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FIRST RESULTS OF THE ANALYSIS OF SOME SPECTRA OF THE AMATEUR SCIENTIFIC PROGRAMME OF THE OBSERVERS ASSOCIATED WITH THE BERNARD LYOT TELESCOPE

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Abstract. We present here the results of an amateur-professional collaboration between the members of the OATBLs (from an inter-school project IPSA/Ecole Polytechnique) and the support astronomers of the OMP and the TBL (Telescope Bernard Lyot) at Pic du Midi. This poster follows the first results presented in Nice in 2019.

Keywords: stars, metallicity, spectroscopy, polarimetry, Zeeman, Doppler

1 The OATBLs and News from TBL : installation of Neo-Narval

Since 2016, the OATBLs have been filling in the duty observer roster, in addition to the statutory staff, if the schedule cannot be filled. Since 2018, the amateur programme focuses on the study of high metallic stars. Some tools and programs are made by members to process the data. The OATBL association is made up of people from different backgrounds. Most are retired and some are students or employees. In 2020 and 2021, an inter-school project has been set up to work on the data. We present here the first results of this collaboration between Ecole Polytechnique and IPSA. Since September 2019, the Narval instrument, which was coupled to the TBL, has been replaced by its successor : Neo-Narval. This instrument provides radial velocity stabilisation $v < 3m/s$ of the Narval/TBL spectrograph. It will also make it possible to study the links between stellar activity and magnetism around exoplanet host stars. In order to organise the data, a new way of structuring them has been introduced using fits files containing everything the instrument produces as output : observation conditions and data in two related extensions.

2 First results: $H\alpha$ line study and Doppler effect

The OATBL has been actively working for two years now on the analysis of the spectra obtained with Narval and Neo Narval since its installation and start-up. The amateur scientific programme of the OATBL consists of 36 spectra, part of which were obtained with Neo-Narval. In the framework of an inter-school project between IPSA and the Ecole Polytechnique, 10 students were able to help the OATBL by analysing a set of 11 spectra from this programme. Moreover, the OATBL and students checked that the Doppler shift on the lines of these spectra corresponds for each star, within the measurement errors, to that obtained in the literature. This shows that the adjustment made by the students of the inter-school project inside OATBL association, is correct. Only two stars stand out from the crowd by their different Doppler coefficient values, due to the multiplicity of their stellar system.

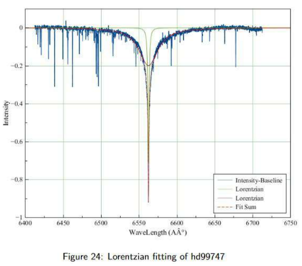
[1] OATBL
[2] IPSA
[3] SAF
[4] École Polytechnique

Nom	Type de décalage	k mesuré	Vélocité radiale mesurée en km/s	k tabulé	Vélocité radiale tabulée km/s	Erreur relative
4cam	*redshift*	$8,38 \times 10^{-5}$	25,14	$7,51 \times 10^{-5}$	22,5	11,6 %
30lmi	*redshift*	$4,28 \times 10^{-5}$	12,84	$4,60 \times 10^{-5}$	13,7	6,9 %
c Her	*blueshift*	$-10,60 \times 10^{-5}$	-31,8	$-10,51 \times 10^{-5}$	-31,5	0,8 %
f UMa	*blueshift*	$-0,15 \times 10^{-5}$	-0,45	$-0,03 \times 10^{-5}$	-0,10	400 %
hd23193	*redshift*	$7,89 \times 10^{-5}$	23,68	$9,11 \times 10^{-5}$	27,3	13,4 %
hd28204	indéterminé	$-5,32 \times 10^{-5}$	-15,95	$3,30 \times 10^{-5}$	9,9	261 %
hd99747	*blueshift*	$-3,34 \times 10^{-5}$	-10,01	$-3,18 \times 10^{-5}$	-9,54	5,0 %
hd169885	*blueshift*	$-1,37 \times 10^{-5}$	-4,11	$-1,23 \times 10^{-5}$	-3,7	11,4 %
hd179143	indéterminé	$-0,91 \times 10^{-5}$	-2,73	$0,92 \times 10^{-5}$	2,76	199 %
hd200407	*blueshift*	$-2,06 \times 10^{-5}$	-6,17	$-2,60 \times 10^{-5}$	-7,8	20,8 %
hr4021	*redshift*	$4,27 \times 10^{-5}$	12,80	$3,6 \times 10^{-5}$	10,8	18,6 %

Fig. 1. Doppler Effect : Measured VS. Tabulated Coefficients

3 First results: Doppler-Zeeman effect, link with polarisation and magnetic field

The inter-school project has shown that it is unfortunately difficult, if not impossible, to obtain correct magnetic field values by studying the Zeeman effect alone. Indeed, despite the high resolution of Neo-Narval, the Zeeman effect is hardly visible even on the Fe I and Fe II lines, which are nevertheless sensitive to it. The lines are not resolved and an important Doppler effect is added to the Zeeman splitting, which makes it almost impossible to obtain the magnetic field by this means. Thus, the students, together with the OATBL, decided to focus on the set of 3 spectra of high metallicity stars obtained by Neo-Narval. Polarisation is the orientation of the electromagnetic field of the light received by the detector. When the star has a stronger or weaker magnetic field, information on the polarisation of the light can be obtained from its spectrum and the value of the star's magnetic field can be determined by knowing the Stokes parameters (I, V, Q and U). A python code was developed by the students to find the intensity I, and the intensity V of the circular component as well. Extracting I and V from the data cube allowed the students and the OATBL, using a fairly simple formula $Bcos\theta = \frac{4\pi mc}{eg_c}\frac{IV}{\lambda^2 \frac{dI}{d\lambda}}$, to propose longitudinal magnetic field values for several lines and for the three high-metallicity stars. The analysis of the results is still in progress but there is for the moment a weak correlation between the expected values from the literature and the magnetic fields found. It is likely that the method of measuring the offset between the centres of the polarised lines, an important value for tracing the magnetic field, is at the origin of these magnetic fields that differ from the expected values. The order of magnitude, however, seems to be appropriate.



(a)

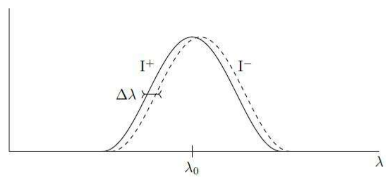
Étoile hd141675
(type A3m)

λ_{th} (en Å)	B cos ϑ (en G)
6609, 11	313, 92
4520, 22	2862, 67
5328, 53	3365, 81
6456, 24	2542, 28
5260, 25	2708, 93

Étoile hd127381
(type B1/B2V)

λ_{th} (en Å)	B cos ϑ (en G)
4520, 23	763, 10
5001, 95	808, 50
5328, 53	483, 06
6546, 24	159, 78
6667, 99	442, 90
6750, 15	8, 93

(b)



(c)

Fig. 2. Lorentzian Fitting (a), Values of B-field obtained (b) , Circular polarisation profiles (c)

4 Conclusion : Prospects for further analysis of the spectra of the OATBL science program

The possibility that a Stark effect influences the structure of the lines of these stars, in particular the Balmer line, is being studied in the literature by the association. Is there a correlation between metallicity and the parameter of this line? What about the magnetic field strength ? Is there a link between metallicity and magnetic field strength? Do these stars have exoplanets around them ? Is there a link between metallicity and the existence of exoplanets taking into account an average magnetic field strength ? These are some questions that the OATBL and all the members who are involved in the analysis of these stars would like to answer.