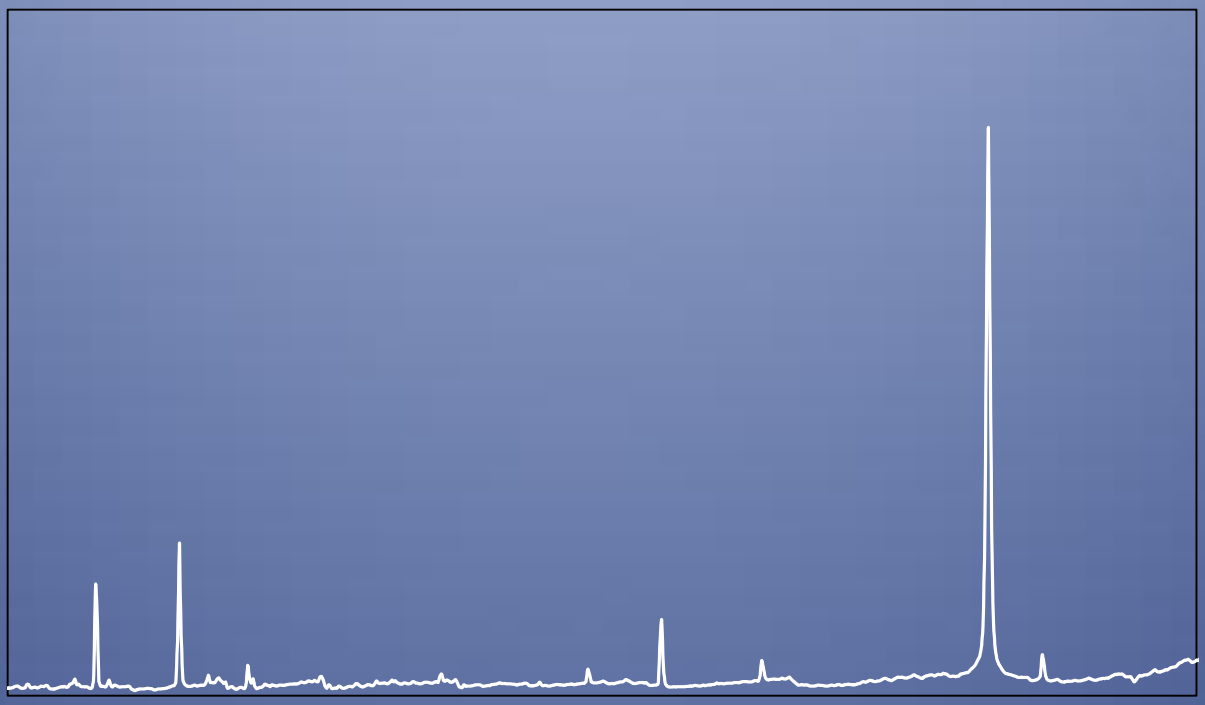
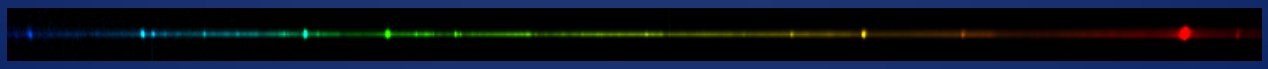


LOW RESOLUTION SPECTROSCOPY

OHP 2013 OBSERVER'S GUIDE

Description of observing projects using low resolution spectroscopy
(LISA – ALPY600 – LHIRES 150/300 – DADOS – LX-200 ..)



LOW resolution spectroscopy
OHP 2013 Observer's guide

Description of observing projects using low resolution spectroscopy
(LISA – ALPY600 – LHIRES 150/300 – DADOS – LX-200 ..)

Version 1 – May 2012

Author : François Teyssier francois.teyssier@dbmail.com

Translation in English : Robin Leadbeater

Sprectra from

Christian Buil
Paolo Berardi
François Teyssier

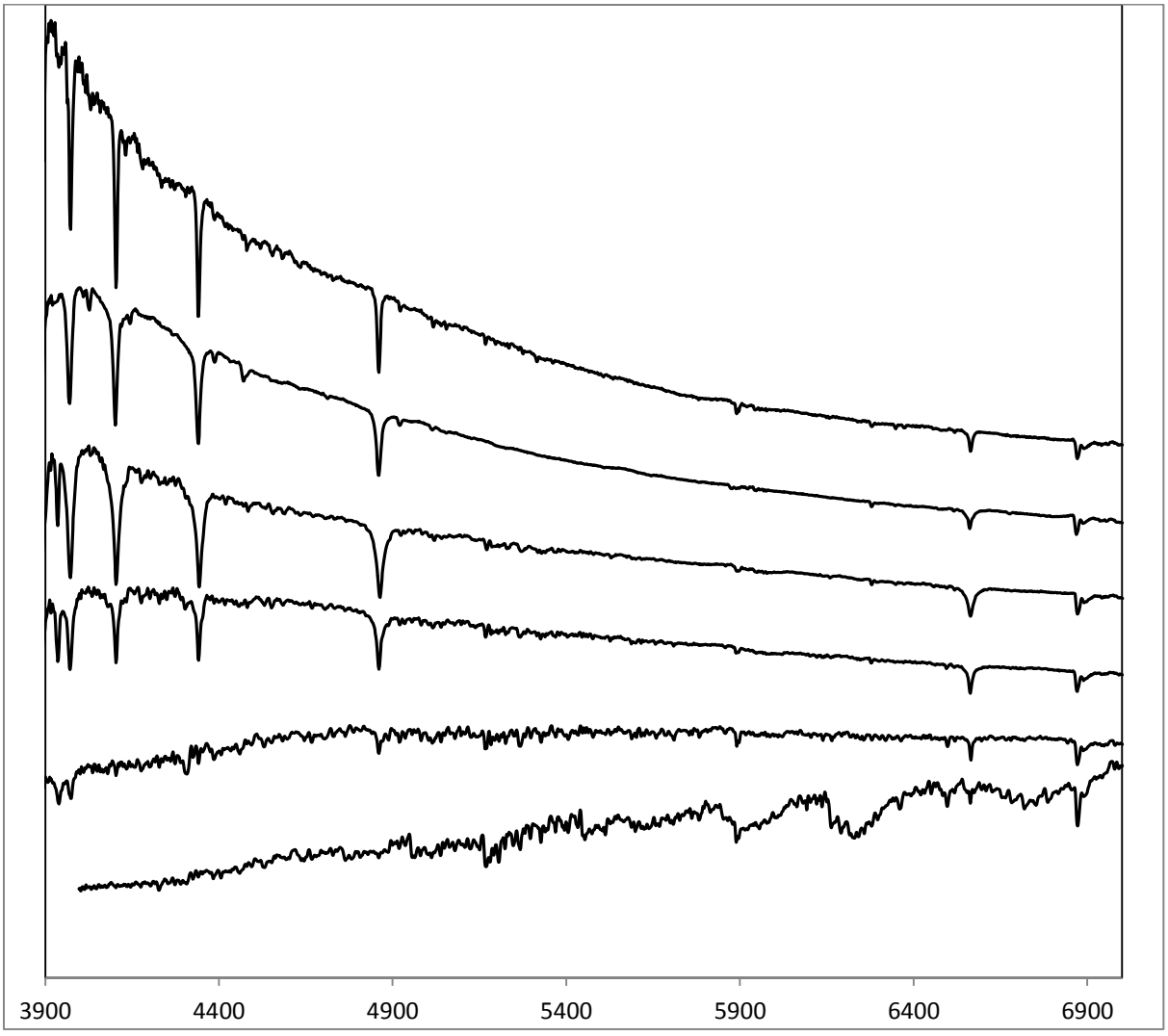
OHP 2013 – Low resolution Spectroscopy

LISA - Alpy600 - Lhires 150 l/mm - DADOS - LX-200 …

1. Spectral Classification : hotter and cooler stars

Lisa and Alpy600 allow spectra to be obtained of stars of different spectral types across the visible range (In the UV it is possible to reach 3850 with LISA, further with Alpy). Generating an atlas allows you to become familiar with the different types : the principal lines and the shape of the continuum...

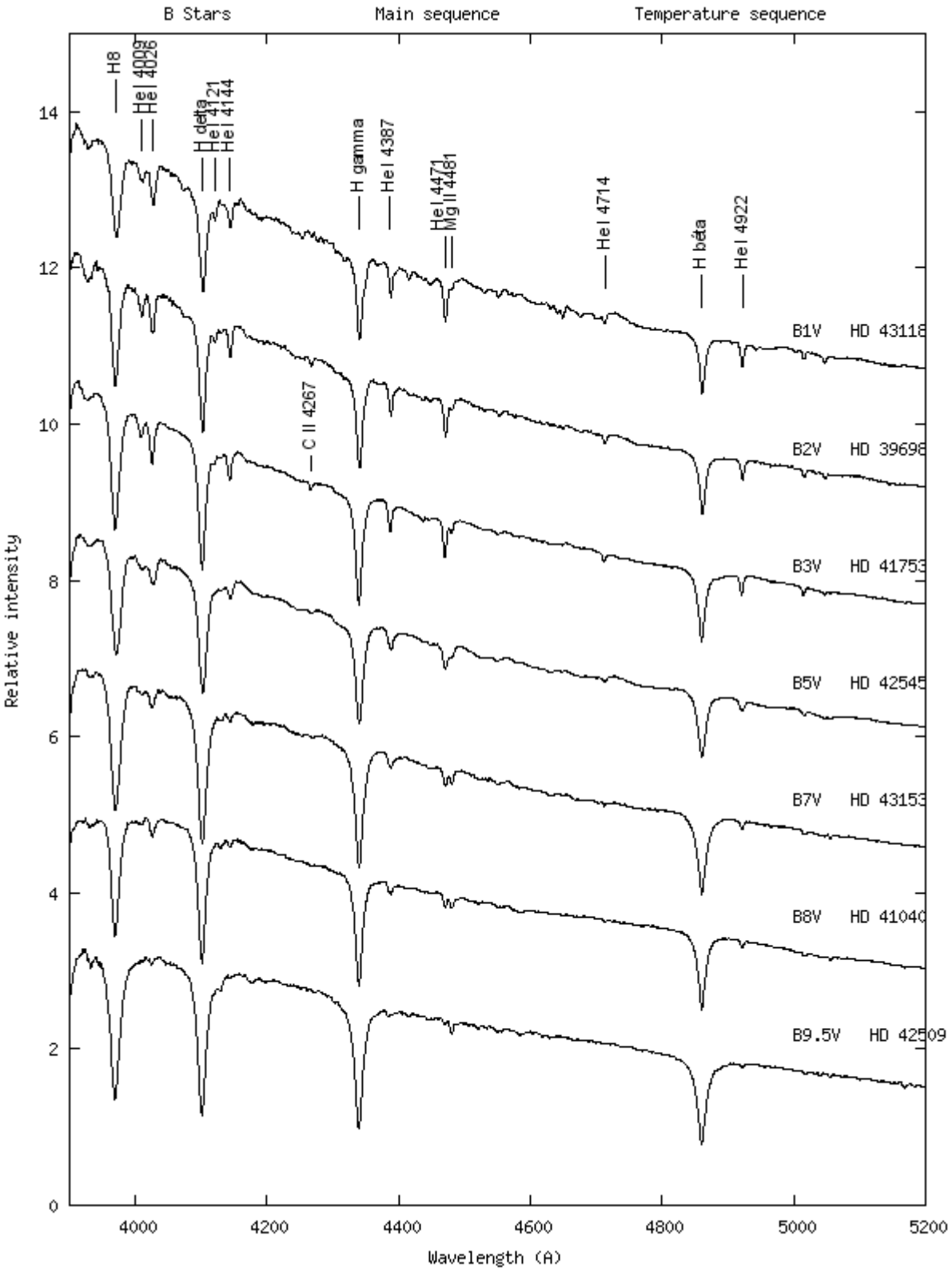
This is an opportunity to practice techniques for reducing spectra including producing masters and correcting for instrumental and atmospheric effects.



Sequence of spectra of stars O to M – LISA R =1000

❑ **Construct a spectroscopic atlas at resolution R = 1000**

The same exercise can be extended to the sub types of the same spectral type. For example : main sequence B stars (« Luminosity class V »). Specific lines allow the sub type to be identified (in particular He I 4471 / Mg II 4481)



B sequence (Luminosity V) – LISA R = 1000

Walker's excellent Spectroscopic Atlas
http://www.ursusmajor.ch/downloads/spectroscopic-atlas-4.0.pdf
Book Stellar spectral classification, Gray & Corbally, Princeton University Press, 2009

2. Oe and Of stars

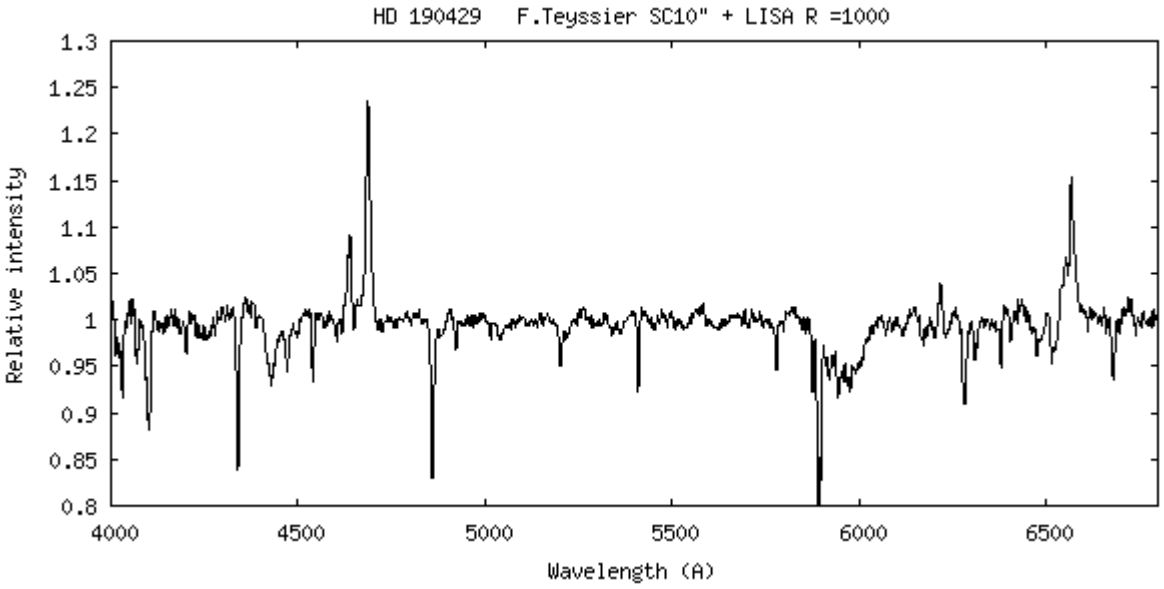
Stars of spectral type O are massive and very hot. Some of them show lines in emission.

The spectra of Oe stars are characterised by the presence of HI lines in emission. Of stars show emission lines from singly ionised Helium (He II). Of+ spectra can be very spectacular. It could be interesting to look for variations in intensity of the lines over different timescales.

Classification of Of stars

Type	NIII 4634-4640	He II 4686	Si IV 1089-4116
f+	Emission	Emission	Emission
f	Emission	Emission	
(f)	Emission	Absorption/Neutral	
((f))	Weak emission	Emission	

Un exemple de Of : HD 190429 - LISA R = 1000



List of Of stars in **appendix p. 30**

List of emission lines observable in **appendix p. 31**

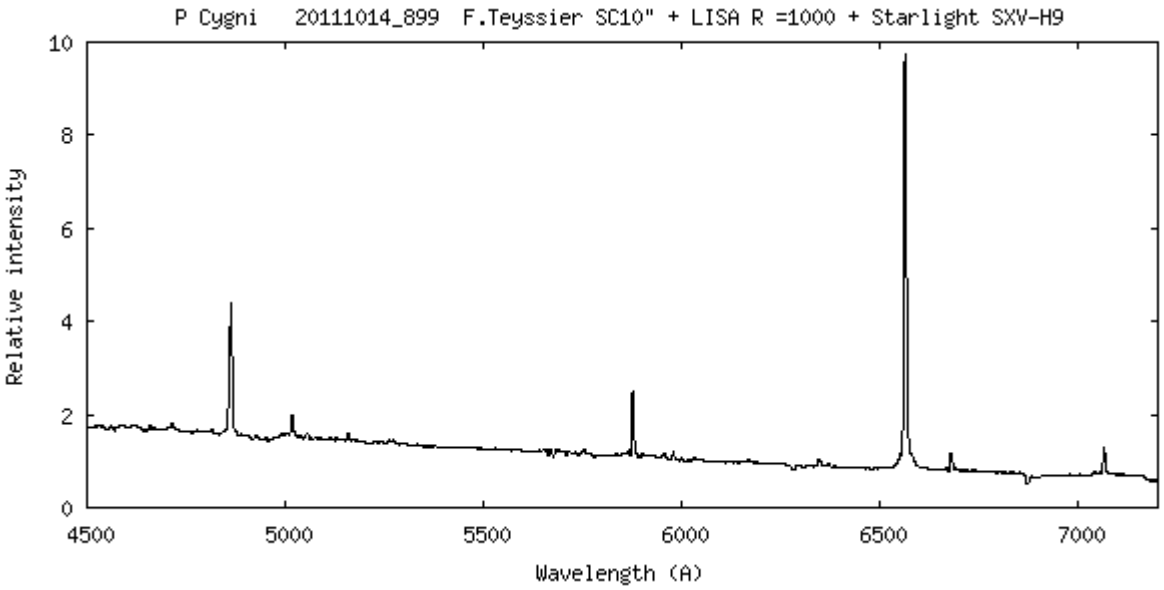
Try to detect variations in the emission lines.

Page Hot stars : http://www.astronomie-amateur.fr/feuilles/Spectroscopie/HotStars.html
Page C. Buil : http://www.astrosurf.com/buil/hotstars/hot_stars.htm

3. LBV : P Cygni

P Cygni is a member of an exclusive group of stars known as Luminous Blue Variables, massive very hot stars with intense stellar winds which produce spectacular emission lines from H, HeI which show a « P Cygni profile » with absorption on the blue side of the line. The instability of LBV stars is seen in outbursts (The luminosity of P Cygni increased spectacularly in 1600 leading to the designation Nova Cyg 1600) but also smaller, more or less periodic variations are seen.

