A&A 407, 631–642 (2003)
DOI: 10.1051/0004-6361:20030741

Astronomy & Astrophysics

Catalogue of averaged stellar effective magnetic fields

I. Chemically peculiar A and B type stars*

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Received 4 November 2002 / Accepted 7 May 2003

Abstract. This paper presents the catalogue and the method of determination of averaged quadratic effective magnetic fields $\langle B_e \rangle$ for 596 main sequence and giant stars. The catalogue is based on measurements of the stellar effective (or mean longitudinal) magnetic field strengths B_e, which were compiled from the existing literature.

We analysed the properties of 352 chemically peculiar A and B stars in the catalogue, including Am, ApSi, He-weak, He-rich, HgMn, ApSrCrEu, and all ApSr type stars. We have found that the number distribution of all chemically peculiar (CP) stars vs. averaged magnetic field strength is described by a decreasing exponential function. Relations of this type hold also for stars of all the analysed subclasses of chemical peculiarity. The exponential form of the above distribution function can break down below about 100 G, the latter value representing approximately the resolution of our analysis for A type stars.

Key words. stars: magnetic fields – stars: fundamental parameters

1. Introduction

Research on stellar magnetic fields is among the most important issues in both observational and theoretical astrophysics. The first measurements of magnetic fields in stars were done more than 50 years ago (Babcock & Burd 1952). From that time, both the number of magnetic field measurements and the number of investigated stars have grown enormously. Therefore we decided to collect and present in some homogeneous form all the published magnetic field measurements. We have also attempted to analyse these preprocessed observational data.

Similar efforts have been made previously, but were based on much less numerous sets of measurements (Brown et al. 1981; Borra et al. 1983; Glagolevskij et al. 1986; Bychkov et al. 1990). The above compilations have been essential for our understanding of the magnetic field strength and structure in stellar atmospheres, and their generation and time evolution in stellar interiors. Taking into account the large increase of the accumulated observational material, we believe that analogous new research of this kind is necessary and fully justified.

The catalog and analyses presented below do not include either isolated degenerate stars (cooling neutron stars and most white dwarfs), or degenerate stars in interacting binaries. Only a few of the brightest white dwarfs are present in the catalog.

2. Averaging of stellar effective magnetic fields

The differential contribution $\mathrm{d}B_e$ to the effective magnetic field of a star is defined as the area-weighted projection of the local vector of the magnetic field $\boldsymbol{B}_{\rm loc}$ onto the line of sight. The local monochromatic intensity I_ν of outgoing radiation is also a weighting factor in that projection. The effective (or mean longitudinal) magnetic field B_e is the weighted mean value, integrated over the visible stellar disc

$$B_e = \frac{\int_0^{2\pi}\int_0^{\pi/2} B_{\rm loc}\cos\gamma\, I_\nu(\theta)\sin\theta\cos\theta\,\mathrm{d}\theta\,\mathrm{d}\varphi}{\int_0^{2\pi}\int_0^{\pi/2} I_\nu(\theta)\sin\theta\cos\theta\,\mathrm{d}\theta\,\mathrm{d}\varphi}, \tag{1}$$

where γ denotes the angle between the local vector $\boldsymbol{B}_{\rm loc}$ and the direction towards the observer. The variable θ denotes the colatitude angle, and φ stands for the azimuthal angle of the angular integration. The above definition assumes a simplified situation, in which the B_e is determined at a single discrete frequency only (Madej 1983).

In general, the specific intensity of radiation $I_\nu(\theta)$ depends strongly on the frequency of radiation ν, and exhibits various

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[*] Table A.1 and its references are only 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/cgi-bin/qcat?J/A+A/407/631`
and Tables 3 to 9 are only available in electronic form at `http://www.edpsciences.org`

limb-darkening relations for different νs. Therefore the value of the effective magnetic field $B_{\rm e}$ is also a frequency dependent quantity, when measured for the given magnetic field configuration of a star.

The dependence of $B_{\rm e}$ on frequency, or on the finite range of frequencies in which measurements were done, has always been ignored in earlier papers, which are collected and analysed here. Therefore also in this paper we do not distinguish $B_{\rm e}$ values measured in the wings of the hydrogen Balmer lines, or elsewhere in the optical spectra of stars.

In most magnetic stars the values of $B_{\rm e}$ change periodically with the rotational phase of the star. Values of $B_{\rm e}$ can be either positive or negative. Moreover, it is possible that a star with strong magnetic field can momentarily exhibit $B_{\rm e} = 0$, depending on the aspect. Therefore it is useful to characterize the magnetic properties of various stars by the averaged quadratic effective magnetic field $\langle B_{\rm e} \rangle$, which is always positive (Borra et al. 1983).

For a series of $B_{\rm e}$ measurements, we define

$$\langle B_{\rm e} \rangle \;=\; \left(\frac{1}{n} \sum_{i=1}^{n} B_{{\rm e}i}^2 \right)^{1/2}, \tag{2}$$

$$\langle \sigma_{\rm e} \rangle \;=\; \left(\frac{1}{n} \sum_{i=1}^{n} \sigma_{{\rm e}i}^2 \right)^{1/2}, \tag{3}$$

where $B_{{\rm e}i}$ denotes the ith measurement of the effective magnetic field, and n is the total number of observations for a given star. The variable $\sigma_{\rm ei}$ is the standard error of $B_{{\rm e}i}$, and $\langle \sigma_{\rm e} \rangle$ is the rms standard error of $\langle B_{\rm e} \rangle$.

The value of χ^2/n (given per single degree of freedom) allows one to judge whether a series of $B_{{\rm e}i}$ for a given star represents a reliable detection of a nonzero effective magnetic field, or whether this series is rather the result of random noise

$$\chi^2/n = \frac{1}{n} \sum_{i=1}^{n} \frac{B_{\rm ei}^2}{\sigma_{\rm ei}^2}. \tag{4}$$

This method for averaging the individual $B_{\rm e}$ measurements of a magnetic star was introduced by Borra et al. (1983), to study magnetic properties of He-weak stars. This evaluation of $\langle B_{\rm e} \rangle$ is particularly useful to study stars with few or high noise $B_{\rm e}$ observations, where full magnetic curves cannot yet be constructed.

Borra et al. (1983) have pointed out that the value of $\langle B_{\rm e} \rangle$ gives an estimate of the amplitude of the $B_{\rm e}$ variations of a given star, provided that this amplitude is substantially larger than $\langle \sigma_{\rm e} \rangle$.

3. Description of the tables

Descriptions of stars and the available magnetic field data about each are included in a series of 10 tables. The basic and most extensive Table A.1, included in Appendix A, presents the full listing of stars for which we performed computations of the quadratic $\langle B_{\rm e} \rangle$ averages. For convenience, these stars are ordered according to their HD number. Successive rows of Table A.1 give: HD number (or BD number in case of faint stars), spectral type, number N of magnetic observations, value of $\langle B_{\rm e} \rangle$ in G, standard deviation σ in G, value of χ^2/n, method of $B_{\rm e}$ determination (abbreviations are explained at the bottom of Table A.1), and numbers referring to papers where we found the original magnetic field measurements. Cross-references between these numbers and the original papers are also given at the bottom of Table A.1.

Table 1. Best fit parameters.

Peculiarity	N	a_1(%)	a_2 (G)	30%	50%	70%
all Ap	352	97.2	789.2	928	525	259
Sr all	167	106.9	1081.2	1360	819	448
Sr only	126	108.6	1018.1	1310	790	447
Am	44	95.3	110.5	127	71	34
He-rich	19	97.2	916.1	1080	609	301
He-weak	60	116.0	717.9	970	604	363
Hg & Mn	39	74.9	515.7	471	208	34
HgMn only	19	75.2	350.1	322	143	25
Si	159	102.0	906.1	1110	646	341

[a] Some of the stars exhibit few different peculiarity types simultaneously, and they are counted in more than one row of Table 1.

Table A.1 contains magnetic data on a total of 596 stars of various spectral types. One can easily see that in the case of many stars listed there, the value of $\langle B_{\rm e} \rangle$ is approximately equal or smaller than $\langle \sigma_{\rm e} \rangle$, which usually means that detection of the magnetic field itself highly uncertain.

Table 1 summarizes our results on the distribution of averaged effective magnetic fields in Ap type stars of various subclasses. In this table, the number N in the second column displays the number of stars of a given peculiarity type in our sample.

