Amateur Astronomical Pro-Am Spectroscopy

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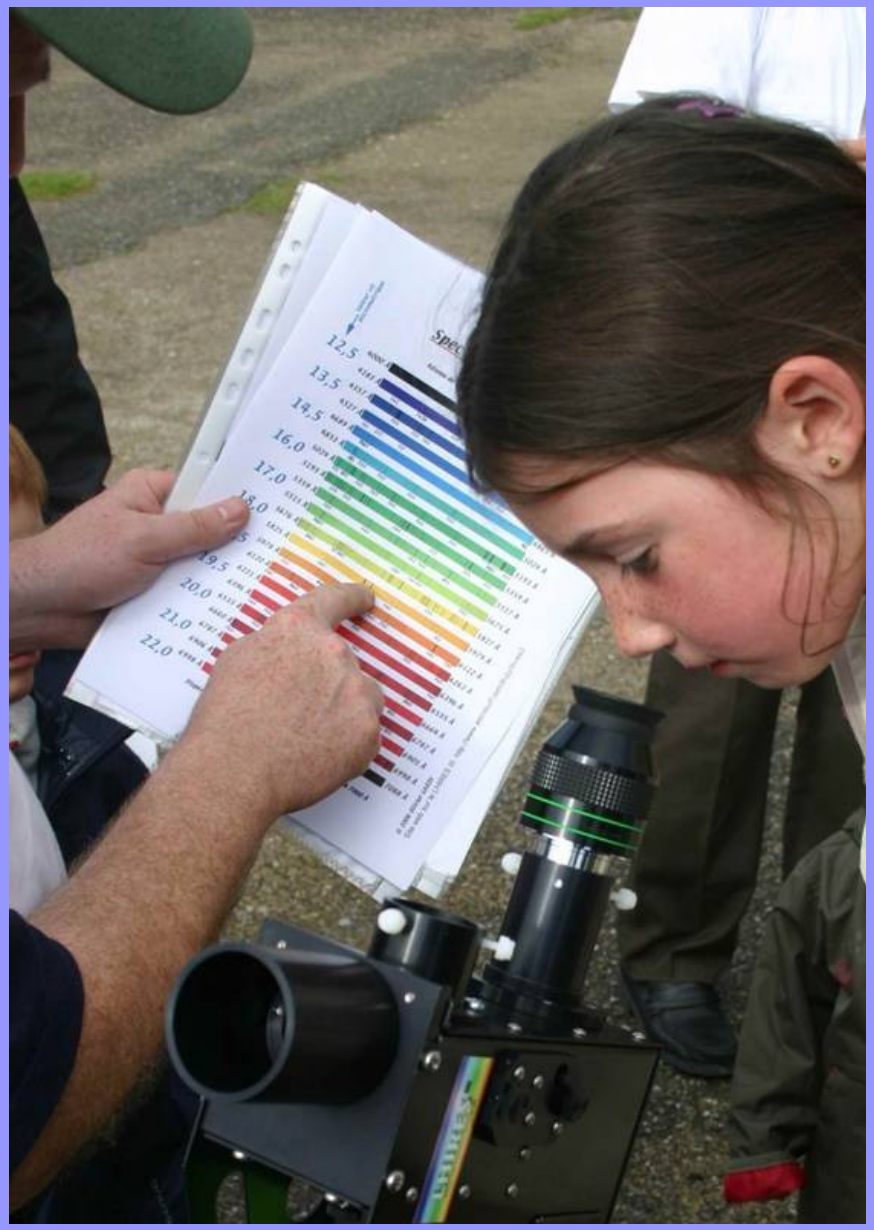
May 25th, 2011
-- SAS ; big Bear, CA --



the “menu”...

- **Introduction**
- *Educational*
- **Pro/Am projects**
  - *Be stars, delta Sco focus*
  - *WR 140, «covento» group*
  - *epsilon Aurigae campaign*

Introduction

Take some good Resolutions !

Resolution
$R = \lambda / \Delta\lambda$

20000

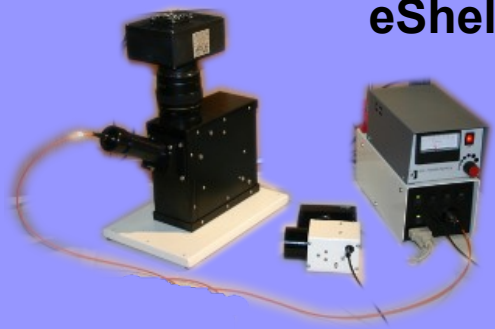
10000

1000

100

Lhires III

eShel



LISA

Star Analyser

Spectral Domain Coverage

	Applications
eShel 	High level education Bright stars line profile (Be stars, pulsations...) Abundances, classification Spectroscopic binaries & exoplanets
Lhires III 	(self) education with low / medium / high resolution modes Stellar classification Bright stars line profile (Be stars, eps Aur, Wolf-Rayet, Slow Pulsating B stars, Herbig Ae/Be...)
LISA 	Education: lamp, classification, nebulae, galaxie redshift... Faint variable stars: cataclysmics, novae, mira... Comets classification Asteroids classification ...
Star Analyser 	Education: star temperature & classification Novae Faint variable stars Supernovae

Some steps back...

Oleron 2003

- **The situation**
  - **Very few pro/am collaboration (e.g. Buil Be star atlas, Maurice Gavin, Dale Mais...), done with custom designed spectrographs.**

- **Oleron 2003**
  - **AUDE/CNRS pro/am official school**
  - **Preceedings book to be published soon**
  - **Kick off for Lhires III design**
  - **Kick off Spectro-L list**
  - **Kick off ARAS website front-end**

La Rochelle: 2006

- **Be Stars Spectra (BeSS) database kick off**
  - **Structuring spectra collection & archiving**
  - **Defining a spectra file format (FITS based)**

- **Workshop on Lhires III (AUDE first kits just received !)**

La Rochelle: 2009

- **10000 amateur spectra in BeSS...**
- **Exoplanet newly observed: pushing the limits...**
- **Dozen of active amateur spectroscopists...**

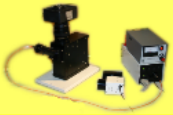
- **==>More professional astronomers looking for help and support from amateurs !**

OHP practical workshops

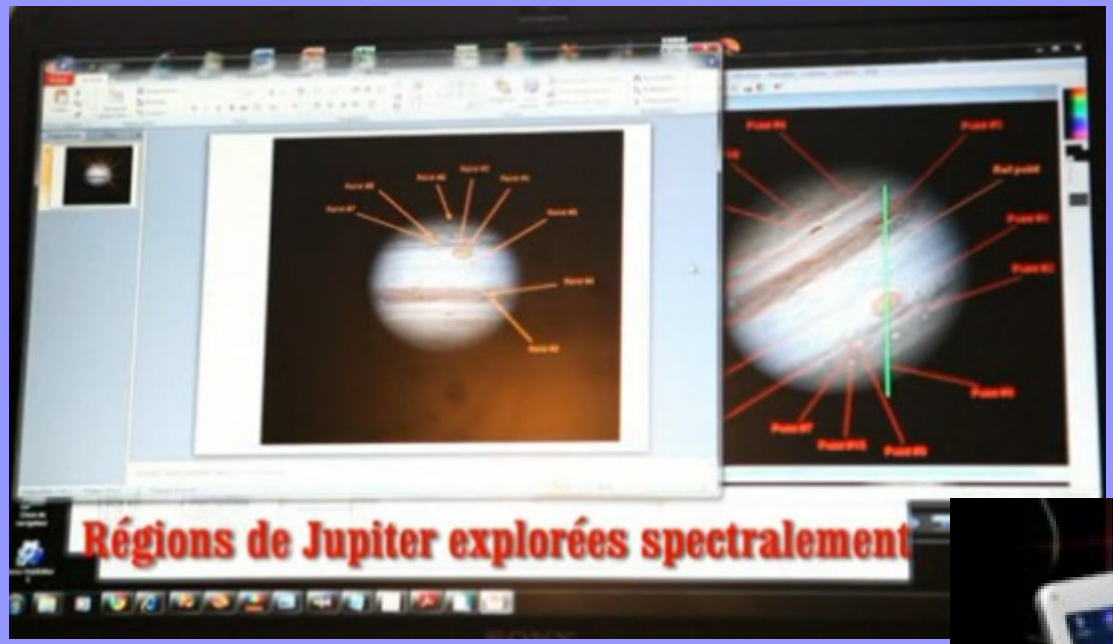
- **2004, 2005, 2007, 2008, 2009, 2010: a growing interest ! International attendance.**
- **30-40 instruments, all with spectrographs !**
- **Different style**
  - **workshop Vs talks, need for some theory**
  - **structured project Vs autonomous groups**
  - **courses Vs star party**
- **… the optimal format is hard to find !**

OHP ambiance...

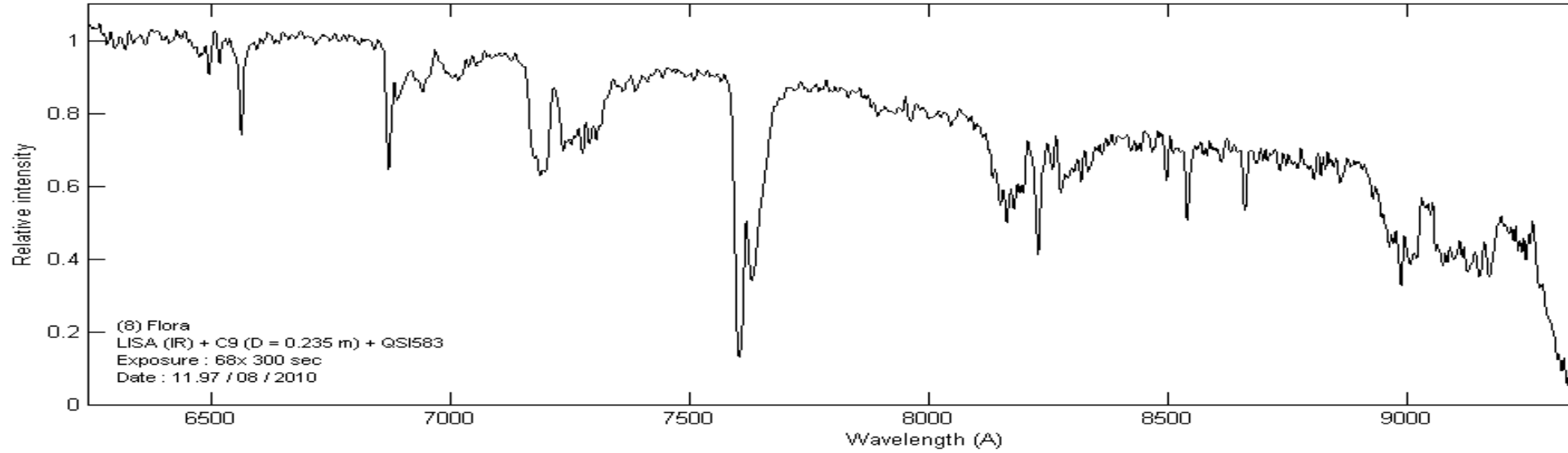
Pro/Am projects

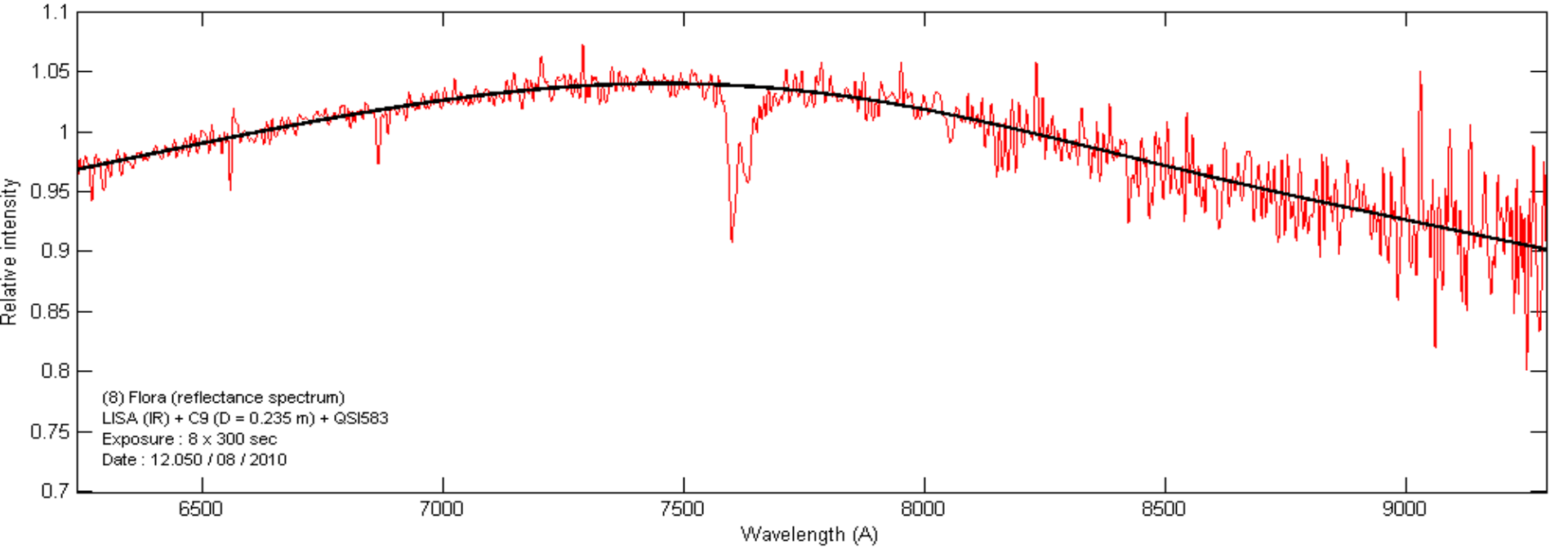
Spectrograph	Star Analyser	LISA	Lhires III	eShel
				
Resolving Power	R ~ 100	R ~ 1000	R ~ 600 – 17000	R ~ 11000
Solar System				
Earth atmosphere		Aurora spectra.	150: Aurora spectra.	
Meteors	Meteor spectra: how useful ???			
Moon		Geology changes during impact.	150: Geology changes during impact.	
Planet atmosphere		Spectra of atmospheric features (near IR ?)		
Comets		Composition, classification.	150-300: Composition, classification.	Bight comets ?
Asteroids		Classification.		
Binaries				
Spectroscopic binaries			2400: bright binaries period/orbit follow up	Binaries period and orbital elements improvements.
Exoplanets				Orbital elements follow up. Discoveries around A-type stars?
Variable Stars				
Be Stars		Monitoring, outburst detection, Survey/Discovery, classification.	2400: pulsations (hours) ? 1200-2400: Line profile changes (days/years) 150-600: Monitoring, outburst detection, Survey/Discovery, classification.	Line profile changes (days/years).
Binary Be Stars: delta Sco, VV Cep, zeta Tau, ups Sgr...		Monitoring, Outburst detection.	1200-2400: RV measurement (ex: delta Sco) 1200-2400: Line profile changes: delta Sco, zeta Tau...	RV measurement (ex: delta Sco) Line profile changes: delta Sco, zeta Tau...
Herbig Ae/Be			1200: spectral changes in few hours. 300-600: changes over the years / outburst	Changes over the years / outburst
LBV (P Cygni)			1200-2400: line profile changes (years)	Line profile changes (years)
Active hot stars (Rigel, Deneb...)			1200-2400: line profile changes (years ?)	Line profile changes (years ?)
Wolf-Rayet		Classification.	1200-2400: line profile changes (years ?) 150-300: classification	
Binary Wolf-Rayet: WR 140...			1200-2400: periastron studies	Periastron studies; orbital elements; spectral changes.
epsilon Aurigae (every 27 years !)			2400: line profile change, KI line change (modified Lhires III)... eclipse folllow up.	Line profile changes.
Cataclysmic variables	Outburst monitoring	Initial classification, monitoring. Line profile changes. Expansion speed.	1200: Line profile changes at initial stage. Expansion speed. 150-600: Initial classification, monitoring.	Line profile changes at initial stage. Expansion speed measurement.
Novae	Initial classification, monitoring	Initial classification, monitoring. Line profile changes. Expansion speed.	1200: Line profile changes at initial stage. Expansion speed. 150-600: Initial classification, monitoring.	Line profile changes at initial stage. Expansion speed measurement.
Mira		Monitoring during all period.	1200: at maximum brightness. 150: follow up. during (almost) all period.	At maximum brightness.
Pulsating stars (RR Lyrae, BW Vul, SPB...)			600-1200: RV of absorption lines.	RV changes of absorption lines.
Supernovae	Initial classification (SN type)	Initial classification (SN type)		

Planetology

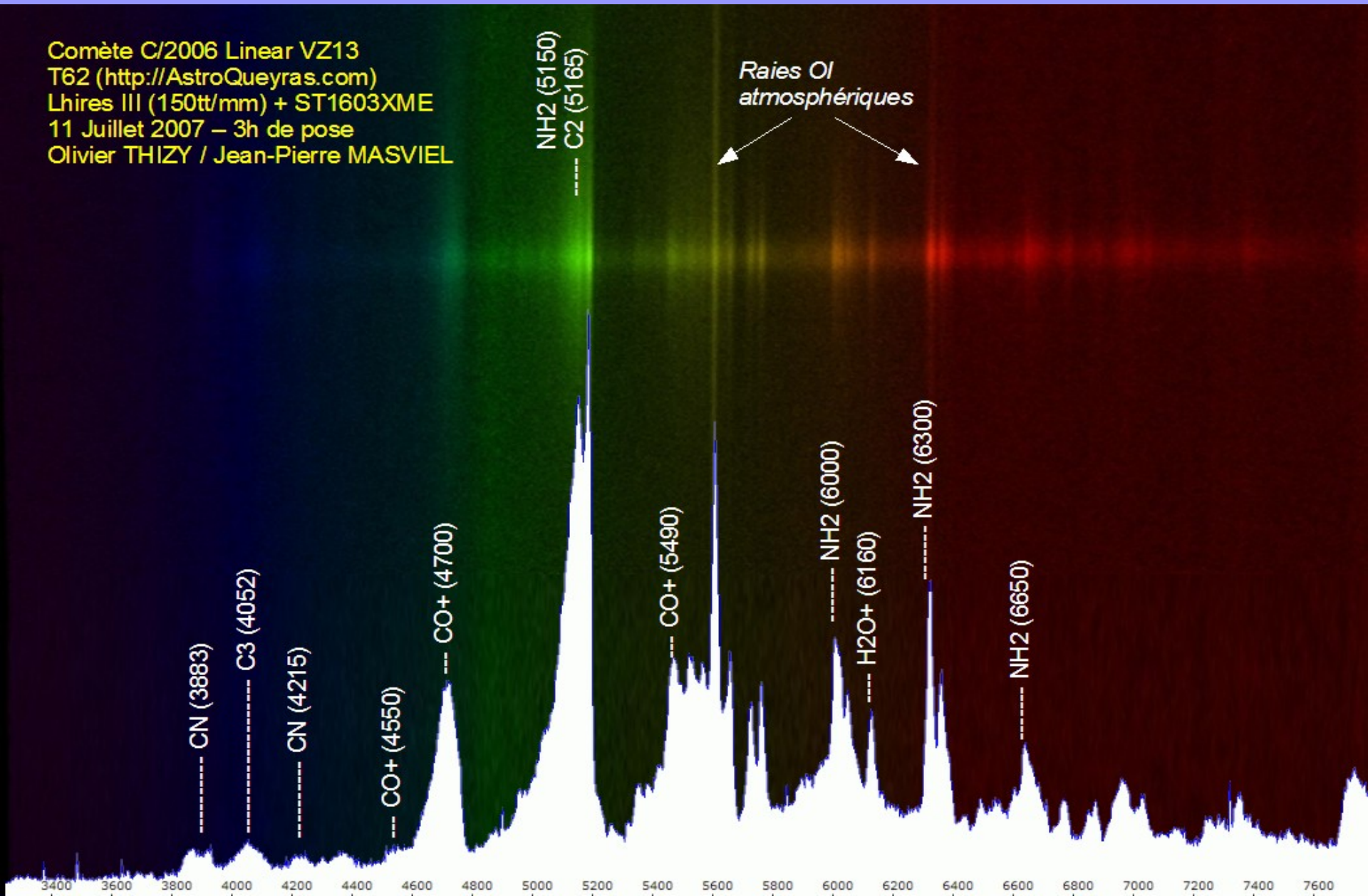


Asteroids classification





Comets


Comète C/2006 Linear VZ13
T62 (http://AstroQueyras.com)
Lhires III (150tt/mm) + ST1603XME
11 Juillet 2007 – 3h de pose
Olivier THIZY / Jean-Pierre MASVIEL
NH2 (5150)
C2 (5165)
Raies OI
atmosphériques
CN (3883)
C3 (4052)
CN (4215)
CO+ (4550)
CO+ (4700)
CO+ (5490)
NH2 (6000)
H2O+ (6160)
NH2 (6300)
NH2 (6650)
3400
3600
3800
4000
4200
4400
4600
4800
5000
5200
5400
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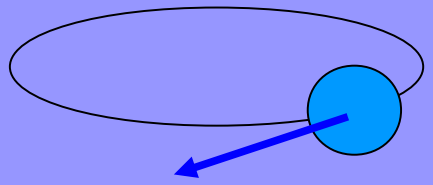
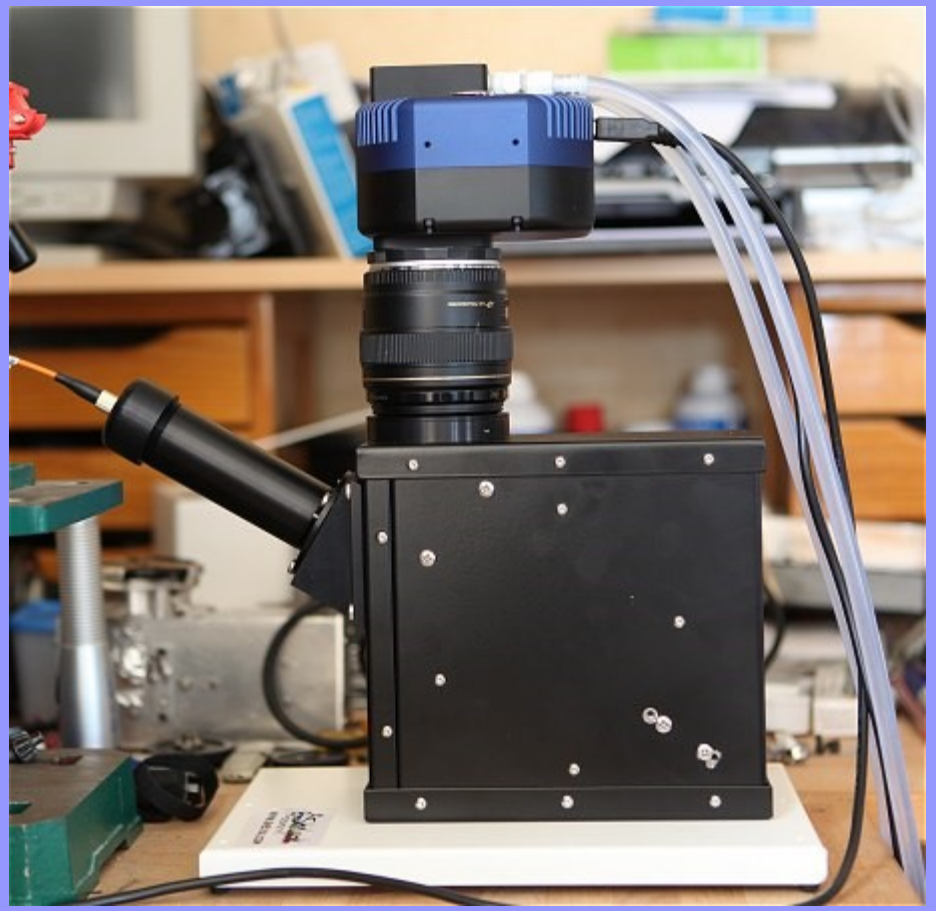
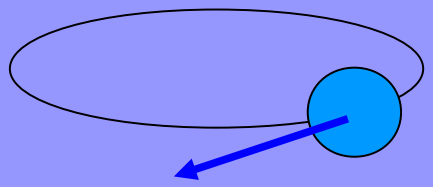
6400
6600
6800
7000
7200
7400
7600

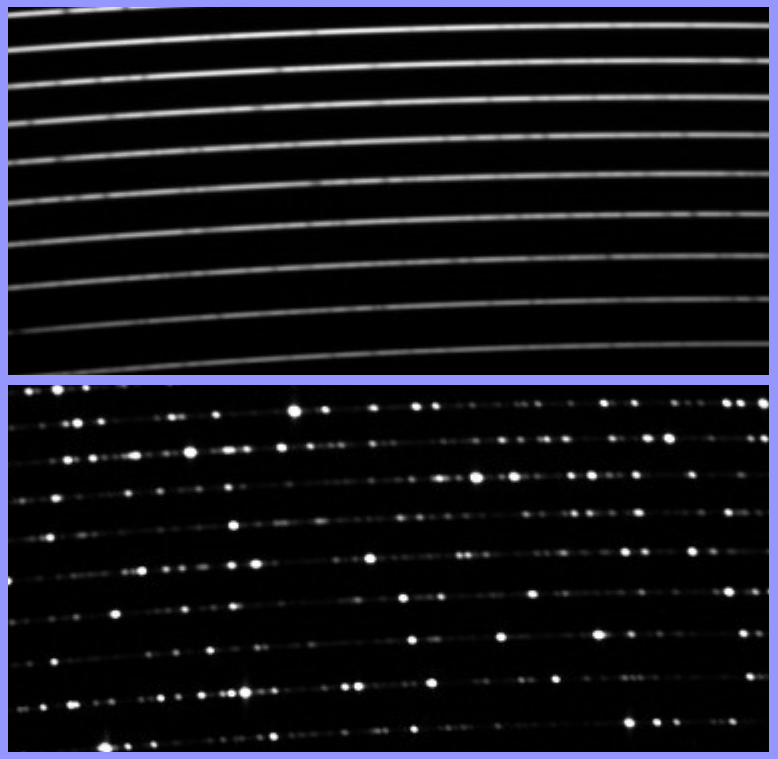


exoplanets !