Name	AD (2000)	Dec. (2000)	Mag. V	Sp. Type
P Cygni	**20 17 47.2**	**+38 01 58.5**	**4.8**	**B1lapeq**



The resolution of spectra obtained using a LISA is sufficient to estimate the Equivalent Width of the H alpha line. Spectra should be sent to Ernst Pollmann : ernst-pollmann at t-online.de

Another study which can be accomplished with the LISA or Alpy 600 is to look for short timescale variations (« Flickering »). An example from 14/10/2011 resulting from processing 192 spectra in groups of 8 :

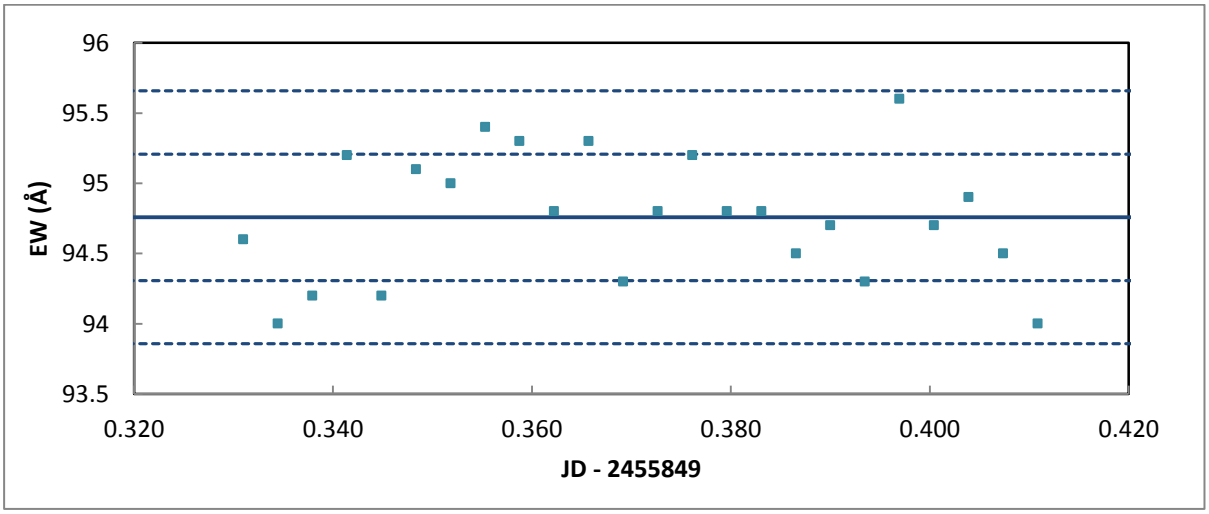


Figure 1 - P Cygni - Time Series H alpha Equivalent Width - LISA R = 1000

- ❑ **Monitor regularly, optimising the resolution around H alpha.**
- ❑ **Take time series looking for evidence of flickering.**

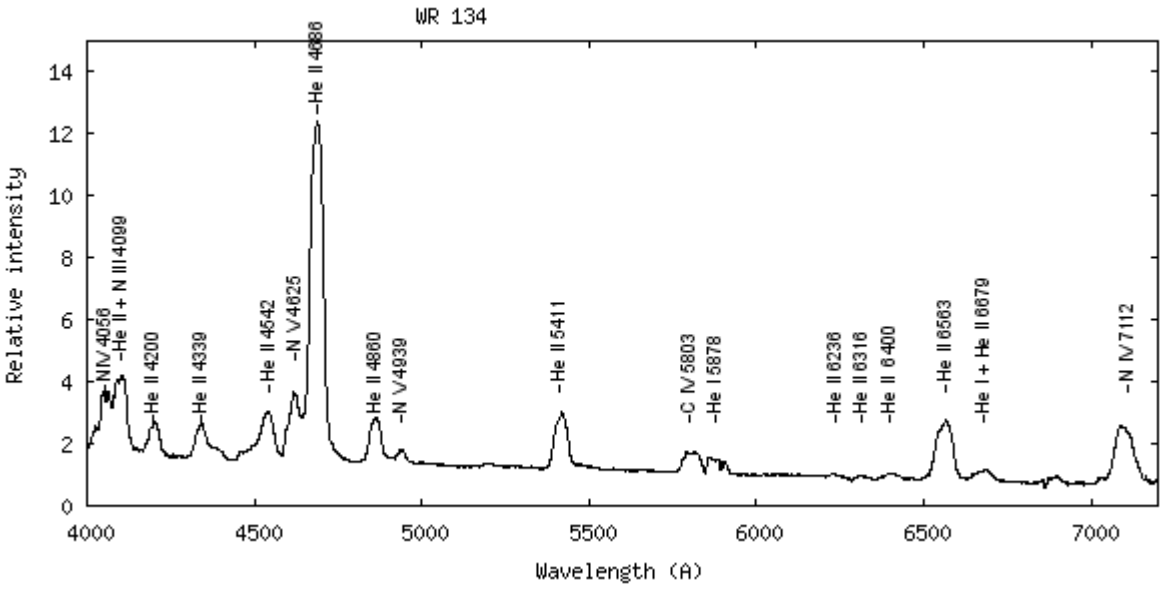
4. Wolf Rayet stars

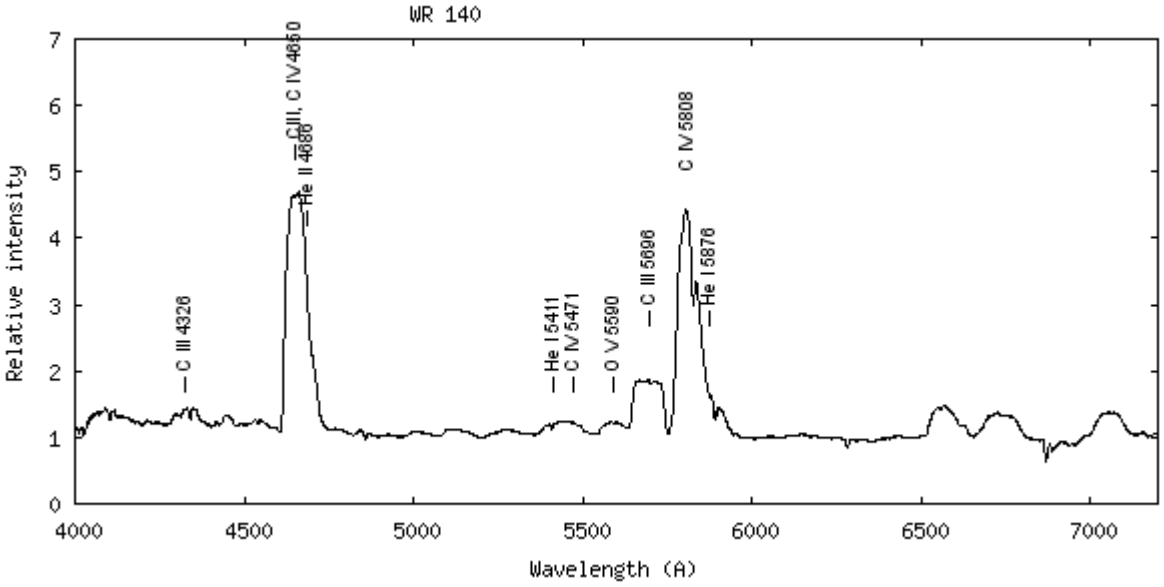
Wolf Rayet stars are very active giant type O stars, massive (from 7 à 55 $M_\odot$), hot (26000 à 80000 K) and very luminous (4.10^4 à 8.10^5 $M_\odot$). This results in a significant loss of mass through stellar winds in which form intense, broad emission lines (700 to 3200 km.s^{-1} wide). They are spectacular targets at low resolution.

There are two principle classes, depending on composition:

WN : N et He lines predominate
WC : Very intense He, C et O lines

Two examples at resolution R = 1000 : WR 134 (WN) and WR 140 (WC)





List of bright Wolf Rayet stars in **appendix p. 32**

List of type N Wolf Rayet emission lines in **appendix p. 33**

http://www.astronomie-amateur.fr/Projets%20Spectro3%20WR.html

Atlas http://www.astrosurf.com/buil/survey/wrstars/wrstars.html
Atlas http://www.astronomie-amateur.fr/ProjetsSpectro3_WRAtlas_Lisa.html

5. Etoiles Be

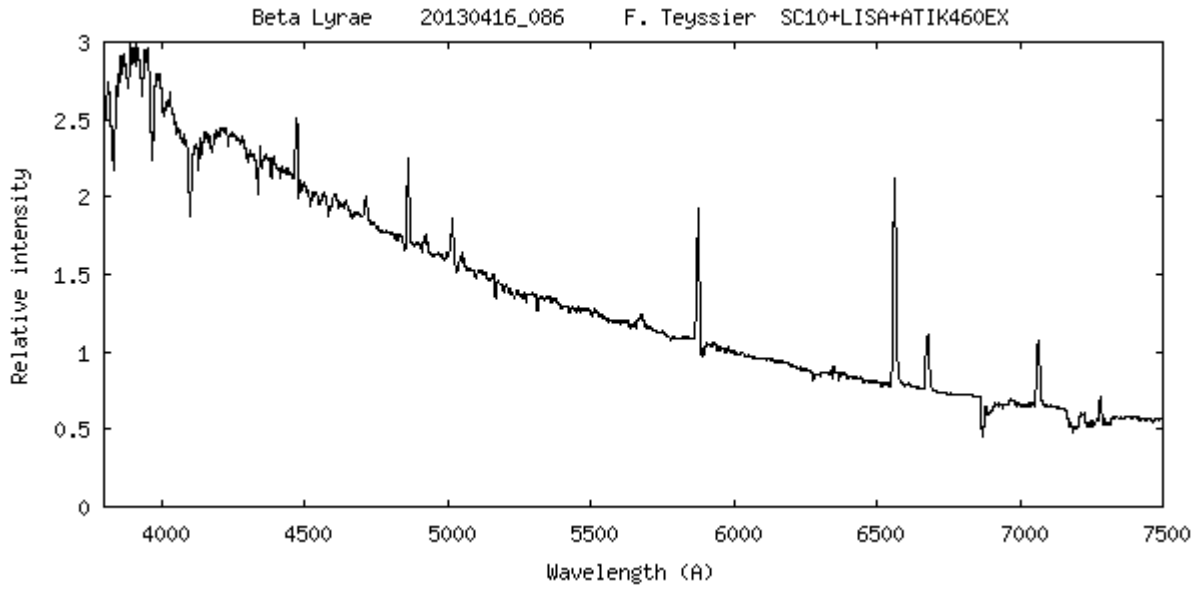
Be stars are of stars of spectral type O, B or A which have shown at some time one or more Balmer lines in emission.

5.1. First observations of bright Be stars

There are some « unmissable » Be stars which make a good introdution to spectroscopy. It is difficult to spend a night at OHP without hearing their names mentioned more than once....

Name	AD (2000)	Dec. (2000)	Mag. V	Sp. Type
γ Cas	00 56 42.5	+60 43 00.2	2.47	B0.5IVpe
δ Sco	16 00 20.0	-22 37 18.1	2.29	B0.2IVe
β Lyr	18 50 04.8	+33 21 45.6	3.52	B8II-IIIep

These bright stars are prime targets as an introduction to spectroscopy. The resolution however is insufficient for a detailed study of their behaviour, notably radial velocity measurements of the emission components.



5.2. Detect an outburst

Even if the resolution is insufficient for further study, outbursts in some Be stars may be detectable in low resolution spectra, raising an alert for high resolution observations.

5.3. Faint Be stars

Among the 787 stars in the BeSS database with declination greater -10°, 262 do not yet have any spectra. 73 of these stars have a magnitude less than 10, so easy with low resolution. 73 others have a magnitude between 10 and 12 so are potentially accessible with good guiding allowing longer integration times.

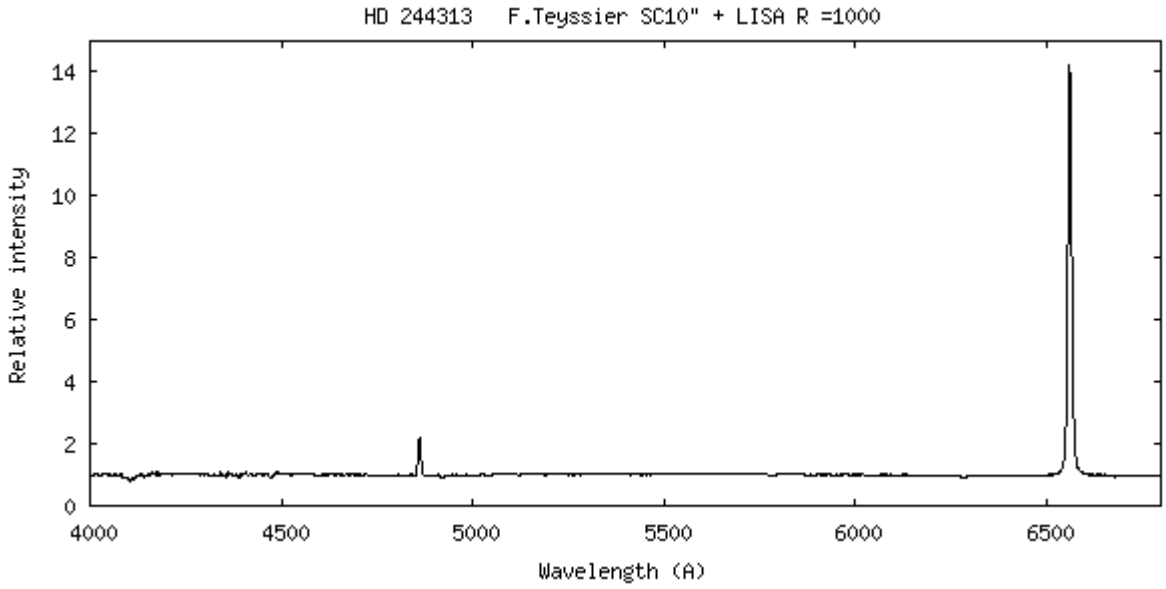


Figure 2 HD344313, first low resolution spectrum in the BESS database– 02-04-2013
Note the unusual shape of the continuum, the result of strong interstellar (estimated at E_{B-V} = 0.75)

A list of stars in BeSS without spectra can be found in **Appendix p. 34-35**

5.4. Discover a new Be ?

Mag	Nb Bess	Nb Tycho	% Be/Tycho
0	0	4	0%
1	0	16	0%
2	4	23	17%
3	10	62	16%
4	33	241	14%
5	37	666	6%
6	77	1506	5%
7	95	2987	3%
8	139	5591	2%
9	146	9759	1%

The adjacent table gives the proportion of all B stars which are Be, by magnitude.

Among the bright stars (up to mag 4), around 15% of B type stars are Be. Above magnitude 5 the proportion drops dramatically to just 1 or 2% by mag 9. This suggests that there is a significant proportion still to be discovered.

A research program could therefore consist of taking a large number of spectra of B type stars fainter than mag 5. It is advisable to chose stars with luminosity class III to IV and high temperature (B0 to B3).

- ❑ **Detection of outbursts**
- ❑ **Complete the Bess database with spectra of faint Be stars**
- ❑ **Discover a new Be star**

AraBeam is the interface between the amateur and profesisonal world for the study of Be stars
http://arasbeam.free.fr/?lang=en
Bess http://basebe.obspm.fr/basebe/Accueil.php

6. RR Lyrae

RR Lyrae type stars are pulsating stars with periods of the order of 12 hours. Certain stars of this type show long term variations in amplitude and period, called the Blazkho effect after the discoverer. Their origin has not been established. A campaign of photometric and spectroscopic observations of the prototype star RR Lyr, which includes amateurs, is led being by Jean François Leborgne (IRAP, Research Institute for Astrophysics and Planetology, CNRS, Toulouse University, France).

Name	AD (2000)	Dec. (2000)	Mag. V	Sp. Type
RR Lyr	**19 25 27.9**	**+42 47 03.7**	**7.2 – 7.9**	**A8 – F7**

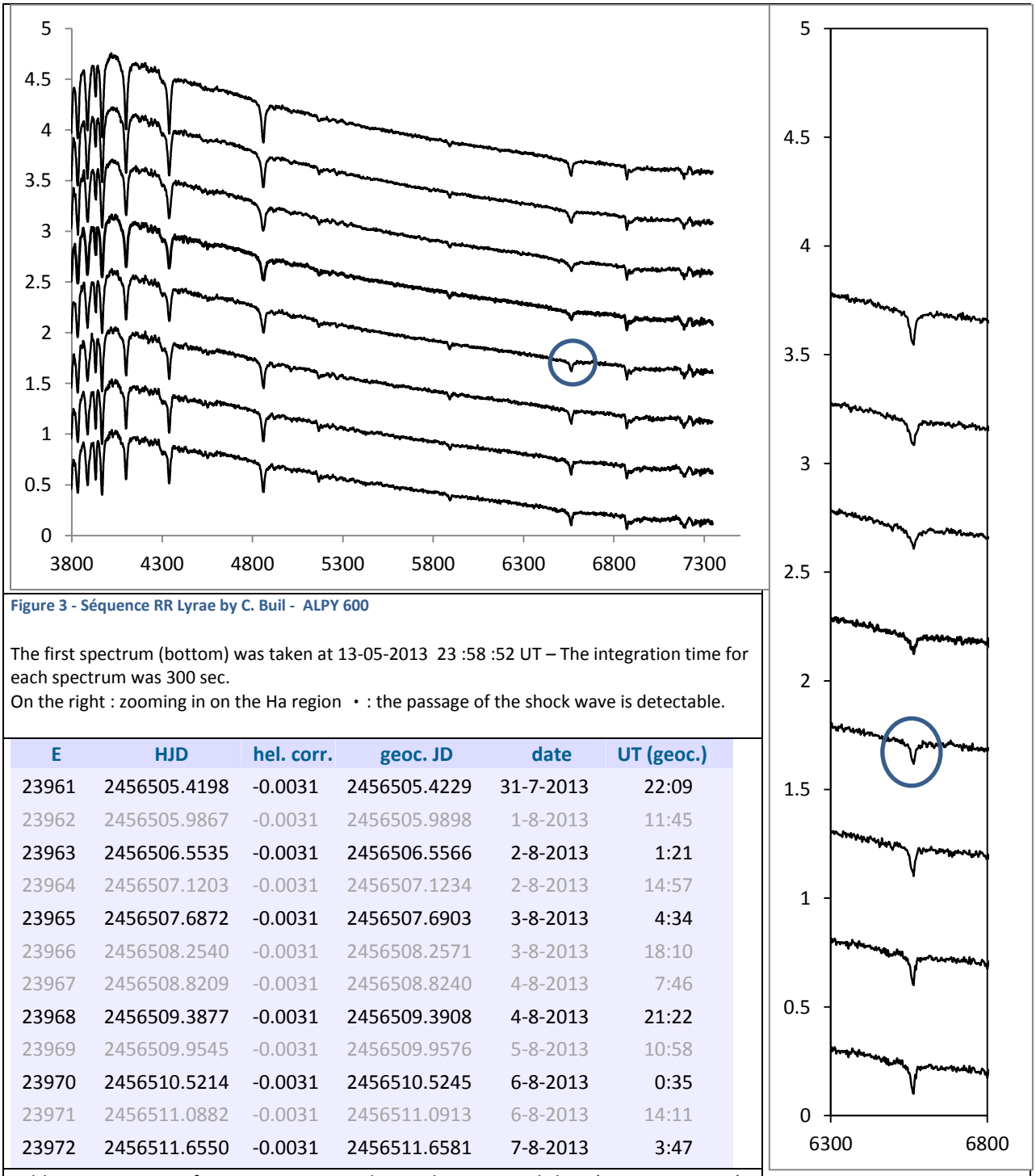


Figure 3 - Séquence RR Lyrae by C. Buil - ALPY 600

The first spectrum (bottom) was taken at 13-05-2013 23 :58 :52 UT – The integration time for each spectrum was 300 sec.
On the right : zooming in on the Ha region ・: the passage of the shock wave is detectable.