One should note that some CP stars exhibit more than one type of chemical peculiarity simultaneously. For example, it is a well known observational fact that some Si-type stars appears also as He-weak stars, etc. When this happened, we have included such ambiguous stars in both samples. Consequently, the sum of all Ap stars (352) is lower than the number of stars summed over all particular types of peculiarity in Table 1.

Tables 2–9, which are put in the main body of the paper, present lists of the 352 Ap stars of the sample distributed into various types of spectral peculiarity. The tables present individual stars and give for each of them: HD number, HR number, name of the star (or BD number), and spectral type including the type of peculiarity. No magnetic field data are listed here.

Due to enormous complexity of Sr-like chemical peculiarities which have been identified in some Ap stars, we have attempted to separate 136 stars which exhibit essentially only the SrCrEu spectral type. These stars are listed in Table 8. Complementing this table, Table 9 presents list of the other 43 Sr-type stars which exhibit SrCrEu type mixed with other peculiarities. The logical sum of Tables 8 and 9 forms the class “Sr all”, which contains 179 stars and is a single entry in Table 1.

The stars listed in Tables 2–9 are exactly the objects which were used to construct Figs. 1–9, and to obtain number

Table 2. List of He-weak stars.

HD	HR	Name	Sp. type
4778	234	GO And	A1 CrSrEu He-w
5737	280	α Scl	B6p SrTi He-w
19400	939	θ Hyi	B3V+A0IV He-w
19805		PPM45935	A0 He-w Si
21699	1063	V396 Per	B8IIIp MnSi He-w
22470	1100	20 Eri	B9p Si He-w
22920	1121	22 Eri	B8p Si4200 He-w
23387		PPM92834	A0 He-w SiCr
23408	1149	20 Tau	B8IIIp Hg He-w
28843	1441	DZ Eri	B5-B9 Si He-w
35298		V1156 Ori	B6 He-w
35456		GC 6661	B7 He-w
35502		BD -2 1241	B6 He-w
36313		V1093 Ori	B8 Si He-w
36429		PPM149092	B4 He-w
36526		V1099 Ori	B8 He-w
36540		V1101 Ori	B7 He-w
36629		PPM188166	B3 He-w
36668		V1107 Ori	B7 Si He-w
36916		V1045 Ori	B8 SiMn He-w
37043	1899	ι Ori B	O9III He-w
37058		V359 Ori	B3p SrTi He-w
37129		PPM188247	B2.5Vp He-w
37140		V1130 Ori	B8 He-w SiSr
37151		V1179 Ori	B8pSi He-w
37210		V1133 Ori	B8 He-w Si
37642		V1148 Ori	B9 Si He-w
37807		PPM188352	B4 He-w
49333	2509	12 CMa	B7IIIp He-w Si
49606	2519	33 Gem	B7III MnHgSi He-w
51688	2605	40 Gem	B8III Hg He-w
79158	3652	36 Lyn	B9IIIp SrTiMn He-w
109026	4773	γ Mus	B5V He-w
120709	5210	V983 Cen	B5III He-w
125823	5378	V761 Cen	B7IIIpvSi He-w
131120	5543		B7IIIpSi He-w
137509		NN Aps	B8p SiCrFe He-w
142301	5912	V927 Sco	B8IIIp Si He-w
142884		V928 Sco	B9 Si He-w
142990	5942	V913 Sco	B6IV He-w
143699	5967		B4(6)IV He-w
144334	5988	V929 Sco	B4(8)p Si He-w
144661	5998		B4(7)IIIp He-w
144844	6003		B5(9)IVp Si He-w
145501	6026	14 ν Sco	B8V+B9p Si He-w
146001	6054		B6(B7IV) He-w
148199		GC 22126	B9 SiSr He-w
162374	6647	V957 Sco	B7V He-w
168733	6870	V4050 Sgr	B8p TiSr He-w
175156	7119		B4(5)II SrTi He-w
175362	7129	V686 CrA	B6IVp SiMn He-w
179527	7283	19 Lyr	B9p Si He-w
182568	7372	2 Cyg	B3IV He-w
183339	7401		B8IV Si He-w
200311		BD+43 3786	B9p SiCrHg He-w
202671	8137	30 Cap	B6(8)III SrTi He-wm
212454	8535		B8III SrCrEuHg He-w
217833	8770	V638 Cas	B9III SiCr He-w
218393		PPM41495	Bpe He-w
224926	9087	29 Psc	B6(7)III-IV Si He-w

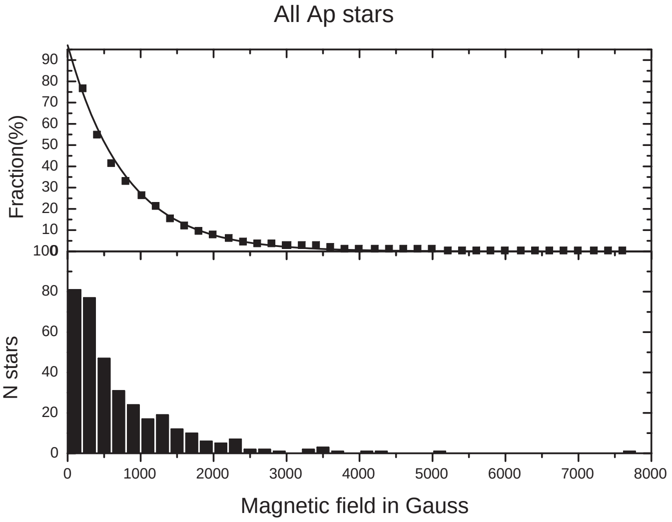

Fig. 1. Integrated distribution function $N_{\mathrm{Int}}(B)$ in percent (upper panel), and the number distribution function $N(B)$ (lower panel) for all Ap stars.

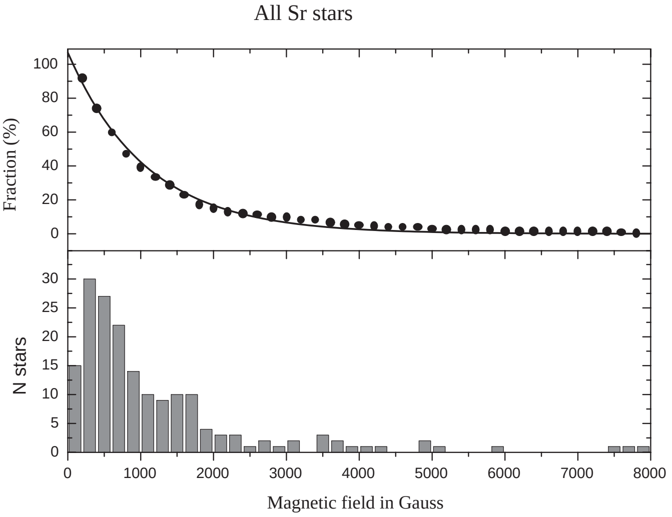

Fig. 2. The same for all Sr type stars, also those with mixed peculiarities.

distribution functions of the averaged quadratic magnetic fields $\langle B_\mathrm{e}\rangle$ for each types of peculiarity considered among the A type stars on the main sequence.

3.1. Reevaluation of $\langle B_e\rangle$ errors

For many years observers have always estimated the *standard error* of effective magnetic field measurements. However, some early papers tabulated probable errors of B_e, which should be transformed to standard errors to ensure their compatibility.

Moreover, some of the early $\langle B_\mathrm{e}\rangle$ measurements have unrealistically small standard errors of the order of a few tens of G. This comment refers mostly to photographic magnetic field observations; see papers by Babcock et al. in the list of references, for example.

An independent error estimate of published B_e determinations can be obtained by one of the following methods.