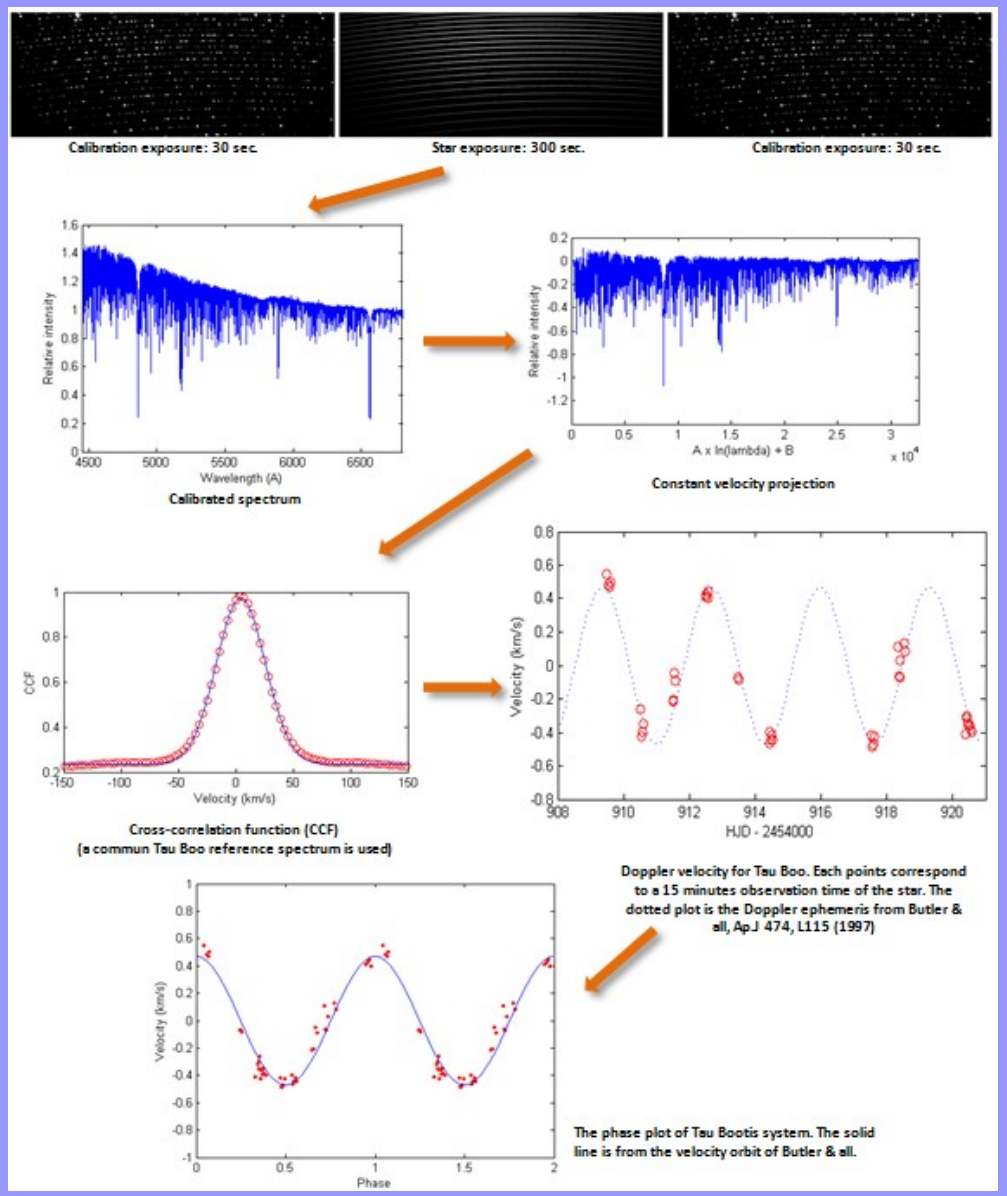


Exoplanet: tau Boo



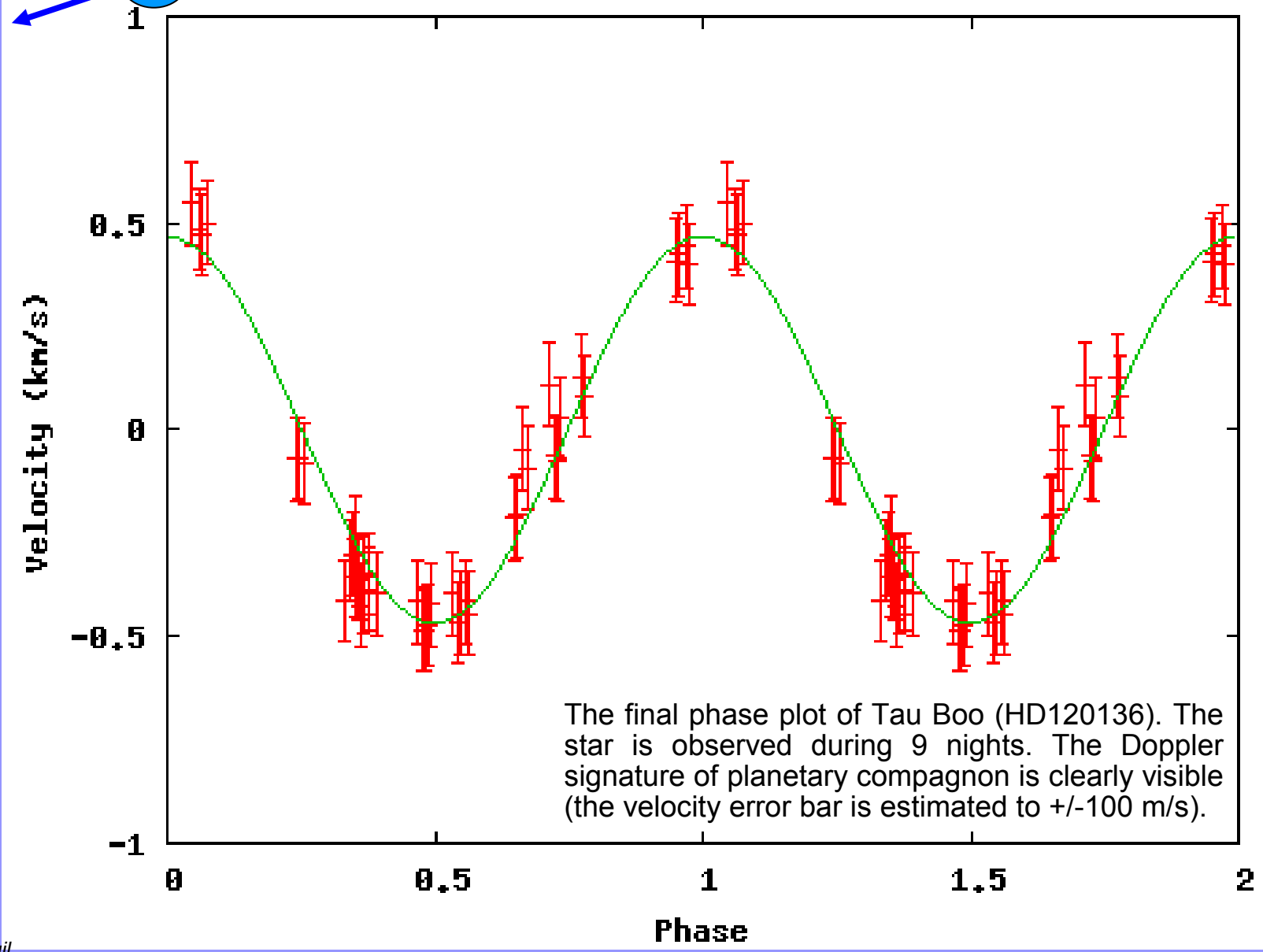


The CCF is computed by using the spectral range 4400-6445 A (the Halpha line is excluded).
The total velocity Doppler spectral amplitude shift represents only 1/25th part of the spectrograph resolution. The data
are collected between March 19-March 29, 2009.



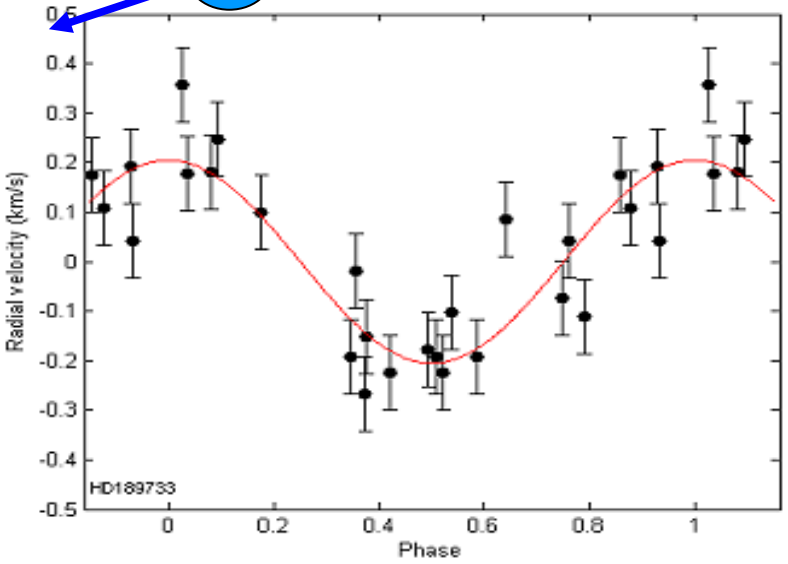
Christian Buil

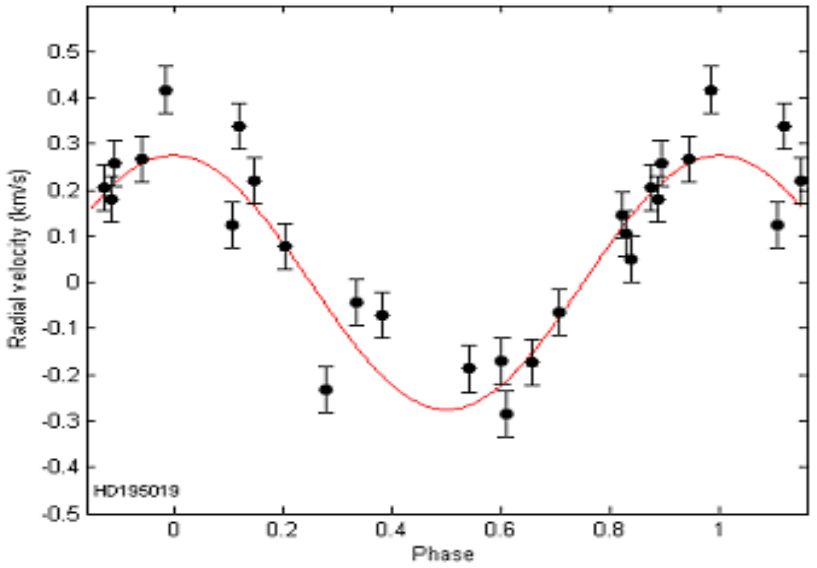
Exoplanet: tau Boo

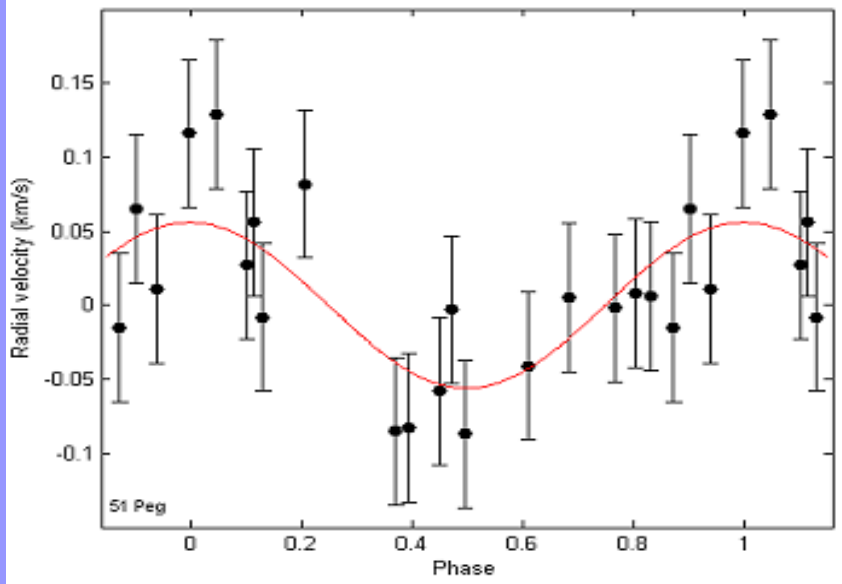


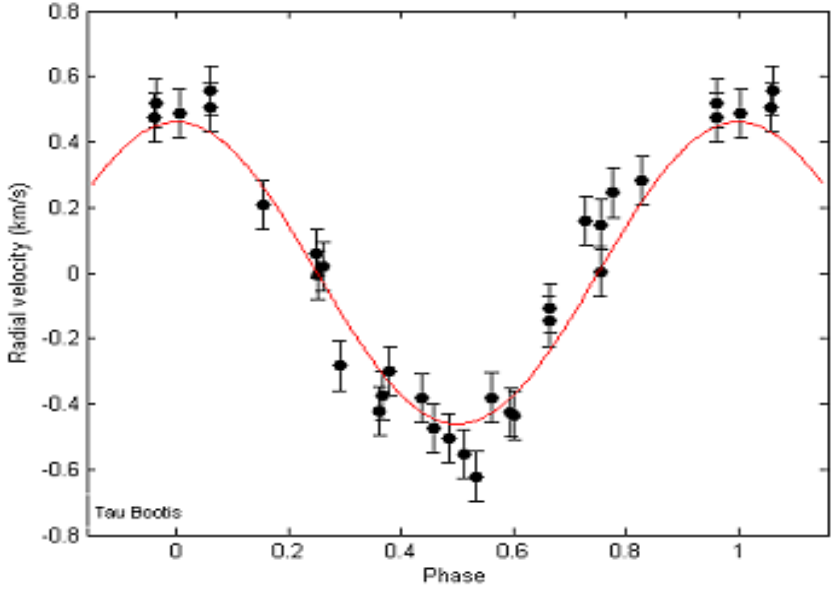
The final phase plot of Tau Boo (HD120136). The star is observed during 9 nights. The Doppler signature of planetary compagnon is clearly visible (the velocity error bar is estimated to +/-100 m/s).

Exoplanets: 4 done so far









Christian Buil / Valérie Desnoux / Michel Pujol / Olivier Thizy

Magnitude	Celestron 11 - f/5.9	60 cm - f/3.5
3	37 m/s	18 m/s
4	56 m/s	28 m/s
5	95 m/s	46 m/s
6	175 m/s	75 m/s
7	360 m/s	140 m/

Exoplanets: proam ?

- **Known exoplanets: refine orbital elements ?**
- **Opportunities to discover exoplanet around A-type stars where resolution is limited by star itself ?**
  ==>requiring lot of observing time !

- **Contact: Claire Moutou (Observatory Marseille)**
  (cf slideset & talk done at La Rochelle 2009)

- **Publications:**
  - 2008DPS....40.1113V : Search of Exoplanets - Phase I
  - http://astrosurf.com/buil/extrasolar/obs.htm

Variable stars in general !

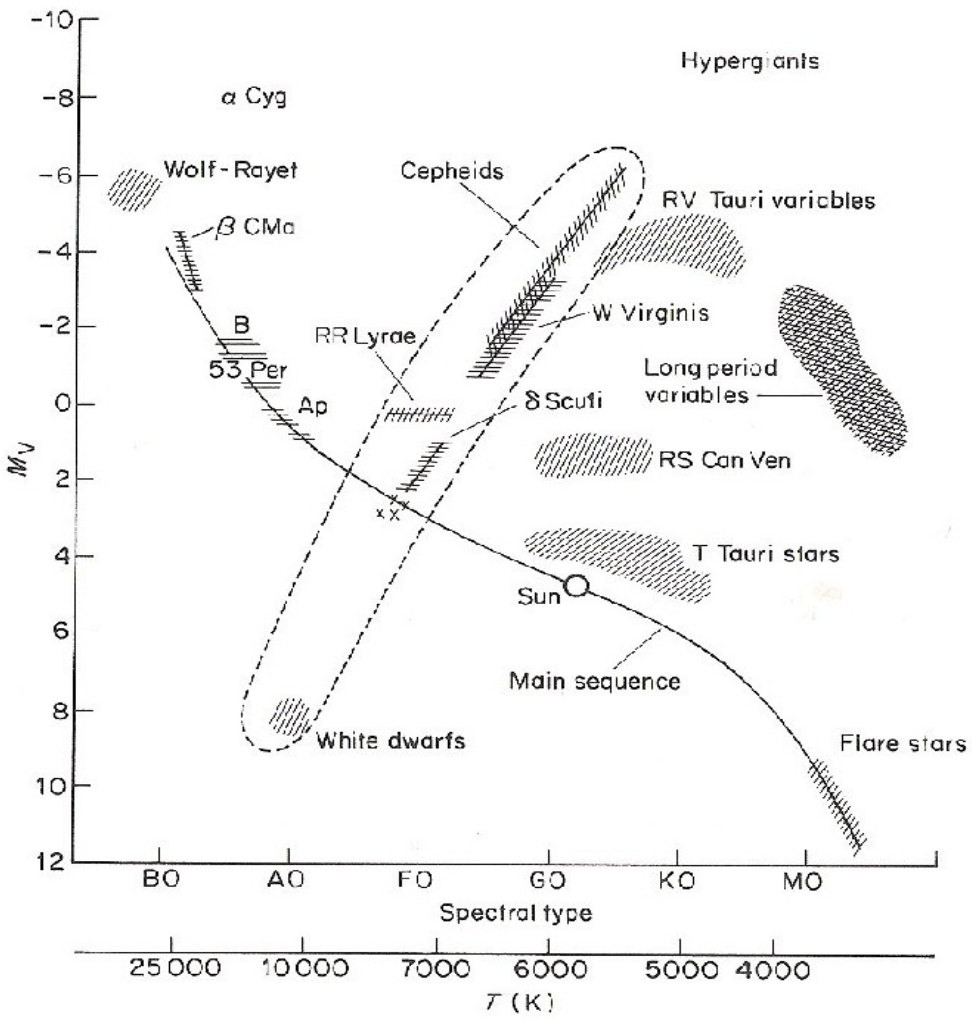
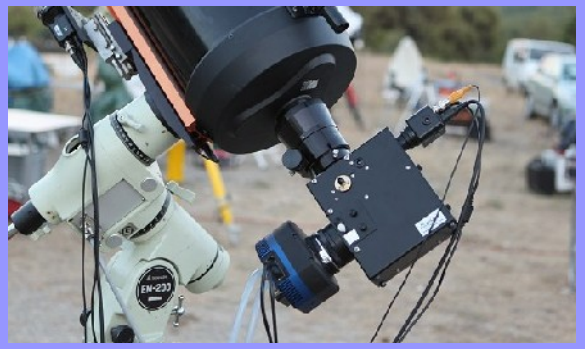


Figure 12.1 A Hertzsprung Russell diagram showing the approximate location of various types of intrinsically variable star discussed in the text. Cataclysmic variables are binaries containing a compact star (usually a white dwarf) together with a red giant or main sequence star.

Source: Getting the measure of the stars (WA Cooper & EN Walker)

LISA: a new tool for faint variable stars

...or when spectroscopist & AAVSO community meet !



Integration time : 1 hour (6 x 600 sec)
Signal to noise ratio = 10 (@ Halpha)
Type A0V star
CCD KAF-8300 (Binning 1 x1)

Altitude 0 m - Suburban

	Slit 23 µm R = 1100	Slit 50 µm R = 600	Slit 100 µm R = 290
D = 12.8 cm F/D = 8	12.5	13.1	13.4
D = 28 cm F/D = 6.8	13.6	14.6	15.0
D = 35 cm F/D = 6.8	13.9	14.9	15.4
D = 50 cm F/D = 6.0	14.4	15.5	16.2
D = 100 cm F/D = 6.0	15.2	16.3	17.2

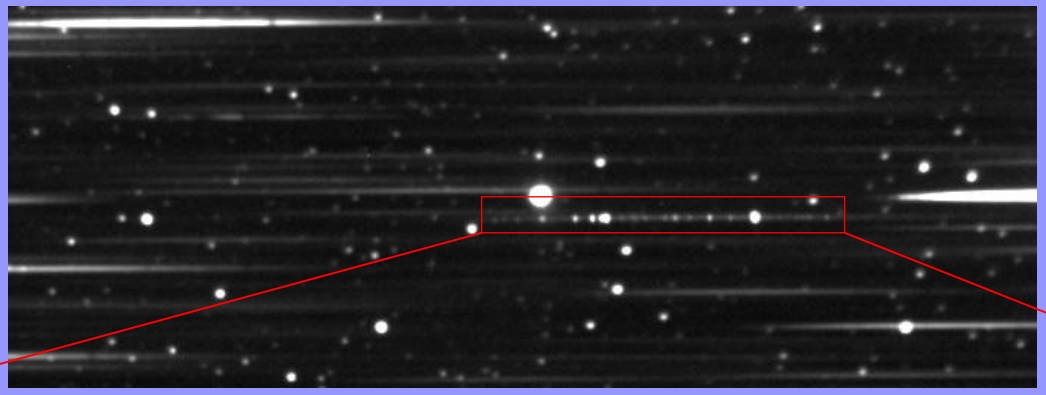
Altitude 3000 m – Dark sky

	Slit 23 µm R = 1100	Slit 50 µm R = 600	Slit 100 µm R = 290
D = 12.8 cm F/D = 8	13.1	13.6	13.9
D = 28 cm F/D = 6.8	14.5	15.2	15.6
D = 35 cm F/D = 6.8	14.8	15.6	16.1
D = 50 cm F/D = 6.0	15.3	16.3	16.9
D = 100 cm F/D = 6.0	16.1	17.3	18.2

KAF3200: push 0.5 mag further...