E	HJD	hel. corr.	geoc. JD	date	UT (geoc.)
23961	2456505.4198	-0.0031	2456505.4229	31-7-2013	22:09
23962	2456505.9867	-0.0031	2456505.9898	1-8-2013	11:45
23963	2456506.5535	-0.0031	2456506.5566	2-8-2013	1:21
23964	2456507.1203	-0.0031	2456507.1234	2-8-2013	14:57
23965	2456507.6872	-0.0031	2456507.6903	3-8-2013	4:34
23966	2456508.2540	-0.0031	2456508.2571	3-8-2013	18:10
23967	2456508.8209	-0.0031	2456508.8240	4-8-2013	7:46
23968	2456509.3877	-0.0031	2456509.3908	4-8-2013	21:22
23969	2456509.9545	-0.0031	2456509.9576	5-8-2013	10:58
23970	2456510.5214	-0.0031	2456510.5245	6-8-2013	0:35
23971	2456511.0882	-0.0031	2456511.0913	6-8-2013	14:11
23972	2456511.6550	-0.0031	2456511.6581	7-8-2013	3:47

Tableau 1 Maxima of RR Lyrae occuring during the OHP workshop (GEOS DataBase)

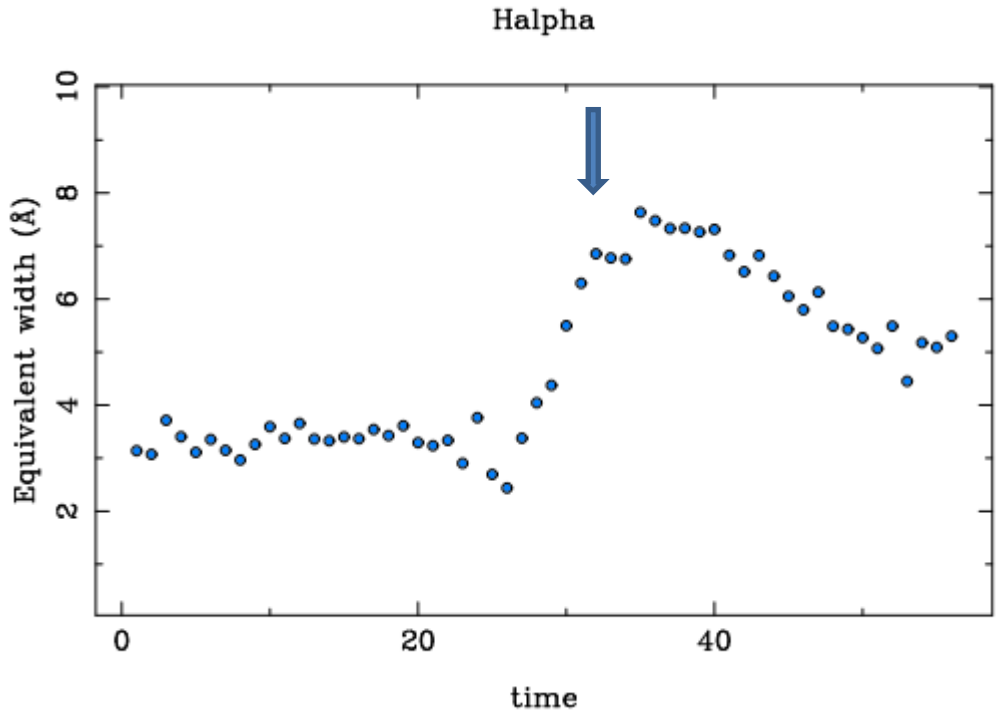


Figure 4 – Measurement of the Equivalent Width of H alpha during the series by série C. Buil du 13-05-2013 highlighting the passage of the shock wave (blue arrow)

At R = 1000, the LISA gives more detail in the H alpha line with a SNR which is still sufficient. .

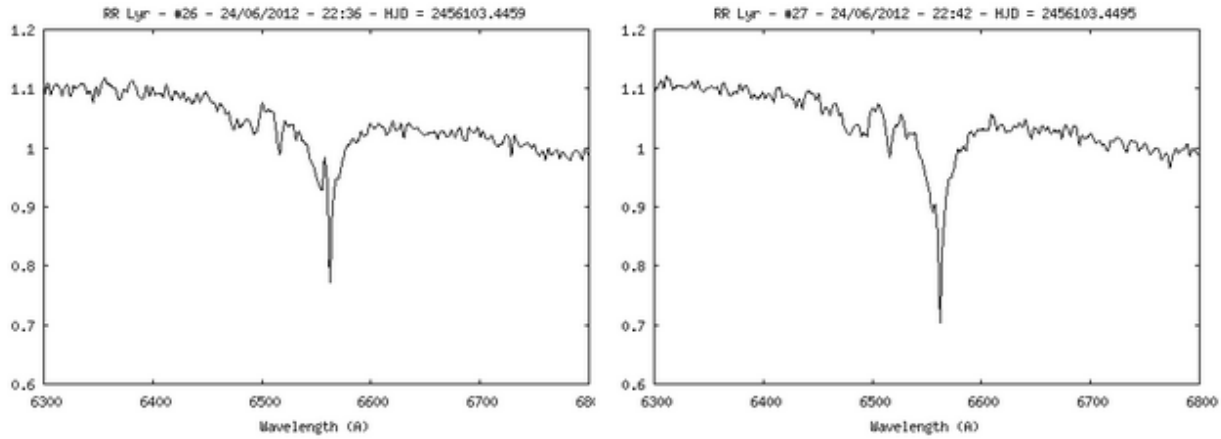


Figure 5 – Raie Hα sur une série C. Buil du 24-06-2013 au LISA R = 1000

Wide participation is needed in this exciting project.

There is the opportunity:

❑ To refine the Instrumental Response correction (Taking into account the wide variation in air mass)
❑ To combine spectroscopy and photometry in parallel (or to use spectrophotometry : see preliminary work on the subject by Christian : http://www.astrosurf.com/buil/campaign/rrlyr/13052013.htm)

❑ **Campaign RR Lyrae 2013 Time-series Photometry and Spectroscopy**

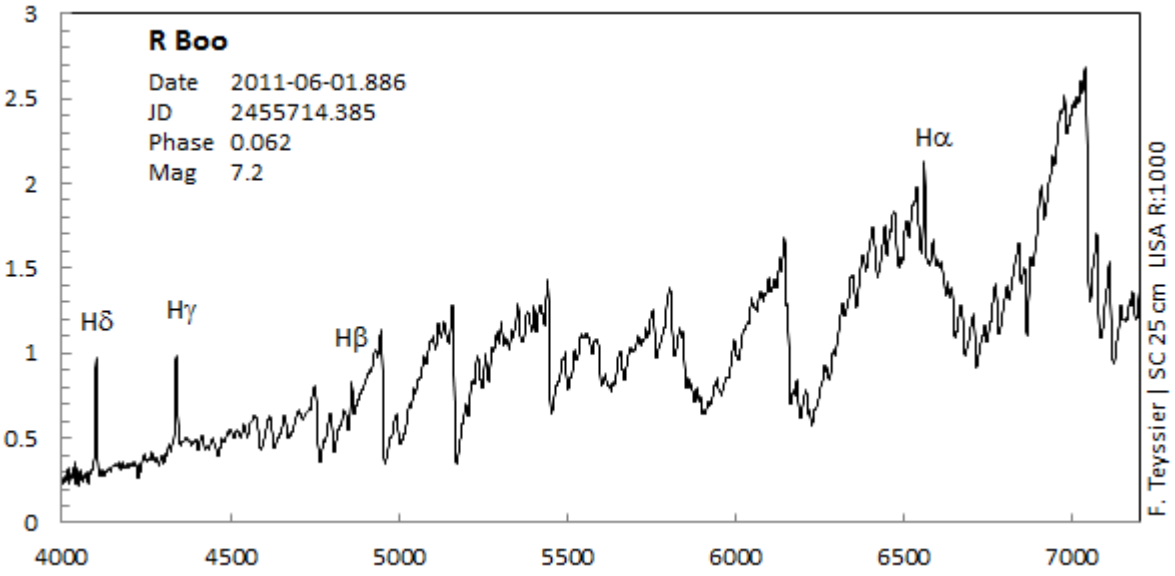
Main page for the campaign	http://rr-lyr.ast.obs-mip.fr/dokuwiki/doku.php?id=rrlyr2013
Forum ARAS	http://www.spectro-aras.com/forum/viewforum.php?f=23
Page C. Buil	http://www.astrosurf.com/buil/rrlyr2/rrlyr_campaign.htm

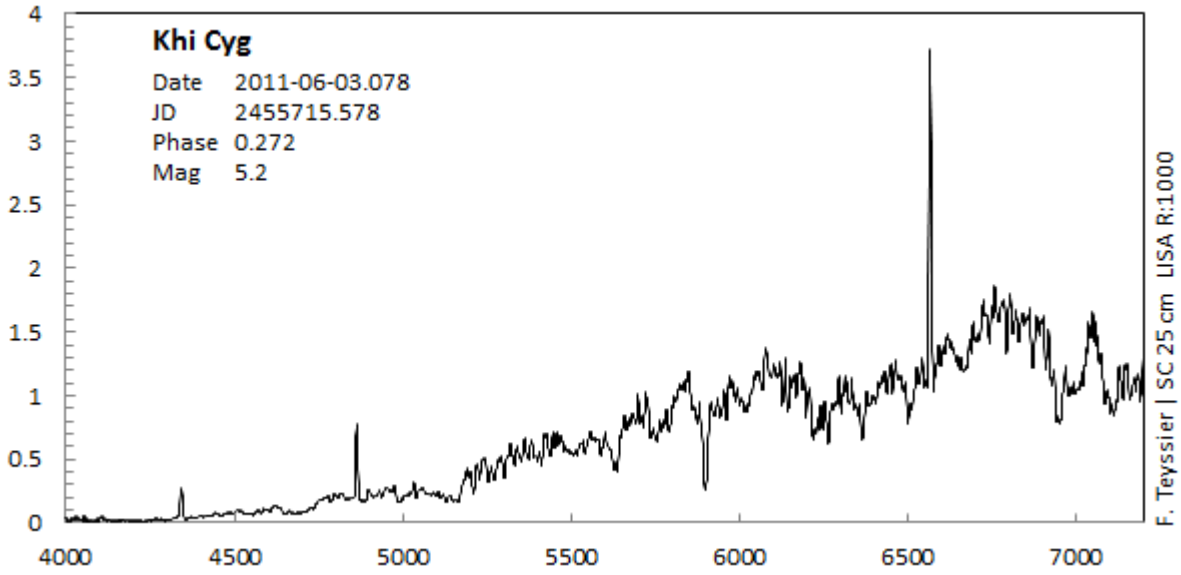
7. Miras at maximum

Around maximum luminosity, the spectra of Miras generally show Balmer lines in emission. Two: R Boo (Mira type M) and Khi Cygni (Mira type S).

In type M Miras, these lines have a peculiarity: the Balmer decrement abnormal. The intensity of the lines increases from Ha to Hd. Long attributed in errror to the absorption of the light by the atmosphere of the giant star, this anomaly is in fact explained by the formation of these lines at different depths in the stellar atmosphere which the shock wave passes through.

.





List of bright Miras **Appendix p. 36**

❑ **Follow the emission lines in Miras**

Page Miras : http://www.astronomie-amateur.fr/feuilles/Spectroscopie/Miras.html

8. Etoiles T Tauri

T Tauri stars are very young stars in the process of evolving onto the main sequence of the HR diagram. They are surounded by a disc of dust and gas, the source of emission lines.

A campaign to observe several of them using photometry and spectroscopy has been launched by Darryl Sergisson (University of Excester). The amateur observations are being coordinated by ARAS.

For 2013, Darryl Sergisson proposes a study of V410 Tau at low resolution. The objective is to clarify periodic phenomena. One spectrum per day is requested.

OHP 2013 is perhaps an oportunity to obtain the first spectra of the new campaign with observations made shortly before the end of the night.

Name	AD (2000)	Dec. (2000)	Mag. V	Sp. Type
V410 Tau	04 18 31.1	+28 27 16.1	~8	K4IV

Référence star :

Name	AD (2000)	Dec. (2000)	Mag. V	Sp. Type
HD 29646	04 41 19.8	+28 36 54.0	5.726	A2V

An example of a spectrum of a T Tauri star:

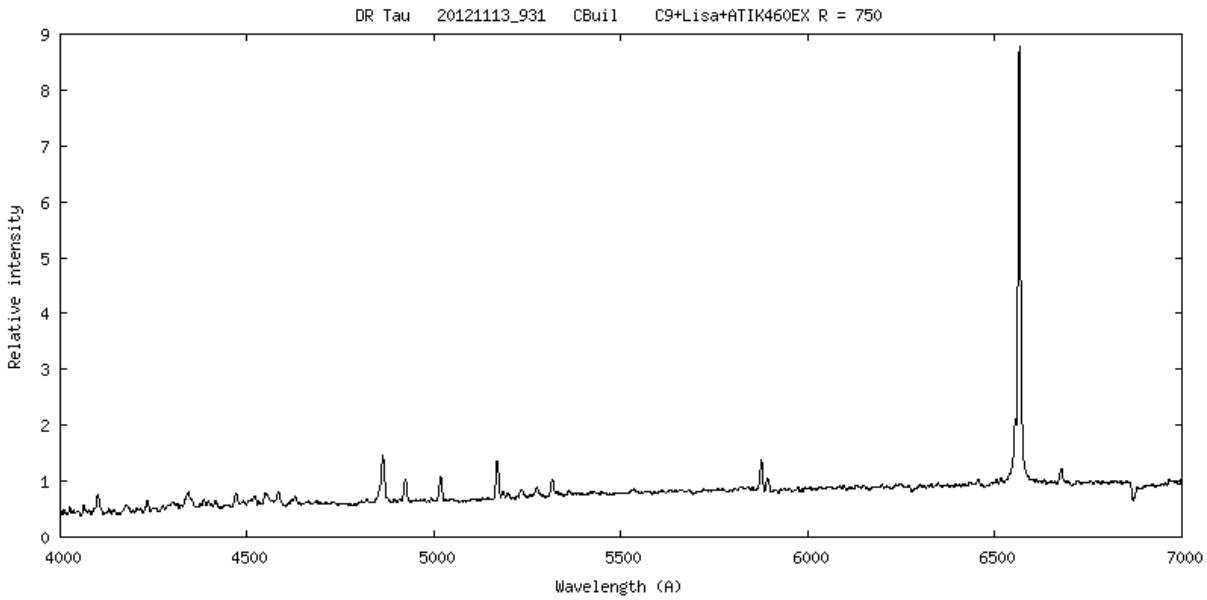


Figure 6 **DR Tau by C. Buil (LISA R = 750)**

Additionally, high resolution spectra of RY Tau are also requested

❑ **Campaign 2013 V410 Tau Target: 1 spectrum per day**

Pages ARAS http://www.astrosurf.com/aras/Aras_TTauri/T_Tauri_Campaign.html
Forum ARAS http://www.spectro-aras.com/forum/viewforum.php?f=28

9. Planetary nebulae

Favourite targets of amateur astrophotographers, planetary nebulae are also spectacular in low resolution spectroscopy.

9.1. Starting off with bright nebulae

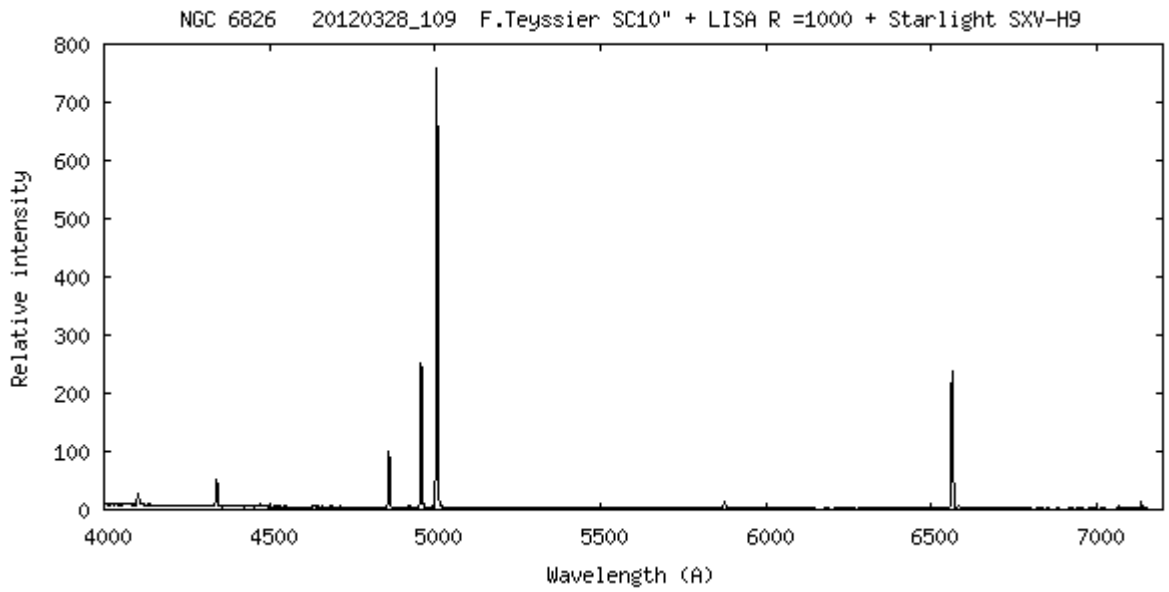


Figure 7 Spectrum of the Planetary Nebula NGC 6826 – LISA R =1000

List of bright nebulae: **Appendix page 37**

9.2. Identify the lines

- List of the brightest lines in nebulae **Appendix p. 38**
- Example of identification in NGC 7027 **Appendix p. 39**

9.3. Déterminer les paramètres Physiques (température, densité avec les raies [OIII], [NII], [SII]

Well calibrated in flux after having been dereddened, spectra obtained using LISA or Alpy600 can be used to determine the principal physical parameters of planetary nebulae: temperature, electron density …

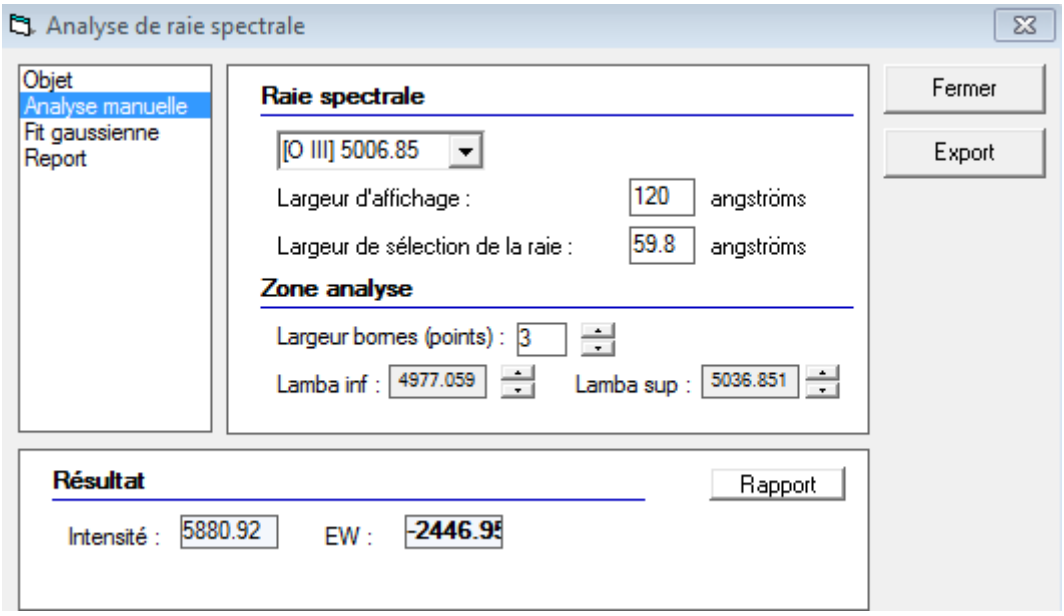
An example (NGC 2392) is described here:

http://www.astronomie-amateur.fr/feuilles/Spectroscopie/NGC2392.html

The measurements are in very good agreement with the published values.