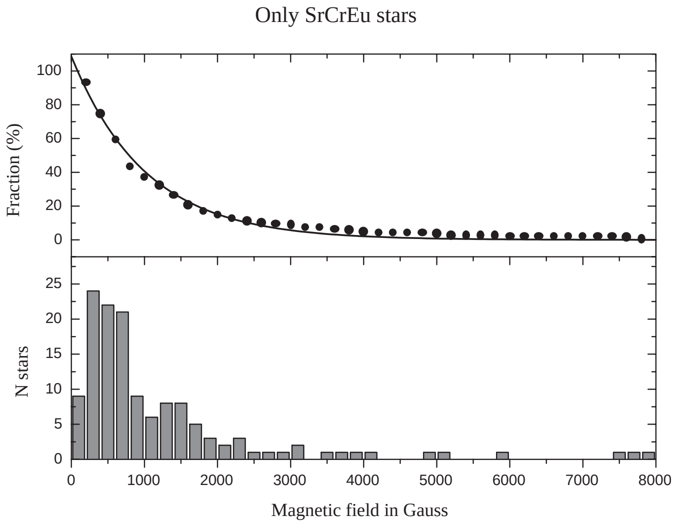

Fig. 3. The same for SrCrEu stars.

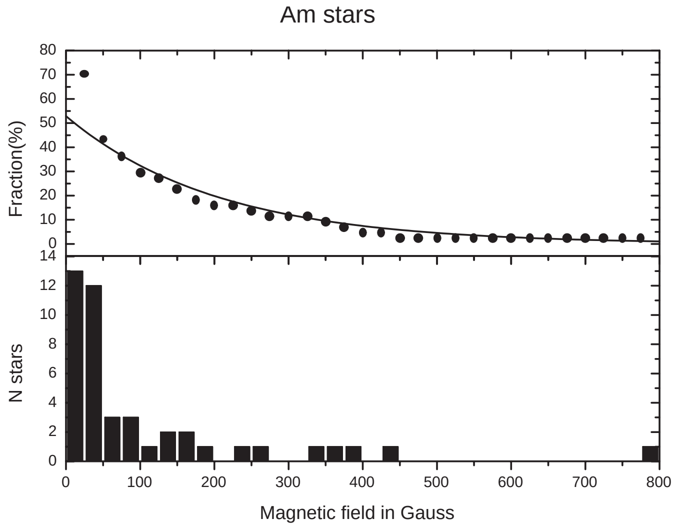

Fig. 4. The same for Am stars.

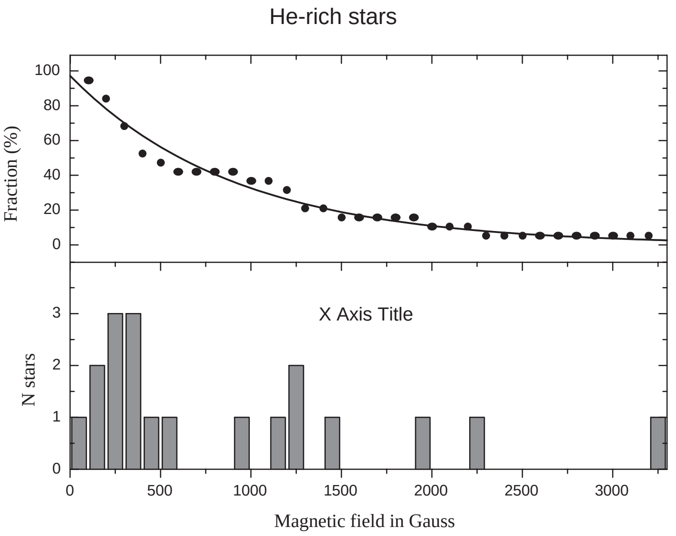

Fig. 5. The same for He-rich stars.

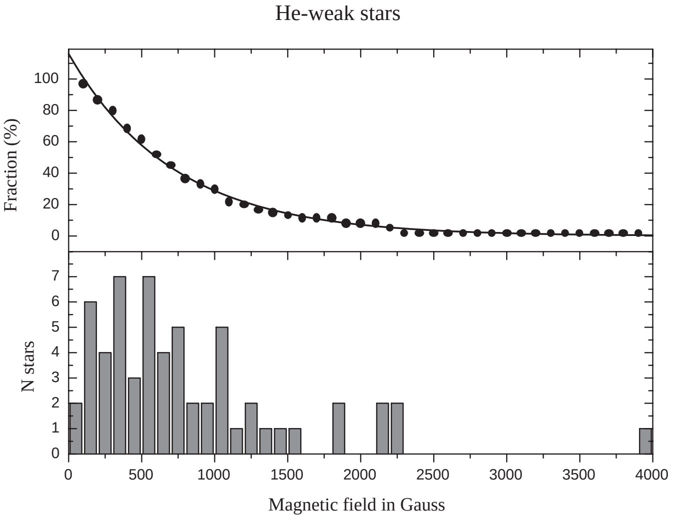

Fig. 6. The same for He-weak stars.

1. Consider a star with no apparent B_e variations. In the case where we have a sufficiently large set of B_e measurements, we can simply determine the mean $\langle B_e \rangle$ value and the error of a single B_e measurement in the standard manner.

2. If the magnetic field B_e varies with time, and the parameters of phase variability are unknown, then we can estimate the $\langle B_e \rangle$ and the upper limit of error of a single measurement in the same standard way. In this case the observed scatter of individual B_e observations include both real errors plus the unknown magnetic field variability. The lower the contribution of B_e variability is to the scatter, the more realistic the error estimates are.

3. If the magnetic field varies with time, and if the parameters of (periodic) phase variability are known, then we simply determine the mean $B_e(\varphi)$ phase curve and compute the predicted magnetic field strength corresponding to each observed point. Finally, we determine the error of single measurement as was done in paragraph **1**.

The general considerations presented above should be supplemented by the following comments:

4. The averaged value of the effective field, $\langle B_e \rangle$, significantly depends on the choice of useful spectral lines. This is particularly important for early observations, since then analysing instruments worked in narrow spectral windows (200–300 Å), and the number of lines used for the B_e determination was very small.

5. The best average $B_e(\varphi)$ curves were obtained analysing Zeeman splitting of the Balmer lines. However, B_e measurements obtained from Balmer lines and metallic lines can differ substantially due to the well-known effect of inhomogeneous distribution of elements over the surface of a magnetic star.

6. The accuracy of B_e measurements depends not only on the particular set of spectral lines and their total number, but also on the apparent rotational broadening, i.e. on $v \sin i$. Rotational broadening of lines strongly influences the accuracy.

In order to obtain reliable error estimates of older B_e measurements, we have selected 21 stars observed by the

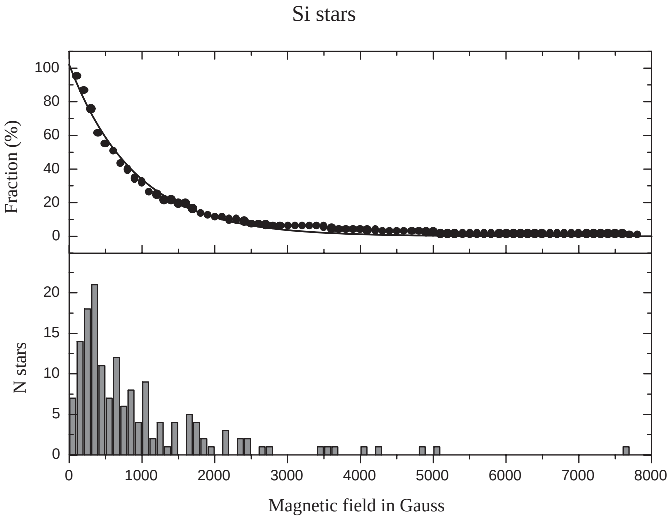

Fig. 7. The same for Si stars.

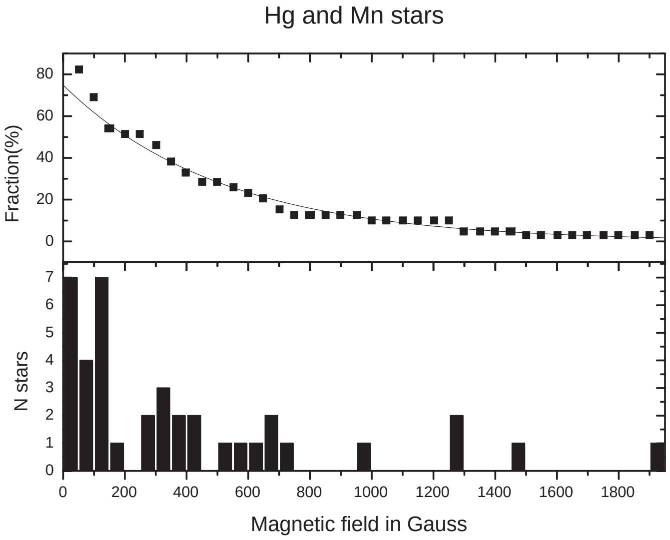

Fig. 8. The same for all stars including Hg or Mn, also of mixed peculiarities.

