PCA application to ZDI images of solar type starts

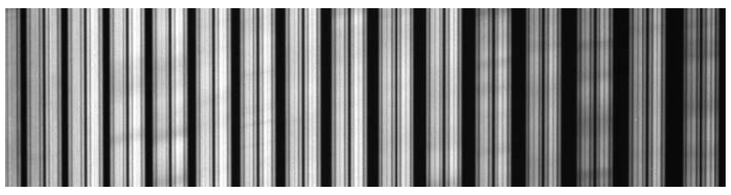
Julio Ramirez and Meir Semel, Observatoire Paris Meudon, France

julio.ramirez@obspm.fr, meir.semel@obspm.fr

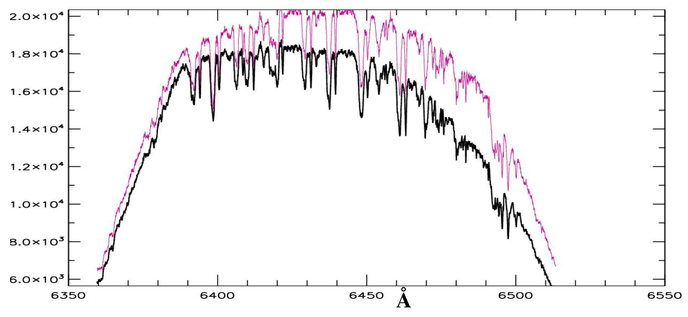
Abstract: We present here a new method to obtain the Circular Polarization (*V*) in the stellar observations. To find the polarized signal we use wides high spectral resolution ranges, an interval of approx 3000 Å, containing thousand of polarized lines. To get the contribution of all these lines we employ the PCA technique: We apply the SVD to a database created with the COSSAM code. In this robust code, that provide us all the stokes parameters, we use as principal parameters the stellar Temperature and the Magnetic Field strength. We found that the use of the first 10 eigenvectors are enough to approximate successfully the contribution of all the lines to the resultant averaged polarized signal.

Analysis of measured data set

Stellar observations : Several spectropolarimetric observations campaigns have carried out **at the AAT telescope.** We analyze here two samples, Dec 2001 and Sept 2004. With the **Sempol polarizer** it's possible to obtain all the stokes parameters. Here we present only the results for circular polarization (V). After all data reduction we get the signals **I ± V** in the approximated range form 4500 to 7500 Å.



In the graphic below, example of one cross dispersion spectral order after data reduction, i.e., "*Ordinary*" and "*Extraordinary*" beams.



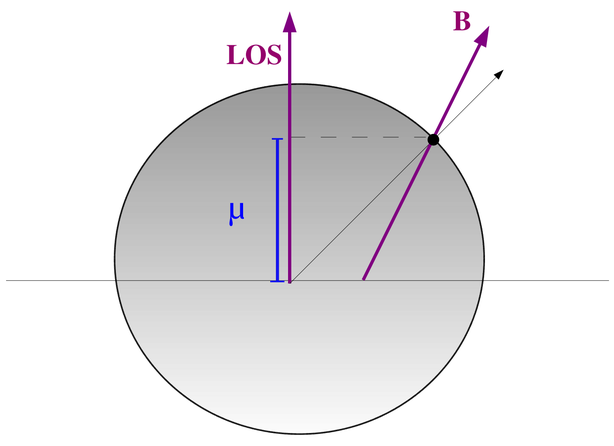
To get a better level S/N of the polarization V, we try to improve the line addition method as suggested by Semel (1989), see also Donati et al. (1997).

Analysis of synthetic data set

COSSAM (Stift, 1985) is an object-oriented code that solves the four coupled equations for polarized radiation transfer under the LTE regime. We worked 3 atmosphere models with temperatures values of **T**=(3500,4750,5750)°K.

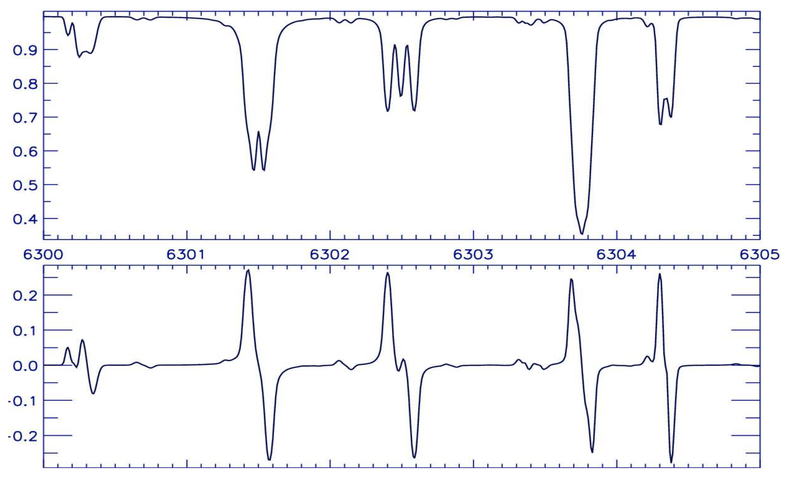
We span the magnetic fields from 0 to 2000 Gauss (steps of 250), the angle Θ in the Line Of Sight (LOS) from 0 to 90 degree (step of 15) and we used μ = 0.2, 0.6 and 1.