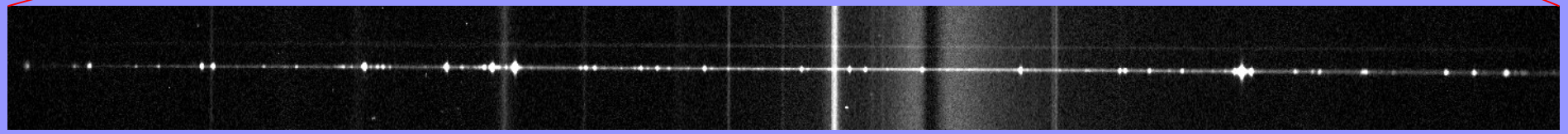
Typical aspect of LISA 2D spectra

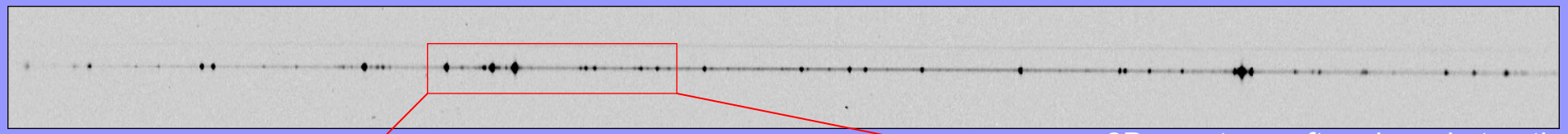
Symbiotic star V1016 Cyg



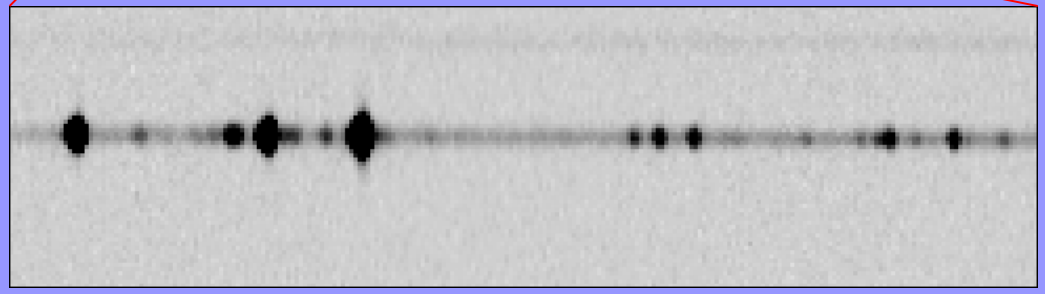
Star Analyser

2D spectrum before sky removal (23 µm slit)

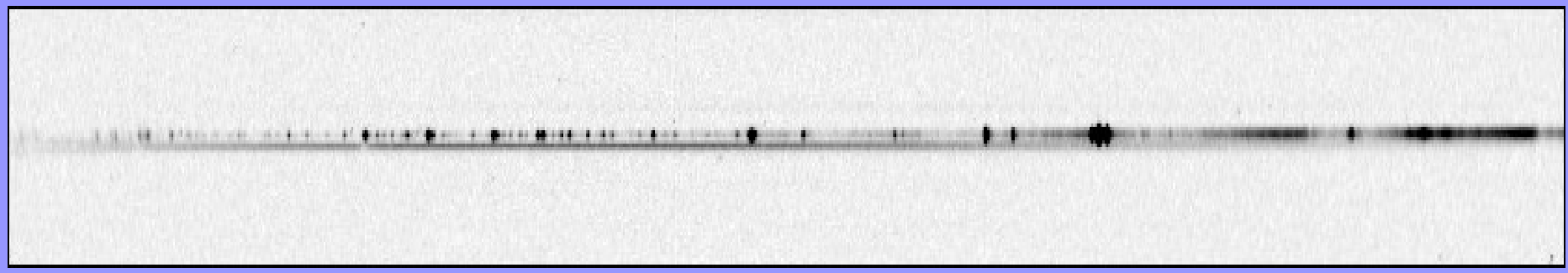




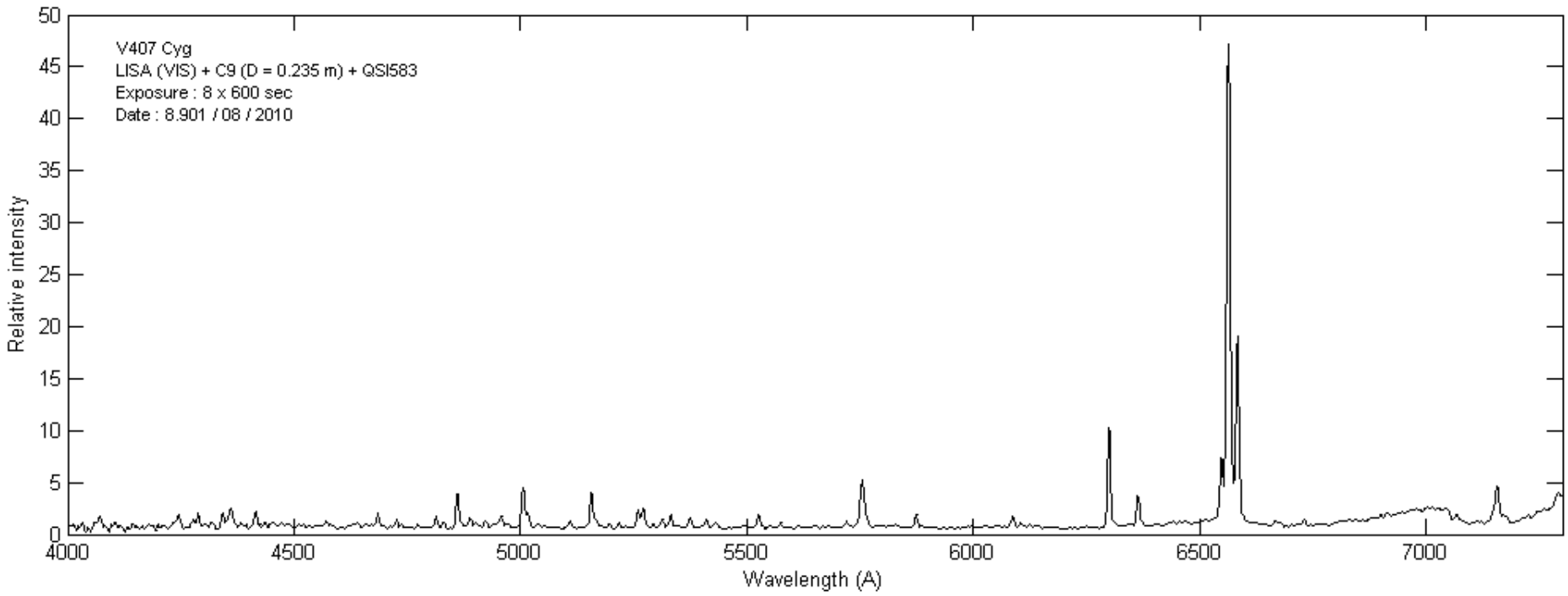
2D spectrum after sky substraction



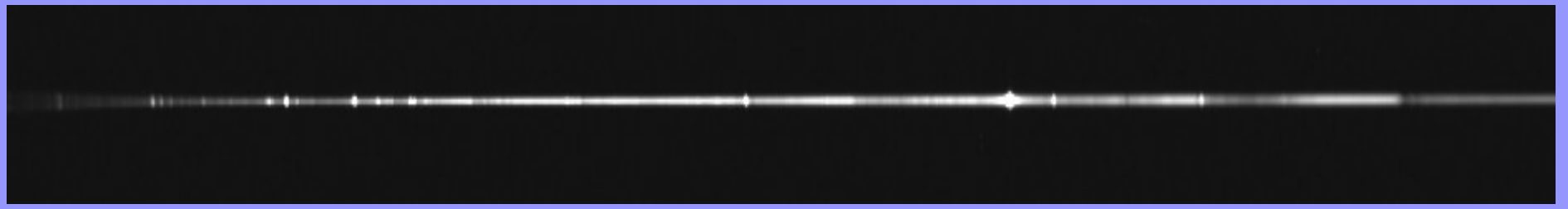
Symbiotic stars: V407 Cyg

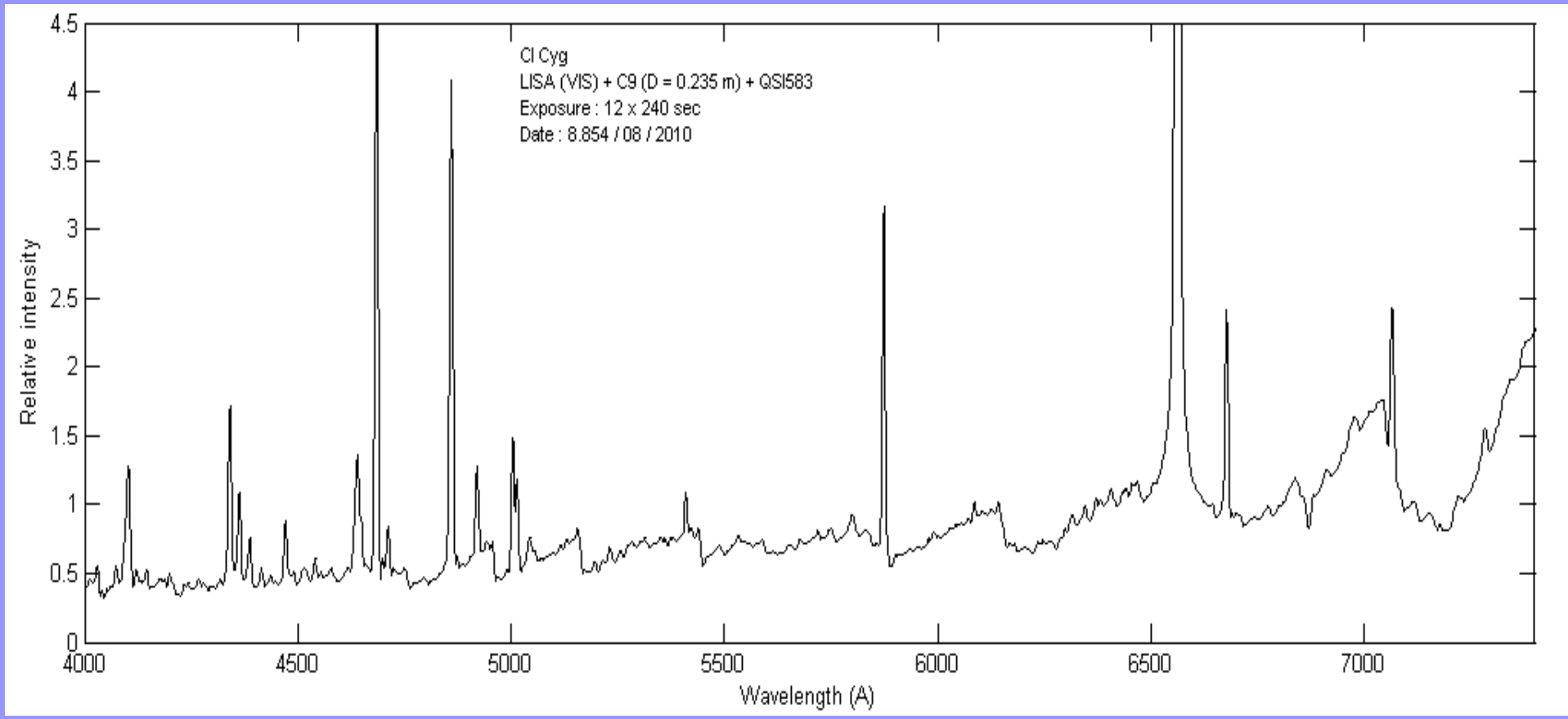


Note: another star spectrum is closed to V407 Cyg spectrum...

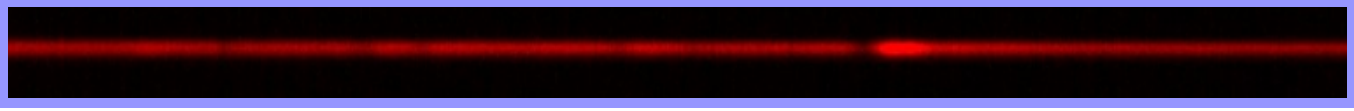


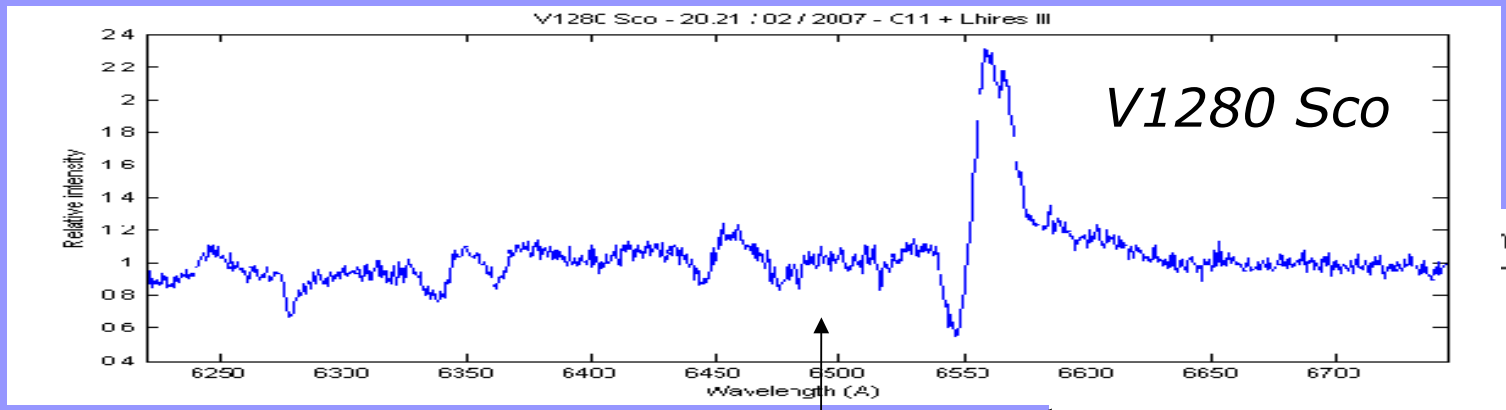
Symbiotic stars: CI Cyg

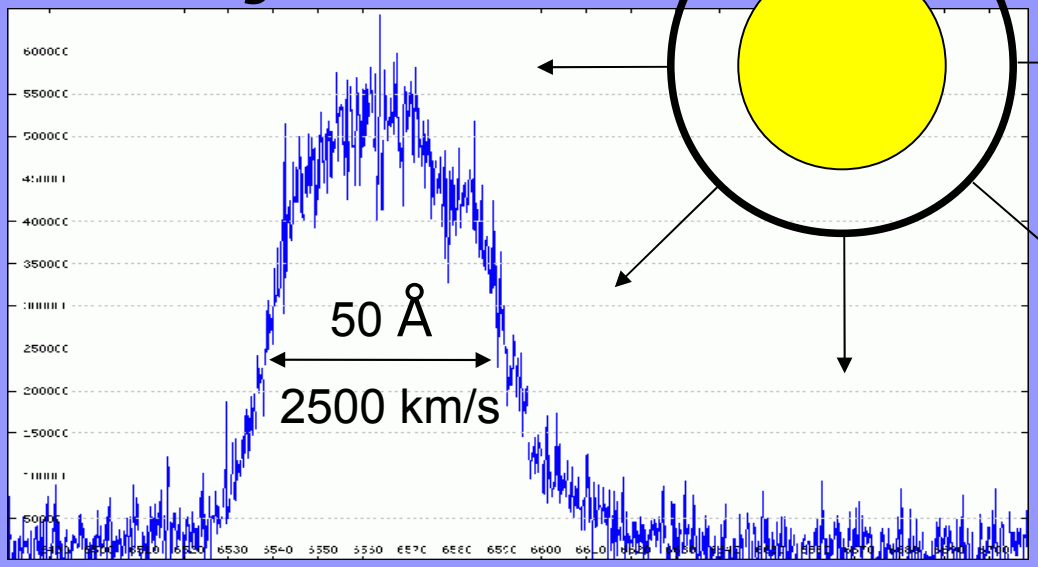


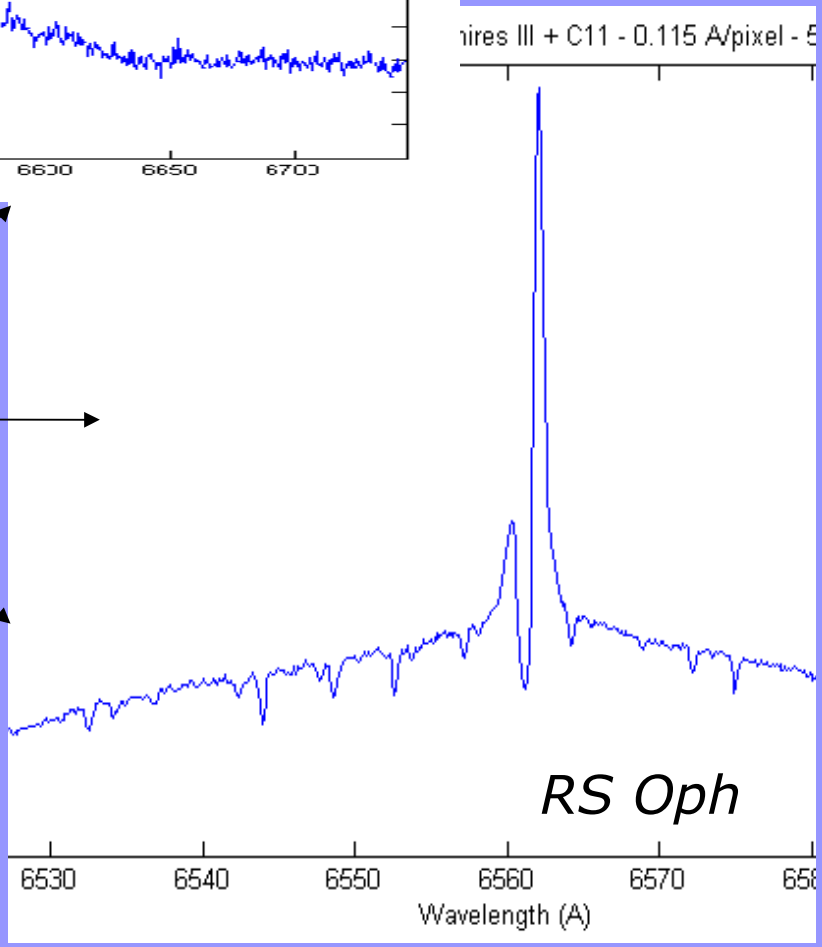


Novae

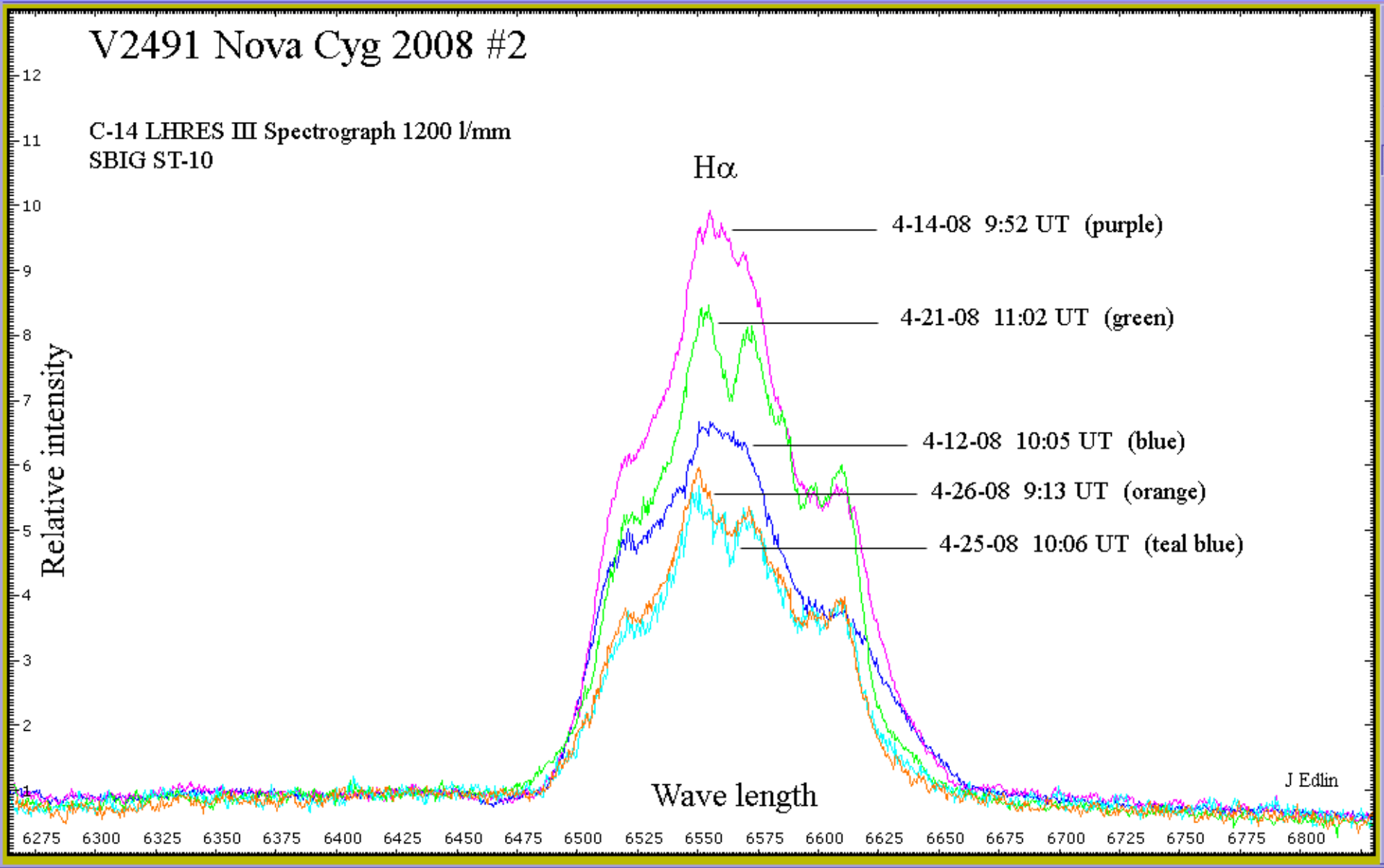



V1280 Sco - 20.21 : 02 / 2007 - C11 + Lhires III
Relative intensity
Wavelength (A)
V1280 Sco