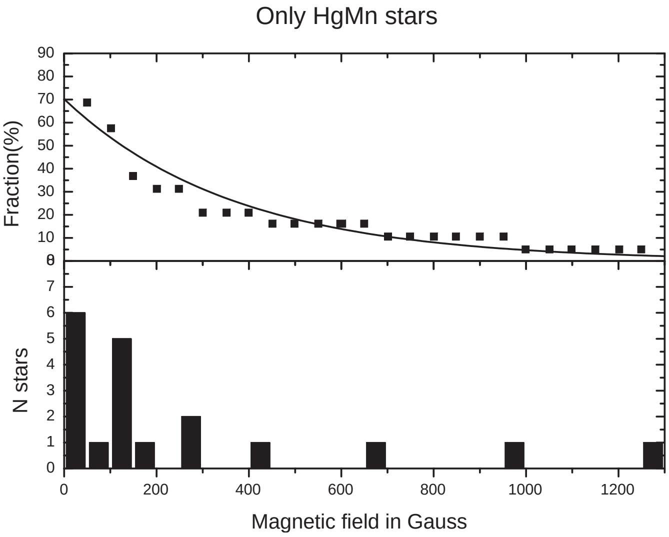

Fig. 9. The same for classical HgMn stars.

following authors: H. W. Babcock, G. W. Preston, S. C. Wolff. and W. K. Bonsack. Those stars were not necessarily observed by all four of them. We also took into account papers in which they were present in the author's list (cf. Bibliography in this paper).

The set of 21 stars consists of (HD numbers): 9996, 18296, 24712, 32633, 62140, 65339, 71866, 74521, 112413, 118022, 125248, 133029, 137909, 152107, 153882, 168733, 175362, 187474, 188041, 196502, 201601, and 215441. For all of them projected rotational velocities $\upsilon \sin i$ are known. Numerous B_e determinations for these stars were obtained both with the "old" photographic technique, and with new high-accuracy methods. Details of our error calibrations of the earliest B_e, and its dependence on both $\upsilon \sin i$ and the effective temperature T_eff, will be presented in a forthcoming paper.

From our analysis, we obtained the following standard errors of B_e, corresponding to photographic observations of the most active authors:

Babcock, H.W. $\sigma = 237.6 \times \exp(0.0465\, \upsilon \sin i)$
Wolff, S.C. $\sigma = 196.4 \times \exp(0.0369\, \upsilon \sin i)$
Preston, G.W. $\sigma = 194.9 \times \exp(0.0558\, \upsilon \sin i)$
Bonsack, W.K. $\sigma = 151.3 \times \exp(0.0610\, \upsilon \sin i)$.

The standard error σ is given in G, and velocity $\upsilon \sin i$ is in km s^{-1}. As is evident, the accuracy of B_e measurements increases from the earliest observations by H. W. Babcock to later data by W. K. Bonsack.

We have recomputed errors of B_e measurements of the above observers with the above relations in all cases in which their original errors were not given or were apparently unrealistically small. In this way have ensured compatibility of the earliest and modern B_e determinations.

4. Distribution of averaged effective magnetic fields

Let us substitute $B = \langle B_\mathrm{e} \rangle$ for brevity. From the data collected in Table A.1 and in Tables 2–9 we have constructed two types of relations. They display the dependence of the number distribution function $N(B)$, and its integral over B, on the average effective magnetic field B of the A type stars.

Quantity $N(B)\,\mathrm{d}B$ gives the number of stars in a given group having the average quadratic effective magnetic field B in the range $[B, B + \mathrm{d}B]$.

4.1. Integrated distribution function

We define the integrated distribution function as

$$N_\mathrm{Int}(B) = N_\mathrm{tot} - \int\limits_0^B N(B')\,\mathrm{d}B', \tag{5}$$

where $N_{\rm tot}$ denotes the total number of stars belonging to that group.

We have investigated separately $N(B)$ for Am, He-weak, He-rich, Si, HgMn, SrCrEu, all Sr-type, and all stars displaying Hg or Mn. Discussion of the distribution function for stars of other spectral types has been deferred to the following papers.

For a given subclass of stars, we have divided the range of the quadratic averaged magnetic field $\langle B_{\rm e}\rangle$ from zero to the maximum field in this group into up to 40 bins of equal length (80 bins for Si stars), and counted the number of stars in each bin. Figures 1–9 display the relation between the discrete $\langle B_{\rm e}\rangle$ and the summed number of stars located in higher bins, expressed in percent of the total number of stars in that peculiarity class. Such a relation represents the integrated distribution function $N_{\rm Int}(B)$, and describes the probability that upon investigating a new star of this chemical peculiarity, its $\langle B_{\rm e}\rangle$ will be higher than the value of B. That relation is given by series of dots in the figures.

Figures 1–9 demonstrate the striking rule, that all the corresponding functions $N_{\rm Int}(B)$ are well approximated by the exponential function, normalized to unity at $B = 0$

$$N_{\rm Int}(B)/N_{\rm tot} = \frac{a_1}{100\%}\,\exp\left(-B/a_2\right). \qquad (6)$$

Coefficients a_1 (in %) and a_2 (in G) depend on the class of chemical peculiarity.

Columns 3–4 of Table 1 present the best fit coefficients a_1 and a_2 for all the analysed subclasses. The last three columns present the fixed values of magnetic field intensity $\langle B_{\rm e}\rangle^{\rm fix}$ (in G), defined that the number of stars with $\langle B_{\rm e}\rangle \geq \langle B_{\rm e}\rangle^{\rm fix}$ constitutes 30%, 50%, and 70% of the total number of stars belonging to this peculiarity type, cf. Col. 2. In fact, these three columns are just some exemplary solutions of Eq. (6) for the magnetic field B.

4.2. The distribution function

The distribution function can immediately be obtained from $N_{\rm Int}$ by the relation

$$N(B) = -\frac{{\rm d}N_{\rm Int}}{{\rm d}B}\cdot \qquad (7)$$

The function $N(B)$ is therefore also an exponential function with the above analytic approximation

$$N(B) = N_{\rm tot}\,\frac{a_1}{100\%}\,a_2^{-1}\,\exp\left(-B/a_2\right). \qquad (8)$$

If one attempts to construct the distribution function in direct way, based on the tabulated data, then this function would exhibit serious noise due to the limited number of data points.

One should note that the above exponential dependence has been determined using a resolution $\Delta B \approx 100$ G only, which corresponds to average size of single bin in Figs. 1–9. This implies that with our method of figure construction, we cannot say anything about the shape of the distribution function in the region of the weakest magnetic fields B below ≈100 G. Note that the value of ΔB resolution mentioned above is averaged over all spectral subclasses, in fact, it is in the range $\Delta B = 25{-}200$ G (see the figures).

It is important to stress here, that we have set the total number of stars of a given subtype $N_{\rm tot}$ to 100%, no matter whether the given stars had detectable magnetic fields or not.

4.3. Distortion of the distribution functions

The referee pointed out that our $\langle B_{\rm e}\rangle$ and $\langle\sigma_{\rm e}\rangle$ statistics, and the distribution functions $N_{\rm int}$ presented in this paper, can be distorted due to the following reasons.

1. Errors of $B_{\rm e}$ measurements taken by different observers and techniques sometimes strongly differ. In such case average values of $\langle B_{\rm e}\rangle$ and $\langle\sigma_{\rm e}\rangle$ in Table A.1 can be inflated by few very inaccurate measurements with large individual $\sigma_{\rm e}$, cf. Eqs. (2) and (3). This is particularly important for stars with weak magnetic fields, for which the number of available $B_{\rm e}$ observations is small (e.g. the Am star 68 Tau).

The most accurate $B_{\rm e}$ measurements should weight mostly when computing averages $\langle B_{\rm e}\rangle$ and $\langle\sigma_{\rm e}\rangle$. However, Eqs. (2) and (3) defined by Borra et al. (1983) assign the same weight of unity to all $B_{\rm e}$ measurements; i.e. their $\langle B_{\rm e}\rangle$ and $\langle\sigma_{\rm e}\rangle$ statistics are most meaningful when they resulted from data with comparable errors. In the present paper we follow strictly the above definitions, Eqs. (2), (3), and did not alter them in any way e.g. by eliminating $B_{\rm e}$ data of outstanding $\sigma_{\rm e}$ errors.

