	3.25728	8503.105		−0.4		A5-
122989	68979	35250	ACV	8.870	8.913	1.67568	8501.4916		2.2		B9 Si
125081	69848	35740		7.414	7.461	0.1539810	8500.0620		1.2		F3 Sr Cr Eu
126198	70530	35970	ACV	7.952	8.039	4.8324	8500.63	12	−0.4		B9 Si
127575	71359	36280	ACV	7.727	7.788	3.7263	8500.123	48		<30	B9 Si
128775	71727	36640	ACV	6.561	6.601	1.63364	8500.4142		3.1	<30	B9 Si
129750?	72377	37000	ACV	7.082	7.140	6.987	8503.34			<30	B9 Si
131120	72800	37270	SPB	4.957	4.980	1.56895	8500.6542		−0.2	130	B7 He Fbl.
132515	73479	37610	EA	8.778	9.094	1.61907	8500.7300				F8 Sr
132742?	73473	37660	EA/SD	4.924	5.933	2.32737	8502.1655		−0.2	75	A0
138764?	76243	39510	SPB	5.111	5.154	1.25859	8500.180		0.2	20	B6 Si
139319?	76196	39670	EA/SD	7.406	8.963	2.80689	8500.9687		0.6	50	A6-F1
141641	77657	40220	ACV	8.875	8.987	3.4364	8500.527	21	1.0		B8 Si
142301*	77909	40380	SXARI	5.841	5.863	1.45955	8501.1291		1.0	50	B8 He Fbl.Si
143473	78533	40620	ACV	7.415	7.473	2.79286	8501.0708	45	2.2	30	B9 Si
143939*	78756	40790	ACV	6.902	6.941	1.8489	8500.701		4.0		B9 Si Cr Eu
145792	79530	41280	ACV	6.398	6.432	0.84780	8500.085		−0.2	25	B6 He Fbl.
147173	80395	41580	ACV	8.706	8.831	1.85789	8500.659				B9 Si
149250	81554	42230	ACV	9.275	9.344	3.5478	8501.545				A0 Eu Cr
149420?	81066	42290		6.923	6.954	1.6972	8501.303			25	A9-
149764	81477	42360	ACV	6.920	6.976	0.639328	8500.3692	21		70	A0 Si
151363	82335	42820	ACV	7.781	7.823	2.57281	8502.3182			105	B9 Si
152564	83150	43220	ACV	5.746	5.769	2.1637	8500.527		0.9	75	A0 Si
154856	84025	43750	ACV	8.767	8.824	1.9525	8501.486				B8 Si
156049	84686	44020	ACV	8.211	8.306	1.80495	8500.6500				B9 Cr Eu
159829	86712	44960	EA	9.648	10.022	4.2799	8503.210				A2-A8
161841	87257	45680	ACV	7.516	7.564	3.21048	8500.738	14	−0.2		B9 Si
162613	87580	45910	ACV	7.950	8.008	3.5832	8501.123				A0 Si
165814?	88905	46706	EB	6.686	7.148	2.24810	8502.2030		−0.1		B9 Si
166427	89225	46840	ACV	8.096	8.145	1.96607	8500.4720			35	B9 Si Sr
167356?	89470	47035	ACV	6.091	6.123	2.3595	8501.138		2.6	25	A1 Si
167858?	89601	47080		6.660	6.747	1.30700	8500.193		−0.3	13	F0
168403?	89955	47190	ACV	6.802	6.851	4.7992	8501.584				A0 Eu Cr Sr
169952	90293	47600	ACV	7.321	7.349	2.1223	8500.673		1.5		B9 Si
171184	91001	47930	ACV	7.928	7.995	2.79926	8500.3360				A0 Si
171263	90990	47960	ACV	7.778	7.837	3.9980	8503.131				B8 Si
171782	91224	48130	ACV	7.832	7.883	4.466	8500.69				B9 Si Cr Eu
174638?	92420	48890	EB	3.373	4.317	12.940	8512.086		4.0	120	B8 He
179213?	94693	49790	EB	9.067	9.253	2.50364	8501.3024				A3-A9
182255\	95260	50370	SPB	5.144	5.182	1.26239	8500.727		−0.4	40	B6 He Fbl.
184242	96011	50840	EA	6.938	>7.180	1.86742	8501.1262				A3-A9
187418?	97756	51680	EB	8.292	8.750	1.61311	8500.44		2.0		A2-A7