V4743 Sgr
50 Å
2500 km/s

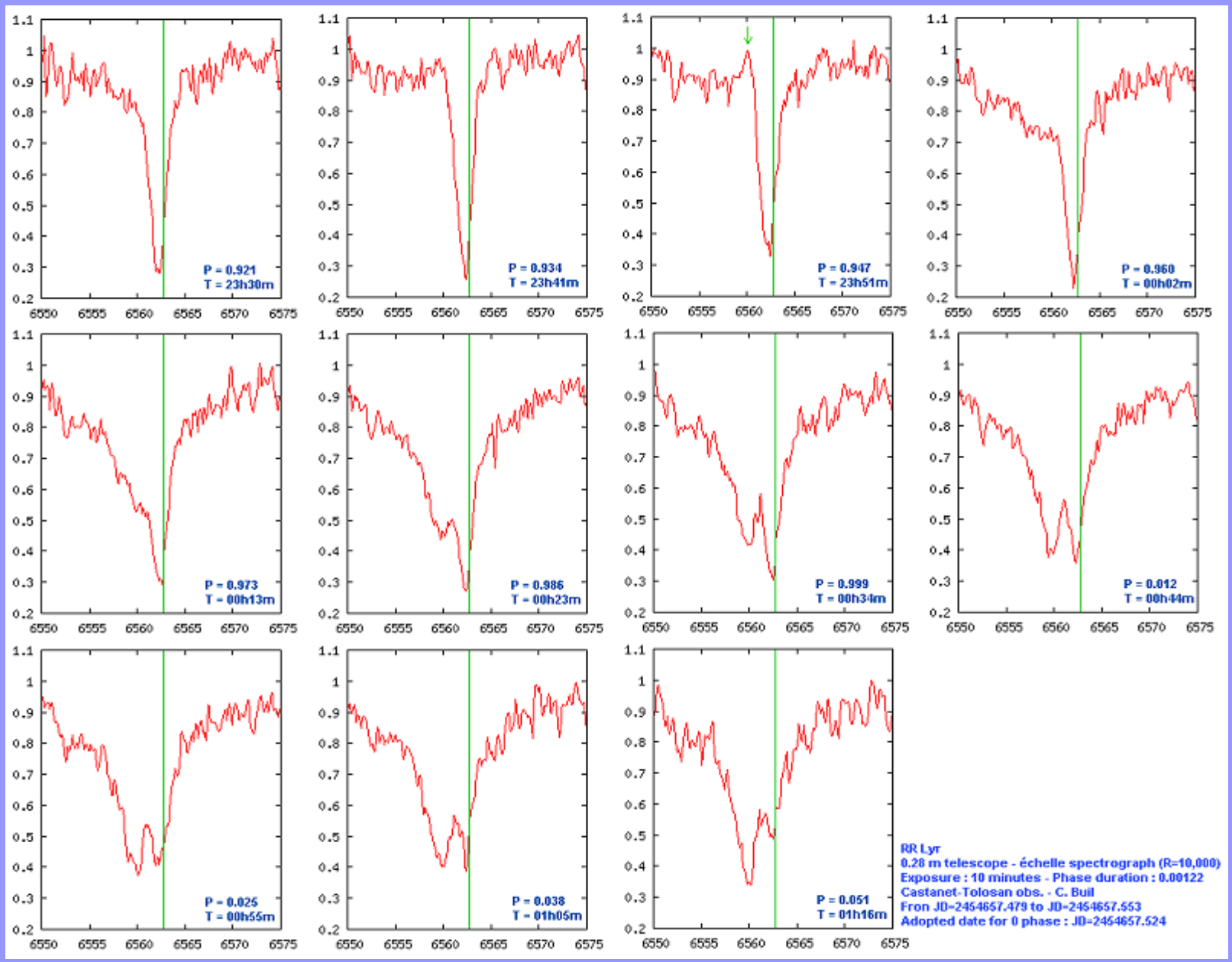

Wavelength (A)
RS Oph

Novae



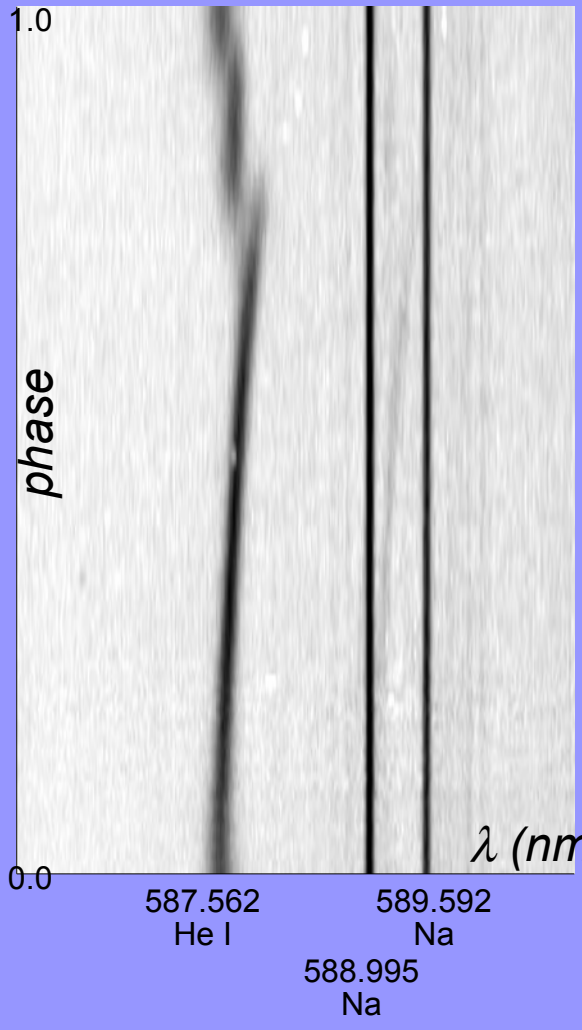
Source: Jim Edlin; Lhires III (1200 gr/mm) + ST10

RR Lyrae: seeing stars pulsating live !

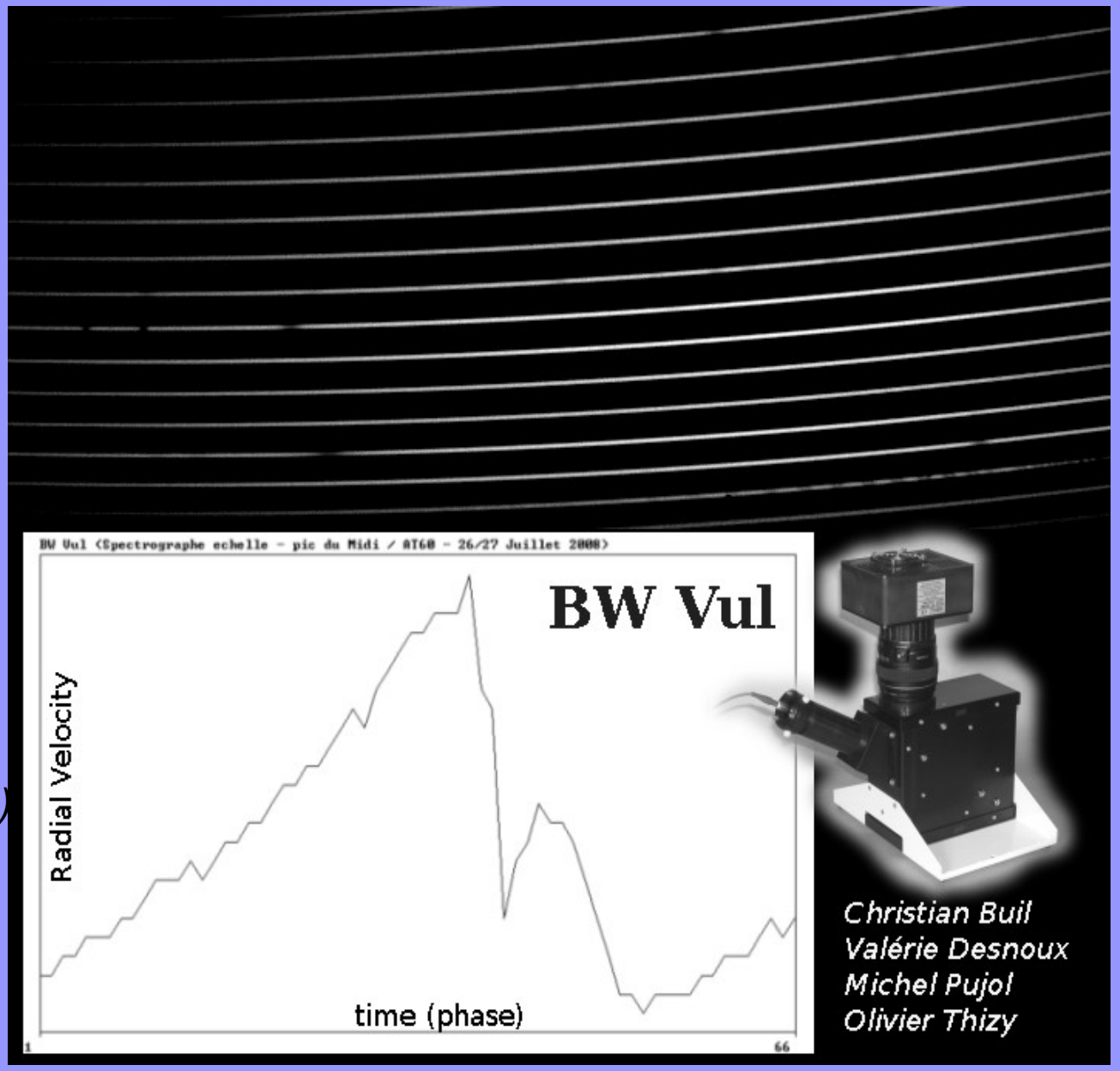


C.Buil

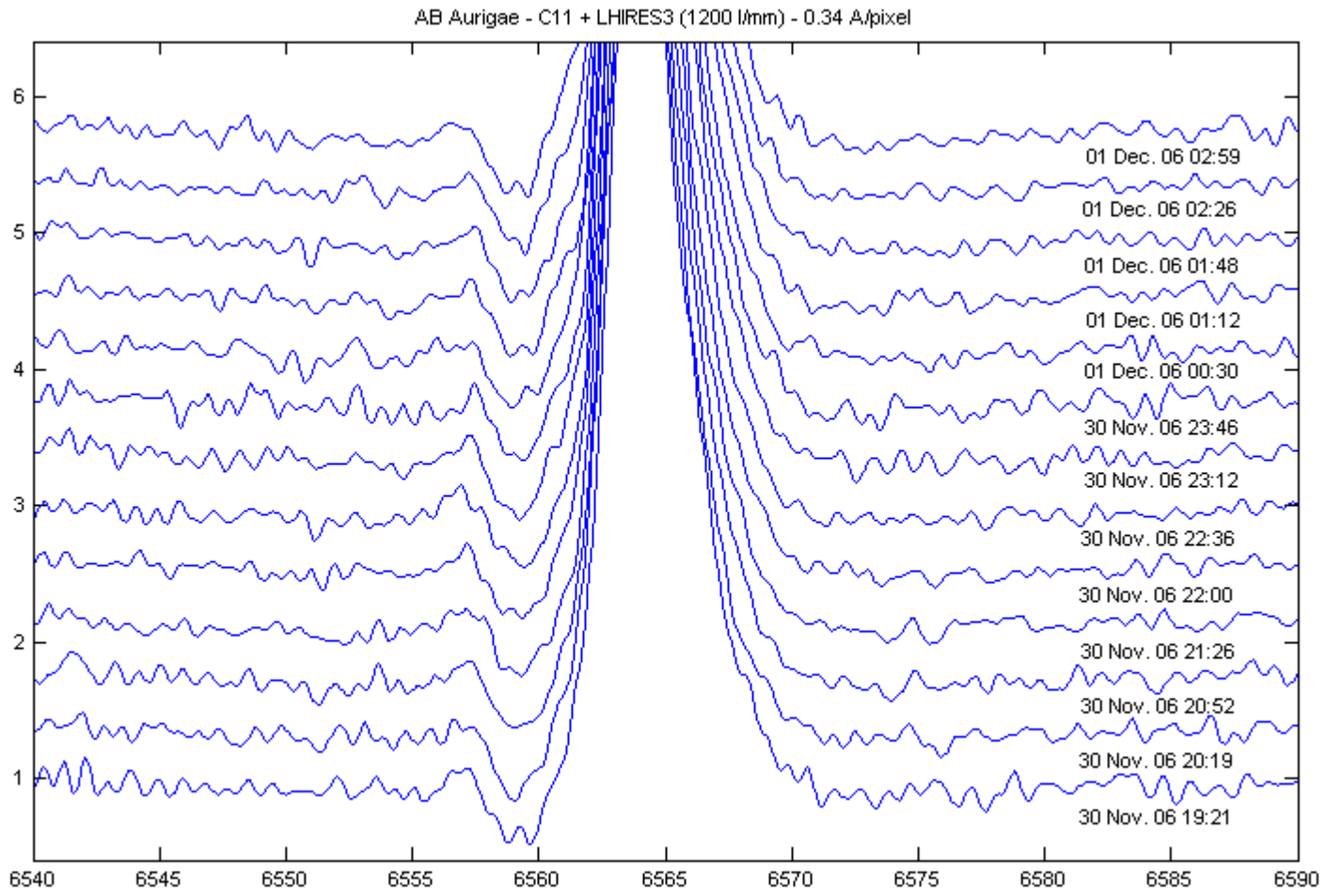
BW Vul: at the heart of a star !!!



Spectrogram of HeI/Sodium doublet of BW Vul
(5min expoure, 60cm f/3.5 telescope at pic du Midi)

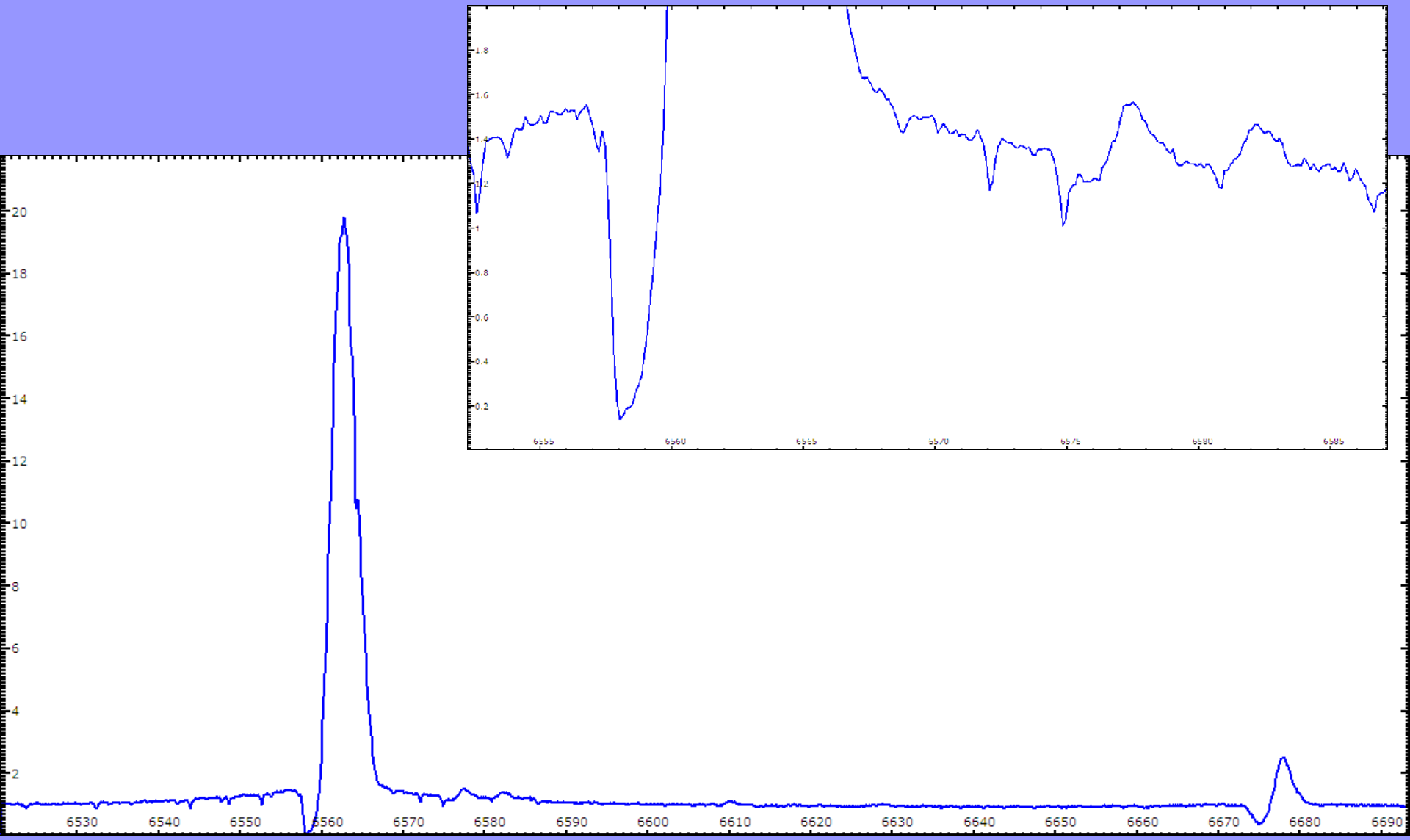


Herbig Ae/Be stars

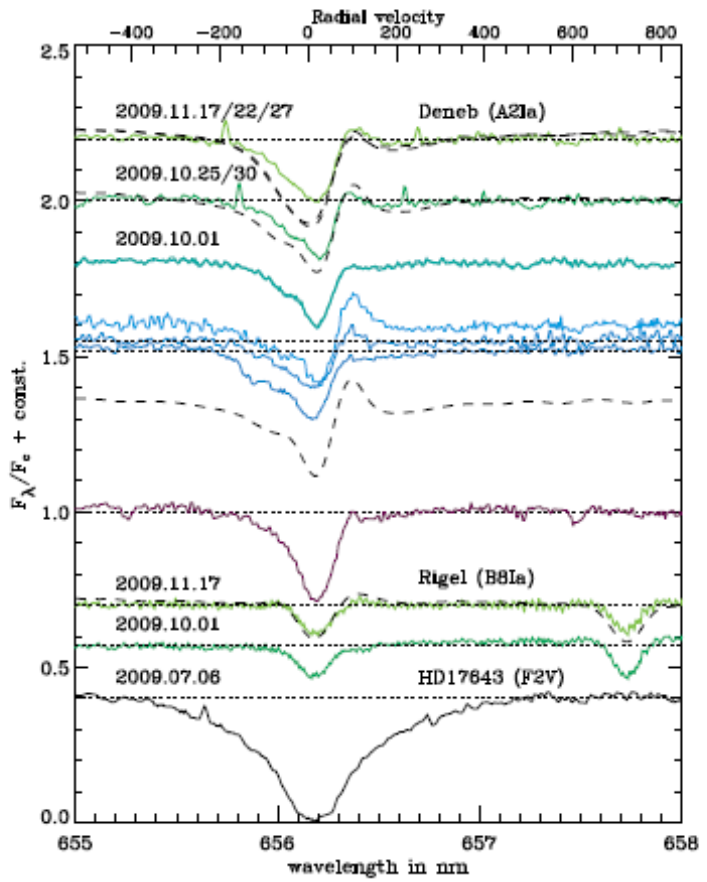


C.Buil

P Cygni


20
18
16
14
12
10
8
6
4
2
6530
6540
6550
6560
6570
6580
6590
6600
6610
6620
6630
6640
6650
6660
6670
6680
6690

other Active Hot Stars: Rigel, Deneb



tion about the spectral FWHM and position of the interferometric signal. The spectral location of the differential visibility and differential phase dips are stable at a level of 0.005 nm (~3 km s^{-1}). Information from the blue camera was also used, as some important lines, e.g. SiII 6343–6371Å can be investigated (see Fig. 3 and Sect. 3.3).

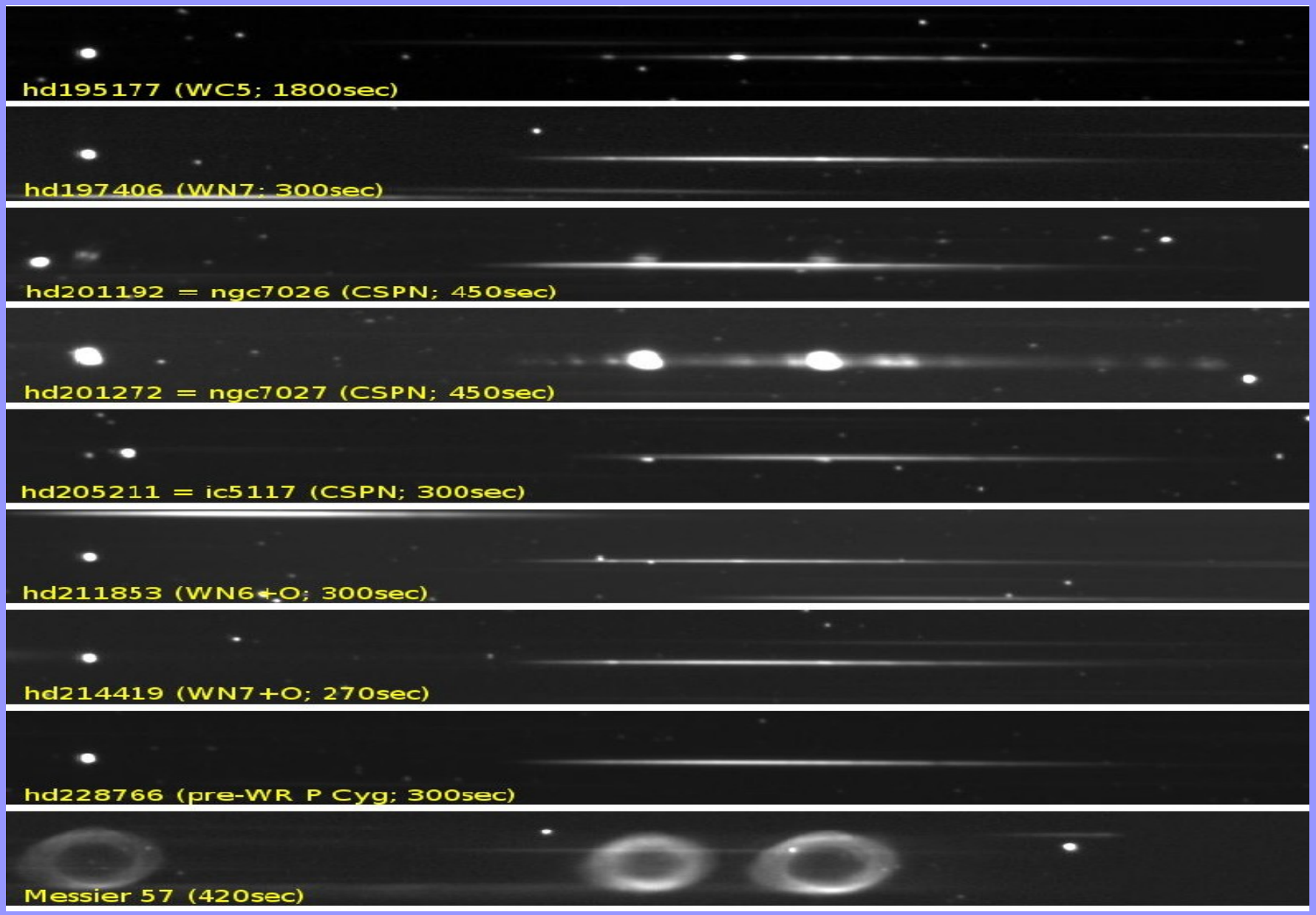
2.2. Spectroscopy from amateur astronomers

Several Hα spectra were obtained during the same period with the 0.28 m amateur telescope (Celestron 11) located in Castanet-Tolosan (France) equipped with the eShel spectrograph and a QSI532 CCD camera (CCD KAF3200ME). These spectra were used in this study as an indication of the emission level and variability of the stars. The typical resolution of these spectra is ~11 000.