	Value from spectra of 6-04-2011	Published value
Temperature [OIII]	12800 K	12700 K (Henry & al., 2000)
Temperature [NII]	11400 K	10800 K (Henry & al., 2000)
Electronic density	3400 e.cm^{-3}	3000 e.cm^{-3} (Baker, 1991)

VSpec (V. Desnoux) allows the values to be determined easily (Assistant>Analyse the spectral lines)



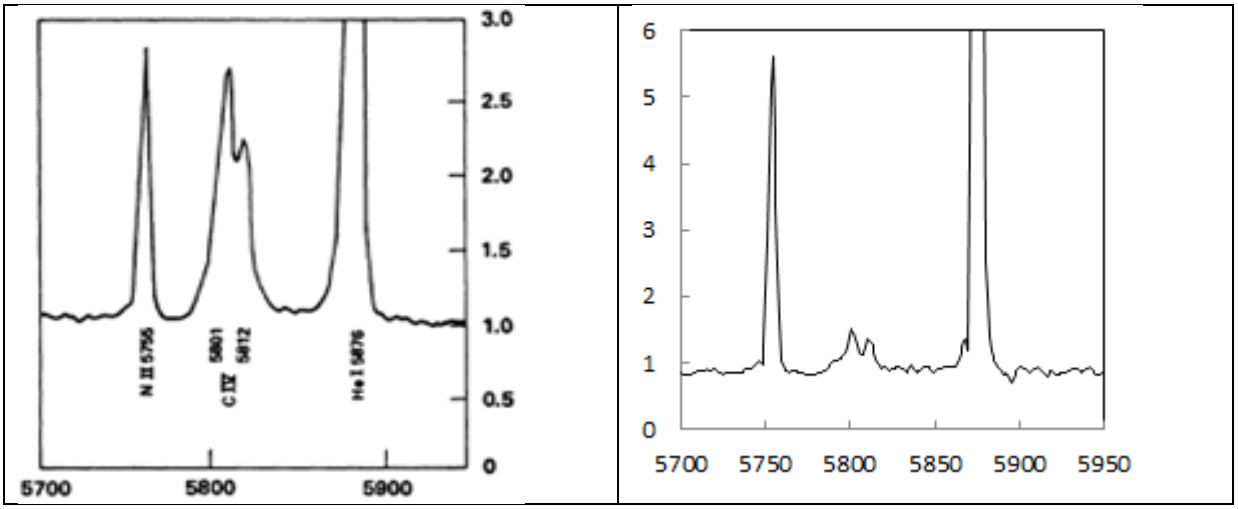
This is an excellent introduction into the measurement of physical parameters which can also be used to measure variable objects such as symbiotic stars.

9.4. Variable planetary nebulae

A few PNe show variations in certain lines. Long term monitoring of these nebulae long term is of interest.

Name	AD (2000)	Dec. (2000)	Mag. V
IC 4997	20 20 08.8	+16 43 53	11.0
NGC 6572	18 12 7.5	+06 51 25	10.8

Un exemple sur NGC 6572



Significant variation in the relative intensities of [NII] 5755 and CIV 5801,5812
Left : spectra W.A. Feibelman & al., 1992 obtained 25-06-1974 | Right : F. Teyssier, 18-09-2012

Voir : http://www.astronomie-amateur.fr/feuilles/Spectroscopie/Planetary_Nebulae_Variability_IC4997.html
http://www.astronomie-amateur.fr/feuilles/Spectroscopie/Planetary_Nebulae_Variability_NGC6572.html

A presentation on amateur spectroscopy of PNe:

http://www.astronomie-amateur.fr/Documents%20Spectro/PresentationPNw.pptx

❑ **Evolution of lines in IC 4997 and NGC 6572**

Atlas http://www.astronomie-amateur.fr/feuilles/Spectroscopie/Planetary_Nebulae.html
Atlas C. Buil http://www.astrosurf.com/buil/nebula/nebula.html
Determination of the temperature and density of NCG 2392
http://www.astronomie-amateur.fr/feuilles/Spectroscopie/NGC2392.html

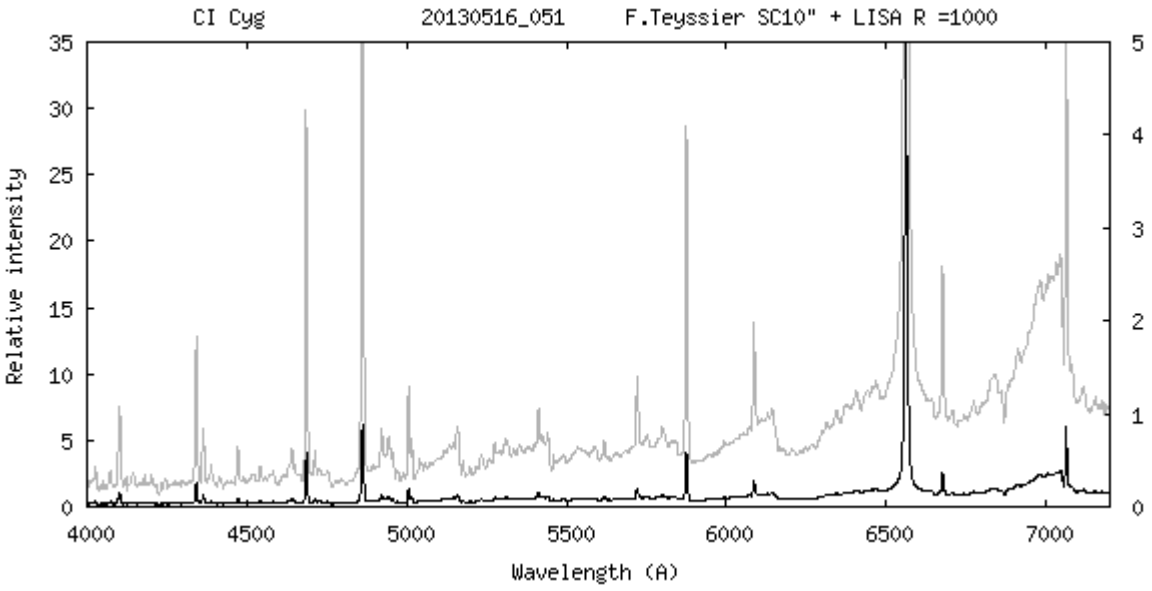
10. Symbiotic Stars

Binary stars consisting of a compact hot component (usually a white dwarf), and a red giant. The stellar wind emitted by the giant forms a nebula ionised by UV radiation from the white dwarf which can produce spectacular emission lines (up to[Fe VII]).

Long period binary stars (from a 100 to several thousand days), subject to outbursts, showing nova-like events, symbiotic stars are prime targets for long term monitoring.

The appearance of the spectrum can vary greatly from one symbiotic to another: Symbiotics are certainly a heterogeneous group **Appendix p. 41**

Spectrum of a classic symbiotic: CI Cygni
Numerous emission lines (including intense He II and [Fe VII] and a composite continuum in which TiO absorption bands predominate.



The spectrum of V1016 Cyg, a symbiotic in outburst since 1967 (very slow nova), which gives an idea of the variation in symbiotic spectra: It is very similar to that of a PNe.

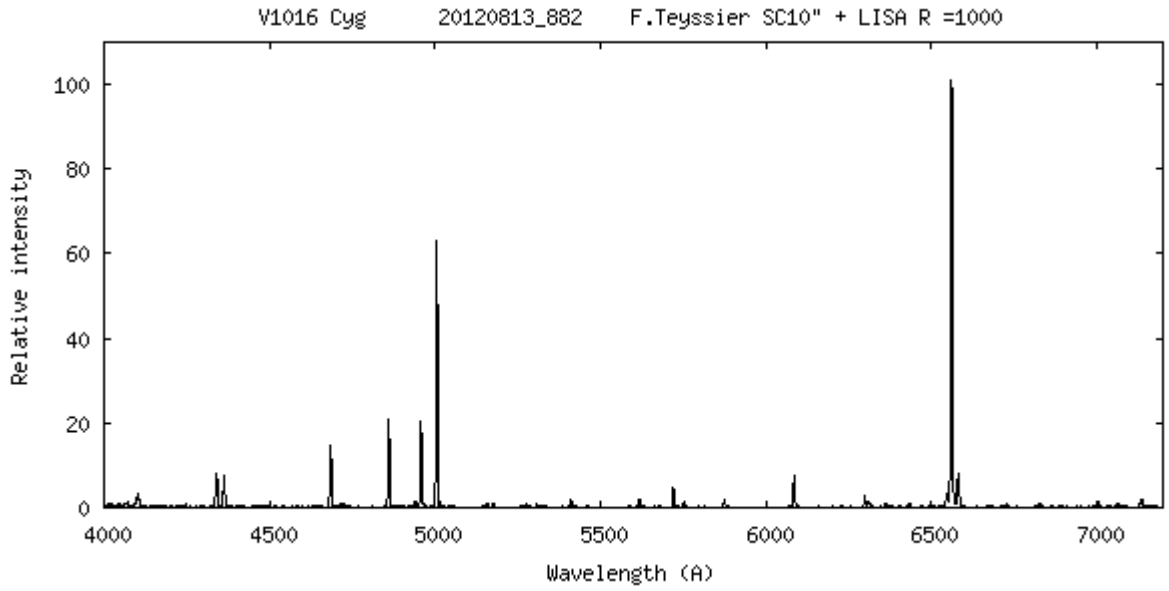


Figure 8 – V1016 Cygni – Symbiotic nova – LISA R = 1000

An example to follow long term: CI Cygni
These stars, with variations related to orbital phase and activity, are prime targets for long term monitoring by amateurs.

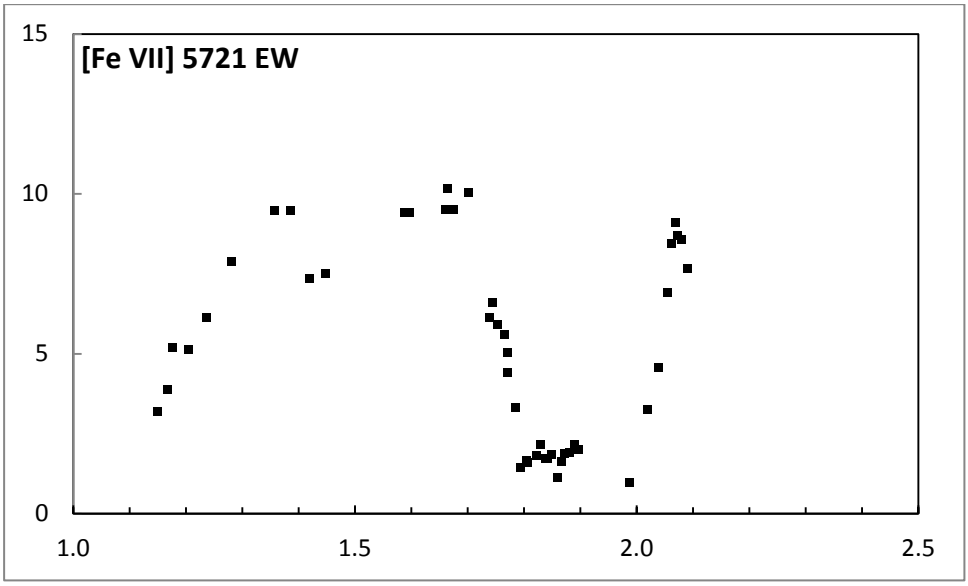


Figure 9- CI Cygni : Variation in Equivalent Width of the [Fe VII] 5721 line over one orbital period (March 2011 to May 2013)

The measurement of intensities of certain lines allows some physical parameters prevailing in these objects to be estimated.

An example of the estimation of the hot star temperature in CI Cyg using Helium lines (HeI 4471 and HeII 4686)

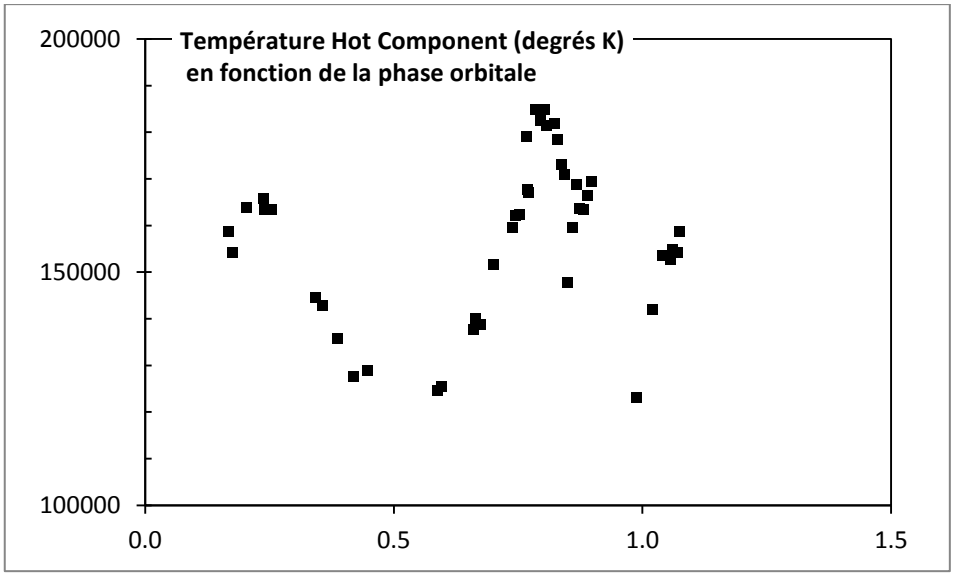


Figure 10 - CI Cygni : variations in the temperature of the hot star over the length of an orbital period (March 2001 to May 2013)

An example of a regularly followed symbiotic : T CrB is one of 10 recurrent novae, which reaches mag 2 in outburst (1866 et 1946), while in its quiescent state it is mag 10. A new outburst could happen at any time

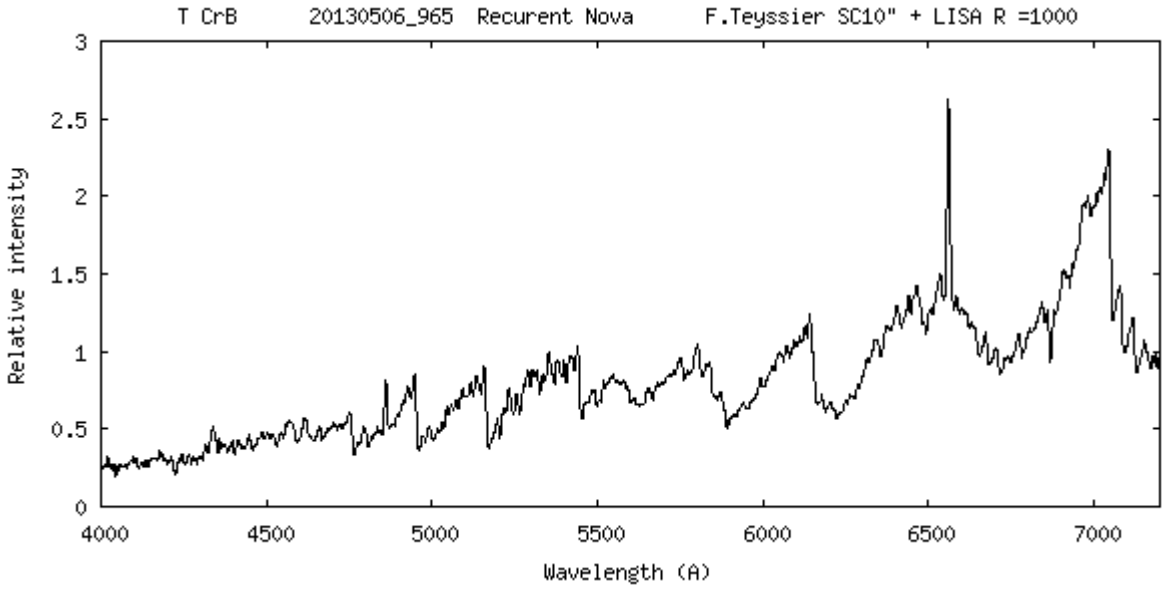


Figure 11 – T CrB, récurrent nova – LISA R =1000

List of the brightest symbiotic stars in Appendix p. 40

Identification of lines in Appendix p. 41

❑ **Suivi CI Cygni, CH Cygni, AX per, R Aqr, T CrB, V694 Mon**

Page symbiotiques : http://www.astronomie-amateur.fr/Projets%20Spectro1%20SySt.html
Atlas : http://www.astronomie-amateur.fr/AtlasSpectroscopique_EtoilesSymbiotiques_Lisa.html
Atlas : http://www.astrosurf.com/buil/survey/symbiotic/symbiotic.html

NEW : CH Cygni 2013 campaign upon the request of Dr M. Karaskova

10. Cataclysmic stars

Close binaries with short periods (a few hours), consisting of a main sequence star which fills its roche lobe and loses material through the Lagrange point. This material forms an accretion disc around the second component, a white dwarf. The accretion disc is the site of outbursts (brightening by 2 to 8 magnitudes), giving rise to the term « dwarf novae » given to non magnetic cataclysmic stars.

Prototypes : SS Cyg, UGem, SU UMa, WZ Sge.