Table 1. c) Table 1b continued

HD	HIC	RNS	Type	Min	Max	Period	Epoch	Δa	Δp	$v \sin i$	Spec.
190786?	98955	53060	EA/DM	8.566	>9.320	2.34698	8500.6622			40	A1-A3
191439	99615	53340	ACV	8.888	8.927	1.62718	8500.1028	46			B9 Cr Eu Sr
193637	100258	54040	EA/DM	8.39	9.030	4.00519	8500.58		2.5		A5-F2
196270	101569	54710	ACV	8.173	8.221	1.30217	8500.3993		1.7		B9 Si
197018	101949	54940	ACV	6.020	6.038	5.960	8501.58		0.3		B7 Mn
199532	104043	55600	EB	5.221	5.260	2.87700	8500.3616		1.9	85	F2-
204038?	105739	56830	EW/KE	8.321	8.720	0.785848	8500.5030		0.2		A3-F0
205938	106604	57340	ACV	6.415	6.467	8.340	8506.79				B9 Si
206155	106981	57410	EA/DM	6.997	7.607	2.62817	8502.2388			40	A2-A5
206653	107525	57500	ACV	7.161	7.205	1.78706	8500.670	23		<30	B9 Si
207098*	107556	57630	EB	2.920	>3.070	1.022767	8500.8500		0.6	90	A5-F4 DD
210071*	109124	58470	E	6.332	6.401	1.43246	8500.9310		0.6	75	B9 Si Cr Hg
213871	111360	59320	ACV	7.344	7.395	1.9505	8500.925				B9 Si
219815	115065	60340	EB	6.014	6.171	3.21952	8500.732			80	A5-F2
220147	115267	60450	ACV	8.120	8.175	10.990	8501.978				B9 Cr Si Eu
220885?	115755	60550	ACV	5.733	5.770	1.47946	8500.055		1.1	55	B9 Mn
223967?	117853	61360	ACV	7.029	7.063	1.27712	8500.643				B9 Si

Notes to Table 1:
Col. 1: HD number with probability mark according to Renson (1991).
Col. 2: HIC number.
Col. 3: Renson number.
Col. 4: type of variability, abbreviations as in the HVA.
Cols. 5, 6: Min and Max of the variations.
Col. 7: observed period in days.
Col. 8: Epoch as in the HVA.
Cols. 9, 10: Δa in mmag and Δp.
Col. 11: $v \sin i$ value from the literature.
Col. 12: spectral type according to Renson (1991).

2. Program stars

The catalogue of Ap and Am stars by Renson (1991) was used to search for entries in the HVA. 293 objects were found in the first part (periodic variables) whereas 106 objects are included in the second part (unsolved variables). The latter will be discussed in a forthcoming paper. From these 293 objects, we excluded 33 because:

- Twelve are well known δ Scuti or δ Delphini stars and no "classical" CP stars, these are: HD 2628, HD 67523, HD 67911, HD 93137, HD 101696, HD 106384, HD 115604, HD 172748, HD 185139, HD 197461, HD 201707 and HD 213534.
- Eighteen have no period due to poor phase coverage or other reasons, these are: HD 5303, HD 30050, HD 34364, HD 36412, HD 40183, HD 82829, HD 89143, HD 113158, HD 128661, HD 156965, HD 161321, HD 178001, HD 185257, HD 187474, HD 205234, HD 209147, HD 215661 and HD 216429.
- Three are very probably no CP stars since the exhibit a non-peculiar Δa index despite their B-type characteristics, these are: HD 24587 (B6; $\Delta a = -1$), HD 38602 (B9 Si; $\Delta a = -2$) and HD 66546 (B7 Si; $\Delta a = -6$).

From the remaining 260 program stars, half have already been included in the catalogue of observed periods of Ap and Bp stars by Catalano & Renson (1997). We will discuss only those cases where the period given in this catalogue does not agree (within the error bars) with HVA. In the following we will concentrate on the newly discovered variable CP stars. The fraction of rotationally variable CP stars constitutes an increase of about 20 percent related to the catalogue of Catalano & Renson.

3. Results

In order to reinforce the assignments of peculiarity in Renson's catalogue, additional parameters for the intrinsic (chemically) peculiarity such as Δa (Maitzen 1976) and Δp (Masana et al. 1998) are presented. Unfortunately, Δp is not as specific (for CP2 stars) as the Δa index especially for stars later than A0. We have not included the Geneva peculiarity index Δ(V1–G) because of its dependence on the interstellar reddening.

Six stars (HD 40312, HD 148112, HD 151965, HD 175362, HD 193722 and HD 219749) from Catalano & Renson (1997) have a period agreeing with HVA but the period quoted there from the literature does not agree with that of Catalano & Renson.

Furthermore we have identified eight possible members (HD 4058, HD 75202, HD 79781, HD 95321, HD 111709, HD 125081, HD 149420 and HD 167858) of the γ Doradus stars (Breger & Beichbuchner 1996). The given spectral types and found periods are typical for this group of pulsating stars. But further observational efforts are needed to establish their true nature.

