Multi-Element Doppler imaging of the Ap star ϵ Ursae Majoris

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Abstract. The surface distribution of five elements: *iron*, *chromium*, *titanium*, *magnesium* and *manganese* on the magnetic A0pCr star ϵ UMa, have been calculated using the Doppler imaging technique. We found that *iron*, *chromium* and *manganese* are correlated with the assumed dipole magnetic field geometry of this star, which is apparently not the case of *magnesium* and *titanium*.

Key words: Stars: abundances – Stars: chemically peculiar – Stars: magnetic fields – Stars: Doppler imaging – Stars: individual: ϵ UMa

1. Introduction

The scientific goal of applying the Doppler imaging technique to Ap stars, is to provide observational constraints on the diffusion mechanism in the presence of a global magnetic field. ϵ UMa (HD 112185, HR 4905), an A0pCr star, is known as the brightest member (V=1.77) of the class of peculiar A type stars. Bohlender and Landstreet (1990) measured a weak, reversing magnetic field for ϵ UMa, that appears to be dominated by a dipole component with a polar magnetic field strength in the order of 400 Gauss. Furthermore, maps of *chromium*, *iron* (Rice & Wehlau, 1997), *oxygen* and *calcium* (Babel et al., 1995) have been published, whereby the distribution of each of these elements appears to be correlated with the assumed dipole magnetic field geometry.

2. Observations

Observations of ϵ UMa were done in June 1994 and in March 1995 at the Observatoire de Haute-Provence using the spectrograph AURÉLIE (attached to the 1.52-m telescope) in two spectral regions: 4060 - 4260 Å and 4440 - 4640 Å. The spectral resolution is about 20000 and the Signal-to-Noise ratio above 150.

3. Input data for Doppler imaging

The maps were calculated by using the surface imaging technique described by Piskunov and Rice (1993). A Kurucz ATLAS9 model atmosphere with $T_{\rm eff}$ = 9500 K and $\log g$ = 3.6 was used for computing the local line profile tables.

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The value of $v \sin i$ was assumed to be $35\,\mathrm{km\,s^{-1}}$ and the inclination angle i was chosen as $45\ ^{\circ}$. Both values give a minimal deviation of the observed line profiles from the computed ones. The rotation phases of the spectra we used for mapping were computed according to: $JD = 2434131.124 + 5^{d}.0887\,E$.

4. Discussion

The surface abundance distributions of the five elements we treated can be divided into two groups.

The *iron* and *chromium* (Figure 1) distributions show a clear depleted band which coincides with the assumed magnetic equator, confirming the results of Rice & Wehlau. The *manganese* distribution is very similar to that of these elements, which accumulate near the magnetic poles. They are all slightly over-abundant compared to solar values: *manganese* and *chromium* are about 0.8 dex above solar values, while *iron* is 1 dex above.

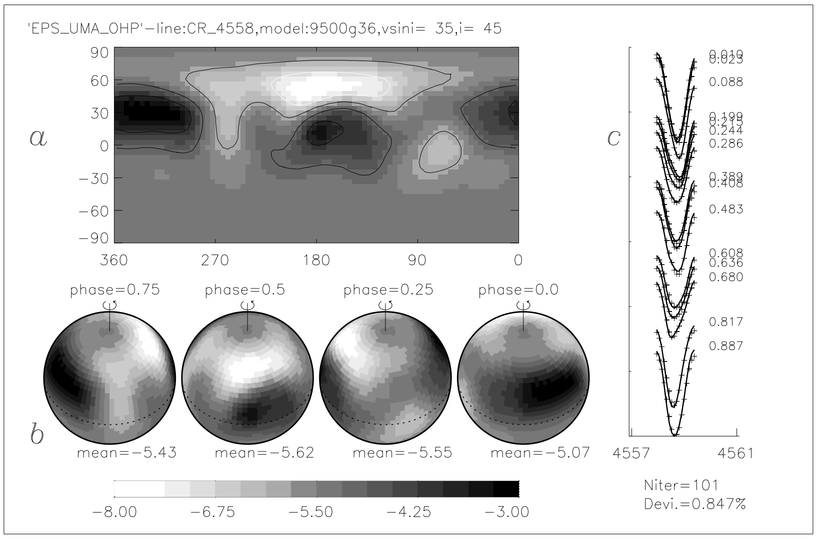

Figure 1. The chromium abundance distribution of ϵ UMa was obtained from the Cr II, 4558 Å line. This element appears to be on average, about 0.8 dex more abundant than in the Sun.

However, the *titanium* (Figure 2) and *magnesium* surface structures have much less contrast in terms of peak-to-peak abundances and are apparently not significantly correlated with the magnetic dipole geometry. So far, seven different elements have been mapped for ϵ UMa.

Together with the *oxygen* and *calcium* maps published by Babel et al. (1995), which reveal abundance enhancements located at the magnetic equator, the maps of *iron*, *chromium*, *magnesium*, *manganese* and *titanium* provide important constraints for building models of diffusion in the presence of a global magnetic field. This should provide a better understanding of the hydrodynamics in the atmospheres of Ap stars.

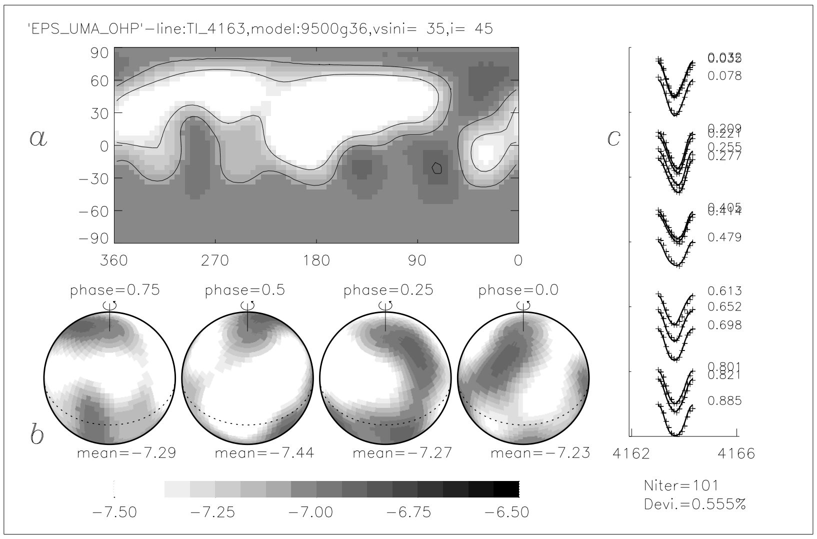

Figure 2. Titanium abundance distribution of ϵ UMa. The Ti II, 4163 Å line was used for the inversion procedure. Titanium is on average slightly depleted on the surface of this star compared to solar abundance.

References

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