2. The above effect implies also, that the distributions of $N_{\rm int}$ are certainly distorted by inclusion of stars for which $\langle B_{\rm e}\rangle$ has been exaggerated. This is particularly important at low field end of $N_{\rm int}$ for all subclasses of Ap stars, and for the whole group of essentially nonmagnetic Am stars, see Fig. 4 (see also the following subsection). Therefore runs of $N_{\rm int}$ derived in this paper certainly are distorted below ≈100 to 300 G, or so,

In spite of this effect we believe that even for Am stars constructing our $N_{\rm int}$ makes sense, because it represents the upper limit constraining their true distribution, $N_{\rm int}^{\rm true}$.

4.4. Low magnetic fields

One can easily see that the distribution function $N(B)$ exhibits a significant drop of the averaged quadratic field at the limit $B \rightarrow 0$. Such behaviour can be seen for almost all of investigated classes of chemical peculiarities, with the exception of Am stars only.

The origin of this behavior of the directly measured $N(B)$ cannot be explained with full confidence. On one hand, the numbers of star counts in B bins in Figs. 1–9 is very low, and therefore strong random fluctuations are very likely. On the other hand, we believe that such asymptotic drops of $N(B)$ are rather due to random errors of the directly measured effective magnetic fields $B_{\rm e}$. The quadratic average of errors $\Delta B_{\rm e}$ is not likely to approach 0 G, particularly for poorer observations, and it is comparable with the width of a bin. Therefore a low number of stars with quadratic field $B \approx 0$ represents just some type of statistical selection effect.

As was pointed out by the referee, the observational data analysed here for magnetic star calsses probably exhibit a deficiency of stars with low magnetic fields. This is because observers frequently were not interested in observing stars in which the intrinsic magnetic field appeared to be small, and stars with stronger fields were always favoured. Such a personal bias certainly distorts the observed distributions $N_{\rm Int}$ in each subclass of A type stars, which are convolutions of intrinsic distributions with an "observer interest" distribution. The effect is very difficult, if not impossible, to correct in general. We believe, however, that the effect influences counts $N_{\rm Int}$ only in the lowest bins of our histograms, which are underpopulated also due to reasons discussed in the previous paragraph.

The above selection effect started from the earliest observations by H. W. Babcock, who first identified strong magnetic fields in Ap stars after many unsuccessful attempts. Indeed, stellar magnetic data sets now available exhibit a strong tendency to present stars with strong or even extreme fields. This selection effect can be avoided only when measuring a "canonical" distribution of the magnetic fields for all stars in a fixed volume of space. We are aware that there exists general understanding of this problem, and that there are observational projects of this type in progress.

The amount of necessary observational effort is very large, and it will take years to complete. Our paper, however, was prepared taking into account all existing $B_{\rm e}$ measurements disregarding the observational selection.

5. Comments on CP classification

Classification of chemically peculiar stars represents a very complex problem. Commonly adopted criteria of classification rely on the presence of particular elements or groups of elements in the spectra of Ap stars. Such observables represent only the surface properties of the magnetic field configuration of a star, and the resulting surface chemical anomalies. The resulting classification of Ap stars into subclasses is very complex and not unique, which is also reflected in Table 1 of this paper.

The referee suggested that since the existing classifications of magnetic Ap stars are very inhomogeneous, one could divide them by colour, $(U-B)_0$ for example. Such a choice would give a rough division of Ap stars collected here by mass, which may be a more physically meaningful parameter than the surface peculiarities.

We agree that one should seek for classification criteria among Ap stars which are more physically meaningful than just the apparent surface peculiarities. This will be a subject of our research in the near future. In this paper, however, we adopt spectroscopic classification of chemical peculiarities in various CP stars.

5.1. HgMn stars

The group of HgMn stars exhibits rather inhomogeneous content, similar th the Sr group discussed in previous Sections (cf. Figs. 2 and 3). There exists small group of classical HgMn stars (e.g. ι CrB and α And) for which no really convincing evidence of longitudinal fields is available. There exist also other Ap stars (such as HD 21699 and 79158) which display Hg or Mn along with numerous other peculiarities in their spectra. These subgroups should be investigated separately.

In the case of HgMn stars we have investigated the distribution functions $N_{\rm Int}$ for the whole the group (see Fig. 8 and Table 5), and for only the classical HgMn stars (Fig. 9 and Table 6). Figure 9 clearly shows the well-known fact that the classical HgMn stars have very weak longitudinal magnetic fields. They are substantially different than other Hg or Mn stars, which simultaneously exhibit also other chemical peculiarities. The latter stars exhibit sometimes strong fields $\langle B_{\rm e}\rangle$.

Figure 9 shows that only three classical HgMn stars apparently exhibit noticeable magnetic field $\langle B_{\rm e}\rangle$: HD 172044, HD 210873, and HD 221507. However, in all three cases the accuracy of $B_{\rm e}$ observations is relatively low. We speculate that their $\langle B_{\rm e}\rangle$ reflect essentially errors of measurement, and that high precision $B_{\rm e}$ measurements will yield much weaker averaged longitudinal magnetic fields for all three HgMn stars.

One should keep in mind that the detailed investigation of various subclasses of chemical peculiarities among CP stars is limited by the small number of stars in subclaasses. For example. there are only 15 classical HgMn stars in our compilation with which to construct Fig. 9 and Table 6.

6. Summary and conclusions

The most important results of this paper can be summarized in the following list:

1. We present an extensive list of the averaged quadratic effective magnetic fields $\langle B_{\rm e}\rangle$ for main sequence and giant stars. Individual $B_{\rm e}$ observations were compiled from the existing literature, and were further processed to obtain a homogeneous set of averaged effective magnetic fields. We consider our averaged values of $\langle B_{\rm e}\rangle$ as a reasonable representative measure of the field strength in the atmosphere of a given star. This is because the value of $\langle B_{\rm e}\rangle$ results directly from the observed effective magnetic field strengths $B_{\rm e}$ and is a strictly model-independent quantity.

Moreover, it is a single scalar parameter which describes the magnetic field of a star even if the number of individual $B_{\rm e}$ is low or the $B_{\rm e}$ observations are noisy. In such a case the full curve describing $B_{\rm e}(\phi)$ changes with rotational phase ϕ cannot be constructed.

2. We have determined for the first time that the relation between the number of occurences $N_{\rm Int}$ of the magnetic field higher than a specified $\langle B_{\rm e}\rangle$ is given by the decreasing exponential function, at least starting from the minimum value of $\langle B_{\rm e}\rangle \approx 100$ G

$$N_{\rm Int}(\langle B_{\rm e}\rangle) = N_{\rm tot}\,\frac{a_1}{100\%}\,\exp\left(-\langle B_{\rm e}\rangle/a_2\right). \qquad (9)$$

Therefore the number distribution function $N(\langle B_{\rm e}\rangle)$ of Ap type stars is also given by a decreasing exponential function. This relations is found to hold for all analysed subclasses: Am, Si, He-weak, He-rich, HgMn, SrCrEu, and all Sr type stars. We determined and listed values of the parameters a_1 and a_2 for each subclass, see Table 1.

3. We cannot rule out the possibility, that this exponential relation represents just the tail of the true distribution, with its maximum hidden below $\langle B_\mathrm{e}\rangle \approx 100$ G. This is because our figures and fitting curves have limited resolution in the independent variable $\langle B_\mathrm{e}\rangle$, which is limited by the observational errors and limited sample sizes to the width of the average bin, typically of the order of 100 G (in each individual sample the value of the resolution is between 25 G and 200 G).

4. Our results demonstrate that the number distribution of the averaged quadratic effective magnetic fields $N(\langle B_\mathrm{e}\rangle)$ is not similar in any way to tail of the Gaussian distribution, which would be proportional to $\exp(-\langle B_\mathrm{e}\rangle^2/a_2^2)$.

The analysis presented in this paper is concentrated on the integrated distribution function $N_\mathrm{Int}(B)$, due to the rather low number of stars available in most chemical peculiarity classes. Still, the function N_Int seems relatively smooth in all the subclasses, and is credibly represented by an exponent. However, some small distortions can be easily seen in upper panels of all the Figs. 1–9.