Cataclysmics in which the white dwarf has a strong magnetic field are called polars or semi-polars: the magnetic field partially or completely prevents the disc forming. Prototypes are AM Her, AH Her.

In the low state cataclysmic star spectra are characterised by broad H and He emission lines. In outburst, the continuum is reinforced in the blue, the lines change to absorption, sometimes filled with an emisison component. He II appears, indicating a large increase in temperature of the disc. (15 to 20000 K).

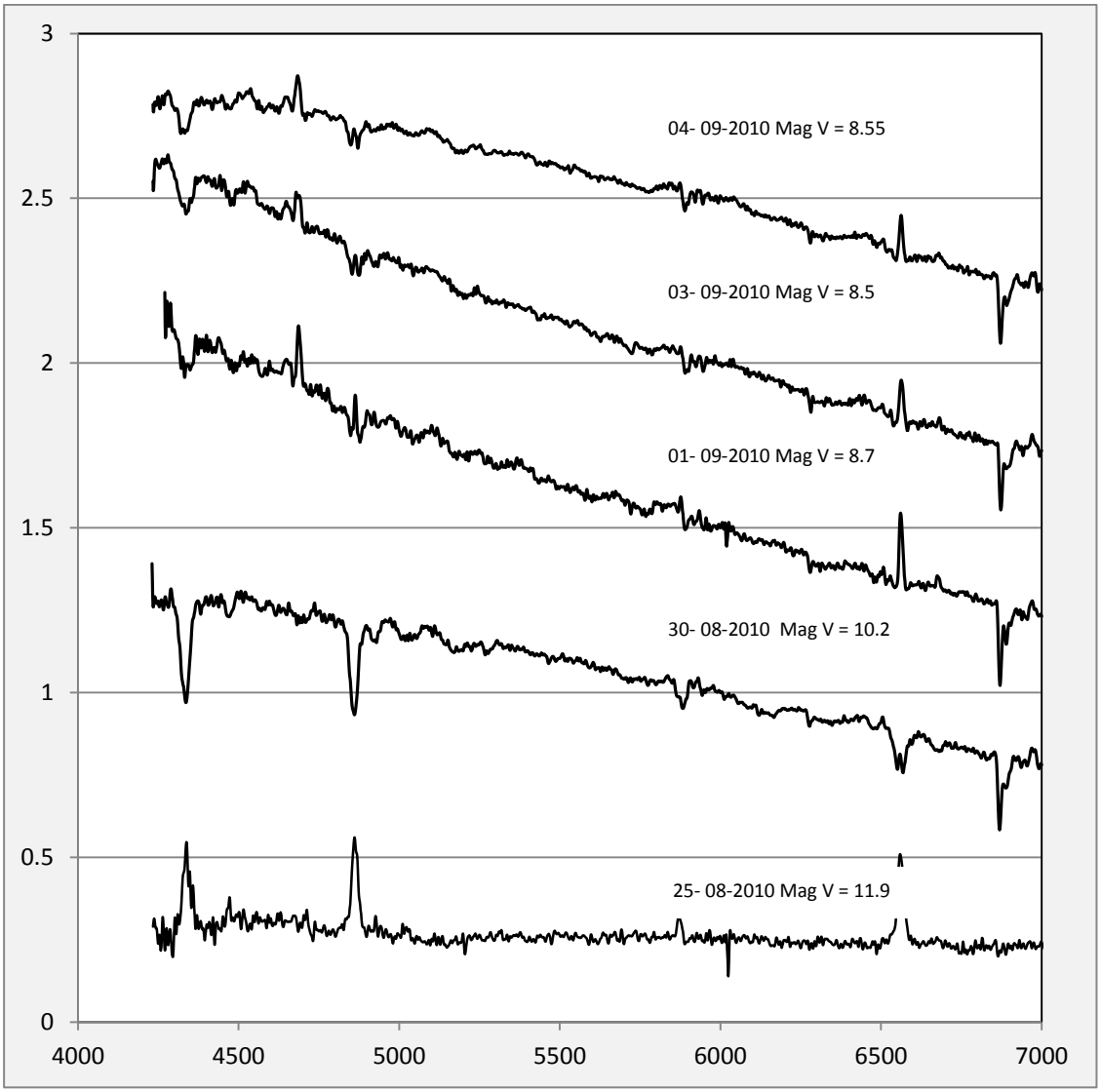


Figure 12 - Evolution du spectre de SS Cygni durant un outburst (Sept. 2010) – LHIRES 150 l/mm

Note : the number of published spectra of cataclysmic stars is very small.

Alongside the cataclysmics is a « catch all » class of stars called « nova-like » among which are found some very interesting objects, including V Sge.

Name	AD (2000)	Dec. (2000)	Mag. V
V Sge	20 20 14.7	+21 06 10.4	11.2 ~

In addition to HI, HeI, He II lines (the latter, particulalry intense), one finds CIV 5804.

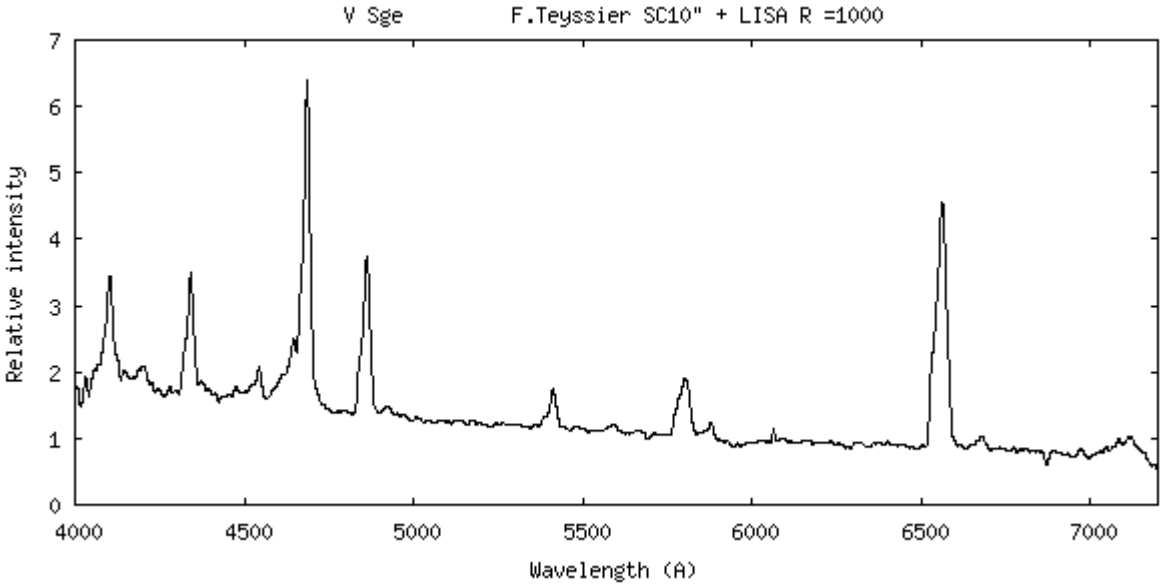


Figure 13 - V Sge – LISA R = 1000

The light curve of V Sge shows primary and secondary minima. The ephemeris of the main minima is given in Kreiner, 2004 : **HJD = 2452500.222 + E x 0.514190** [Kreiner 2004]

Steven Shore (University of Pisa) suggests monitoring V Sge to clarify variations the in the spectrum.

- ❑ **Monitor outbursts of SS Cygni**
- ❑ **Spectra of Cataclysmics in outburst**
- ❑ **V Sge : variations during the orbital period and medium term**

The AAVSO section devoted to cataclysmics, with regular updates of the stars in outburst :
https://sites.google.com/site/aavsocvsection/
Page on cataclysmics : http://www.astronomie-amateur.fr/Variables%20Cataclysmiques.html

11. Novae : classification and evolution

Novae are produced by a thermonuclear explosion in the surface layer of Hydrogen/Helium which accumulates on the surface of a white dwarf in a cataclysmic or symbiotic binary system. The increase in brightness of around 8 magnitudes is generally fast (1 to 2 days). est généralement rapide (1 à 2 jours). The decline is very variable. They are a quite rare phenomenon (perhaps a dozen per year), most common near the galactic centre.

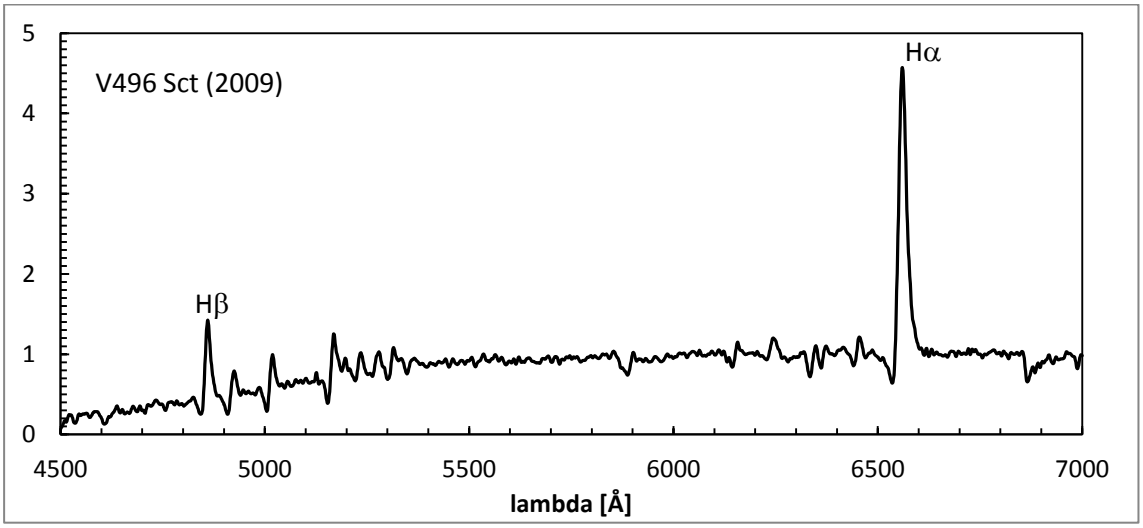
OHP 2012 was exceptional opportunity for combined observations of nova Monocerotis 2012 with the first spectra obtained by J. Edlin and S. Charbonnel.

ARAS amateurs regularly monitor novae. The observations are summarised at http://www.astrosurf.com/aras/novae/Novae_Aras.html

11.1. Classification

Around maximum brightness, the nature and appearance of the lines allow novae to be classified into two types (Williams 1991) :

Novae Fe II : Narrow lines (a few hundred km/s), the most intense lines from Iron (Fe II)



Novae He/N : Broad lines (> 2500 km.s-1) from He I, He II and N II

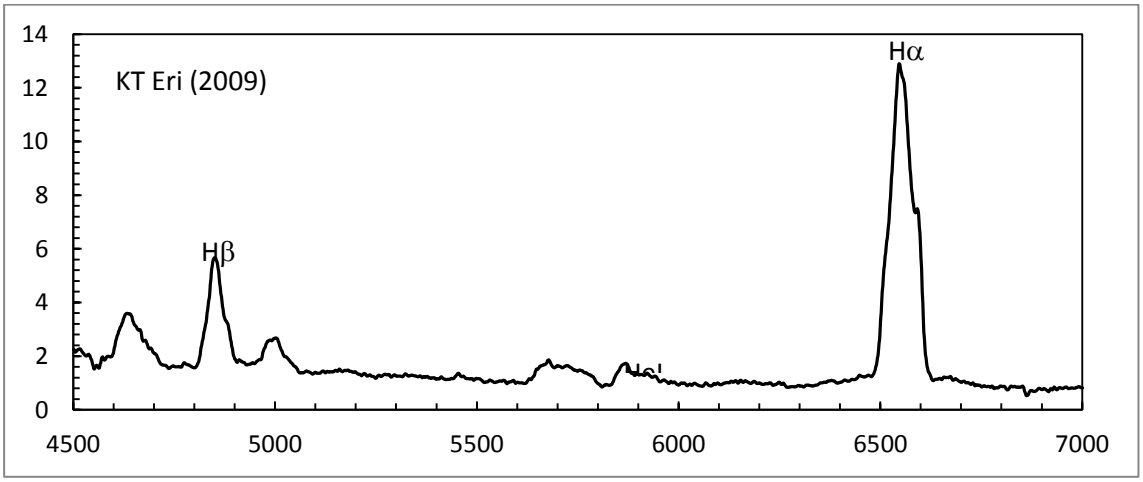
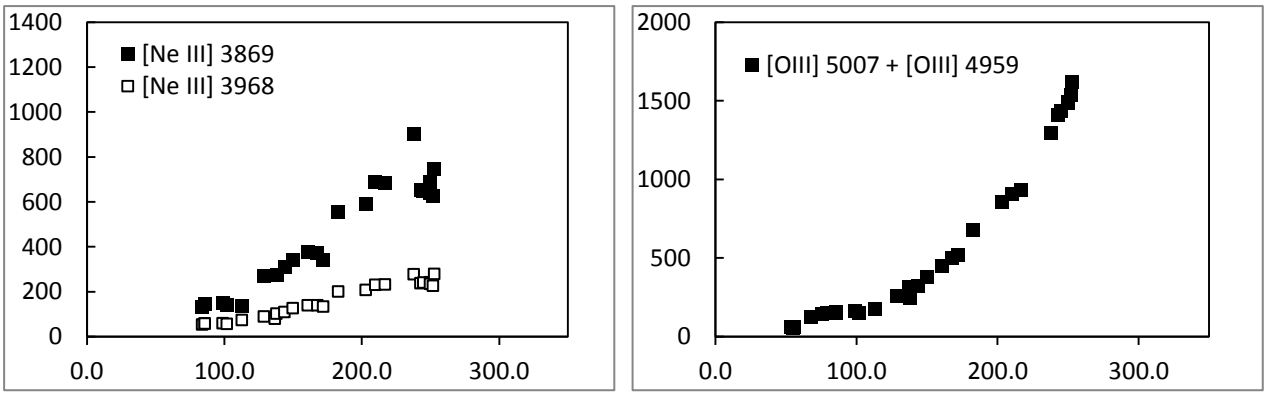


Figure 14 – Novae 496 Sct et KT Eri – LHIRES III 150 l/mm

11.2. Evolution

Le suivi régulier de la nova Mon 2012 durant plus de 6 mois par les amateurs d'ARAS a permis d'établir des l'évolution des principales raies de cette nova ONe exceptionnelle. Exemples :



X axis : estimated days since maximum (25-06-2012)

Y axis : intensity relative to H beta = 100

Figure 15 – Evolution de la largeur équivalente de certaines raies de la nova Mon 2012 – Différents observateurs – LISA et ALPY600

Evolution of V496 Sct into a spectacular nebular spectrum (with [OIII] 4959 and 5007 predominating)

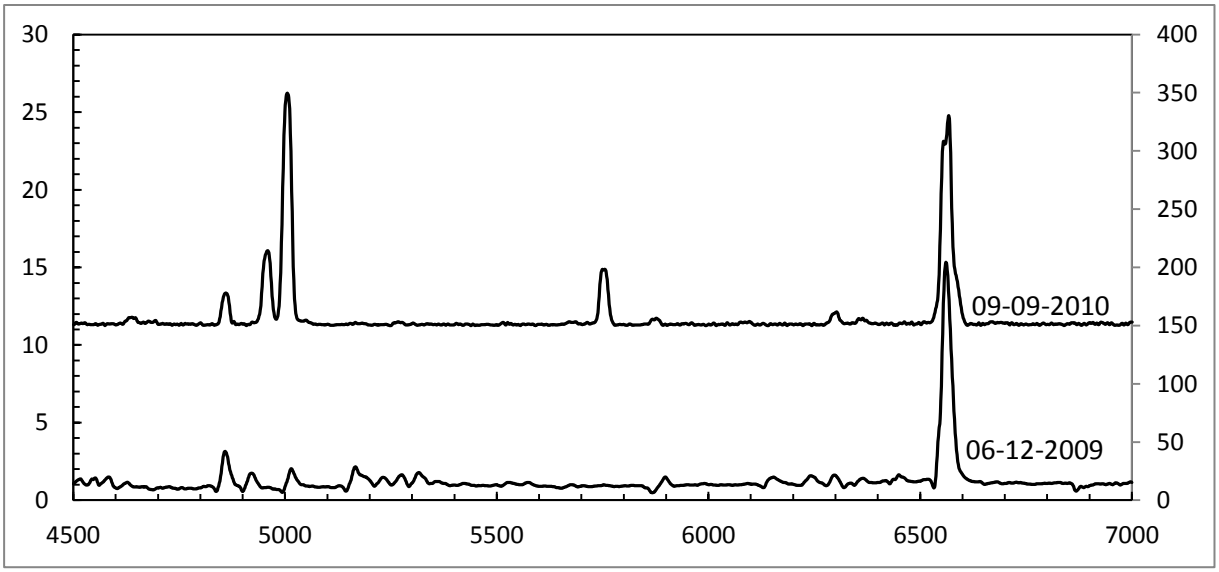


Figure 16 – Changement de l'aspect du spectre de V496 Sct entre la phase des raies permises (09-09-2009) et la phase nébulaire (6-12-2010)

- ❑ **Recover Nova Mon 2012 at dawn during September**
- ❑ **Wait for the next nova...**

Ressources

Page ARAS : http://www.astrosurf.com/aras/novae/Novae_Aras.html
Pages Christian Buil : http://www.astrosurf.com/buil/us/spe7/novae.htm
Page on the formation of the different types of novae spectra:
http://www.astronomie-amateur.fr/Projets%20Spectro4%20Novae.html
List of lines found in novae (From Williams, 2012)
http://www.astronomie-amateur.fr/Documents%20Novae/Raies_Novae.pdf

11. Supernovae : classification and evolution

The destructive end for some stars, supernovae are among the most energetic events in the universe.

There are essentially two types,

- supernovae type Ia, resulting from the collapse of a white dwarf when it exceeds the Chandrasekhar limit
- supernovae type II, Ib, Ic, produced by very massive stars

In general the absorption lines are very broad and (several thousand km/s) and strongly blue shifted.

SN Ia : Characterised near maximum brightness by strong absorption around 6150 produced by Silicon and the absence of Hydrogen lines.