The reduction of these data was performed using the standard echelle pipeline (Reshel software V1.11). H2O telluric lines are removed by means of division by a synthetic H2O spectrum using Vspec software - the telluric-line list was taken from GEISA database (LMD/CNRS). We corrected for the diurnal and annual earth velocity are corrected for (spectral wavelengths are given in an heliocentric reference for a stan-

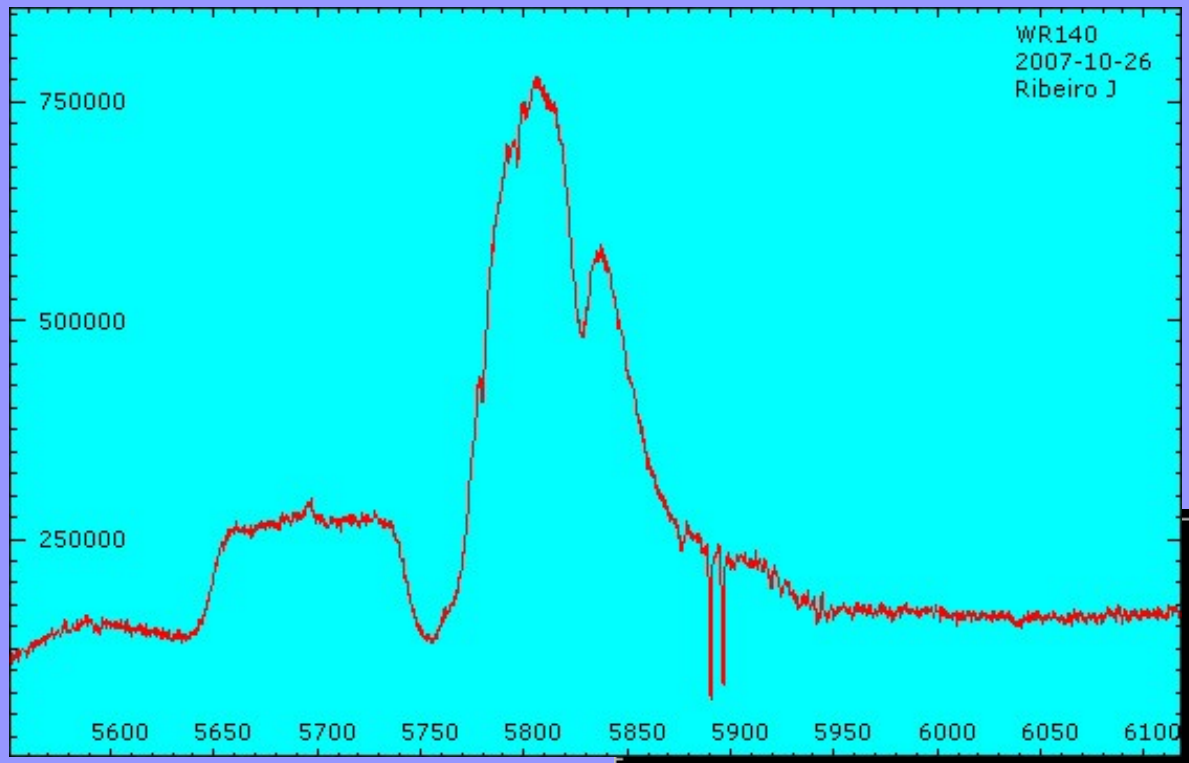
- **Ref:** arXiv:1007.2095v1 : Time, spatial, and spectral resolution of the Halpha line-formation region of Deneb and Rigel with the VEGA/CHARA interferometer

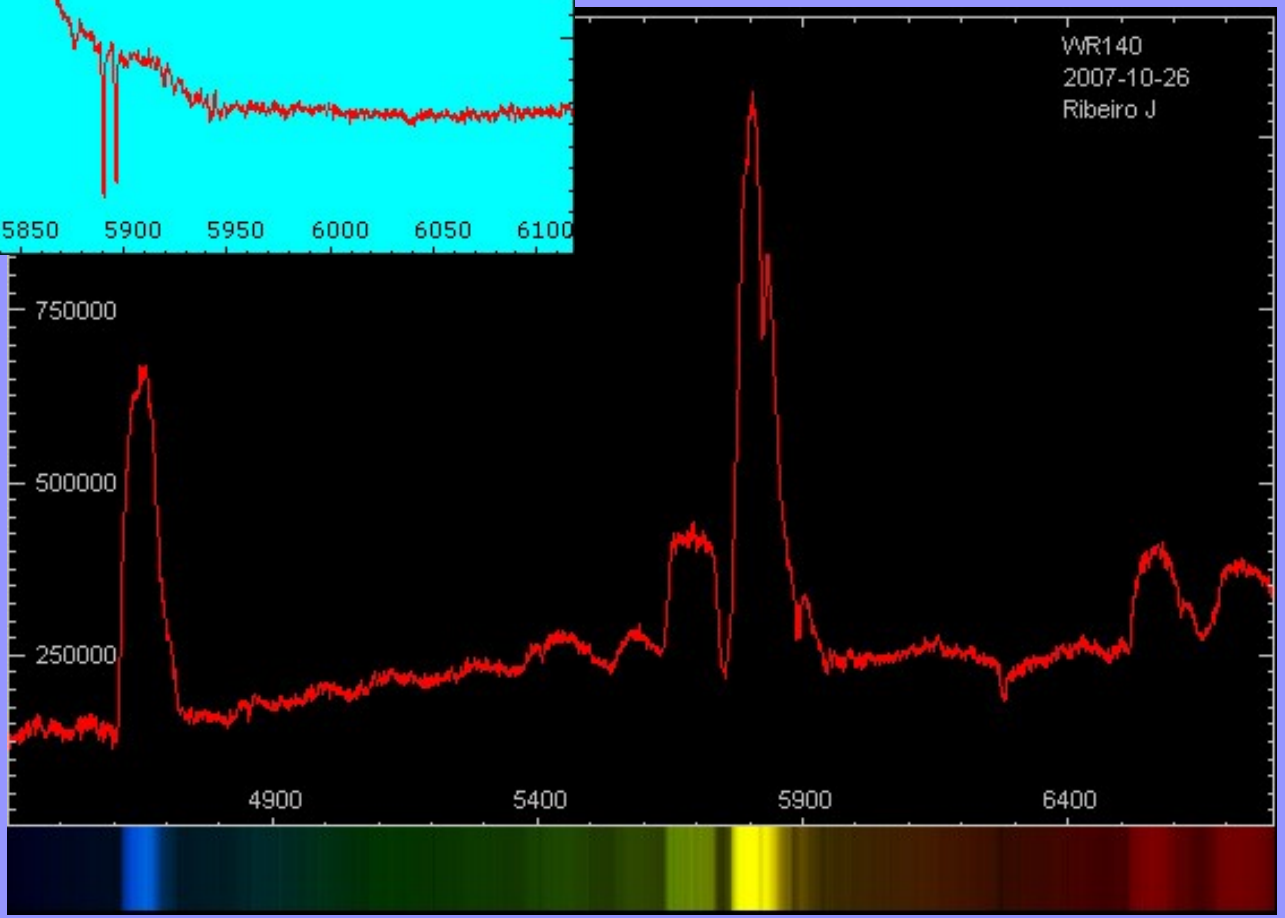
Wolf-Rayet



O.Thizy

WR140

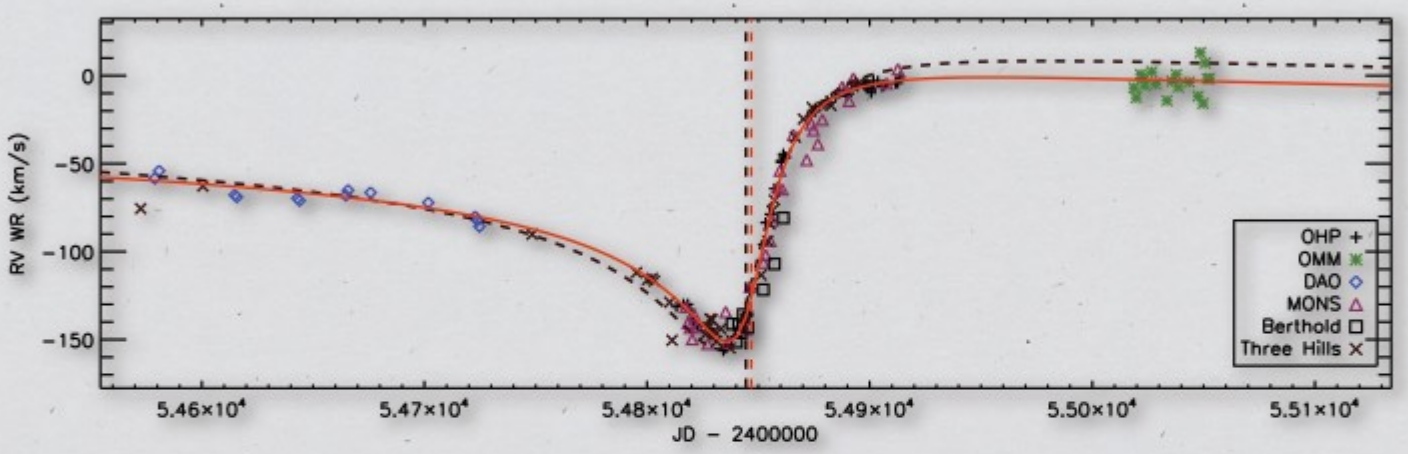


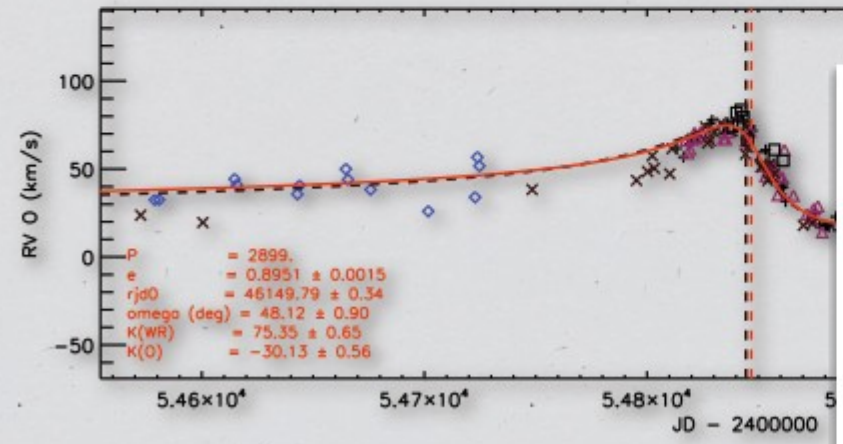


Jose Ribeiro

WR140 / 2009 periastron

Radial Velocities



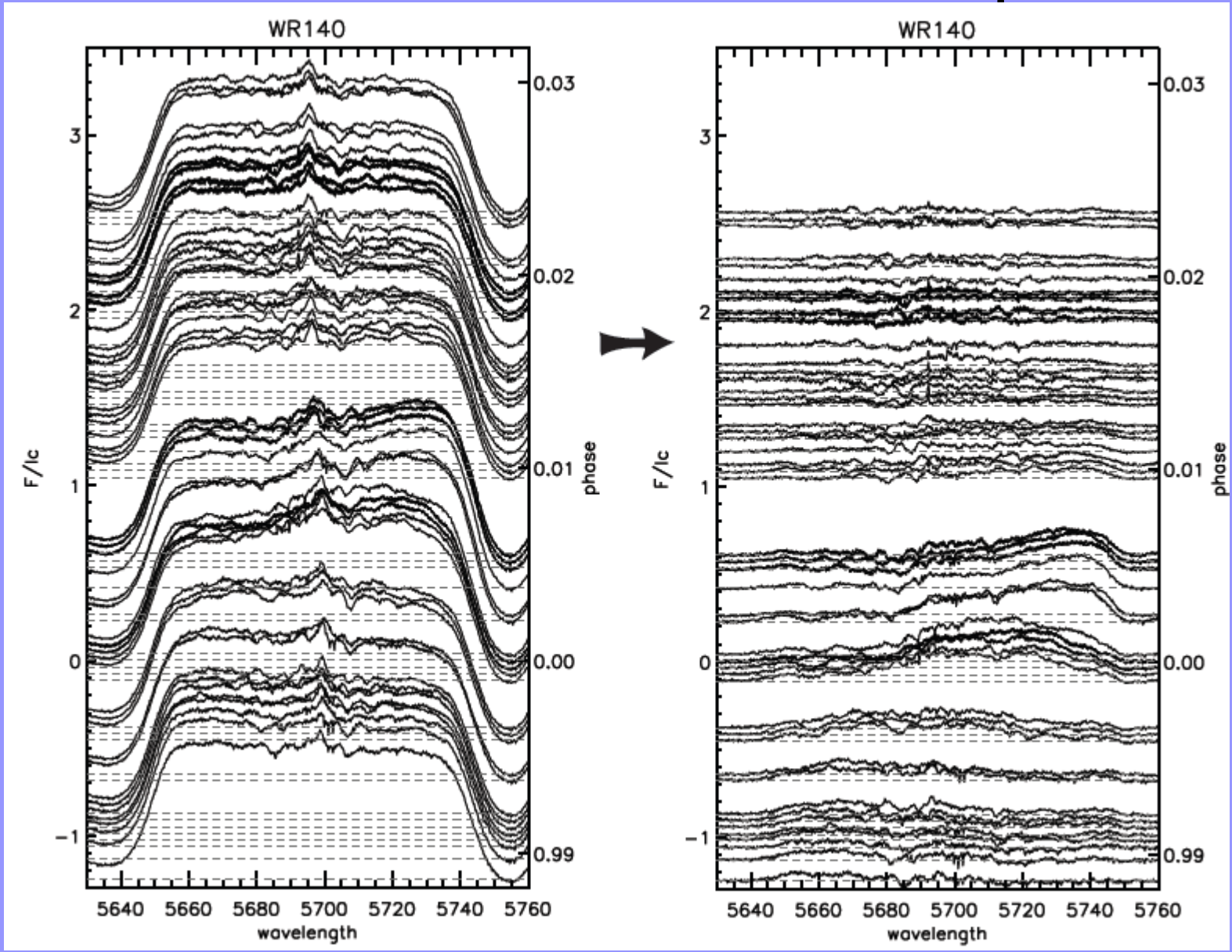


ORBITAL ELEMENTS OF WR 140

Element	WR	O
K (km s^{-1})	82.0 ± 2.3	30.5 ± 1.9
$a \sin i$ (10^{10} km)	0.154 ± 0.007	0.057 ± 0.004
γ	assumed: 0.0	3.1 ± 1.0
P (days)	2899.0 ± 1.3	...
e	0.881 ± 0.005	...
T_0 (HJD 2,440,000+)	6147.4 ± 3.7	...
ω	46.7 ± 1.6	...

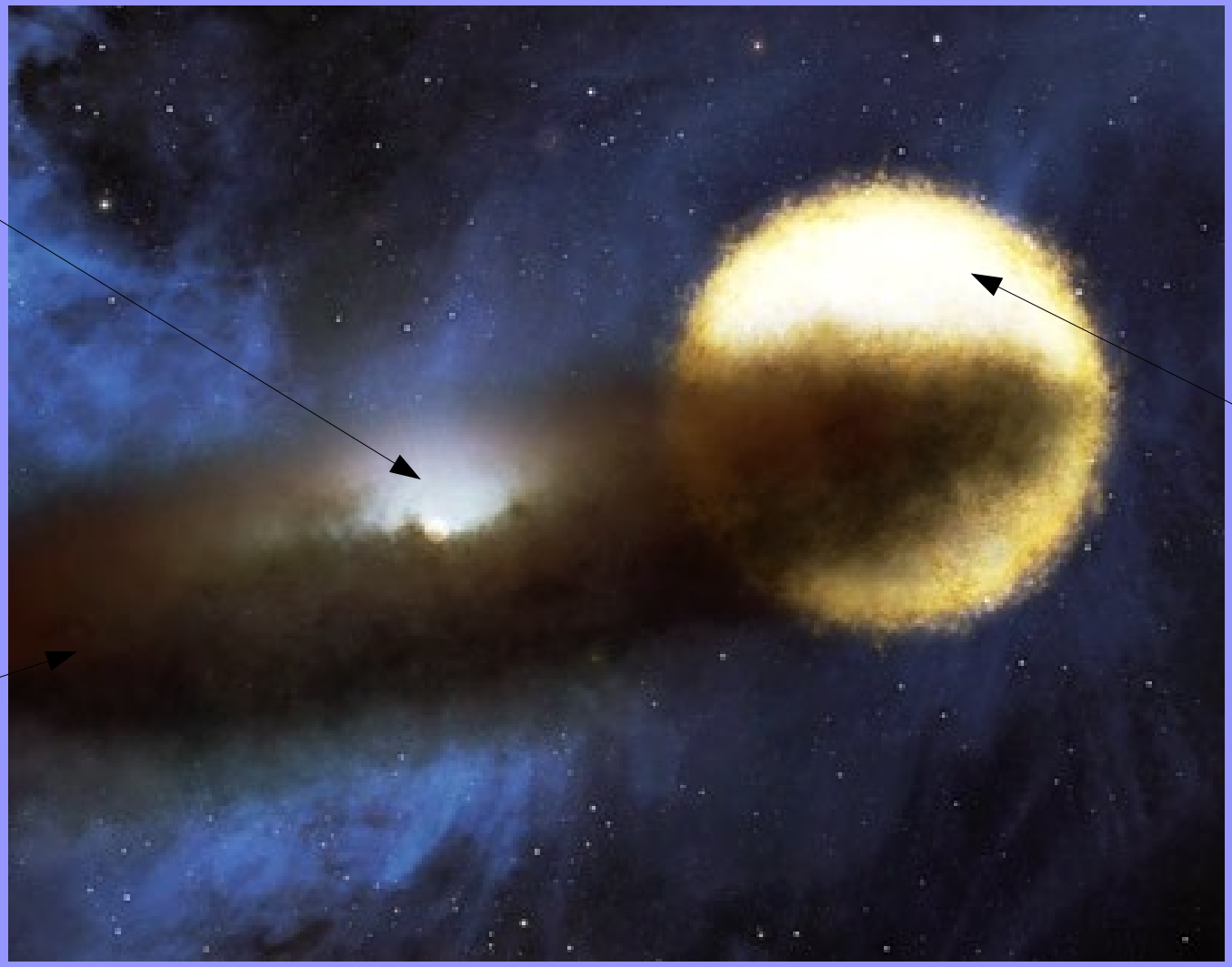
Rémy Fahed et al.

WR140 / 2009 periastron



Rémy Fahed et al.: CIII 5696 flat top line as function of phase / excess emission (right)

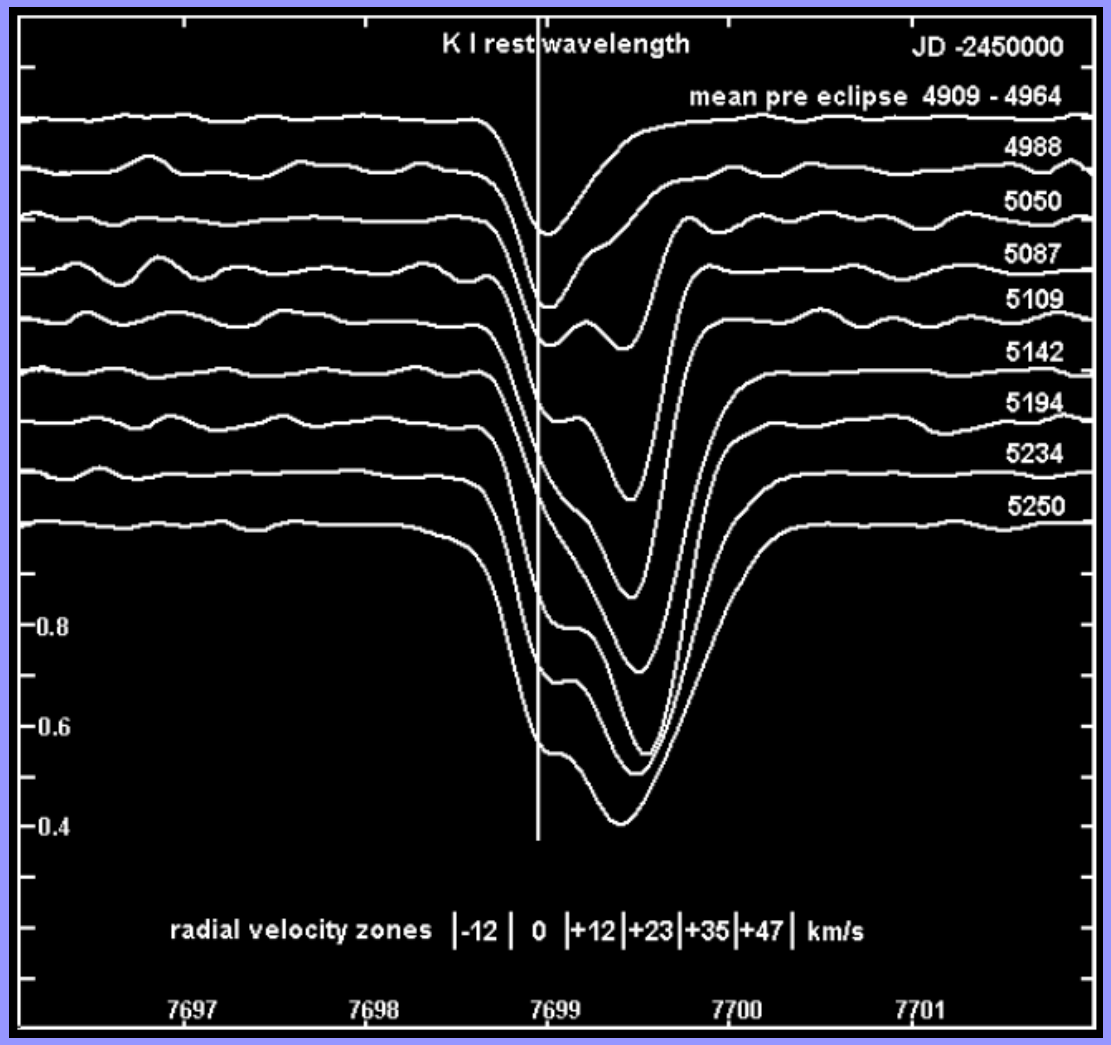
Eps Aurigae eclipse



- Eclipse every 27 years !!!
- ~15 amateurs contributing
- Over 130 spectra to date ?