The distribution function $N(B)$ is the first derivative of N_Int, and obviously all numerical distortions of the latter involve fluctuations of the derivative. This is seen in lower panels of Figs. 1–9, in which directly measured distribution functions exhibit serious noise. Therefore the exponential shape of the distribution function $N(B)$, given in Eq. (8), is just an extrapolation of the smoothed N_Int, which is not inconsistent with the measured $N(B)$.

We exclude from the above rule region of the lowest magnetic fields B of extend comparable with the resolution ΔB of our histograms.

Note added in proof: The most actual list of both all HgMn stars and classical (pure) HgMn stars has been recently published by Adelman et al. (2003).

Acknowledgements. We are grateful to J. D. Landstreet, the referee, for his criticism and numerous suggestions which helped us to improve this paper. Our research is based on data compiled and posted in the SIMBAD, ADS, and CDS databases. We acknowledge support from the Polish Committee for Scientific Research grant No. 2 P03D 021 22.

Appendix A: The catalogue of averaged effective magnetic fields

Table A.1 presents the complete listing of stars with individual averaged quadratic values of $\langle B_\mathrm{e}\rangle$ and the additional data. Columns of the table list: HD number, spectral type of the star, number N of individual B_e values, standard deviation σ, corresponding value of χ^2 per one degree of freedom, method of B_e determination, and reference numbers. The list of references for Table A.1[1] is given at the end of this table.

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[1] Table A.1 is only available at the CDS.

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Online Material

Table 3. List of He-rich stars.

HD	HR	Name	Sp. type
35912	1820		B2V He-r
36430	1848		B2V He-r
36485	1851	δ Ori B	B2p He-r
37017	1890		B1.5V He-r
37479	1932	σ Ori E	B2Vp He-r Be
37776		PPM175998	B3 He-r
47777		PPM151028	B2 He-r
58260		PPM283900	B3 He-r
60344		PPM252646	B3 He-r
64740	3089		B1.5Vp He-r
93030	4199	θ Car	B0Vp He-r
96446		PPM339754	B2 He-r
120640	5206		B2Vp He-r
133518		PPM343417	B3 He-r
151346		PPM265974	B4 He-r
177003	7210		B2.5IV He-r
184927		PPM83182	B2 He-r
186205		PPM168470	B3 He-r
209339	8399		B0IV He-r

Table 4. List of Am-stars.

HD	HR	Name	Sp. type
20210	976	V423 Per	A1m
27962	1389	68 Tau	A3V Am
29140	1458	88 Tau	A5 Am
29173	1460		A1m
31295	1570	π^1 Ori	A0V Am
48915	2491	α CMa	A1Vm
56495		PPM190112	Am
60178	2890	α Gem B	A2Vm
73709		PPM125572	F2IIIm
76756	3572	65 α Cnc	A5m
78209	3619	15 UMa	A1m
78362	3624	τ UMa	F3m
89021	4033	33 UMa	A2IVm
90277	4090	30 LMi	F2m
94334	4248	ω UMa	G5IIIa
95418	4295	β UMa	A1Vm
95608	4300	60 Leo	A1m
97633	4359	70 θ Leo	A2m
104513	4594	DP UMa	A7m
108642	4750		A7m
108651	4751	17 Com B	A0p Am
109485	4789	23 Com	A0IVm
110380	4826	γ Vir B	F0Vm
110951	4847	32 Vir	F2m
112412	4914	α^1 CVn	F3m
114330	4963	51 θ Vir	A1IVs+Am
116657	5055	ζ UMa	A1m
123998	5303	η Aps	A2(m) CrEu
125337	5359	λ Vir	A2m
126661	5405	22 Boo	F1m
130841	5531	9 α^2 Lib	A3-7m(A3IV) CrSr
141675	5887		F3m
141795	5892	37 ϵ Ser	A7m
144197	5980	δ Nor	A3p (Am) Sr?
159560	6555	ν^2 Dra	F0m
173648	7056	6 ζ^1 Lyr	A4m
188728	7610	ϕ Aql	
189849	7653	15 NT Vul	A4IIIm
195479	7839		F2m
198743	7990	6 μ Aqr	A3m
205073		PPM61601	Am
207098	8322	49 δ Cap	A6mv
209790	8417	ξ Cep	A3m
214994	8641	o Peg	A1IIIm

Table 5. List of Mn and Hg stars.

HD	HR	Name	Sp. type
358	15	α And	B9p HgMn
21699	1063	V396 Per	B8IIIp MnSi He-w
22316	1094	GC 4315	B9p HgMnCrSi
23408	1149	20 Tau	B8IIIP Hg He-w
27295	1339	53 Tau	B9HgMn
27376	1347	41 υ^4 Eri	B9V HgMn
33904	1702	μ Lep	B9p HgMn
36916		V1045 Ori	B8 SiMn He-w
37752	1951		B8p HgMn
49606	2519	33 Gem	B7III MnHgPSi He-w
51688	2605	40 Gem	B8III HgP He-w
63975	3059	13 ζ CMi	B8HgMn
75333	3500	14 Hya	B9HgMn
77350	3595	ν Cnc	B9p Si4012,CrHg
78316	3623	κ Cnc	B8IIIp MnHg
79158	3652	36 Lyn	B9IIIp SrTiMn He-w
89822	4072	ET UMa	A0p SiSrHgMn
106625	4662	γ Crv	B8gMn
110073	4817	1 Cen	B8p SiMn 4121,4128
112185	4905	77 ϵ UMa	A1 CrEuMn
112413	4915	12 α^2 CVn	A0p SiEuHgCr
116458	5049		A0p SrEuCrSiHgMn
120709	5210	3 Cen A	HgMn
129174	5475	29 π^1 Boo	B9p HgMn
141556	5883	5 χ Lup	B9IV HgMn
143807	5971	14 ι CrB	AOp MnHg
144206	5982	6 ν Her	B9III MnHg
145389	6023	11 ϕ Her	B9p HgMn
169027		38 Dra	A0 Mn A-horiz.br.star
172044	6997		B8II-IIIp HgMn
172883	7028	GC 25559	B9p SiHgMn
173524	7049	46 Dra	B9.5p Hg
174933	7113	112 Her	B9II-IIIp Hg
177517	7230		B9V HgSi
200311		BD+43 3786	B9p SiCrHg He-w
210873	8473		B9p HgMn
212454	8535		B8III SrCrEuHg He-w
216494	8704	74 HI Aqr	B9III HgMn binary star
221507	8936	β Scl	B9.5IVp HgMnEu

Table 6. List of only HgMn stars.

HD	HR	Name	Sp. type
358	15	α And	B9p HgMn
27295	1339	53 Tau	B9HgMn
27376	1347	41 υ^4 Eri	B9V HgMn
33904	1702	μ Lep	B9p HgMn
37752	1951		B8p HgMn
63975	3059	ζ CMi	B8HgMn
75333	3500	14 Hya	B9HgMn
78316	3623	κ Cnc	B8IIIp MnHg
120709	5210	3 Cen A	HgMn
129174	5475	29 π^1 Boo	B9p HgMn
141556	5883	5 χ Lup	B9IV HgMn
143807	5971	14 ι CrB	AOp MnHg
144206	5982	6 ν Her	B9III MnHg
145389	6023	11 ϕ Her	B9p HgMn
172044	6997		B8II-IIIp HgMn
172883	7028	GC 25559	B9p SiHgMn
210873	8473		B9p HgMn
216494	8704	74 HI Aqr	B9III HgMn binary star
221507	8936	β Scl	B9.5IVp HgMnEu

Table 7. List of Si stars.