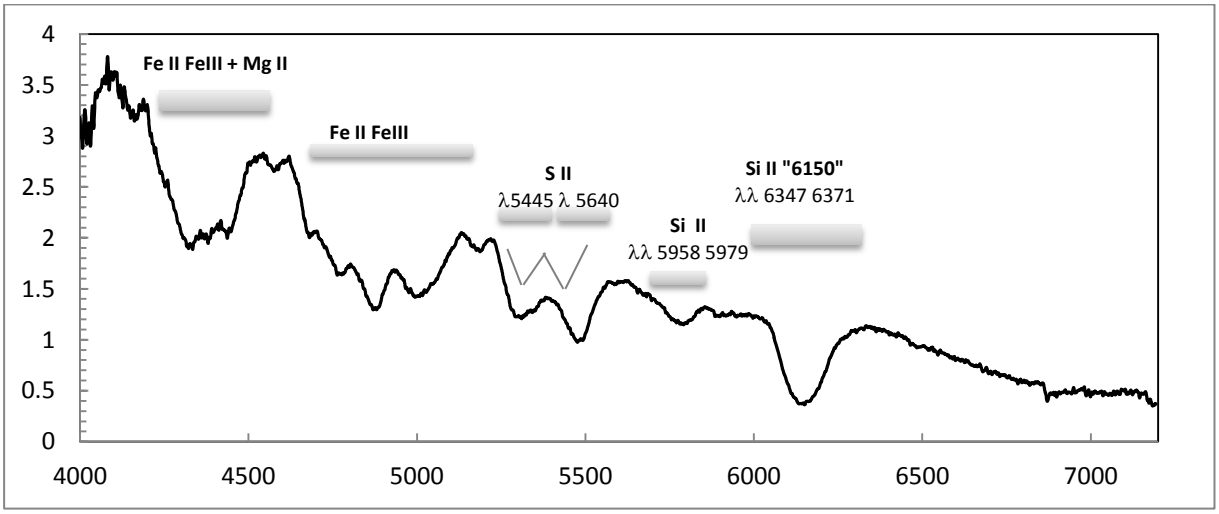


Figure 17 – Spectrum ofSN 2011fe dans M101 13-09-2011 - LISA

SN II : deep P Cygni profile (max. near 6300 Å) before H alpha

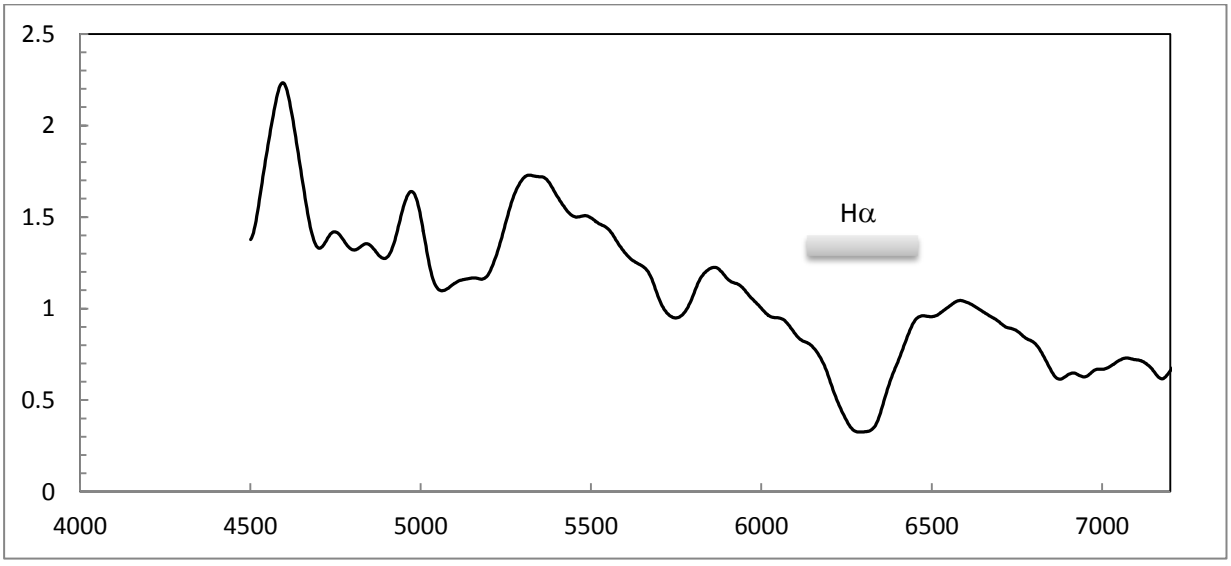
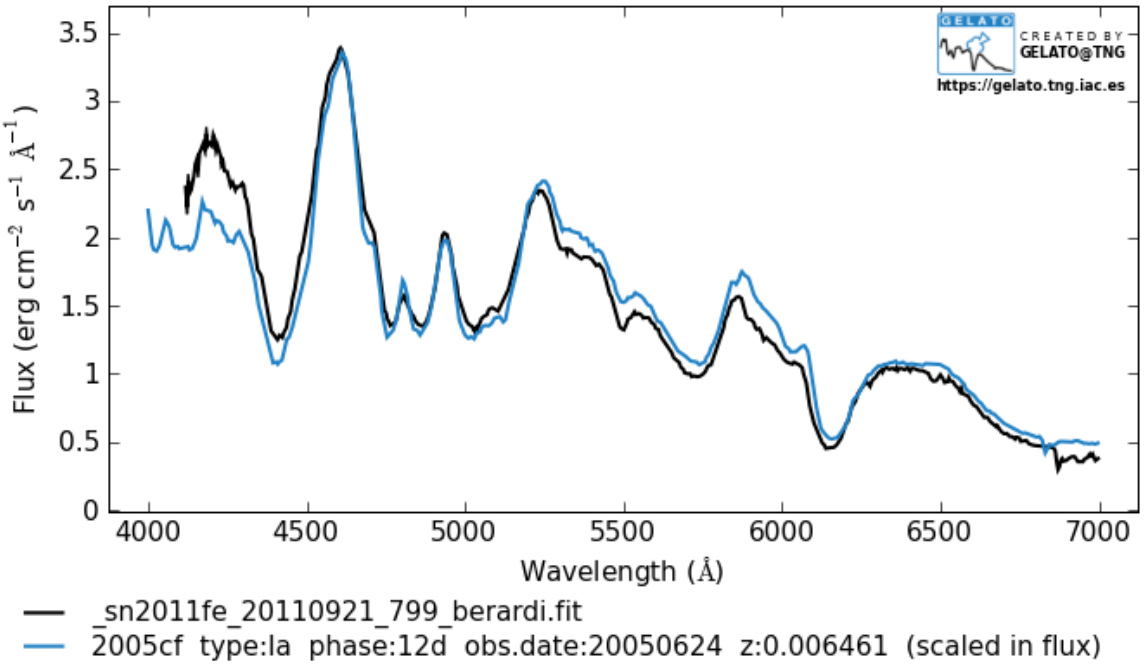


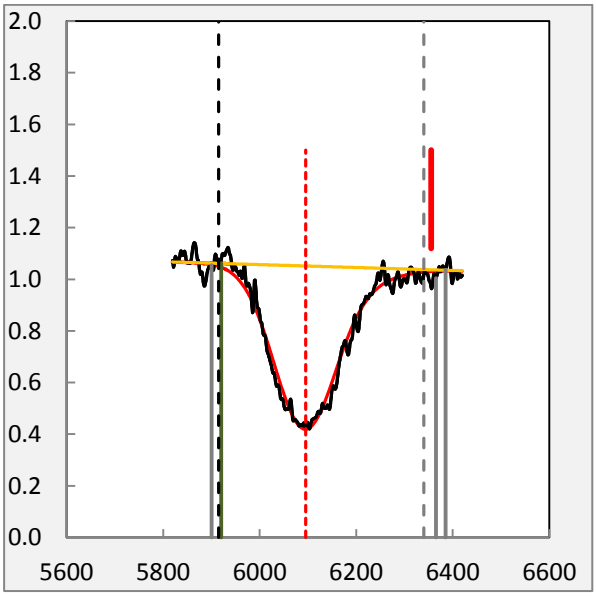
Figure 18 – Spectrum of SN 2011dh (Type IIb) dans M51 – 16-06-2011 – LISA R = 800

The **GELATO** program allow the type and age (time since maximum) of the supernovae to be indentified.

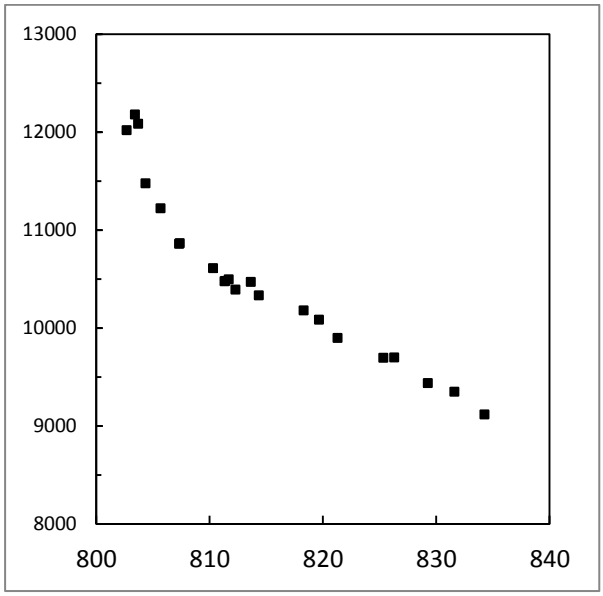
An example using a spectrum of SN 2011 fe (M101) acquired by Paolo Berardi :



Examples of measurements which can be made: the expansion velocity of SN 2011 fe (M101)



Measurement of the expansion velocity from the Doppler shift of the Si « 6150 » line from the rest wavelength of 6355 Å (thick red line). The line centre is defined using a Gaussian fit (Excel spreadsheet)



The expansion velocity (in km.s^{-1}) as a function of time (JD – 2455000) measured using the Si II « 6150 » line – Spectra from ARAS

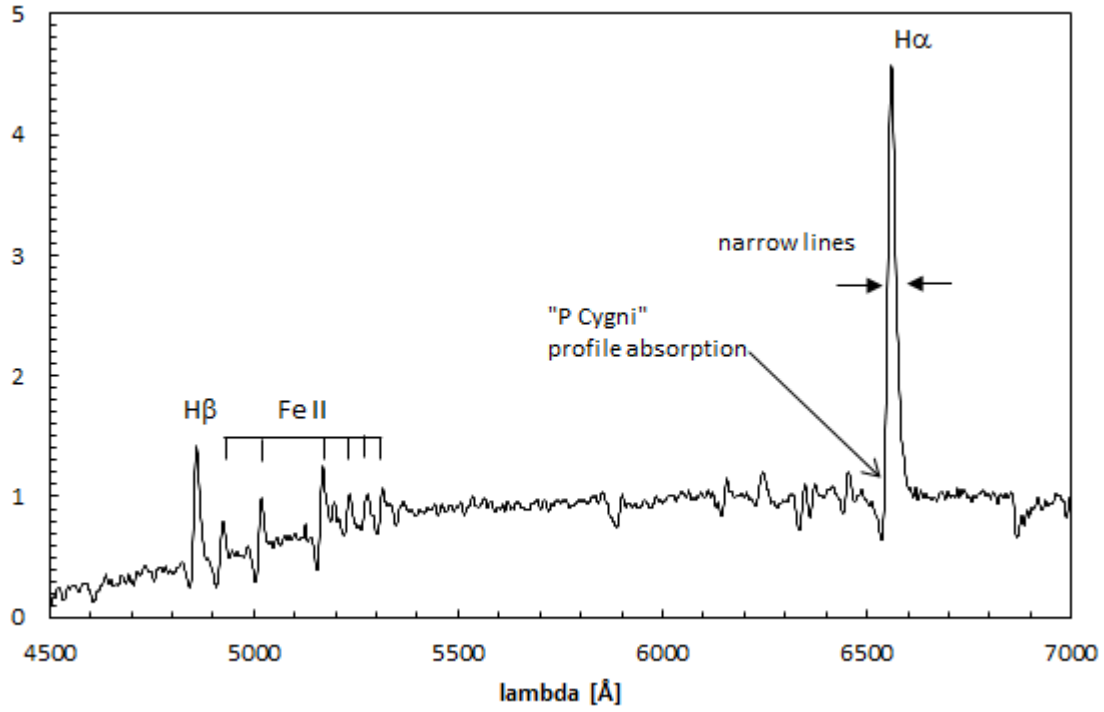
- ❑ **Participate in the ARAS campaigns on bright supernovae**
- ❑ **Mount a LISA or Alpy600 on a 60-90 cm aperture telescope, to identify supernovae to magnitude 17-18 ...**

Alerts CBAT http://www.cbat.eps.harvard.edu/unconf/tocp.html
Database of Supernovae http://www.rochesterastronomy.org/supernova.html
Program for identification https://gelato.tng.iac.es/login.cgi
Pages Christian Buil http://www.astrosurf.com/buil/supernovae/survey.htm
Page on the formation of type 1a supernovae spectra http://www.astronomie-amateur.fr/feuilles/Spectroscopie/SuperNovae_Ia.html

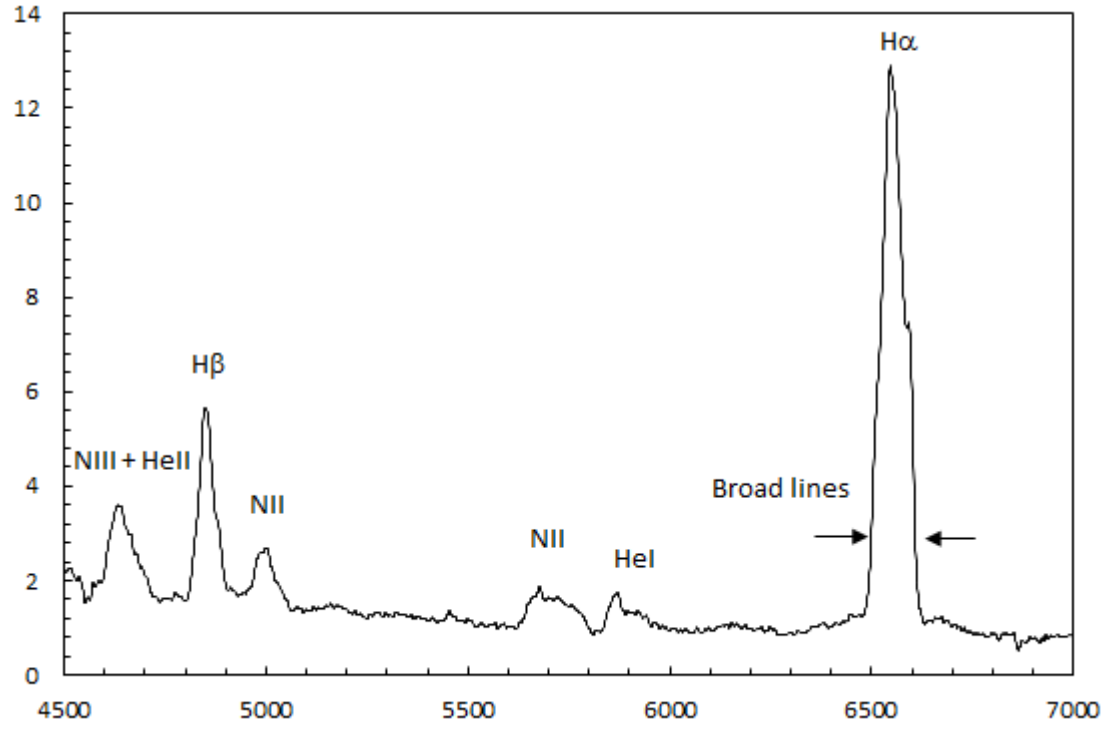
12. Identification of « new stars »

« New » stars are usually detected using photometry. Spectroscopy then allows the nature of the object to be confirmed. In recent years amateurs in ARAS have contributed to these identifications.

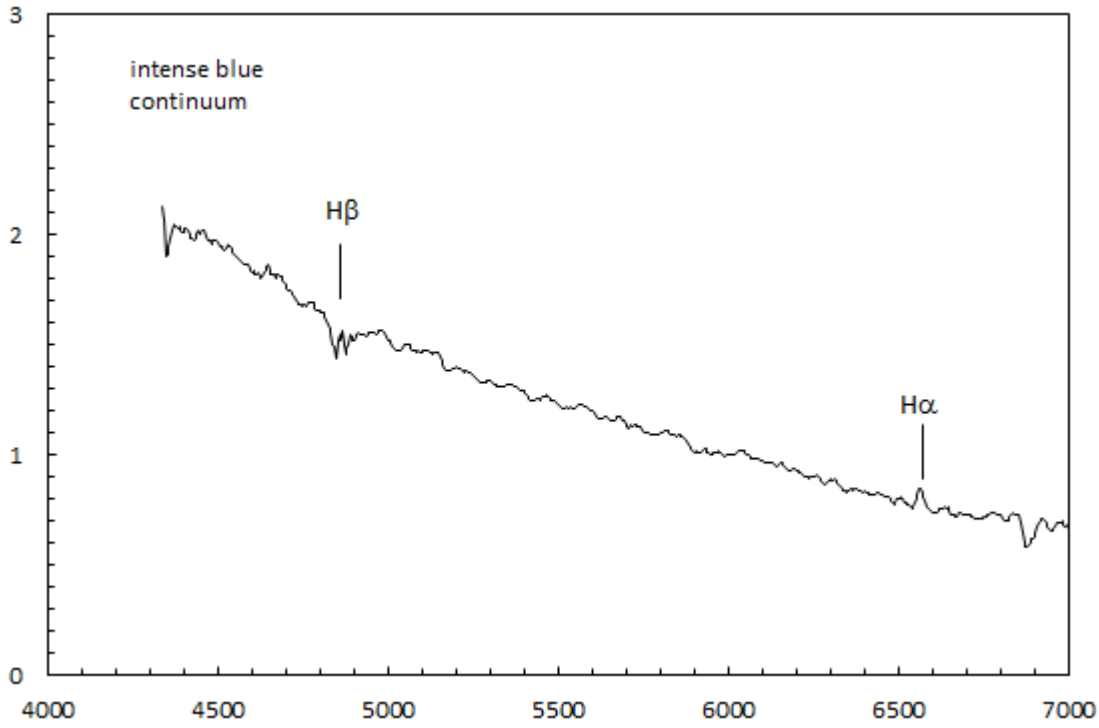
Nova Fe II



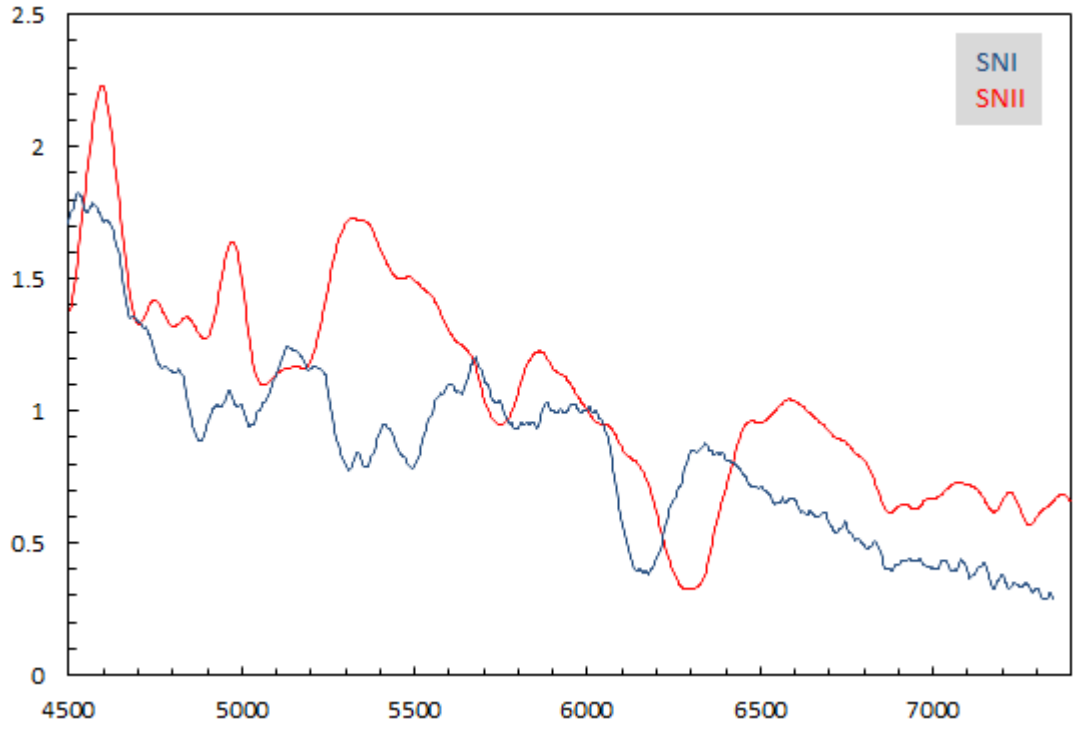
Nova He/N



Cataclysmique type WZ Sge



Supernovae Types SNIa et SN II



Alerts are issued on CBAT http://www.cbat.eps.harvard.edu/unconf/tocp.html, CVNET, VSNET, ARAS forum and Spectro-l list …

