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Magnetization of stars vs. effective temperature

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Abstract. In this paper we present results of our search for some general signatures of magnetic fields in Ap stars.

Key words: stars: magnetic fields – stars: chemically peculiar

1 Introduction

On the basis of all the available published magnetic measurements for Ap stars we have found a few relations describing the frequency of occurrence of the specific magnetic field intensity for all types of chemical peculiarities (Bychkov et al. 2003a). Subsequently, we renormalized these relations assuming that the extremely 'non-magnetic' Am stars represent the reference level, and we estimated the relative value of 'magnetization' (M) for Ap stars of various types of peculiarity (Bychkov et al. 2003b). At the same time we credibly separated all chemically peculiar stars into two groups: they either are 'weakly'-magnetic objects (Am and Hg-Mn stars), or 'strongly'-magnetic objects (SrCrEu, Sr, Si, He-w and He-r stars). Magnetization of stars in the 'strongly'-magnetic group exceeds that in the 'weak'-magnetic group typically by a factor of 5–10, on the average. This is clearly seen in Fig. 3 of this paper. This is a quantitative estimate for the well known observational fact.

One of the most important and easily measurable physical parameter of stellar atmospheres is the effective temperature, T_{eff}. In this paper we analyze and discuss the relation between magnetization and the T_{eff} for chemically peculiar stars.

2 Observational data and relations

Fig. 1 shows the distribution of 'magnetic' Ap stars as a function of T_{eff}, and Fig. 2 shows the same for 'non-magnetic' Ap stars, respectively. Both dependences were obtained for the same sample of Ap stars, which previously was used to derive distribution functions of Ap stars (Bychkov et al. 2003a). Effective temperatures of all stars displayed here were either taken from Hauck & North (1993), Glagolevskij (1994, 2002), Sokolov (1998), or were determined following the relations by Paunzen et al. (2005). Fig. 1 clearly shows the dependences of number distribution for stars vs. T_{eff}, for various types of spectral peculiarity. The relative magnetization of stars depends also on T_{eff}, which is shown in Fig. 3 according to the data presented in Table 1.

Table 1 presents values of the average T_{eff} and the average magnetization for various classes of chemical peculiarity.

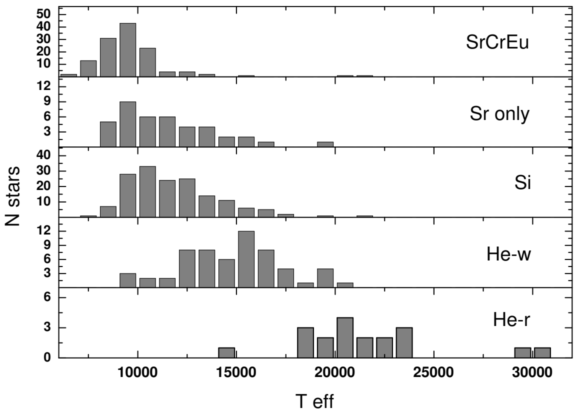

Figure 1: Number distribution of 'magnetic' chemically peculiar stars vs. effective temperature T_{eff} for various types of peculiarity.

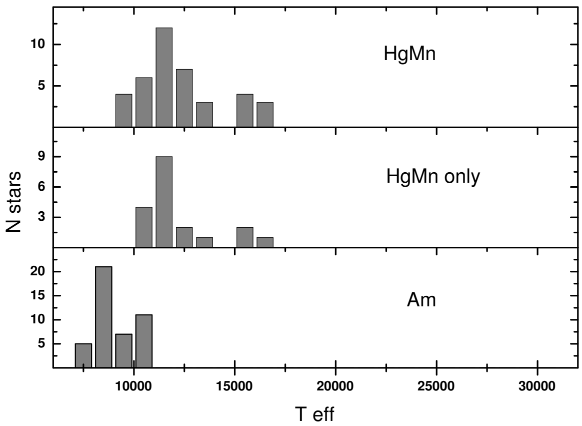

Figure 2: Number distribution of 'non-magnetic' chemically peculiar stars vs. effective temperature T_{eff} for various types of peculiarity.

Table 1: T_{eff} and the average magnetization, M, for stars of various classes of chemical peculiarity

Type of stars	N stars	Mean T_{eff}	σ T_{eff}	M	σ M
Am	44	9086	940	1.0	
Sr all	125	9680	1990	11.8	0.74
Sr only	40	11600	2440	11.5	0.83
Si	158	11895	2280	9.3	0.38
HgMn only	19	12130	1770	1.7	0.54
Hg Mn	39	12218	1960	2.5	0.80
He-weak	60	15199	3810	8.9	0.92
He-rich	19	21500	3590	8.7	0.12

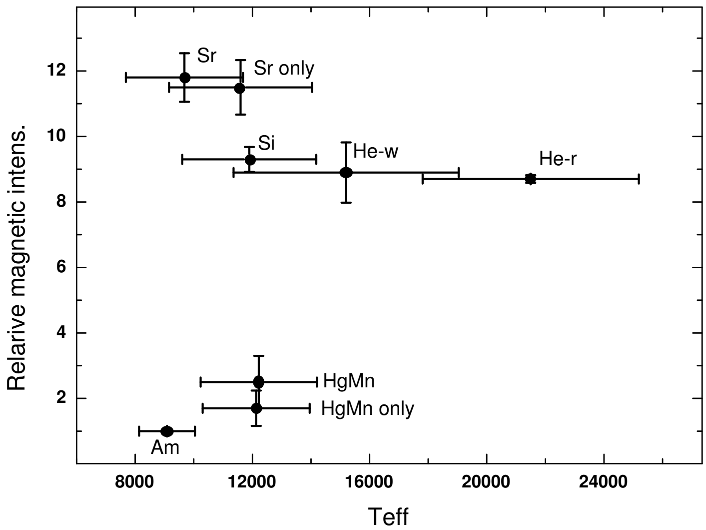

Figure 3: The relative magnetization (M) vs. T_{eff} for various types of peculiarity.

3 Discussion

As was shown in Fig. 3, the parameter of magnetization in the group of 'strongly'-magnetic stars distinctly decreases with increasing T_{eff}. Therefore, magnetization in this group apparently reduces with increasing temperature. As all members of the 'strongly'-magnetic group of Ap stars belong to the main sequence, the increase of T_{eff} imply the increase of stellar mass, while the age of a star diminishes. Therefore, He-r stars are younger by almost two orders of magnitude than SrCrEu stars and are 6 times as massive on the average.

All of these considerations inconsistent with the hypothesis of the 'relic mechanism' of the origin of magnetic field (Moss 1989, 2001; Landstreet & Mathys 2000). If this mechanism worked in our sample of CP stars, then the situation must be the opposite: the younger and more massive are stars, the stronger magnetic fields must be present (on the average), as the result of magnetic flux conservation.

The effect is most important in relatively cooler low-mass stars which have stronger magnetic field, especially because the Hayashi phase of stellar evolution conceivably destroys relic magnetic fields. It is possible that the 'relic mechanism' can supply only the initial, inoculating magnetic field.

Finally, we point out two unsolved problems:
1. Why are strong magnetic fields observed solely in some types of chemically peculiar stars?
2. Does a single mechanism exist for the creation of global magnetic fields in all these stars?

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