HD	HR	Name	Sp. type
8855		BD+43 301	B9 SiCr
9996	465	GY And	B9p CrEuSi
10221	478	43 Cas	A0p SiSrCr
10783		UZ Psc	A2 SrCrSi
11187		BD+54 393	A0 SiCrSr
11503	545	γ^2 Ari	A1p SiCrEu
12288		V540 Cas	A2p CrSi
12447	596	α Psc	A0p SiSrCr
12767	612	ν For	B9.5p Si
14392	682	63 PZ And	B9p Si
14437		BD+42 502	B9p CrEuSiSr
18296	873	21 Per	B9p SiSrCrEu
19805		BD+48 862	A0 Si He-w
19832	954	56 Ari	B9p Si
20283	979		B9VpSi
21590		BD+16 450	B9 Si
21699	1063	V396 Per	B8IIIp MnSi He-w
22316	1094	GC 4315	B9p HgMnCrSi
22374		V486 Tau	A1 CrSrSi
22401		BD+47 865	B9p CrSiSr
22470	1100	20 Eri	B9p Si He-w
22920	1121	22 Eri	B8p Si4200 He-w
23387		BD+23 512	A0 CrSi He-w
24155	1194	V766 Tau	B9p SiSrCr
25267	1240	τ^9 Eri	B9+B9.5V Si
25823	1268	41 Tau	B9p SiSrCr
27309	1341	56 Tau	A0p SiCr
28843	1441	DZ Eri	B5-B9 Si He-w
29009	1449	46 Eri	B9p Si
29305	1465	α Dor	A0III Si
30466		V473 Tau	A0 SiCr
32549	1638	11 Ori	A0p SiCr
32633		HZ Aur	B9 SiCr4012
34452	1732	IQ Aur	A0p Si
35008		BD-1 872	B9 Si
35497	1791	β Tau	B7III SiCr?
36313		V1093 Ori	B8Si He-w
36668		V1107 Ori	B7 Si He-w
36916		V1045 Ori	B8 SiMn He-w
37140		V1130 Ori	B8 He-w SiSr
37151		V1179 Ori	B8pSi He-w
37210		V1133 Ori	B8 He-w Si
37470		BD-6 1274	B8p Si
37642		V1148 Ori	B9 Si He-w
39317	2033	V809 Tau	B9p SiCrEu
40312	2095	θ Aur	A0p Si
43819	2258	V1155 Ori	B9IIIp Si4012,Cr
49333	2509	12 CMa	B7IIIn He-w Si
49606	2519	33 Gem	B7III MnHgPSi He-w
54118	2683	V386 Car	A0p Si
56022	2746	OU Pup	A0p SiSrCr
63401	3032	OX Pup	B8III Si
64486	3082		B9p Si
66255	3151	PY Pup	A0p Si
68351	3215	15 Cnc	A0p SiCrSr
70331		CoD-47 3803	B8p Si
71866		TZ Lyn	A1 SiSrEu
73340	3413	HV Vel	B9 Si
74521	3465	49 Cnc	A1p EuSiCr
77350	3595	69 ν Cnc	B9p Si4012,CrHg
83625		IO Vel	A0 SiSr
89822	4072	ET UMa	A0p SiSrHgMn
90044	4082	25 Sex	B9p SiCrSr
90569	4101	45 Leo	A0p SiCrSrEu
92664	4185	V364 Car	B9p Si
93507		CoD-67 1494	A0p SiCr
94660	4263	KQ Vel	A0p EuCrSi
96910		CoD -47 6547	B9 SiCrEu
98088	4369	SV Crt	A8IVp SrCrSiEu
98457		LS Hya	A0p Si
103192	4552	β Hya	B9IIIp SiCrSr
108662	4752	17 Com A	A0p SrCrEuSi
110073	4817		B8p SiMn 4121,4128
112381		V823 Cen	A0 SiCr
112413	4915	12 α^2 CVn	A0p SiEuHgCr
114365	4965	V824 Cen	A0p Si
116458	5049		A0p SrEuCrSiHgMn
119419	5158	V827 Cen	A0p SiCrEu
122532	5269	V828 Cen	B9 Si
124224	5313	CU Vir	B9Vp Si
125823	5378	V761 Cen	B7IIIpvSi He-w
126759		PPM 319563	B9 Si
128775		IT Lup	B9 Si
128974	5466		A0p Si
130158	5514	55 Hya	A0p Si
130557	5522		B9V Si:Cr:v
131120	5543		B7IIIp Si He-w
133029	5597	BX Boo	B9p SiCrSr
133652	5619	HZ Lup	A0p SiCr
133880	5624	HR Lup	B9p Si4200
134759	5652	24 ι^1 Lib	A0p Si(B7)
136347	5697		A0p Si
136933	5719	ν Lup	A0p Si
137193		HQ Lup	B9 Si
137389	5731		A0p Si
137509		NN Aps	B8p SiCrFe He-w
139525		KU Lup	B8 Si
140728	5857		A0p SiCr
141988		PPM 19594	A2p Si:Sr
142301	5912	3 Sco	B8IIIp Si He-w
142884		V928 Sco	B9 Si He-w
143473		LL Lup	B9 Si
144334	5988	V929 Sco	B4(8)p Si He-w
144844	6003		B5(9)IVp Si He-w
145102		V952 Sco	B9p Si
145501	6026	14 ν Sco	B8V+B9p Si He-w

Table 7. continued.

HD	HR	Name	Sp. type
147010		V933 Sco	B9p SiCrFeSr
147550	6096		B9V Si
147890		V936 Sco	B9.5p SiSr
148199		GC 22126	B9 SiSr He-w
148330	6127	DQ Dra	A2 Si3955v:SrCrEu
149822	6176	V773 Her	B9p SiCrSr
149911	6179	GC 22360	A0p CrEuSiSr
150549	6204	LP TrA	A0p Si
151965		V911 Sco	B9 Si
164429	6718	V771 Her	B9p SiSrCrEu
168605		PPM 134572	A0 SiSr
170000	6920	43 ϕ Dra	A0p Si
170397	6932	V432 Sct	B9p CrSiEu
170973	6958	MV Ser	A0p SiCrEuSr
172883	7028	GC 25559	B9p SiHgMn
173650	7058	V535 Her	A0p SiSrCr
175132	7118		B9p Si
175362	7129	V686 CrA	B6IVp SiMn He-w
175744	7147	V828 Her	B9p Si
177410	7224	EE Dra	B9p Si
177517	7230		B9V HgSi
179527	7283	19 Lyr	B9p Si He-w
179761	7287	21 Aql	B8II-III Si
183056	7395	4 Cyg	B9p Si
183339	7401		B8IV Si He-w
184905		V1264 Cyg	A0 SiSrCr
187474	7552	V3961 Sgr	A0p EuCrSi
189160		V2095 Cyg	A0(B8)p Si3955 Cr4012
192913		MW Vul	A0 SiCr
196178	7870		B8p Si
200311		BD+43 3786	B9p SiCrHg He-w
204131	8206	GC 30005	B9p SiSrCr
205087	8240		B9p SiSrCrEu
206742	8305	9 ι Psa	A0V Si
207840	8348		B6(8)V(III)p Si
208095	8357		B6IV-V SiSrCrEu
209308		PPM 40124	B9 Si
209664		PPM 62435	B9 Si
213871		V414 Lac	B9 Si
213918		V362 Lac	B6p SiSrFe
214783		PPM 88051	B9p SiFeTi,Y
215441		GL Lac	B9 Si
217833	8770	V638 Cas	B9III SiCr He-w
219749	8861	ET And	B9p Si
220825	8911	8 κ Psc	A1p CrSi:SrEu
221006	8919	GC Tuc	A0p Si
221394	8933	GC 32719	A0p SrCrEu:Si
221760	8949	ι Phe	A2Vp SrCrEuSi
223640	9031	ET Aqr	B9p SiSrCr
224166		PV And	B9 Si
224801	9080	CG And	B9.5p SiCrEu
224926	9087	29 Psc	B6(7)III-IV Si He-w

Table 8. List of SrCrEu stars.