Identifying charactéristics :
http://www.astronomie-amateur.fr/feuilles/Spectroscopie/NewStars.html

13. Quasars and Seyfert galaxies : redshift and distance

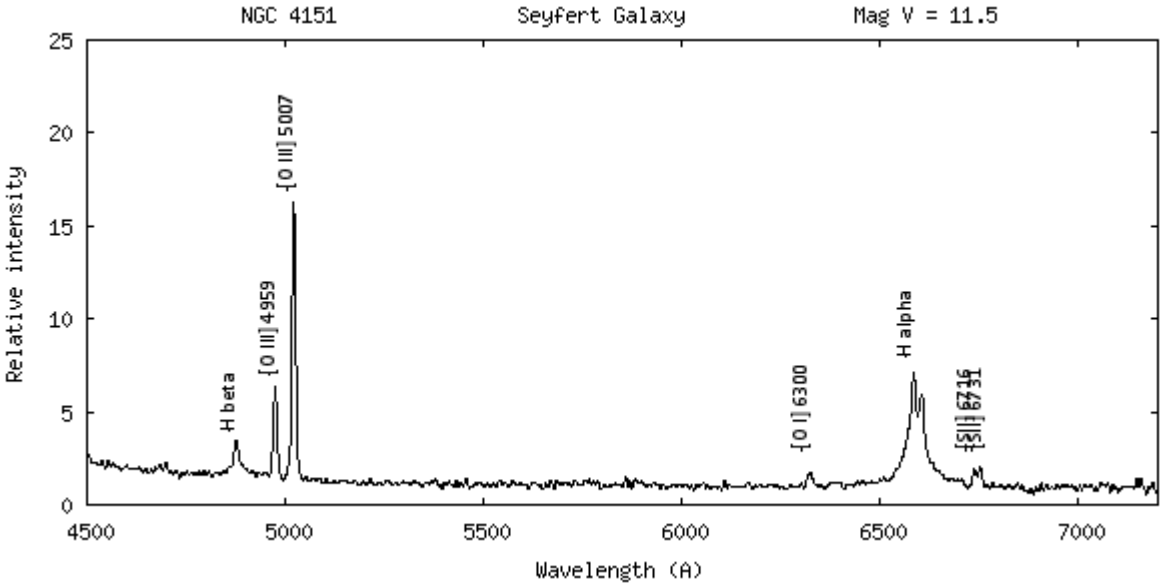
Quasars and Seyfert galaxies are galaxies with active nuclei (black holes) and their spectra show many emission lines. The redshift of these lines allows the recession velocity and the distance to be measured.

A selection of quasars and galaxies with active nuclei

Name	AD (2000)	Dec. (2000)	Mag. V	z
3C273	12 29 06.7	+02 03 08.7	12.85	0.173
NGC 4051	12 03 09.7	+44 31 52.5	12.92	0.00216
NGC 4151	12 10 32.6	+39 24 20.9	11.48	0.00326
NGC 7469	23 03 15.7	+08 52 25.3	13.00	0.01588
NGC 7603	23 18 56.7	+00 14 37.6	14.01	0.02930
NGC 1275	03 19 48.16	+41 30 42.1	12.48	0.01756
M77	02 42 40.77	-00 00 47.84	8.87	0.00379
M87	12 30 49.42	+12 23 28.0	8.63	0.00423
APM 08279+5255	08 31 42	+52 45 17	15.2	3.85

The challenge : APM 08279+5255 at a distance of 12 billion light years.

an example of a galaxy with an active nucleus, NGC 4151 :



With a good wavelength calibration, the shift in wavelength (Doppler effect) can be measured to determine the redshift and recession velocity.

The values obtained for NGC 4151 are in good agreement with those published..

λ Å	λ0 Å	Δ λ Å	Δ λ /λ	v km.s^{-1}
5021.9	5006.8	15.1	0.00301	
4974.5	4958.9	15.6	0.00314	
moyenne			**0.0031**	**921**

Measure the redshift of NGC 4151 (Simbad gives z = 0.00326)

Page Christian Buil http://www.astrosurf.com/buil/galaxies/spectra.html

14. Other objects and observing projects

Comets

See the spectra of Panstarrs produced by P. Berardi in early 2013 :

http://www.spectro-aras.com/forum/viewforum.php?f=6

Ephemerides and magnitudes :

http://www.minorplanetcenter.net/iau/Ephemerides/Comets/index.html
http://www.aerith.net/comet/weekly/current.html
http://pgj.pagesperso-orange.fr/magmois.htm

For Autumn 2013 :

2P Encke	Magnitude 5 on 15-11-2013
C/2012 S1 ISON	Magnitude 0.7 on 01-12-2013

Planets et satellites

Evidence of Sodium cloud from vulcanism on Io

http://www.astrosurf.com/buil/forum/poster_io.png

Microquasars

http://www.astrosurf.com/buil/microquasars/obs.htm

To follow…

Note : all the spectra presented were processed using ISIS software (C. Buil)

Appendices

-

-

Classification of Of stars

	NIII	He II	Si IV	CIII	NIV
	4634-4640-4642		4089-4116	4647-4651	4058
((f))	weak em.	strong abs.			
(f)	medium em.	neutr. Or weak abs.			
f	strong em.	strong em.			
((f+))	weak em.	strong abs.	em.		
(f+)	medium em.	neutr. Or weak abs.	em.		
f+	strong em.	strong em.	em.		
((f*))		strong abs.			em. > NIII
(f*)		neutr. Or weak abs.			em. > NIII
f*		strong em.			em. > NIII
f?p	em.			em.	

Liste of bright Of stars

A more exhaustive list can be found here:
http://www.astronomie-amateur.fr/feuilles/Spectroscopie/HotStars.html

HD	Name	AD	Dec	Mag V	Sp. Type	Of type	Source
225160		00 04 03.7	+62 13 19.0	8.22	O8 Ib(f)	f	Walborn 1971
14947		02 26 46.9	+58 52 33.1	8.05	O5 I	f+	Lamers Leitherer 1993
15558		02 32 42.5	+61 27 21.5	7.95	O5 III	(f)	Lamers Leitherer 1993
15570		02 32 49.4	+61 22 42.0	8.16	O4 I	f+	Lamers Leitherer 1993
15629		02 33 20.5	+61 31 18.1	8.46	O5 V	((f))	Lamers Leitherer 1993
24912	ksi Per	03 58 57.9	+35 47 27.7	2.62	O7.5 III	(f)	Lamers Leitherer 1993
36861	lam Ori	05 35 08.2	+09 56 02.9	3.3	O8 III	((f))	Lamers Leitherer 1993
46150		06 31 55.5	+04 56 34.2	6.75	O5 V	((f))	Lamers Leitherer 1993
46223		06 32 09.3	+04 49 24.6	7.32	O4 V	((f))	Lamers Leitherer 1993
47839	15 Mon	06 40 58.6	+09 53 44.7	4.64	O7 V	((f))	Lamers Leitherer 1993
151804	V973 Sco	16 51 33.7	-41 13 49.9	5.25	O8 III	f	Lamers Leitherer 1993
152408		16 54 58.5	-41 09 03.0	5.82	O8: Iafpe	f	Lamers Leitherer 1993
164794	9 Sgr	18 03 52.4	-24 21 38.6	5.93	O4 V((f))	((f))	Lamers Leitherer 1993
175754		18 57 35.7	-19 09 11.2	7.02	O8 Iaf	f	Walborn 1990
188001	9 Sge	19 52 21.7	+18 40 18.7	6.24	O7.5 Iaf	f	Lamers Leitherer 1993
190429A		20 03 29.4	+36 01 30.6	7.1	O4 If+	f+	Lamers Leitherer 1993
190864		20 05 39.8	+35 36 27.9	7.79	O6.5 III(f)	(f)	Lamers Leitherer 1993
210839		22 11 30.5	+59 24 52.1	5.08	O6 I(n)fp	f	Lamers Leitherer 1993

	Elément	λ (Å)
m	He II	4199.87
m	He I	4387.93
m	He I	4471.48
m	He II	4541.59
m	He II	4685.68
m	He I	4713.15
m	He I	4921.93
m	He I	5015.68
m	He II	5411.52
m	O III	5592.37
m	C IV	5801.33
m	C IV	5811.98
m	He I	5875.62
m	He II	6406.44
m	He II	6527.16
m	He I	6678.15
m	He II	6683.26
m	He II	6890.88
m	He II	7065.24

List of emission lines in Of stars

List of bright Wolf Rayet stars – Northern Hemisphere

WR	GCVS	HD	RAJ2000 h:m:s	DEJ2000 d:m:s	Type	Mag V	V km/s
1		HD 4004	00 43 28.40	+64 45 35.40	WN4	10.51	2100
2		HD 6327	01 05 23.03	+60 25 18.90	WN2	11.33	3200
3		HD 9974	01 38 55.63	+58 09 22.70	WN3+O4	10.7	
4	V493 Per	HD 16523	02 41 11.68	+56 43 49.70	WC5+?	10.53	1900
5		HD 17638	02 52 11.66	+56 56 07.10	WC6	11.02	2100
7		HD 56925	07 18 29.13	-13 13 01.50	WN4	11.68	1600
110		HD 165688	18 07 56.96	-19 23 56.80	WN5-6	10.3	2100
113	CV Ser	HD 168206	18 19 07.36	-11 37 59.20	WC8d+O8-9IV	9.43	1700
123	V1402 Aql	HD 177230	19 03 59.02	-04 19 01.90	WN8	11.26	970
124	QR Sge		19 11 30.88	+16 51 38.20	WN8h	11.58	710
127	QY Vul	HD 186943	19 46 15.94	+28 16 19.10	WN3+O9.5V	10.33	
128	QT Sge	HD 187282	19 48 32.20	+18 12 03.70	WN4(h)+OB?	10.54	2050
133	V1676 Cyg	HD 190918	20 05 57.33	+35 47 18.20	WN5+O9I	6.7	1800
134	V1769 Cyg	HD 191765	20 10 14.20	+36 10 35.10	WN6	8.23	2050
135	V1042 Cyg	HD 192103	20 11 53.53	+36 11 50.60	WC8	8.36	1525
136	V1770 Cyg	HD 192163	20 12 06.55	+38 21 17.80	WN6(h)	7.65	1750
137	V1679 Cyg	HD 192641	20 14 31.77	+36 39 39.60	WC7pd+O9	8.15	1900
138		HD 193077	20 17 00.03	+37 25 23.80	WN5+B?	8.1	1400
139	V444 Cyg	HD 193576	20 19 32.42	+38 43 54.00	WN5+O6III-V	8.1	1600
140	V1687 Cyg	HD 193793	20 20 27.98	+43 51 16.30	WC7pd+O4-5	7.07	2870
141		HD 193928	20 21 31.73	+36 55 12.80	WN5+O5V-III	10.14	1550
143		HD 195177	20 28 22.68	+38 37 18.90	WC4+OB?	11.95	2750
148	V1696 Cyg	HD 197406	20 41 21.55	+52 35 15.20	WN8h+B3IV/BH	10.46	1000
152		HD 211564	22 16 24.05	+55 37 37.20	WN3(h)	11.67	2000
154		HD 213049	22 27 17.82	+56 15 11.80	WC6	11.54	2050
155	CQ Cep	HD 214419	22 36 53.96	+56 54 21.00	WN6+O9II-Ib	8.75	1400
156			23 00 10.13	+60 55 38.40	WN8h+OB?	11.09	660
157			23 15 12.41	+60 27 01.90	WN5 (+B1II)	9.91	1500
158			23 43 30.60	+61 55 48.10	WN7h+Be?	11.46	900
153ab	GP Cep	HD 211853	22 18 45.61	+56 07 33.90	WN6/WCE+O6I	9.08	1785

Identification of lines in Wolf Rayet Type N

λ Blend	Ion(s)	Ion(s) composant le blend		
4027	He I + He II	He II 4026.6	He I 4026.2	
4056	NIV	N IV 4057.6		
4099	He II + N III	He II 4100	N III 4097.3	
4200	He II	He II 4199.8		
4339	He II	He II 4338.7		
4378	N III	N III 4379.1		
4472	He I	He I 4471.5		
4514	N III	N III 4510.9		
4542	He II	He II 4541.6		
4625	N V	N V 4603.7	N V 4620.0	
4640	N III	N III 4634.2	N III 4640.6	N III 4641.9
4686	He II	He II 4685.7		
4860	He II	He II 4859.3		
4939	N V	N V 4933	N V 4944.6	
5205	N IV	N IV 5200.4		
5411	He II	He II 5411.5		
5476	N II	N II 5462.6	N II 5480.1	N II 5495.7
5803	C IV	C IV 5801.3	C IV 5812.0	
5878	He I	He I 5875.6		
6073	He II	He II 6074.1		
6123	He II	He II 6118.2		
6171	He II	He II 6170.6		
6236	He II	He II 6233.8		
6316	He II	He II 6310.8		
6400	He II	He II 6406.3		
6465	N III	N III 6445		
6563	He II	He II 6560.1		
6679	He I + He II	He I 6678.1	He II 6683.2	
6890	He II	He II 6890.9		
7112	N IV	N IV 7103.3	N IV 7129	

Source : Smith et Kuhi, 1970

List of Be Stars in BeSS without spectra

(19 h < AD < 24 h ; Mag V < 12)

Name	AD (2000)	DE (2000)	V Mag	Sp. Type
EM* AS 341	19 09 55.46	-02 47 37.28	11	Be
HBHA 703-05	19 12 26.94	06 37 44.21	11.174	B5Ile
EM* CDS 1054	19 14 49.90	17 35 51.00	11.16	A0Ile
EM* StHA 166	19 34 46.81	42 26 08.20	11.76	Be
HD 344800	19 42 50.92	22 33 45.86	10.06	B2Vnne
HD 344783	19 43 06.79	23 16 12.40	9.8	B0IVe
HD 344873	19 45 12.63	24 03 04.09	8.81	B0Ile
HD 350559	19 46 57.69	18 14 55.87	10.55	B7IIIe
EM* AS 368	19 52 46.72	28 46 52.84	10.82	Be
HD 333226	20 00 33.37	30 22 53.22	10.26	B1Ve
HBHA 3703-48	20 02 25.92	36 26 49.20	8	B6IVe
HD 333452	20 03 11.02	28 42 20.44	9.49	B0IIInpe
HD 339483	20 04 00.75	26 16 16.76	8.98	B1IIIe
Cl* NGC 6871 BP 2	20 04 54.16	35 51 21.49	11.98	B5Ve
HD 191378	20 08 08.42	37 00 25.39	8.99	A5e
HD 228041	20 09 58.42	35 29 45.78	9.04	B0.5Ve
HD 228104	20 10 38.44	35 52 28.02	9.06	B1IVpe
KT Cyg	20 11 43.99	36 31 13.08	11.9	B5ev
HD 331976	20 13 41.53	32 33 12.71	9.94	B0pe
BD+36 3956B	20 14 40.15	36 38 47.49	10.5	O9e
EM* VES 195	20 17 03.89	42 06 07.54	11.98	O9Ve
EM* AS 396	20 17 30.19	38 05 56.46	10.89	B2.5IVe
HD 228860	20 18 51.55	36 57 40.94	9.72	B0.5IVe
V1322 Cyg	20 23 45.96	38 30 03.12	9.22	Be
BD+38 4093	20 27 10.21	38 54 01.63	10.78	Be
BD+46 2948	20 29 20.18	46 39 59.02	10.18	B1Vnne
BD+47 3148	20 37 14.63	47 42 26.13	10.4	B5e
W Del	20 37 40.09	18 17 03.78	9.81	A0Ve
BD+54 2399	20 40 53.04	55 19 37.20	10.16	B5e
BD+46 3022	20 43 19.55	46 34 14.03	10.43	Be
BD+50 3180	20 43 50.21	50 58 22.34	9.91	Be
EM* MWC 1030	20 46 24.99	44 55 45.22	11.53	Be
BD+44 3594	20 49 11.59	45 24 39.79	9.85	B1Vnpe
BD+46 3087	20 53 05.93	46 41 10.13	10.38	B5e
BD+40 4353	20 54 16.12	40 50 13.71	9.46	B2Ve
EM* CDS 1215	21 04 52.10	47 55 59.16	10.48	B1Vnne
BD+47 3302	21 08 26.54	47 40 26.33	10.5	B2Vnpe
EM* CDS 1228	21 13 32.62	48 23 20.59	10.51	B2Vne
EM* AS 521	21 29 08.19	54 51 34.89	11.34	B5e