The following stars deserve further attention:
HD 4058: Budaj (1996) reported a period which is one day longer than that of the HVA.
HD 23848: The period extracted from literature in the HVA is not correct, Martin & Hube (1988) reported $P = 1.765346$ d.
HD 30466: according to the Photometric Notes and References of HVA the published period 1.3900 days taken from Rakosch & Fiedler (1978) does not fit the Hipparcos data. Vice versa the Rakosch & Fiedler data yield a nearly perfect scatter diagram when reduced with the Hipparcos period of 4.0779 days. This fact is supported by the data basis of Maitzen (1977) leading to a period (2.7795 d) not in accord with the HVA period. On the other hand Maitzen's period reveals a double wave light variation in agreement with the light curve of HVA. A possible cause for deriving a discordant period is the low degree of variability in the Hipparcos photometric band whereas the variability for hot CP2 stars is more pronounced in bluer bands where Rakosch & Fiedler, as well as Maitzen obtained their observations.
HD 74067: There seems to be a misclassification of the variability type (BCEP) in the HVA. Since this star is classified as A0 Cr Sr in Renson (1991) we tend to believe that the variations are due to rotation.
HD 85037: Renson (1983) derived a period which is half the value from HVA.
HD 126515: There is practically unanimous agreement on a 130 days period of this outstanding magnetic star, based on published photometric, spectroscopic and magnetic field variations (see e.g. North & Adelman 1995). The HVA period of 3.16414 days yields a light curve with rather enhanced scatter and should be considered as artifact of the intrinsically long period together with a rather low level of variability in the photometric band of Hipparcos.
HD 145792: Cernicharo et al. (1985) used this star as (an a priori constant) comparison star for HD 145102 and HD 147010. They found periods of 1.69253 and 3.99827d, respectively. These results are probably influenced by the variability of HD 145792 and have to be reanalyzed.
HD 182255: This star is a single-lined spectroscopic binary system with a period of 367d. Hube & Aikman (1991) reported additional variations with an interval of 1.09d. This results is confirmed by HVA although the period is slightly longer.

The newly found rotation periods of stars with known $v \sin i$ values (taken from Uesugi & Fukuda 1982, Abt & Morrell 1995 and Levato et al. 1996), were used (34 objects in total) to test the oblique rotator model. An implication of this model is that the relationship between

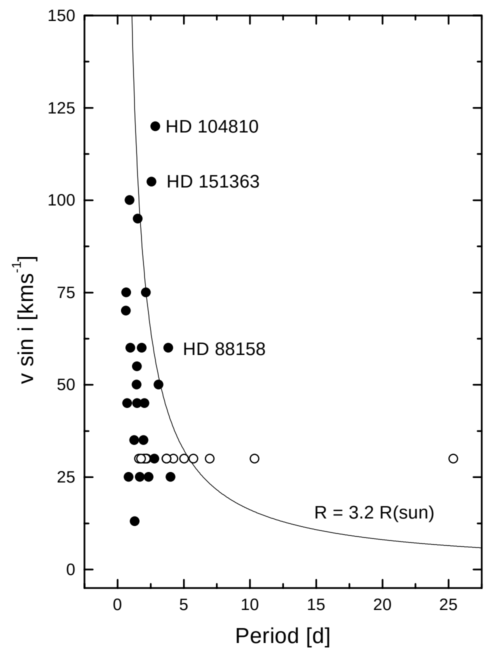

Fig. 1. P vs. $v \sin i$ for 34 CP stars. The open circle indicate stars with only upper values for $v \sin i$ found in the literature

the observed period and the apparent rotation can be estimated as (Preston 1971):

$$v = \frac{50.6\,R}{P}$$

where v is the equatorial rotational velocity, R is the stellar radius in solar units and P is the observed period in days. Since only the projected rotational velocity can be determined, all stars should fall *below* the given relation assuming a certain stellar radius. Figure 1 shows this relation for the selected 34 objects assuming $R = 3.2\,R_{\odot}$. Only three stars (HD 88158, B8 Si; HD 104810, B8 Si and HD 151363, B9 Si) seem to lie above the chosen upper limit. Taking into account that in reality there should be a certain spread in stellar radii we feel justified to state that this result fits nicely into the constraints of the oblique rotator model and therefore also supports the peculiar nature of these stars.

It is interesting to note that all 26 bona fide CP1 stars (beside the eight possible γ Doradus candidates) are members of eclipsing binary systems and no other kind of variability was detected.

Acknowledgements. This research was carried out within the working group *Asteroseismology-AMS* with funding from the Fond zur Förderung der wissenschaftlichen Forschung (project *S7303-AST*). Use was made of the Simbad database, operated at CDS, Strasbourg, France.

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