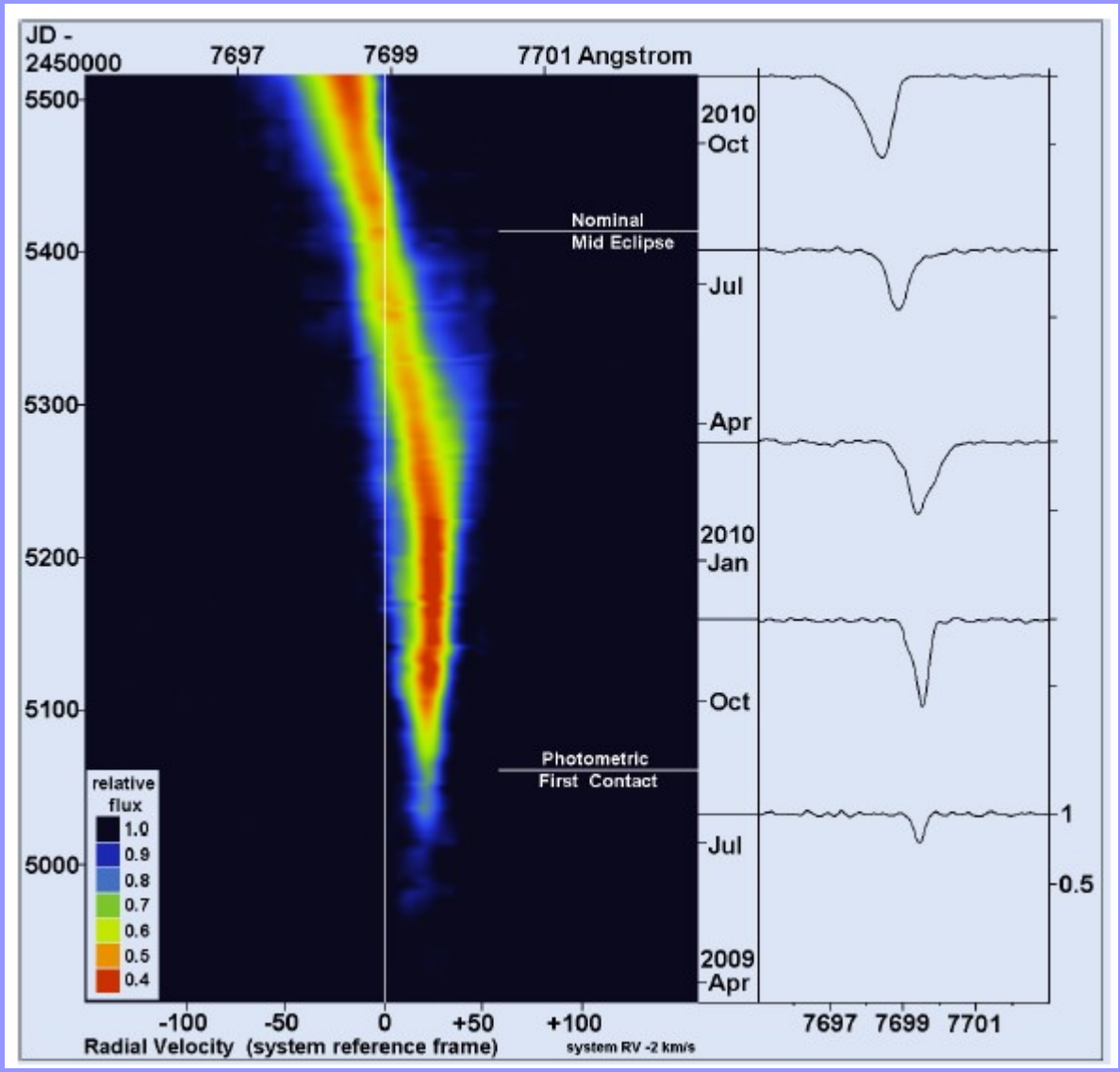
Robin Leadbeater

Eps Aurigae eclipse : KI 7699 line



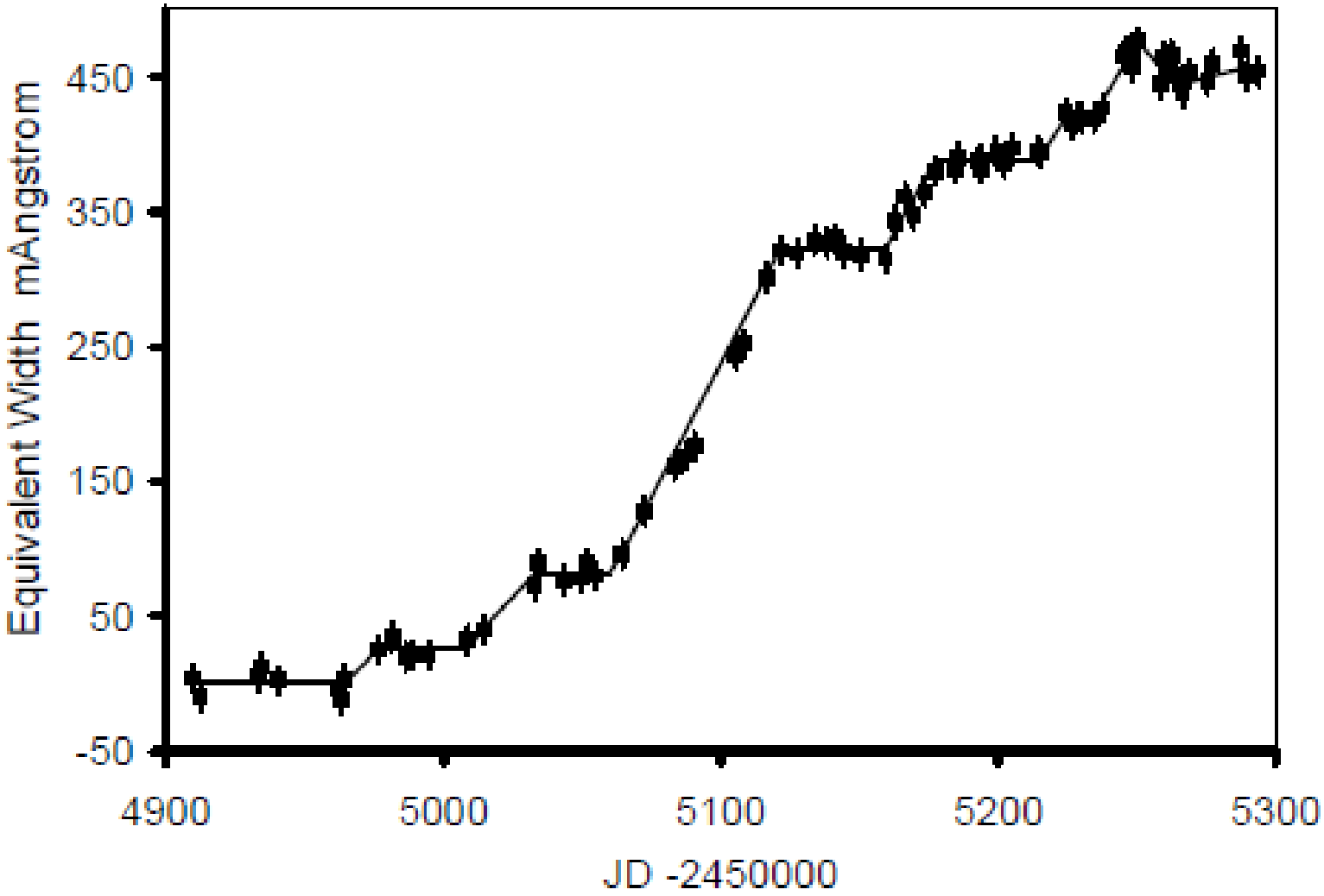
- New absorption line appearing !

Robin Leadbeater (Lhires III), Bob Stencel



Robin Leadbeater (Lhires III), Bob Stencel: Contour plot showing the evolution of the 7699A neutral potassium line after removal of the interstellar component seen outside eclipse. Coverage is 140 days before first contact to 100 days after predicted mid eclipse.

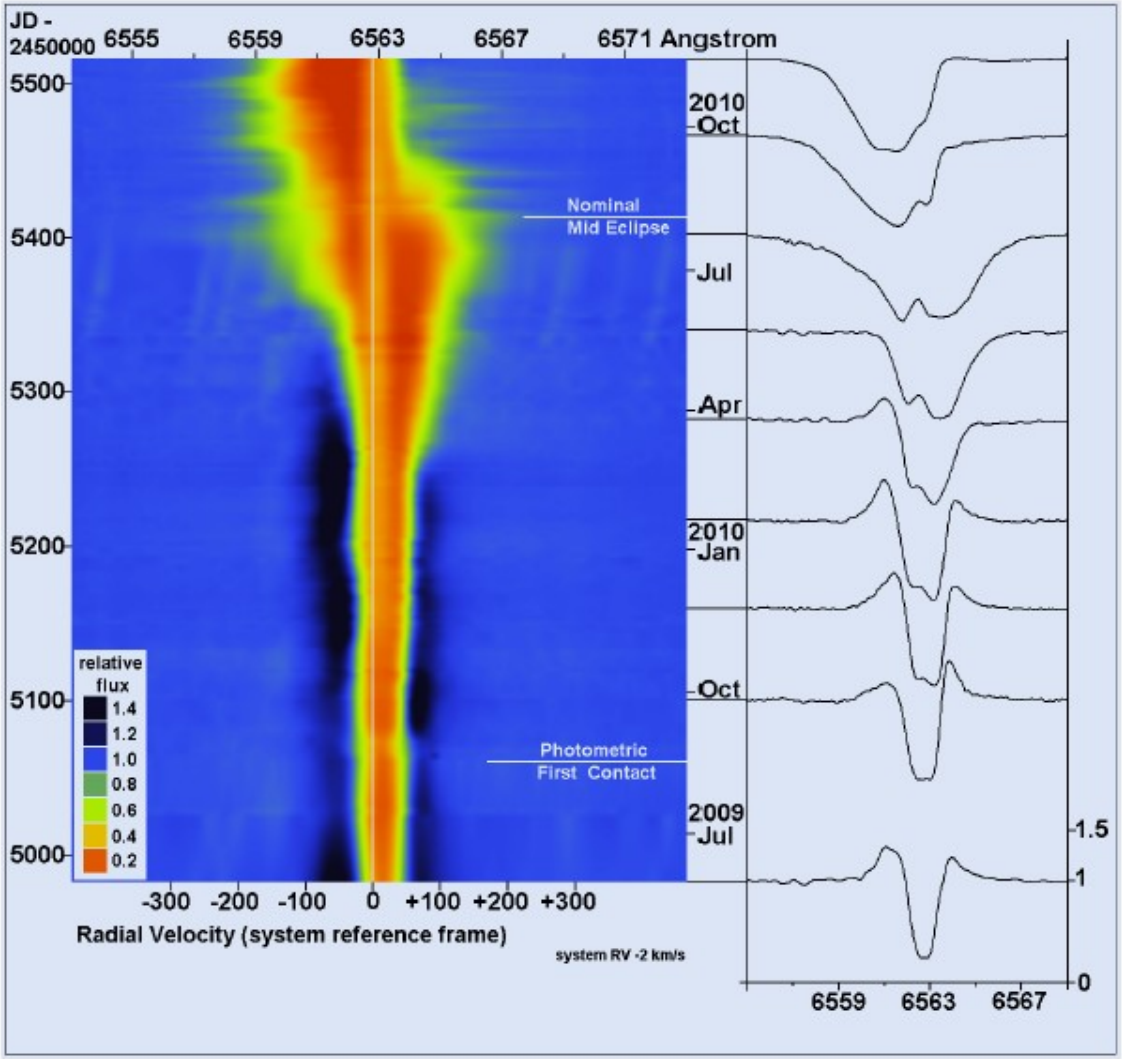
Eps Aurigae eclipse : KI 7699 line

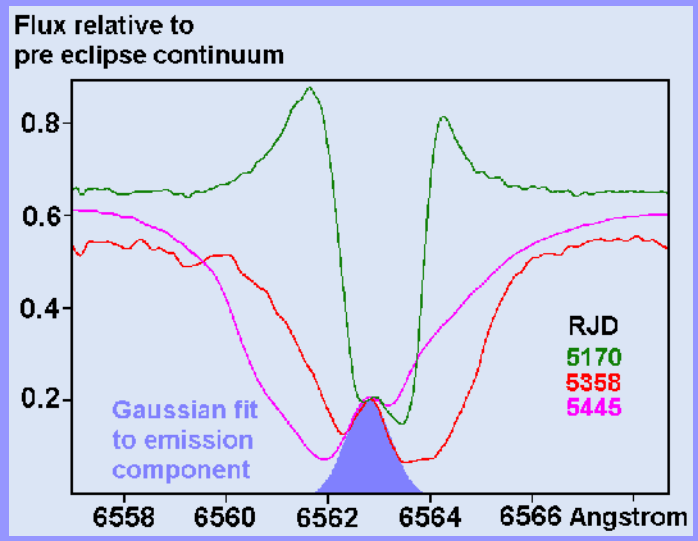


- Disk structures in « rings » ?

Robin Leadbeater, Bob Stencel

Eps Aurigae eclipse : Halpha line





A hidden emission component
An emission component appeared in the core of the H alpha line close to the rest wavelength.

Robin Leadbeater, Bob Stencel: Contour plot showing the evolution of the H alpha line from pre first contact to approximately 100 days after predicted mid eclipse.
It is generated from 159 spectra from all observers.

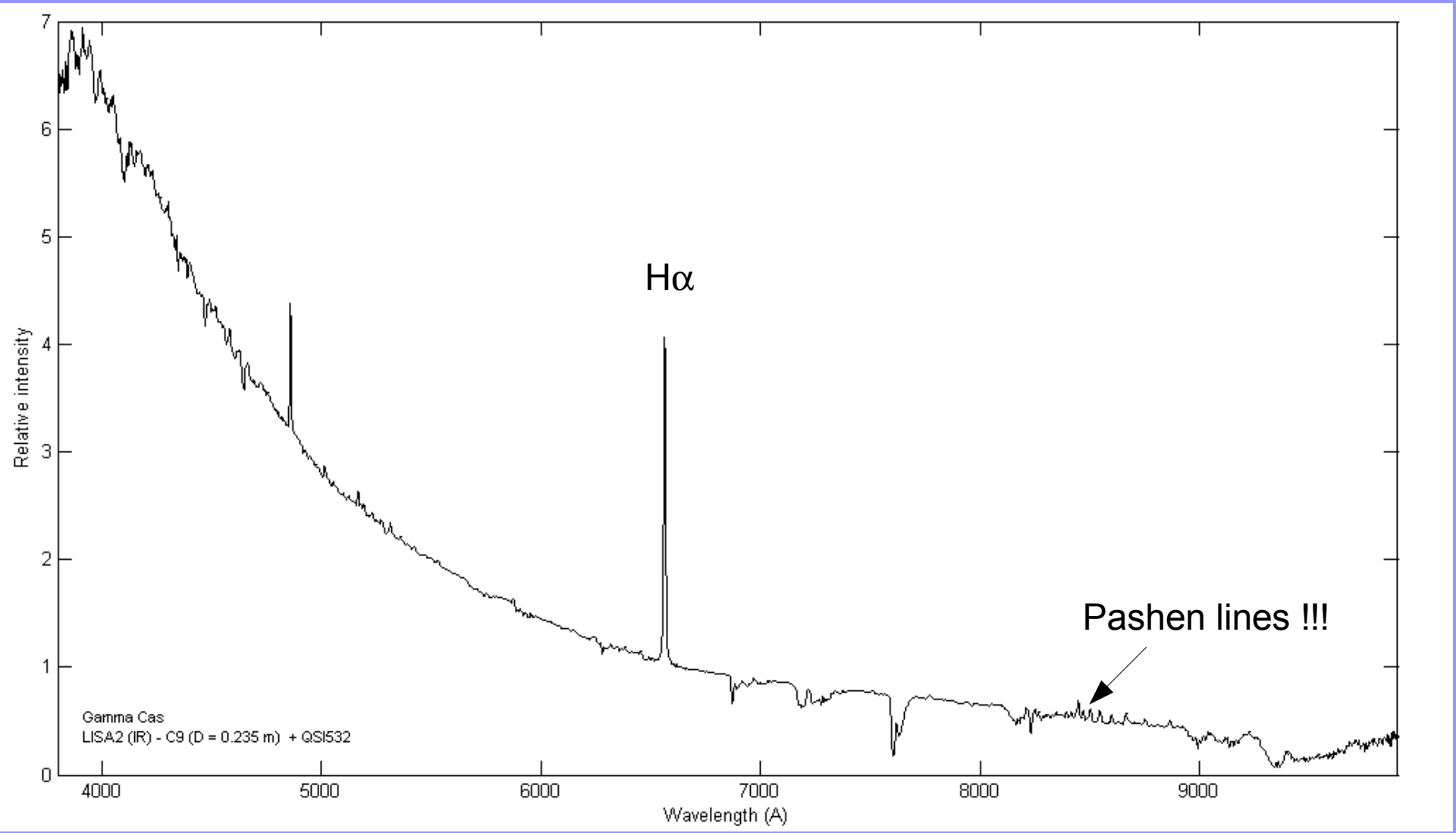
eps Aurigae pro-am campaign

- **Complementary photometry / spectroscopy campaign**
- **Over 600 spectra collected (and increasing) !**

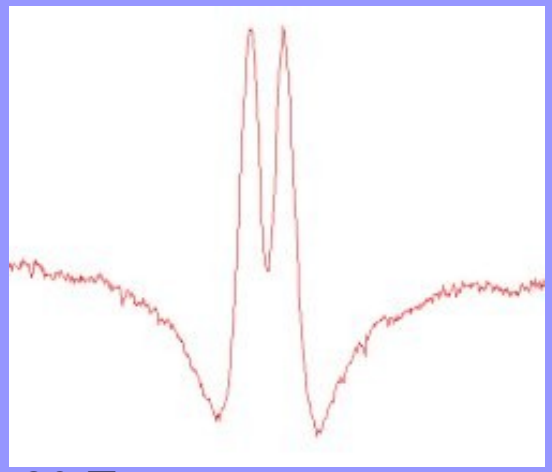
- **Contacts: Robert 'Bob' Stencel (Denver, USA)**
  Jeff Hopkins (amateur; photometry lead)
  Robin Leadbeater (amateur; spectroscopy lead)

- **Publications:**
  - http://www.threehillsobservatory.co.uk/astro/spectra_40.htm
  - arXiv:0807.2855v1 : Gearing Up for Epsilon Aurigae's First Eclipse of the Millennium
  - 2009SASS...28..157H : Epsilon Aurigae Hydrogen Alpha Emission Line Variation: The Horn Dance
  - 2009CBET.1885....1W : Epsilon Aurigae (first detection !)
  - arXiv:1003.3617v2 : Structure in the disc of epsilon Aurigae: Spectroscopic observations of neutral Potassium during eclipse ingress
  - arXiv:1101.1435v1 : The International Epsilon Aurigae Campaign 2009-2011. A description of the campaign and early results to May 2010
  - Article in Sky & Telescope magazine !

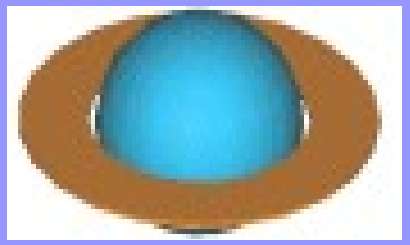
A *state-of-the-art* pro/am project: Be stars

