

The search for magnetic fields in mercury-manganese stars

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Abstract. Mercury-manganese (HgMn) stars were considered to be non-magnetic, showing no evidence of surface spots. However, recent investigations revealed that some stars in this class possess an inhomogeneous distribution of chemical elements on their surfaces. According to our current understanding, the most probable mechanism of spot formation involves magnetic fields. Taking the advantage of a newly-built polarimeter attached to the HARPS spectrometer at the ESO 3.6m-telescope, we performed a high-precision spectropolarimetric survey of a large group of HgMn stars. The main purpose of this study was to find out how typical it is for HgMn stars to have weak magnetic fields. We report no magnetic field detection for any of the studied objects, with a typical precision of the longitudinal field measurements of 10 G and down to 1 Gauss for some of the stars. We conclude that HgMn stars lack large-scale magnetic fields typical of spotted magnetic Ap stars and probably lack any fields capable of creating and sustaining chemical spots. Our study confirms that alongside the magnetically altered atomic diffusion, there must be other structure formation mechanism operating in the atmospheres of late-B main sequence stars.

Keywords. instrumentation: polarimeters, stars: magnetic fields, stars: chemically peculiar

1. Introduction

Mercury-manganese (HgMn) stars form a subclass of the upper main sequence chemically peculiar (CP) stars, showing notable overabundance of Hg, Mn, Y, Sr and other, mostly heavy, chemical elements with respect to the solar chemical composition. HgMn stars are frequently found in binaries and lie on the H-R diagram between the early-A and late-B spectral types, which corresponds to $T_{\text{eff}} = 9500 - 16000$ K. A number of studies during the last decade reported variability of some spectral lines, indicating the presence of chemical spots in HgMn stars (Adelman *et al.* 2002, Kochukhov *et al.* 2005, Hubrig *et al.* 2006). It is believed that the presence of magnetic field is necessary for creating inhomogeneities in stellar atmospheres. In order to clarify the magnetic status of HgMn stars we conducted a major spectropolarimetric survey of these stars. We investigated 47 HgMn stars with $T_{\text{eff}} = 10500 - 14500$ K and $v_{\text{e}} \sin i = 70$ km s⁻¹. Most of these objects were never studied before with high-resolution spectropolarimetry. Taking advantage of a new polarimeter HARPSpol, attached to the HARPS instrument at the ESO 3.6-m telescope in La Silla, Chile, we were able to push the limits of magnetic field detection in early-type stars down to levels.

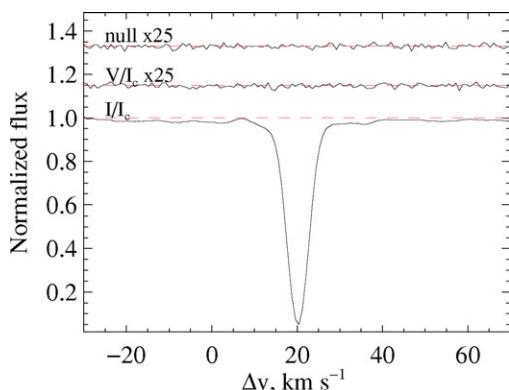


Figure 1. LSD profiles for HD 71066.

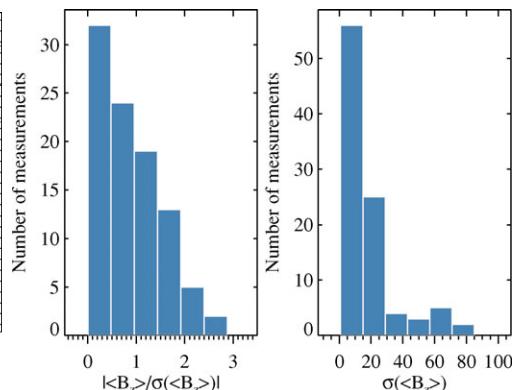


Figure 2. Left: the distribution of longitudinal field normalized by its error bar. Right: the distribution of error bars of $\langle B_z \rangle$ in Gauss.

2. Magnetic field search

It is impossible to draw any conclusion about the presence of weak polarization signatures in individual spectral lines because of noise. To circumvent this problem, we use a multi-line addition technique called Least-Squares Deconvolution (LSD, Donati *et al.* 1997). With the help of this method we were able to decrease noise by a factor of 7-16. The LSD profiles obtained for HD 71066 are shown in Fig. 1. For the assessment of magnetic field detection from Stokes V line profiles we employed χ^2 probability statistics. The analysis of LSD profiles of all HgMn stars yielded no magnetic field detection.

We did not detect any longitudinal magnetic field $\langle B_z \rangle$. For many stars the precision of our $\langle B_z \rangle$ measurements is better than 10 G. The best precision, ± 0.81 G, was achieved for HD 71066. The overall distribution of measurements and error bars is presented in Fig. 2.

3. Conclusions

We confirm that HgMn stars are non-magnetic. Based on the results of our study we can conclude that spot formation in HgMn stars cannot be caused by the global magnetic field. We can also rule out a complex configuration of the magnetic field as it would reveal itself in Stokes V profiles. Hereby, this class of CP stars remains a puzzling example of the chemical spots formation in massive stars, which is possibly related to hydrodynamic instabilities in chemically stratified stellar atmospheres (Kochukhov *et al.* 2007).

References

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