We assume that the 255 combinations, can stand for a complete set.



Example of calculated I/I_cont and V/I_cont for with parameters values:

T = 3500 °K, B = 2000 G, Θ = 30 ° and μ = 0.6



For the ZDI calculations we substitute in the x coordinates originally in Å, by the Doppler coordinates in units of km/s.

Hereafter, we denominate the calculated circular polarization by *Vn(x),* x in km/s, and *n* from 0 to 255 and we proceed to consider the Vn's as vectors.

Data compression

We used the PCA technique to compress the data obtaining a new base of 255 orthonormal eigenvectors (V i).

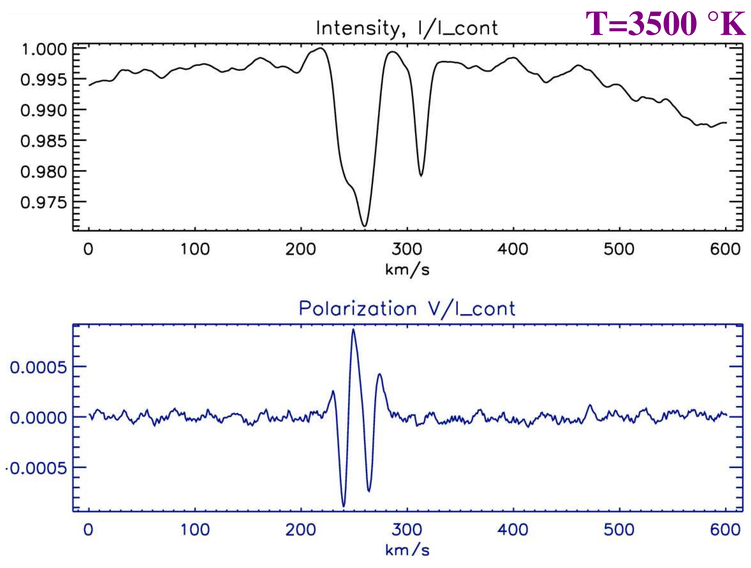
$$Vi \bullet Vj = \delta ij$$

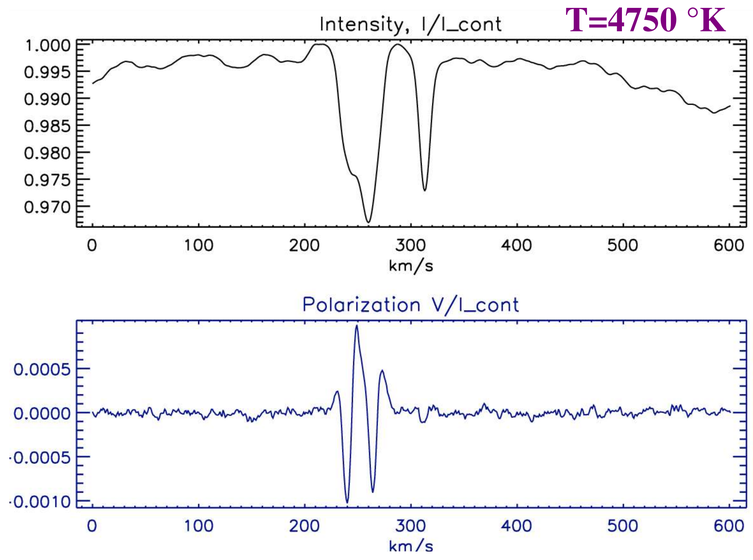
$$Vn = \sum A_{n,i} \bullet Vi$$

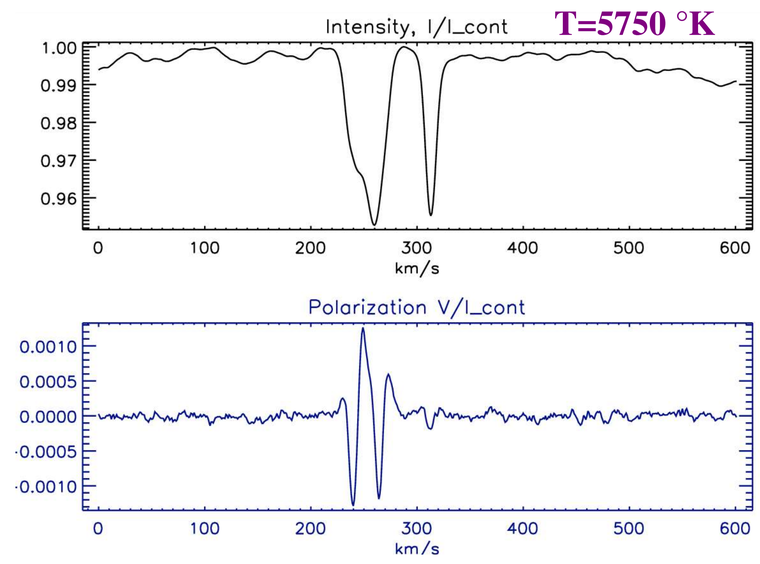
where A n,i are the coefficients produced by the PCA calculations.

RESULTS

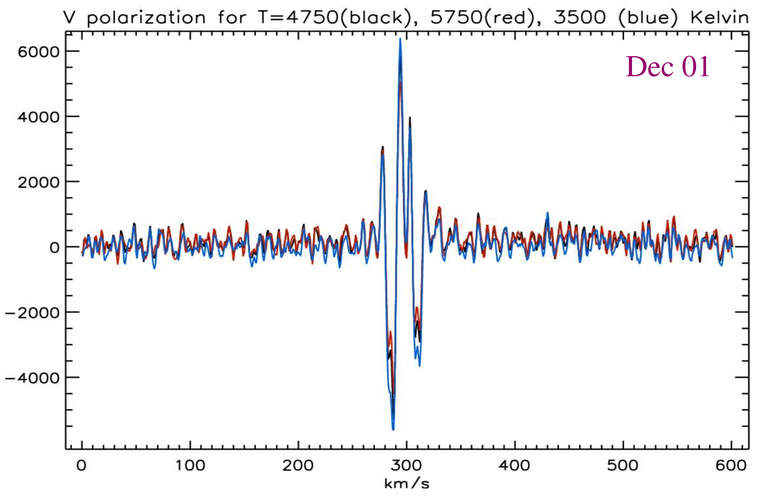
For the campaign in Sept 04, we show the intensity (I) and circular polarization (V) founded for a cold atmospheric model, T=3500, and for two warmers models, T=4750 and T=5750. The observed object is the binary system HR1099.