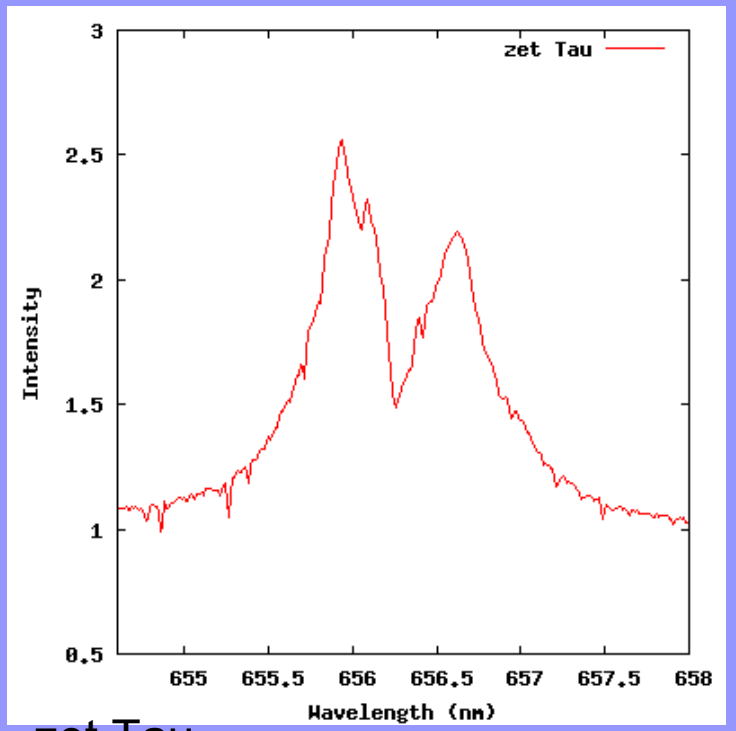


Be stars

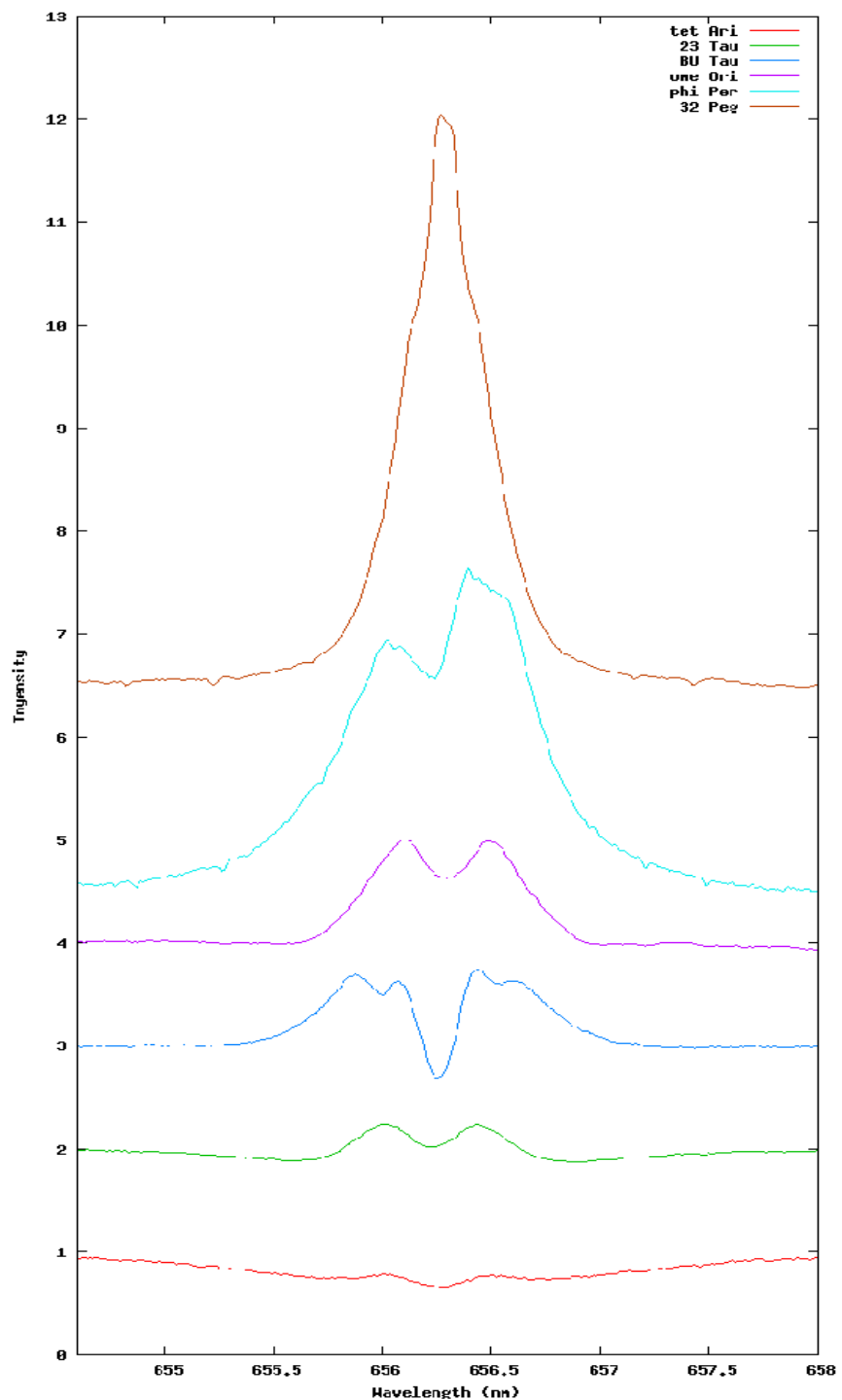


23 Tau

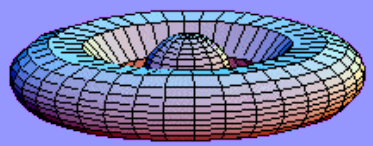


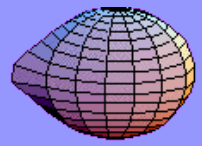


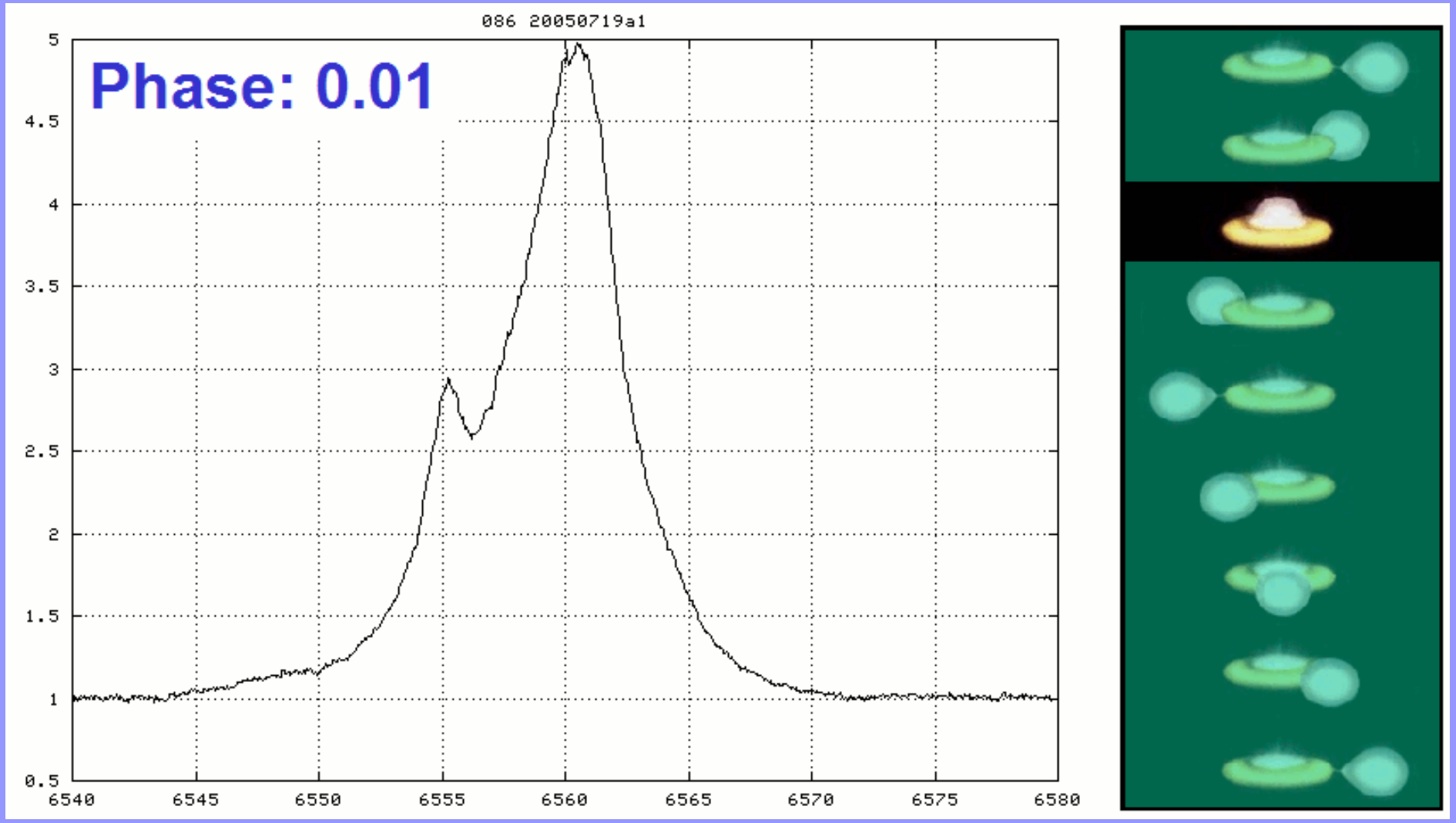
zet Tau



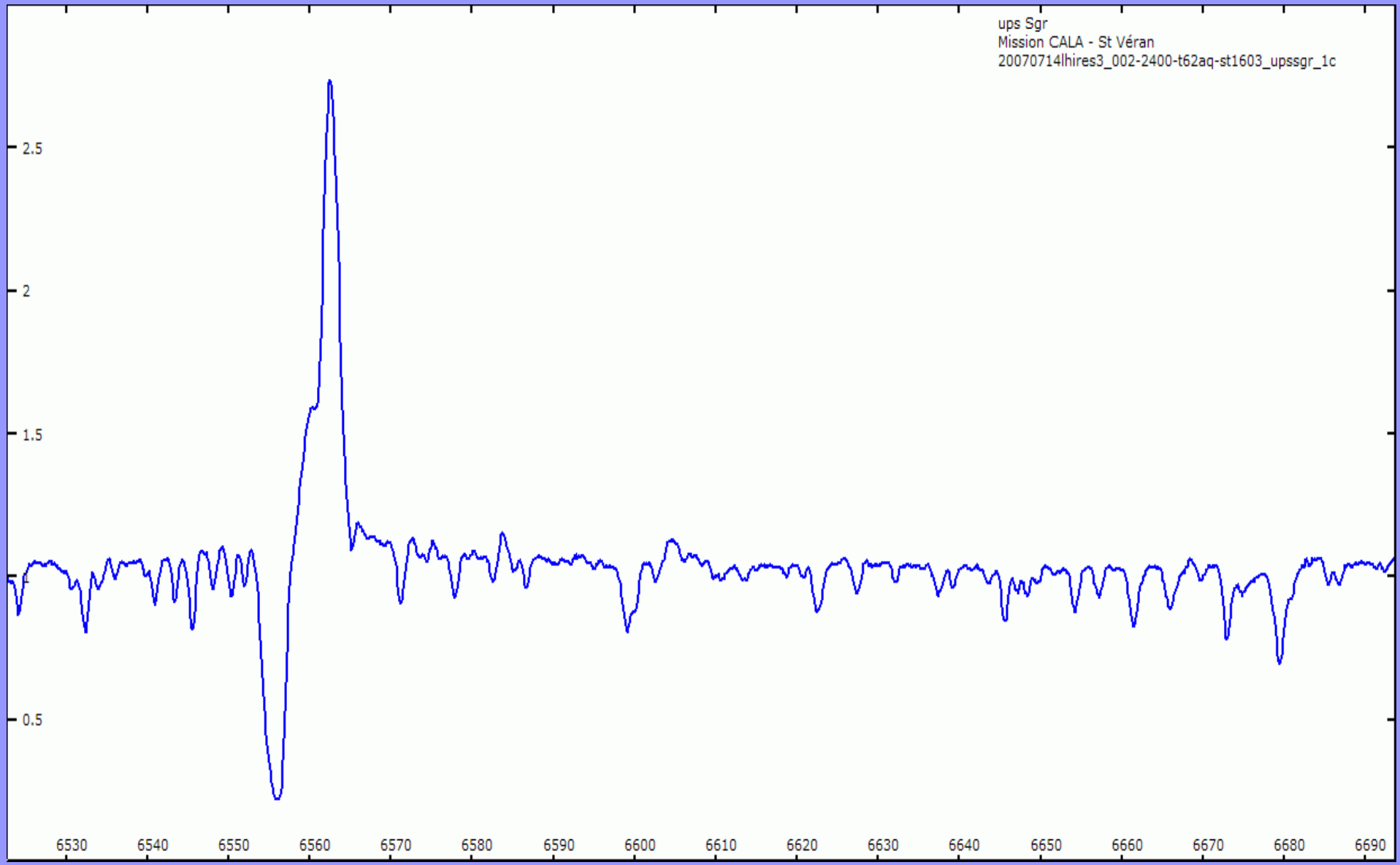
Hα - time evolution β Lyr







Exemple of Be targets: υ Sgr



COROT targets: 64 Ser

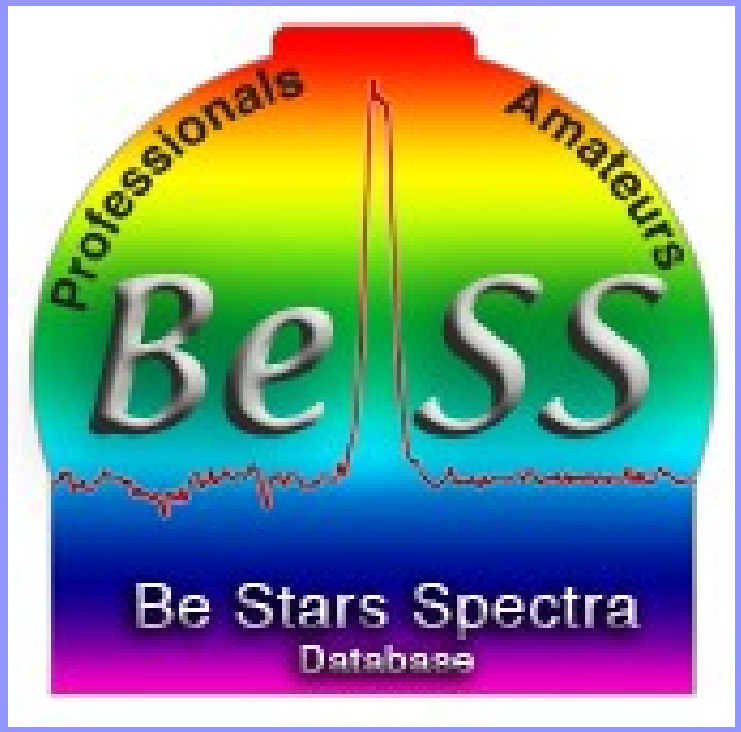
64 Ser (T620 f/15 AstroQueyras + Lhires III 1200lines/mm + ST8E)
11.92 Sep 2006 (60min exposure)
Olivier Thizy / Mission CALA "COROT 2006"

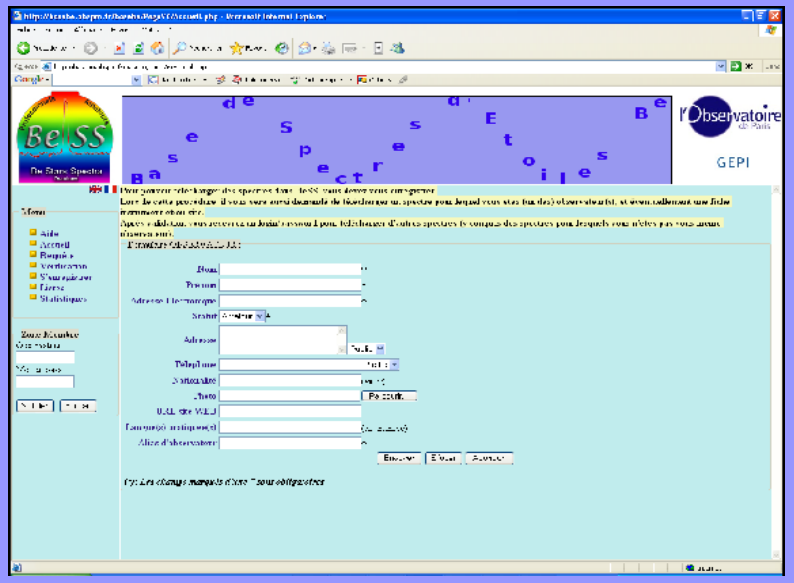
1.1

0.9

6420 6440 6460 6480 6500 6520 6540 6560 6580 6600 6620 6640 6660 6680 6700 6720 6740 6760 6780 6800 6820 6840

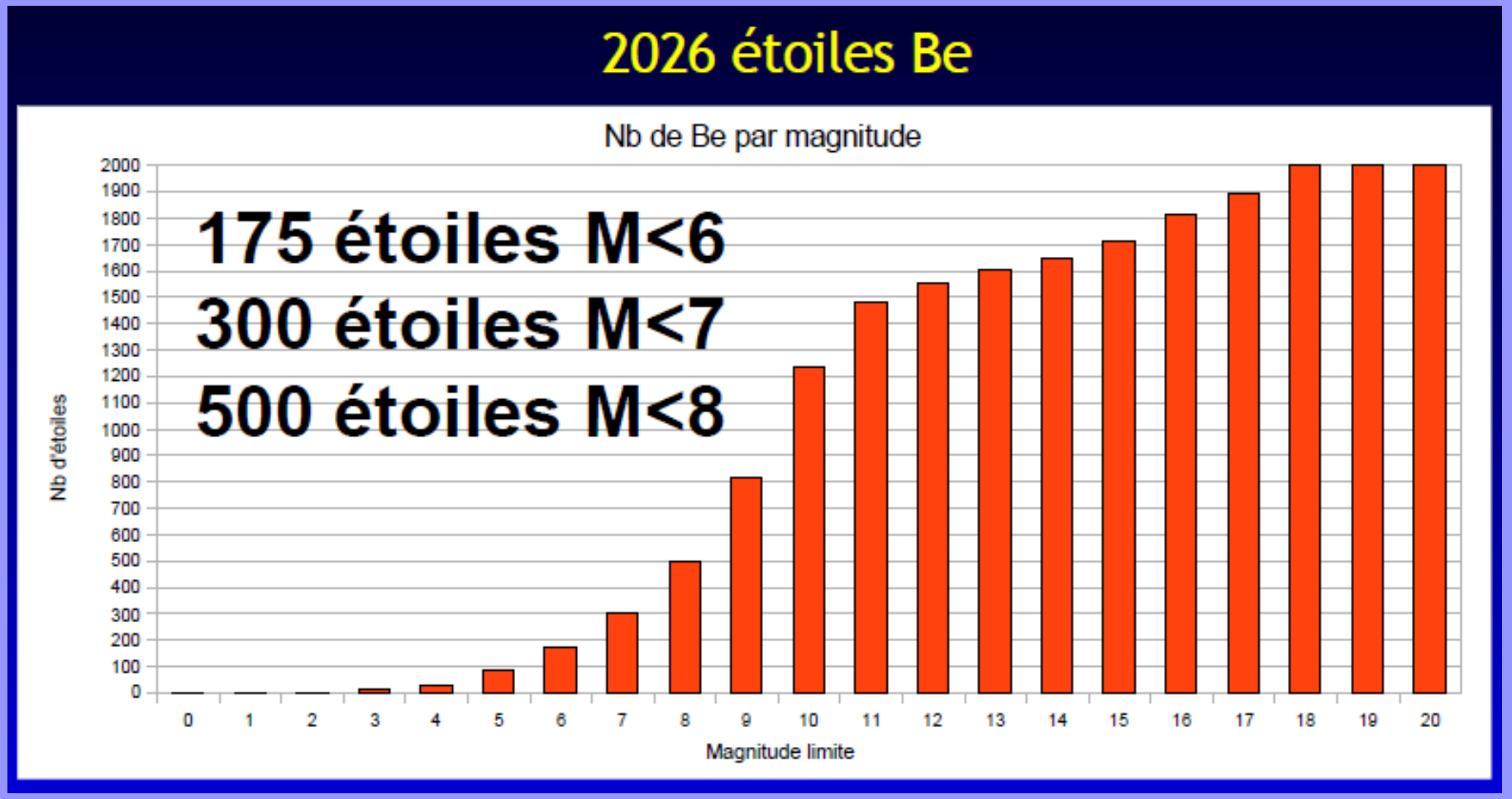
BeSS database





URL: **http://basebe.obspm.fr**

BeSS catalog



F. Cochard / V. Desnoux

- Plenty of BRIGHT stars to work on !!!

BeSS database

Top ten de tous les insomniaques

Spectres	Observateur
37180	Coralie Neiner
34940	Bertrand de Batz
31153	archive ELODIE
7823	Christian Buil
5292	Claude Catala
3978	Olivier Thizy
3015	Huib Henrichs
2650	Anne-Marie Hubert
2601	database INES
1876	Philippe Mathias

Top ten des amateurs insomniaques

Spectres	Observateur
7823	Christian Buil
3978	Olivier Thizy
839	Joan Guarro Fló
575	Valerie Desnoux
467	Thierry GARREL
370	Michel Pujol
358	Ernst Pollmann
240	Benjamin MAUCLAIRE
176	José Ribeiro
169	Jean-Noël TERRY

Top ten des pros insomniaques

Spectres	Observateur
37180	Coralie Neiner
34940	Bertrand de Batz
31153	archive ELODIE
5292	Claude Catala
3015	Huib Henrichs
2650	Anne-Marie Hubert
2601	database INES
1876	Philippe Mathias
1186	database GAUDI
871	Pascale Ehrenfreud

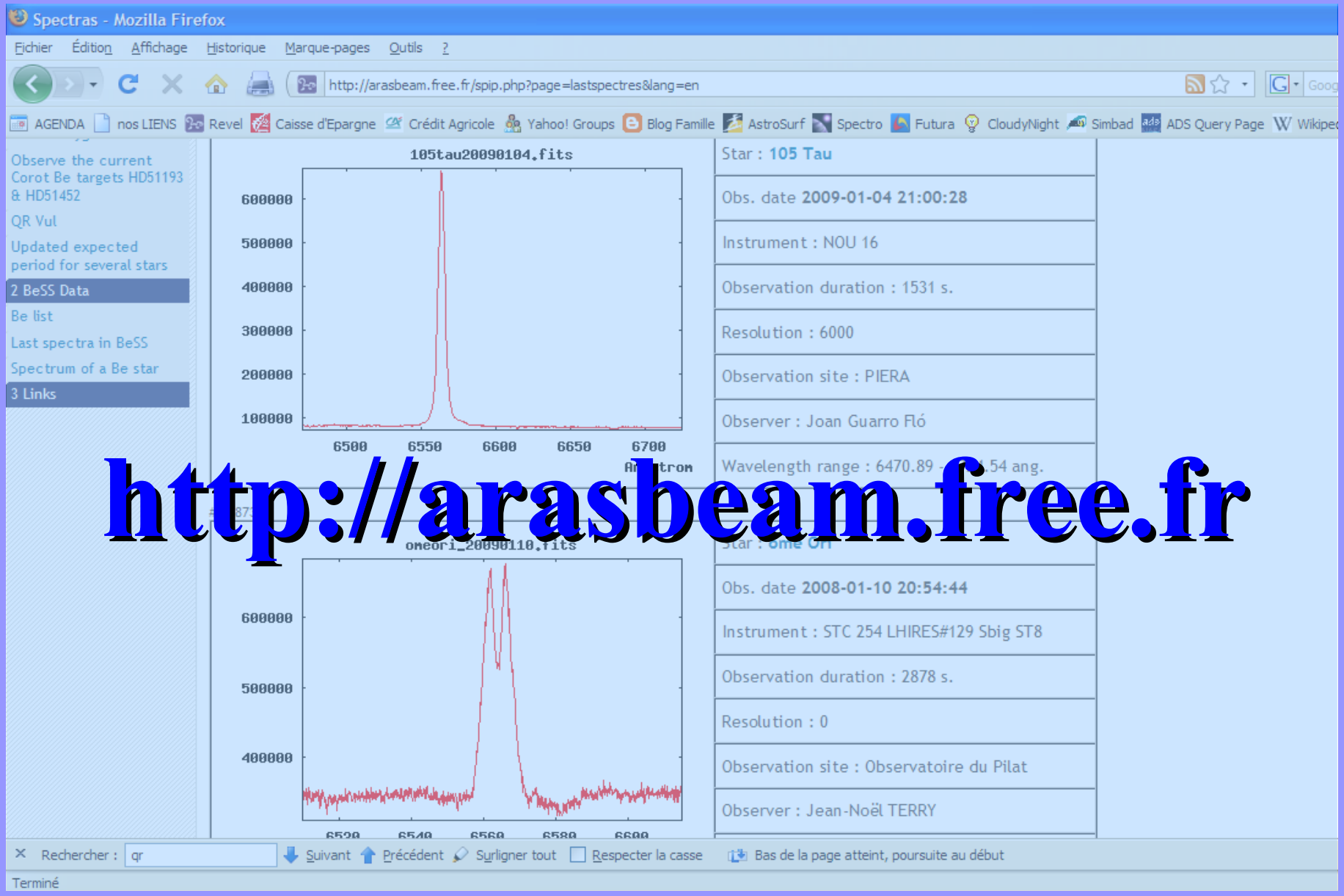
- >11000 amateur spectra from over 30 different users

