Project VeSElkA: analysis of vertical stratification of element abundances in three HgMn stars

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Abstract

Some HgMn stars possess slow axial rotation (Vsini<40 km/s) and can therefore have a hydrodynamically stable atmosphere, where atomic diffusion can be effective and lead to an accumulation of element abundances at certain optical depths. With the aim to search for signatures of vertical abundance stratification of chemical species in stellar atmospheres of HgMn stars, we have analysed spectra of HD49606, HD53929 and HD63975 that have been recently obtained with ESPaDOnS in the frame of Project VeSElkA (Vertical Stratification of Element Abundances). For all studied stars, we have found an enhanced abundance of manganese that confirms the classification of these objects as HgMn stars. From these preliminary results, it appears that the abundance of phosphorus is vertically stratified in the stellar atmospheres of HD53929 and HD63975 increasing its abundance towards the upper atmospheric layers.

Introduction

The vertical stratification of chemical abundances in stellar atmospheres is caused by atomic diffusion, which results from the competition between gravity and the force due to radiation. To verify for the presence of vertical stratification in the atmospheres of our star sample, we have analysed high resolution ESPaDOnS spectra obtained at CFHT while employing the ZEEMAN2 code (Landstreet 1988) and using the procedure described by Khalack et al. (2007).

Table 1. Physical parameters of program stars derived from the fitting Balmer.

Stars	T_{eff} (K)	log g	[M/H]	V_r (km/s)	Vsin i(km/s)
HD49606	12420	3.70	-0.24	10.9 ± 0.8	19.6 ± 1.8
HD53929	13950	3.90	-1.0	14.6 ± 1.8	26.0 ± 1.9
HD63975	12090	3.27	-0.5	32.8 ± 1.6	28.7 ± 0.9

Spectral analysis

The values of T_{eff} and log g were estimated by Khalack and LeBlanc (2015) via the analysis of Balmer line profiles using FITSB2 code of Napiwotzki (2004). A modified version of the ZEEMAN2 code (Khalack et al. 2007) has been employed to perform the abundance analysis of preselected unblended line profiles and to determine V_r and Vsin i of all studied stars. This code simulates each line of a given ion separately.

Results

For HD49606, our abundance estimates for MgII, SiII, MnII and FeII are in agreement with those found by Catanzaro et al. (2016) and the mean values obtained in this study for V_r and Vsin$i$ are in agreement with those found by Abt et al. (2002): Vsin$i$=20 km/s and by Gontcharov (2006): V_r=12 ± 0.8 km/s. Catanzaro et al. (2016) have found that HD49606 is a binary star and the abundance of Mn is probably vertically stratified.

For HD53929, our abundance estimates are in agreement with those found by Smith & Dworetsky (1993) and the mean values of V_r and Vsin$i$ found here are in agreement with results published by Royer et al. (2002): Vsin$i$=25 km/s and by Khalack & LeBlanc (2015): V_r=15 km/s. The mean values of V_r and Vsin$i$ that we found for HD63975 are consistent with results found by Wilson (1953): V_r=32 km/s).

Oxygen is overabundant in the atmosphere of HD53929 and in HD63075 as well. Magnesium is underabundant in all studied stars while P and Cr are overabundant in HD53929 as in HD63975 (see Tab 2). Phosphorus exhibits the same behavior in HD53929 and HD63975 and is found to be stratified in their atmosphere (see Fig 1).

We have also obtained an overabundance for Mn and Fe in all three cases (see Tab 2). Our results confirm that they are all HgMn-type star.

Table 2. Average abundances (relative to their solar value) for different chemical species found in the spectra of studied stars

Element	HD49606		HD53929		HD 63975	
	N	[X/H]	N	[X/H]	N	[X/H]
He I	-	-	3	0.46 ± 0.28	-	-
C II	-	-	-	-	1	0.15
O I	-	-	5	-1.73 ± 0.64	8	-0.55 ± 0.42
Ne I	-	-	-	-	4	2.97 ± 0.29
Mg II	4	-0.56 ± 0.12	2	-0.83 ± 0.15	6	-0.65 ± 0.08
Si II	11	0.04 ± 0.14	12	0.12 ± 0.17	6	-0.42 ± 0.40
P II	-	-	21	1.95 ± 0.27	13	1.86 ± 0.31
S II	-	-	4	-0.07 ± 0.44	-	-
Ti I	-	-	-	-	4	-0.33 ± 0.71
Ti II	-	-	10	0.88 ± 0.41	5	0.02 ± 0.13
Cr I	-	-	-	-	2	1.70 ± 0.06
Cr II	-	-	4	2.32 ± 1.15	-	-
Mn I	-	-	5	1.02 ± 0.88	2	1.73 ± 0.61
Mn II	10	1.30 ± 0.53	13	1.56 ± 0.71	7	1.06 ± 0.88
Fe I	-	-	2	0.77 ± 0.15	-	-
Fe II	82	0.28 ± 0.23	37	0.79 ± 0.21	80	0.57 ± 0.24

Note: N is the number of selected lines.

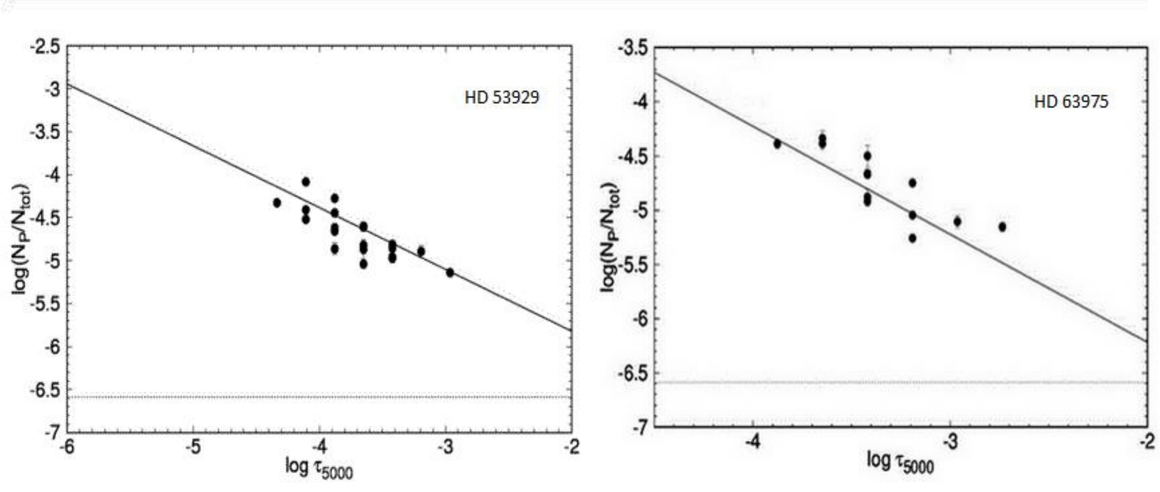

Figure 1. Phosphorus abundance relative to the total number of atoms obtained from individual lines for HD53929 (left-hand panel) and HD63975 (right-hand panel) under consideration as a function of optical depth at 5000 Å. The dashed line represents the solar abundance. Linear fits of the abundance stratification are shown.

Conclusion

This study has revealed vertical stratification of phosphorus abundance in the atmosphere of HD53929 and HD63975. Its abundance increases towards the upper atmospheric layers of these stars. The strong abundance of Mn found in all studied stars therefore seems to indicate that these three stars are most likely HgMn-type stars. The vertical stratification detected for phosphorus indicates that atomic diffusion seems to be present and could play an important role in the atmosphere of HD53929 and HD63975.

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