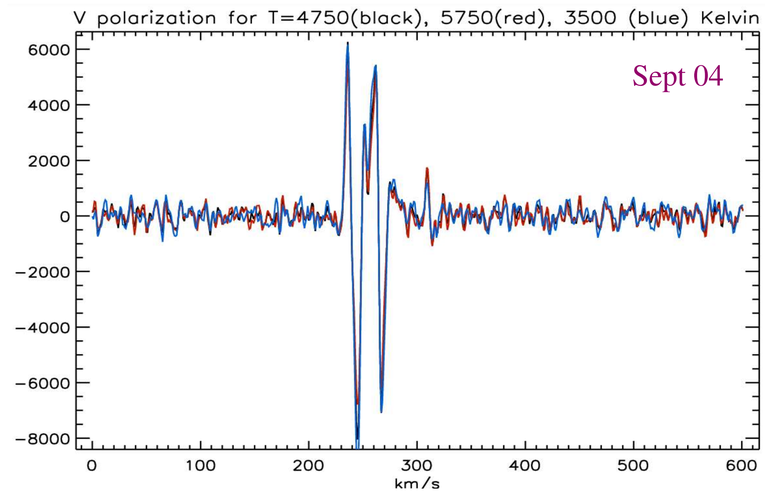






In the next graphics, the we compare the circular polarization of the 3 atmospherics models for the campaigns of Dec 01 and Sept 04.





RESULTS

For the campaign in Sept 04, we show the intensity (I) and circular polarization (V) founded for a cold atmospheric model, T=3500, and for two warmers models, T=4750 and T=5750. The observed object is the binary system HR1099.

Conclusions: The founded signal in circular polarization, with highs levels in the S/N ratio, shows that this new *PCA-method* can take into account all polarized spectral lines to the final signal. This has many new advantages for the future analysis of magnetic stellar fields.

The employed technique in circular polarization V, can also be applied to find the linear polarizations (Q and U).

References: Semel M. A&A, 255, 456, (1989). Donati J.F. et al., MNRS, 291, 658, (1997) , Stift M., MNRS, 217, 55,(1985).