Name	AD (2000)	DE (2000)	V Mag	Sp. Type
BD+56 2626	21 41 40.91	56 41 36.33	10.51	B0.5IIIe
V1578 Cyg	21 52 34.10	47 13 43.61	10.16	B9.5Ve
BD+54 2676	22 03 15.15	55 05 18.27	10.3	B1Vnne
BD+53 2790	22 07 56.24	54 31 06.40	9.93	O9.5IIIe
BD+54 2718	22 14 59.49	55 27 48.82	10.17	B2IIIe
EM* StHA 198	22 21 11.49	77 04 07.99	10.54	Be
BD+61 2292	22 23 12.26	62 41 59.94	10.04	B2Vne
EM* MWC 1063	22 29 08.14	51 13 30.04	10.75	B5e
BD+60 2405	22 31 09.93	61 36 34.26	9.93	B3Vnne
EM* CDS 1367	22 34 32.58	58 19 48.88	10.6	B2IIIe
BD+56 2811	22 35 00.13	57 36 14.38	10.04	Be
BD+53 2964	22 43 23.20	54 04 17.76	9.47	B2IVnnpe
EM* MWC 659	22 47 45.37	57 16 50.78	10.15	B0IIIpe
BD+61 2355	22 52 29.19	62 41 09.81	9.63	B7IVe
BD+62 2158	23 02 12.79	62 49 33.05	10.14	B9Ve
EM* AS 505	23 05 07.49	62 15 37.08	10.04	B5Vpe
EM* CDS 1464	23 22 57.50	58 44 56.04	11.38	B2Ve
NGC 7654 930	23 24 48.96	61 34 22.80	11.6	Be
EM* GGR 144	23 25 12.00	61 37 48.00	11.2	Be
BD+60 2584	23 35 41.50	61 11 19.33	10.33	B1IVpe
BD+61 2494	23 39 47.91	61 55 41.94	10.07	B0Vne
BD+60 2600	23 40 18.57	61 20 43.77	9.34	B9Ve
EM* AS 518	23 57 32.07	72 53 03.69	10.61	Be
BD+65 1970	23 57 34.10	66 25 53.84	10.17	B5e

List of bright MIRAS

Id.	RA 2000	DE 2000	V Max.	V Min.	Période	Phase	Mag. Approx.	Prochain Maximum
W CET	0 2 7.38	-14 40 33	7.6	14.4	351.31	0.203	10	08/05/2014
T CAS	0 23 14.27	55 47 33.2	7.9	11.9	444.83	-0.130	9	28/09/2013
R AND	0 24 1.94	38 34 37.3	6.9	14.3	409.33	-0.490	14	18/02/2014
W AND	2 17 32.95	44 18 17.7	7.4	13.7	395.93	-0.265	11	14/11/2013
OMI CET	2 19 20.78	-2 58 39.5	3.4	9.3	331.96	0.063	4	08/06/2014
U CET	2 33 43.66	-13 8 54.3	7.5	12.6	234.76	0.224	10	31/01/2014
R TRI	2 37 2.33	34 15 51.4	6.2	11.7	266.9	0.421	11	03/01/2014
S CRB	15 21 23.95	31 22 2.6	7.3	12.9	360.26	-0.107	8	09/09/2013
V CRB	15 49 31.31	39 34 17.9	7.5	11	357.63	-0.346	10	03/12/2013
R SER	15 50 41.73	15 8 1.1	6.9	13.4	356.41	-0.061	8	23/08/2013
RU HER	16 10 14.52	25 4 14.4	8	13.7	484.83	-0.272	11	11/12/2013
U HER	16 25 47.46	18 53 32.8	7.5	12.5	406.1	0.384	11	09/04/2014
V OPH	16 26 43.7	-12 25 35.7	7.5	10.2	297.21	0.456	10	10/01/2014
R DRA	16 32 40.22	66 45 17.8	7.6	12.4	245.6	-0.389	11	05/11/2013
S HER	16 51 53.92	14 56 30.6	7.6	12.6	307.28	0.454	12	16/01/2014
RS HER	17 21 42.35	22 55 15.9	7.9	12.5	219.7	-0.168	9	07/09/2013
W LYR	18 14 55.87	36 40 13.1	7.9	12.2	197.88	-0.018	8	05/08/2013
X OPH	18 38 21.13	8 50 2.7	6.8	8.8	328.85	0.007	7	24/06/2014
T HER	18 9 6.2	31 1 16.2	8	12.8	164.98	0.097	9	28/12/2013
R CYG	19 36 49.38	50 11 59.4	7.5	13.9	426.45	-0.037	8	17/08/2013
RT CYG	19 43 37.77	48 46 41.3	7.3	11.8	190.28	-0.286	10	25/09/2013
KHI CYG	19 50 33.91	32 54 50.6	5.2	13.4	408.05	0.210	9	20/06/2014
R AQL	19 6 22.24	8 13 48	6.1	11.5	279	0.140	8	30/03/2014
RS CYG	20 13 23.65	38 43 44.5	7.2	9	417.39	-0.220	8	01/11/2013
U CYG	20 19 36.59	47 53 39	7.2	10.7	463.24	-0.254	9	27/11/2013
T AQR	20 49 56.4	-5 8 48	7.7	13.1	202.1	0.151	9	20/01/2014
RU CYG	21 40 39.08	54 19 28.8	8	9.4	233.43	-0.457	9	16/11/2013
T CEP	21 9 31.78	68 29 27.2	6	10.3	388.14	0.303	9	29/04/2014
V CAS	23 11 40.72	59 41 58.9	7.9	12.2	228.83	0.011	8	16/03/2014
S PEG	23 20 32.62	8 55 8.1	8	13	319.22	0.224	10	06/04/2014
R CAS	23 58 24.87	51 23 19.7	7	12.6	430.46	-0.116	8	20/09/2013
R PEG	23 6 39.17	10 32 36	7.8	13.2	378.1	0.409	12	13/03/2014

In green : Miras at brightness phase between -0.2 and +0.1 in August 2013

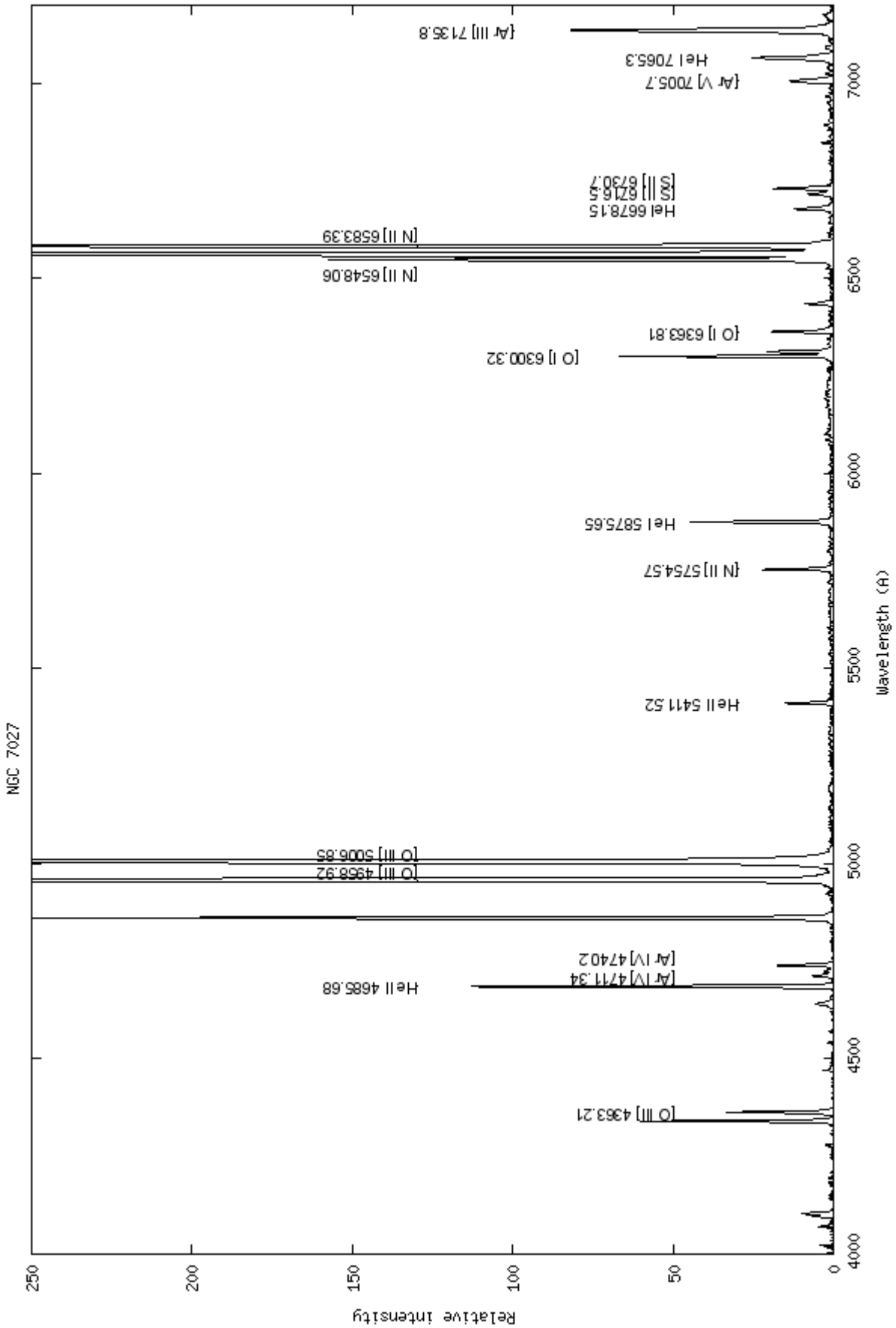
List of bright planetary nebulae

Between RA = 16 h and RA = 2 h

ID	R.A. (E2000)	Dec. (E2000)	Mag.	Size	Const.	Rem
NGC 40	00h 13m 00s	+ 72° 32'	11	0.6	Cep	
NGC 246	00h 47m 00s	- 11° 53'	8	3.8	Psc	
NGC 650-651	01h 42m 18s	+ 51° 34'	12	4.8	Per	Little Dumbbell
NGC 6210	16h 44m 30s	+ 23° 49'	9	0.2	Her	
IC 4634	17h 01m 36s	- 21° 50'	11	0.2	Oph	
NGC 6302	17h 13m 42s	- 37° 06'	13	0.8	Sco	Bug Nebula
NGC 6309	17h 14m 06s	- 12° 55'	11	1.1	Oph	Box Nebula
NGC 6369	17h 29m 18s	- 23° 46'	13	1.1	Oph	
NGC 6445	17h 49m 12s	- 20° 01'	13	0.6	Sgr	Little Gem
NGC 6543	17h 58m 36s	+ 66° 38'	9	5.8	Dra	
NGC 6572	18h 12m 06s	+ 06° 51'	9	0.1	Oph	
NGC 6567	18h 13m 42s	- 19° 05'	12	0.1	Sgr	
NGC 6629	18h 25m 42s	- 23° 12'	12	0.3	Sgr	
NGC 6644	18h 32m 36s	- 25° 08'	12	0.1	Sgr	
NGC 6720	18h 53m 36s	+ 33° 02'	9	2.5	Lyr	Ring Nebula = M57
NGC 6781	19h 18m 24s	+ 06° 33'	12	1.8	Aql	
NGC 6790	19h 23m 12s	+ 01° 31'	10	0.1	Aql	
NGC 6803	19h 31m 18s	+ 10° 03'	11	0.1	Aql	
NGC 6804	19h 31m 36s	+ 09° 13'	12	1.1	Aql	
PLN 64+5.1	19h 34m 46s	+ 30° 31'	9.6	8	Cyg	
NGC 6818	19h 44m 00s	- 14° 09'	10	0.3	Sgr	
NGC 6826	19h 44m 48s	+ 50° 31'	10	2.3	Cyg	Blinking planetary
NGC 6853	19h 59m 36s	+ 22° 43'	8.1	15.2	Vul	Dumbbell Nebula
NGC 6884	20h 10m 24s	+ 46° 28'	13	0.1	Cyg	
NGC 6886	20h 12m 42s	+ 19° 59'	12	0.1	Sge	
NGC 6891	20h 15m 12s	+ 12° 42'	12	1.2	Del	
IC 4997	20h 20m 12s	+ 16° 45'	12	0.03	Sge	
NGC 6905	20h 22m 24s	+ 20° 07'	12	1.7	Del	
NGC 7008	21h 00m 36s	+ 54° 33'	13	1.4	Cyg	
NGC 7009	21h 04m 12s	- 11° 22'	8	1.7	Aqr	Saturn Nebula
NGC 7026	21h 06m 18s	+ 47° 51'	13	0.4	Cyg	
NGC 7027	21h 07m 06s	+ 42° 14'	10	0.3	Cyg	
IC 5217	22h 23m 54s	+ 50° 58'	13	0.1	Lac	
NGC 7293	22h 29m 36s	- 20° 48'	13.5	12.8	Aqr	Helix Nebula
NGC 7662	23h 25m 54s	+ 42° 33'	9	2.2	And	Blue Snowball

List of principal lines in planetary nebulae

Elément	λ (Å)	Elément	λ (Å)
H I	3835.39	He II	5411.52
[Ne III]	3868.76	[Cl III]	5517.7
H I	3889.05	[O I]	5577.4
[Ne III]	3967.47	[N II]	5754.57
H I	3970.07	He I	5875.65
[S II]	4068.6	[O I]	6300.32
H I	4101.74	[S III]	6312.1
H I	4340.47	[O I]	6363.81
[O III]	4363.21	[N II]	6548.06
He I	4471.48	H I	6562.82
He II	4541.59	[N II]	6583.39
N III	4640	HeI	6678.15
He II	4685.68	[S II]	6716.5
[Ar IV]	4711.34	[S II]	6730.7
[Ar IV]	4740.2	[Ar V]	7005.7
H I	4861.33	He I	7065.3
[O III]	4958.92	[Ar III]	7135.8
[O III]	5006.85	[O II]	7319.92
[N I]	5199.2	[O II]	7325



Example of the identification of lines in NGC 7027

List of bright symbiotic stars

	Name	AD2000	DE2000	vmag	spect_type		Max	Min	Current	Outburts
1	EG And	0 44 37.1	40 40 45.7	7.1	M3		7	7.4	7.2	
2	AX Per	1 36 22.7	54 15 2.5	10.9	M6		10.1	11.9	11.5	
3	BD Cam	3 42 9.3	63 13 0.5	5.1	M3,S5.3		5			
4	UV Aur	5 21 48.8	32 30 43.1	8.5	Mira C8.1Je		7.5	10	7.8	
5	V1261 Ori	5 22 18.6	-8 39 58	6.8	S4.1,M3		6.6	6.9	6.7	
6	StHA 55	5 46 42	6 43 48	13.5	C	s				
7	ZZ CMi	7 24 13.9	8 53 51.7	9.9	M6,M5	s	9.8	10.3	10.3	
8	BX Mon	7 25 24	-3 36 0	11.7	M5		10	12.2	10.3	
9	V694 Mon	7 25 51.2	-7 44 8	9.5	M6		9.80	11.4	10.4	
10	NQ Gem	7 31 54.5	24 30 12.5	7.9	C6.2	s	7.9	8.1	8	
11	GH Gem	7 4 4.9	12 2 12	14.6	F2:	s	12	13.9	12.6	
12	StHA 190	21 41 44.8	2 43 54.4	10.5	G5		10.5			
13	TX CVn	12 44 42	36 45 50.6	9.5	early M,K5.		9.7	10.2	10	
14	T CrB	15 59 30.1	25 55 12.6	10.1	M4.5		9.9	10.5	10	3.2
15	AG Dra	16 1 40.5	66 48 9.5	9.1	K2		9.3	10.1	9.8	8.3
16	V503 Her	17 36 46	23 18 18	13.8	M2p	s	12.8	13.4	12.5	
17	RS Oph	17 50 13.2	-6 42 28.4	11.5	M0-M2		10.2	12.2	11.5	5
18	V934 Her	17 6 34.5	23 58 18.5	7.8	M3	s	7.5	7.7		
19	AS 289	18 12 22	-11 40 13	12.1	M3.5		12	13.7	13.2	
20	YY Her	18 14 34.3	20 59 20	12.8	M4		11.9	13.6	12	
21	FG Ser	18 15 6.2	0 18 57.6	11	M5.3,M5		11.6	12.4	11.8	
22	StHA 149	18 18 55.9	27 26 12	13.5	M2		11.7	12.1	12	
23	V443 Her	18 22 8.4	23 27 20	11.5	M5.5		11.2	11.6	11.4	
24	FN Sgr	18 53 52.9	-18 59 42	12.7	M3,M4		13.7	11	12.6	
25	V335 Vul	19 23 14.2	24 27 40.2	11.8	Mira?,C	s	12	14		
26	BF Cyg	19 23 53.4	29 40 25.1	12.3	M5		12.5	9.2	9.5	
27	CH Cyg	19 24 33	50 14 29.1	7.1	M6.5,M7		9.8	6.6	7.6	
28	V919 Sgr	19 3 46	-16 59 53.9	12.2	M4.5/M1		10.7	12.3	12.3	
29	V1413 Aql	19 3 51.6	16 28 31.7	14	M4/M5		11.4	15.2	12.2	
30	HM Sge	19 41 57.1	16 44 39.9	17	Mira,M7		11.8	12.4	12.4	10.5
31	QW Sge	19 45 49.6	18 36 50	12.8	M5/M6		12.1	12.7		
32	CI Cyg	19 50 11.8	35 41 3.2	11	M5.5		9.4	11.2	11	
33	StHA 169	19 51 28.9	46 23 6	11.5	M		13.2			
34	V1016 Cyg	19 57 4.9	39 49 33.9	11.2	Mira		11.4	11.7	11.7	
35	o Ceti	2 19 20.7	-2 58 39.5	6	Mira,M2-7		2.6	9.4	8.7	
36	PU Vul	20 21 12	21 34 41.9	11.6	M6,M6.5		13.20	12.1	12.1	8.5
37	LT Del	20 35 57.3	20 11 34	13.1	G6		13	13.3	13.1	
38	ER Del	20 42 46.4	8 40 56.4	10	S5.5/2.5		10	10.6	10.1	
39	V1329 Cyg	20 51 1.1	35 34 51.2	13.3	M6,M6-7		12.5	14.2	14	
40	V407 Cyg	21 2 13	45 46 30	14	Mira;M6		11	17	17	8.5
41	AG Peg	21 51 1.9	12 37 29.4	9	M3,M4		8.4	9	8.8	
42	V627 Cas	22 57 41.2	58 49 14.9	12.9	Mira M2,M4	s	12.2	13.1	13	
43	Z And	23 33 39.5	48 49 5.4	10.8	M4.5		8.3	10.6	10	
44	R Aqr	23 43 49.4	-15 17 4.2	9.1	Mira;M7,M8		10.2	6.2	8	

List of principal lines in symbiotics

Element /ion	λ (Å)	Element/ion	λ (Å)
He I	4009	[Fe VII]	5159
He I	4026	[Fe VI]	5176
[Fe V]	4071	Fe II	5235
Hδ	4101	[Fe III]	5270
Fe II	4120	[Ca V]	5309
He I	4144	He II	5412
Hγ	4340	[Fe VI]	5677
[O III]	4363	[Ca V]	5705
He I	4388	[Fe VII]	5721
[Fe II]	4416	[N II]	5755
He I	4471	C IV	5804
Fe II	4491	He I	5876
Fe II	4515	[O I]	6300
He II	4541	[O I]	6363
N III	4634-41	[Fe VII]	6087
C III	4647-65	[Ar V]	6434
He II	4686	Hα	6563
He I	4713	He I	6675
Hβ	4861	[S II]	6716
He I	4922	[S II]	6731
[O III]	5007	Raman OIV	6826
He I	5016	[Ar V]	7005
Fe II	5018	He I	7065
He I	5048	Raman OIV	7088
		Ar III	7136

Diversity of symbiotics