HD	HR	Name	Sp. type
2453		GR And	A1 SrEuCr
3980	183	ξ Phe	A7 SrCrEu
4778	234	GO And	A1 CrSrEu He-w
5797		V551 Cas	A0 SrCrEu
6532		AP Scl	A3p SrCr
8441		HN And	A2 SrCrEu
9996	465	GY And	B9p CrEuSi
10221	478	43 Cas	A0p SiSrCr
10783		UZ Psc	A2 SrCrSi
11187		PPM 26824	A0 SiCrSr
11503	545	γ^2 Ari	A1p SiCrEu
12447	596	α Psc	A0p SiSrCr
14437		BD+42 502	B9p CrEuSiSr
15089	707	ι Cas	A5p SrCr
15144	710	AB Cet	A6Vp SrCrEu
17775		PPM 13941	A1 CrEu
18296	873	21 Per	B9p SiSrCrEu
19653		PPM 14140	A0 SrCrEu
19918		CPD-82 54	A5p SrEuCr
20135		PPM45983	A1 CrEu
22374		V486 Tau	A1 CrSrSi
22401		PPM 46394	B9p CrSiSr
24155	1194	V766 Tau	B9p SiSrCr
24712	1217	DO Eri	A9p SrCrEu
25354		V380 Per	A2 SrCrEu
25823	1268	41 Tau	B9p SiSrCr
39317	2033	V809 Tau	B9p SiCrEu
42616		QR Aur	A1 SrCrEu
47103		Rns12630	A SrEu
49976	2534	V592 Mon	A1p SrCrEu
50169		BD-1 1414	A3p SrCrEu
51418		NY Aur	A0 HoDy SrCrEu
55719	2727		A3p CrSrEu
56022	2746	OU Pup	A0p SiSrCr
62140	2977	49 Cam	A8p SrEu
65339	3109	53 Cam	A3p SrCrEu
68351	3215	15 Cnc	A0p SiCrSr
71866		TZ Lyn	A1 SiSrEu
72968	3398	3 Hya	A2 SrCrEu
74521	3465	49 Cnc	A1p EuSiCr
81009	3724	KU Hya	A3p SrCrEuSi
83368	3831	IM Vel	A8p SrCrEu
90044	4082	25 Sex	B9p SiCrSr
90569	4101	45 Leo	A0p SiCrSrEu
94660	4263	KQ Vel	A0p EuCrSi
96616	4327	V815 Cen	A3p SrCrEu
96707	4330	EP UMa	A8-F0p SrCrEu
96910		CoD -47 6547	B9 SiCrEu
98088	4369	SV Crt	A8IVp SrCrSiEu

Table 8. continued.

HD	HR	Name	Sp. type
103192	4552	β Hya	B9IIIp SiCrSr
103498	4561	65 UMa	A1p SrCrEu
108662	4752	17 Com A	A0p SrCrEuSi
108945	4766	UU Com	A2pv SrCr
110066	4816	AX CVn	A1(0)p SrCrEu
111133	4854	EP Vir	A1p SrCrEu
112185	4905	77 ϵ UMa	A1 CrEuMn
112413	4915	12 α^2 CVn	A0p SiEuHgCr
115708		HH Com	A3 SrCrEu
116114		BD-17 3829	F0p SrCrEu
116458	5049		A0p SrEuCrSiHgMn
118022	5105	78 CW Vir	A2p SrCrEu
119213	5153	CQ UMa	A2Vp SrCrEu
119419	5158	V827 Cen	A0p SiCrEu
120198	5187	CR UMa	A0p EuCr
123998	5303	η Aps	A2(m) CrEu
125248	5355	CS Vir	A1p EuCr
126515		FF Vir	A2p CrSr
128898	5463	α Cir	A9p SrCrEu
130559	5523	7 μ Lib A+B	A1p SrCrEu
130841	5531	9 α^2 Lib	A3-7m(A3IV) CrSr
133029	5597	BX Boo	B9p SiCrSr
134214		HI Lib	F2p SrEuCr
134793		LV Ser	A4 SrCrEu
135297		FI Ser	A0 SrCrEu
137909	5747	3 β CrB	A9p SrEuCr
137949		33 Lib	F0p SrCrEu
140160	5843	20 χ Ser	A0p SrCr
141556	5883	5 χ Lup	B9IV HgMnSrEu
144897		CoD-40 10236	B8p EuCr
147010		V933 Sco	B9p SiCrFeSr
147105		V961 Sco	A3p SrCrEu
148112	6117	24 ω Her	A0p CrEu
148321		PPM 265557	A1-A8 Sr
148330	6127	DQ Dra	A2 Si3955v:SrCrEu
148898	6153	9 ω Oph	A6p SrCrEu
149822	6176	V773 Her	B9p SiCrSr
149911	6179	GC 22360	A0p CrEuSiSr
150035		V955 Sco	A3 CrEuSr
152107	6254	52 Her	A3Vp SrCrEu
153286		PPM 55775	A3-F5 Sr
153882	6326	V451 Her	A1p CrEu
164258	6709	V2126 Oph	A3p SrCrEu
164429	6718	V771 Her	B9p SiSrCrEu
165474	6758	BD +12 3382	A7p SrCrEu
166473		CoD-37 12303	A5p SrCrEu
170397	6932	V432 Sct	B9p CrSiEu
170973	6958	MV Ser	A0p SiCrEuSr
171586		FR Ser	A2 SrCr
173650	7058	V535 Her	A0p SiSrCr
176155	7165	FF Aql	F8Ib SrCr
176232	7167	10 Aql	A6p SrCrEu?

Table 8. continued.

HD	HR	Name	Sp. type
184905		V1264 Cyg	A0 SiSrCr
187474	7552	V3961 Sgr	A0p EuCrSi
188041	7575	V1291 Aql	A6p SrCrEu
191742		PPM 59411	A5 SrCrEu
193756		CPD-52 11681	A9p SrCrEu
196502	7879	73 AF Dra	A2p SrCrEu
200177		PPM 60816	A1 CrSrEu
201601	8097	5 γ Equ	A9p SrCrEu
203006	8151	θ^1 Mic	A2 MgCrSrEu
203932		CoD-30 18600	A5p SrEu
204131	8206	GC 30005	B9p SiSrCr
205087	8240		B9p SiSrCrEu
208095	8357		B6IV-V SiSrCrEu
212454	8535		B8III SrCrEuHg He-w
216018		BD-12 6357	A7p SrCrEu
216533		MX Cep	A1 SrCr
217522		CoD-45 14901	A5p SrEuCr
218495		CPD-64 4322	A2p EuSr
220825	8911	8 κ Psc	A1p CrSi:SrEu
221394	8933	GC 32719	A0p SrCrEu:Si
221568		V436 Cas	A1 SrCrEu
221760	8949	ι Phe	A2Vp SrCrEuSi
223640	9031	ET Aqr	B9p SiSrCr
224801	9080	CG And	B9.5p SiCrEu
335238		BD+29 4202	A1p CrEu

Table 9. List of other Sr stars.

HD	HR	Name	Sp. type
5737	280	α Scl	B6p SrTi He-w
8855		PPM 44016	B9 SiCr
12288		V540 Cas	A2p CrSi
22316	1094	GC4315	B9p HgMnCrSi
22407		PPM 185972	Cr
23387		PPM 92834	A0 CrSi He-w
27309	1341	56 Tau	A0p SiCr
30466		V473 Tau	A0 SiCr
32549	1638	11 Ori	A0p SiCr
32633		HZ Aur	B9 SiCr4012
35497	1791	β Tau	B7III SiCr?
37058		V359 Ori	B3p SrTi He-w
37140		V1130 Ori	B8 He-w SiSr
38104	1971	o Aur	A2Vp Cr
43819	2258	V1155 Ori	B9IIIp Si4012,Cr
77350	3595	ν Cnc	B9p Si4012,CrHg
79158	3652	36 Lyn	B9IIIp SrTiMn He-w
83625		IO Vel	A0 SiSr
89822	4072	ET UMa	A0p SiSrHgMn
93507		CoD-67 1494	A0p SiCr
112381		V823 Cen	A0 SiCr
130557	5522		B9V Si:Cr:v
133652	5619	HZ Lup	A0p SiCr
135382	5671	γ TrA	A0 Eu(A1V)
137509		NN Aps	B8p SiCrFe He-w
140728	5857		A0p SiCr
141988		PPM 19594	A2p Si:Sr
144197	5980		A3p (Am) Sr?
147890		V936 Sco	B9.5p SiSr
148199		GC 22126	B9 SiSr He-w
168605		PPM 134572	A0 SiSr
168733	6870	V4050 Sgr	B8p TiSr He-w
175156	7119		B4(5)II SrTi He-w
189160		V2095 Cyg	A0(B8)p Si3955 Cr4012
192678		V1372 Cyg	A2 Cr
192913		MW Vul	A0 SiCr
200311		BD+43 3786	B9p SiCrHg He-w
202671	8137	30 Cap	B6(8)III SrTi He-w
209515	8407	GC 30848	A0IV CrSiMg λ 4012
213918		V362 Lac	B6p SiSrFe
217833	8770	V638 Cas	B9III SiCr He-w