Equipment used

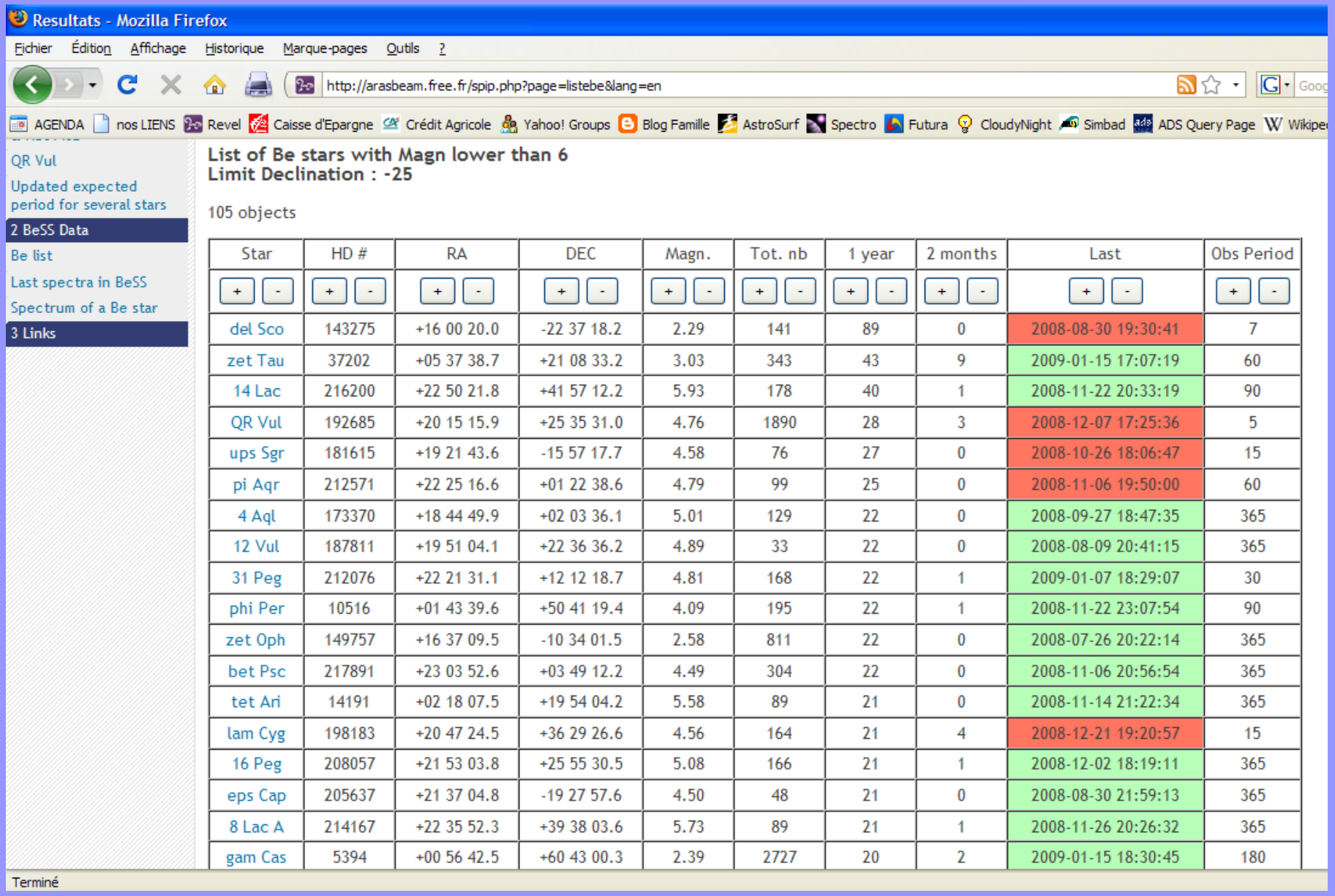
Type	
Lhires III	42
Pro	13
Other	6
eShel	5
Total Résultat	**66**

- Amateur telescope size: 12cm to 62cm
- Mainly Lhires spectrographs used by amateurs
- eShel echelle spectrograph
  provides larger spectral coverage

AraBeAm “amateur” front end



ARAS BeAm « to do » list



Star	HD #	RA	DEC	Magn.	Tot. nb	1 year	2 months	Last	Obs Period
del Sco	143275	+16 00 20.0	-22 37 18.2	2.29	141	89	0	2008-08-30 19:30:41	7
zet Tau	37202	+05 37 38.7	+21 08 33.2	3.03	343	43	9	2009-01-15 17:07:19	60
14 Lac	216200	+22 50 21.8	+41 57 12.2	5.93	178	40	1	2008-11-22 20:33:19	90
QR Vul	192685	+20 15 15.9	+25 35 31.0	4.76	1890	28	3	2008-12-07 17:25:36	5
ups Sgr	181615	+19 21 43.6	-15 57 17.7	4.58	76	27	0	2008-10-26 18:06:47	15
pi Aqr	212571	+22 25 16.6	+01 22 38.6	4.79	99	25	0	2008-11-06 19:50:00	60
4 Aql	173370	+18 44 49.9	+02 03 36.1	5.01	129	22	0	2008-09-27 18:47:35	365
12 Vul	187811	+19 51 04.1	+22 36 36.2	4.89	33	22	0	2008-08-09 20:41:15	365
31 Peg	212076	+22 21 31.1	+12 12 18.7	4.81	168	22	1	2009-01-07 18:29:07	30
phi Per	10516	+01 43 39.6	+50 41 19.4	4.09	195	22	1	2008-11-22 23:07:54	90
zet Oph	149757	+16 37 09.5	-10 34 01.5	2.58	811	22	0	2008-07-26 20:22:14	365
bet Psc	217891	+23 03 52.6	+03 49 12.2	4.49	304	22	0	2008-11-06 20:56:54	365
tet Ari	14191	+02 18 07.5	+19 54 04.2	5.58	89	21	0	2008-11-14 21:22:34	365
lam Cyg	198183	+20 47 24.5	+36 29 26.6	4.56	164	21	4	2008-12-21 19:20:57	15
16 Peg	208057	+21 53 03.8	+25 55 30.5	5.08	166	21	1	2008-12-02 18:19:11	365
eps Cap	205637	+21 37 04.8	-19 27 57.6	4.50	48	21	0	2008-08-30 21:59:13	365
8 Lac A	214167	+22 35 52.3	+39 38 03.6	5.73	89	21	1	2008-11-26 20:26:32	365
gam Cas	5394	+00 56 42.5	+60 43 00.3	2.39	2727	20	2	2009-01-15 18:30:45	180

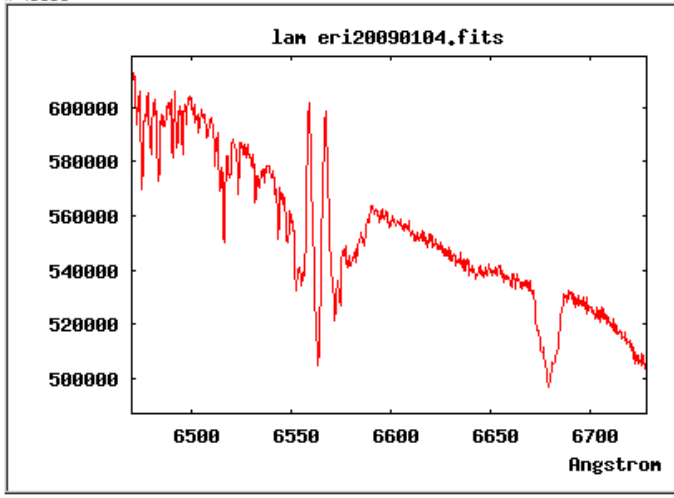
ArasBeAm: detecting outburst

Spectras - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Outils ?

http://arasbeam.free.fr/spip.php?page=spectres&etoile=169&lang=en

AGENDA nos LIENS Revel Caisse d'Epargne Crédit Agricole Yahoo! Groups Blog Famille AstroSurf Spectro Futura CloudyNight Simbad ADS Query Page Wikipe



Obs. date : **2009-01-04 21:35:59**

Instrument : NOU 16

Observation duration : 1531 s.

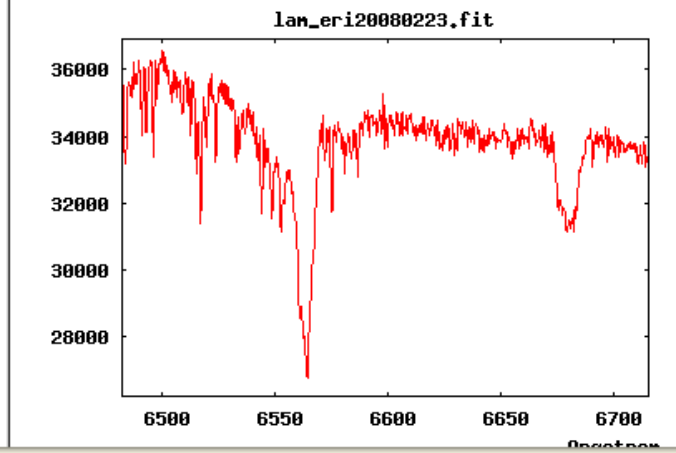
Resolution : 6000

Observation site : PIERA

Observer : Joan Guarro Fló

Wavelength range : 6470 [illegible] 6729.08 ang

37790



Obs. date : **2008-03-2[illegible] 20:05:16**

Instrument : NEWTON 254 - LHIRES-B12t - AUDINE 403

Observation duration : 4496 s.

Resolution : 7000

Observation site : STA. MARIA DE MONTMAGASTRELL

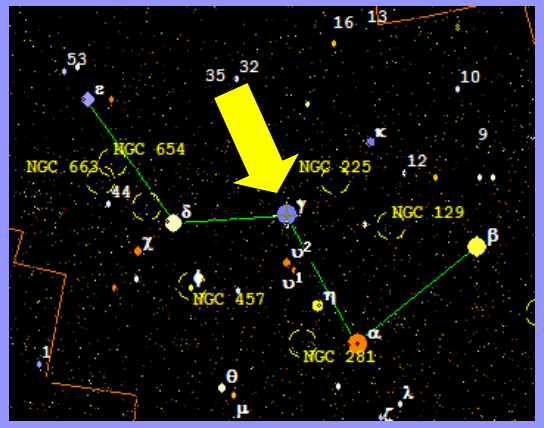
Observer : Joan Guarro Fló

Wavelength range : 6482.04 - 6715.96 ang

several outbursts discovered

Terminé

Recent telegram...



-------- Message original --------

Sujet: [spectro-l] gamma Cas [1 Attachment]

Date : 15 Apr 2011 08:09 GMT

De : Ernst Pollmann <ernst-pollmann@t-online.de>

Répondre à : spectro-l@yahoogroups.com

Pour : Gruppe ARAS <spectro-l@yahoogroups.com>

Dear colleagues !

Myron Smith, Computer Sciences Corporation, Space Telescope Science Institute and my mentor in issues of gamma Cas, is asking for Halpha-EW observations during the coming observation season.

He and his colleague Greg Henry are very interested in correlation between Halpha-EW and photometric brightness within the UBV-system. Meanwhile they monitored the star in this way for 13 years (see fig. 3).

Actually, I gave him the attached compiling plots (fig. 1 & 2) of Halpha EW and visual brightness observations of my colleagues in Hungaria and Germany.

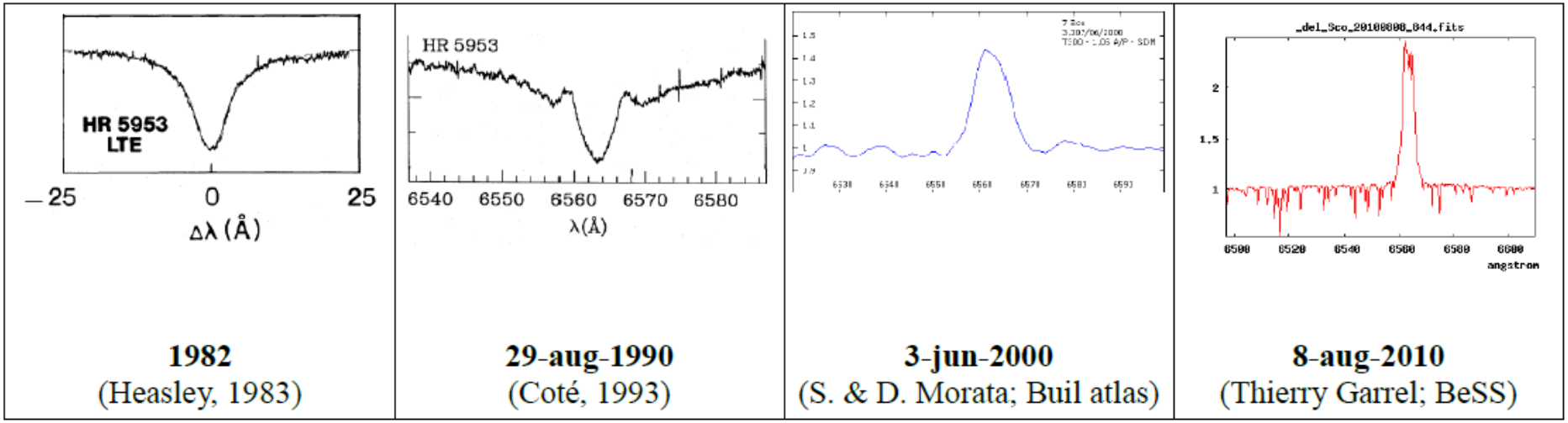
It would be great, if interested observers could measure the Halpha EW for the coming months of visibility.

Ernst Pollmann

Active Spectroscopy in Astronomy
http://www.astrospectroscopy.de

==> mag 2 star !

delta Sco : 2011 periastron !!!

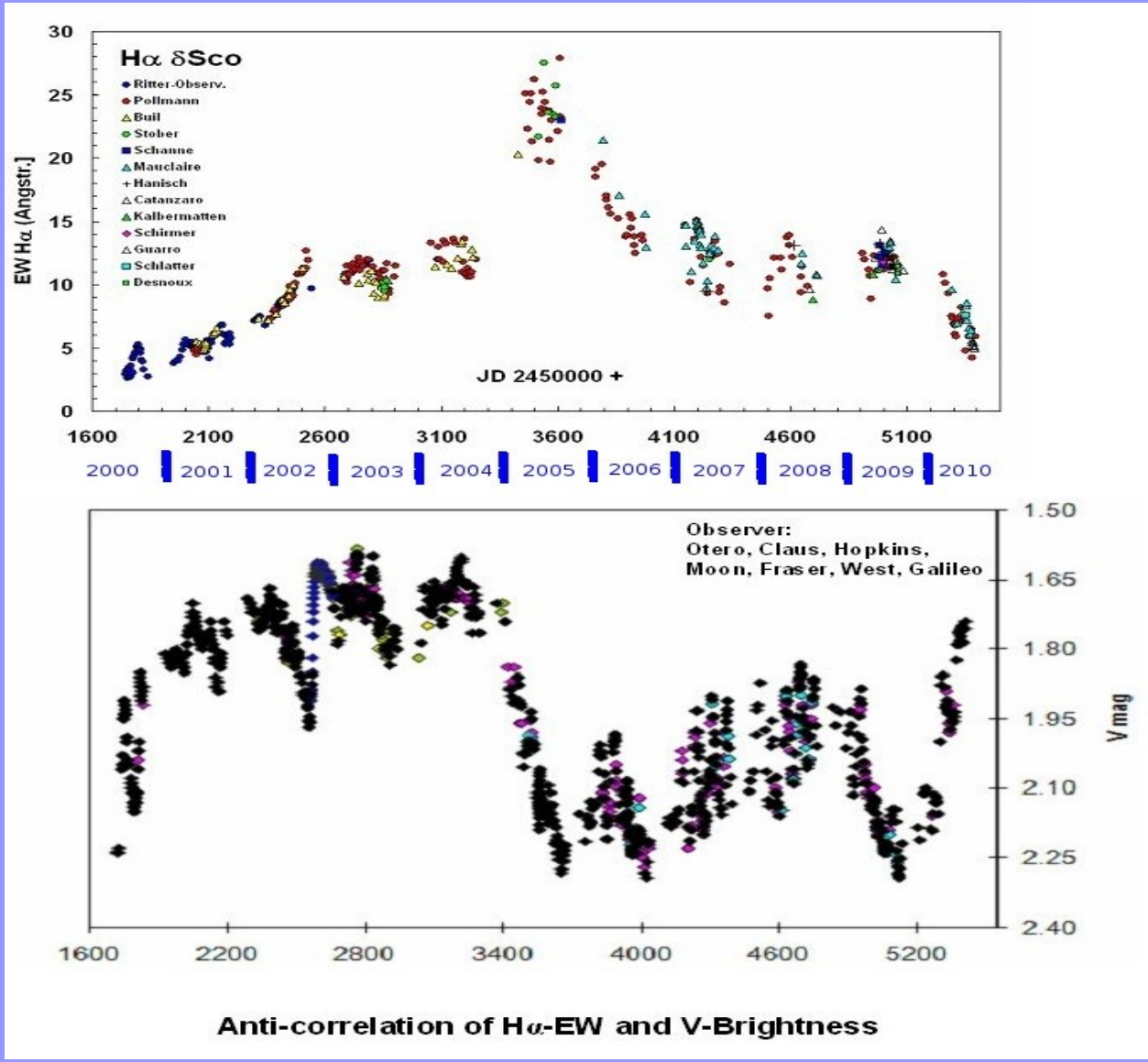


1982	**29-aug-1990**	**3-jun-2000**	**8-aug-2010**
(Heasley, 1983)	(Coté, 1993)	(S. & D. Morata; Buil atlas)	(Thierry Garrel; BeSS)

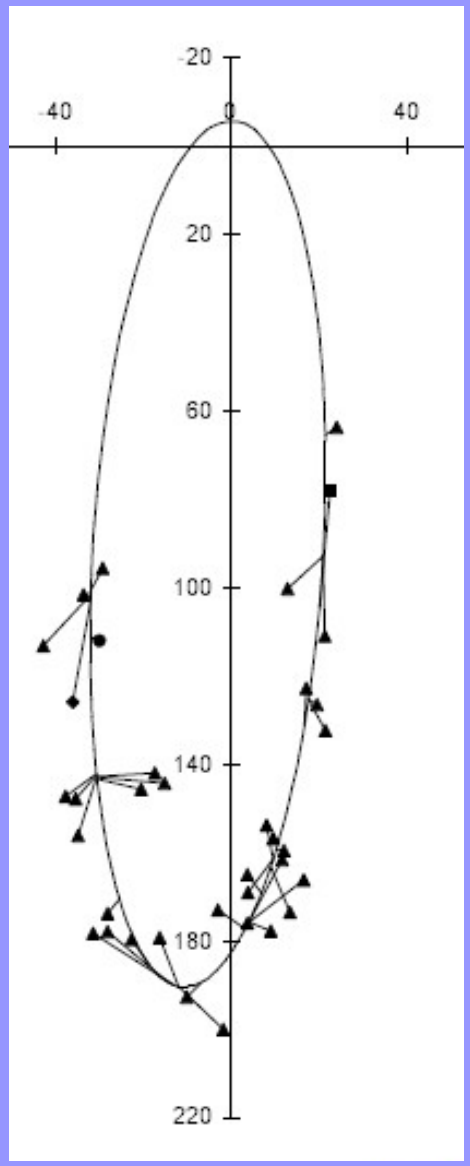
snapshots of delta Sco spectrum (H-alpha) through the years...

- Be stars identified as such in 1993
- Outburst in 2000 with sudden increqse of visual brightness

delta Sco : 2011 periastron !!!

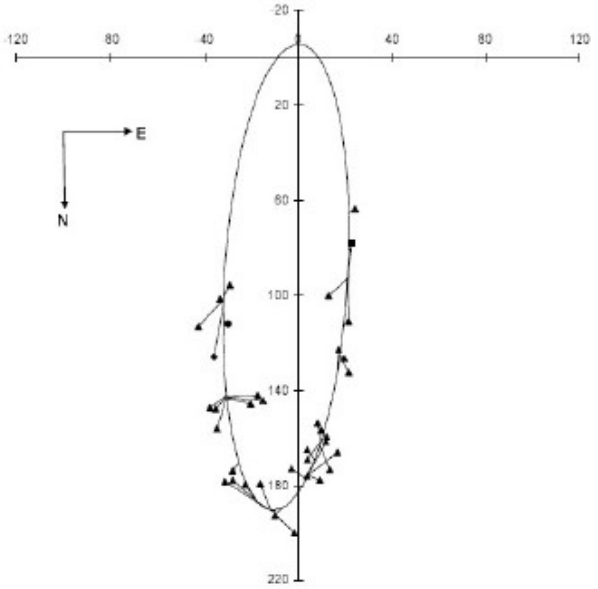


Ernst Pollmann



Tango et al. 2009

delta Sco : 2011 periastron !!!



The orbital elements for δ Sco

Element	Ref. *a*	Ref. *b*	This Work
Period P (yr)	10.58 ± 0.08	10.58[c]	10.74 ± 0.02
Epoch of periastron T	B1971.41 $\pm$ 0.14	J2000.693 $\pm$ 0.008	J2000.69389 $\pm$ 0.00007
Eccentricity e	0.92 ± 0.02	0.94 ± 0.01	0.9401 ± 0.0002
Semimajor axis (mas) a''	107 ± 7	107[c]	98.3 ± 1.2
Inclination i	$48\overset{\circ}{.}5 \pm 6\overset{\circ}{.}6$	$38^\circ \pm 5^\circ$	$38^\circ \pm 6^\circ$
Long. periastron ω	$24^\circ \pm 13^\circ$	$-1^\circ \pm 5^\circ$	$1\overset{\circ}{.}9 \pm 0\overset{\circ}{.}1$
Long. of asc. node Ω	$159\overset{\circ}{.}3 \pm 7\overset{\circ}{.}6$	175°	$175\overset{\circ}{.}2 \pm 0\overset{\circ}{.}6$
Systemic RV V_γ (km·s^{-1})		-6 ± 0.5	-6.72 ± 0.05
RV amplitude K_A (km·s^{-1})			23.84 ± 0.05
Semimajor axis of primary a_A (km)			$(7.1 \pm 0.1) \times 10^8$
Mass function $M_B^3/(M_A + M_B)^2$ ($M_\odot$)			0.9 ± 0.4

Ref. *a* Hartkopf et al. (1996)
Ref. *b* Miroshnichenko et al. (2001)
[c] Value assumed from Ref. *a*

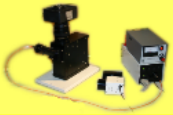
interferometric orbit for delta Sco and orbital elements (Tango et al., 2009)

Recent interferometric observations (Tango et al., 2009) led to new orbital elements and masses estimation: M1 = 15 +/-7 M* and M2 = 8.0 +/-3.6 M*

delta Sco : 2011 periastron !!!

- Exact periastron date unknown (around beginning of July 2011)
- Radial Velocity will change drastically few weeks before
- Monitoring of H alpha is key
- Monitoring of He I 6678 is very interesting too

==> amateur Spectroscopy is required !!!

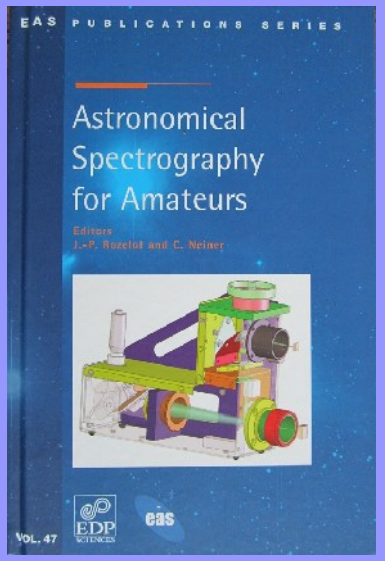
Spectrograph	Star Analyser	LISA	Lhires III	eShel
				
Resolving Power	R ~ 100	R ~ 1000	R ~ 600 – 17000	R ~ 11000
Solar System				
Earth atmosphere		Aurora spectra.	150: Aurora spectra.	
Meteors	Meteor spectra: how useful ???			
Moon		Geology changes during impact.	150: Geology changes during impact.	
Planet atmosphere		Spectra of atmospheric features (near IR ?)		
Comets		Composition, classification.	150-300: Composition, classification.	Bight comets ?
Asteroids		Classification.		
Binaries				
Spectroscopic binaries			2400: bright binaries period/orbit follow up	Binaries period and orbital elements improvements.
Exoplanets				Orbital elements follow up. Discoveries around A-type stars?
Variable Stars				
Be Stars		Monitoring, outburst detection, Survey/Discovery, classification.	2400: pulsations (hours) ? 1200-2400: Line profile changes (days/years) 150-600: Monitoring, outburst detection, Survey/Discovery, classification.	Line profile changes (days/years).
Binary Be Stars: delta Sco, VV Cep, zeta Tau, ups Sgr...		Monitoring, Outburst detection.	1200-2400: RV measurement (ex: delta Sco) 1200-2400: Line profile changes: delta Sco, zeta Tau...	RV measurement (ex: delta Sco) Line profile changes: delta Sco, zeta Tau...
Herbig Ae/Be			1200: spectral changes in few hours. 300-600: changes over the years / outburst	Changes over the years / outburst
LBV (P Cygni)			1200-2400: line profile changes (years)	Line profile changes (years)
Active hot stars (Rigel, Deneb...)			1200-2400: line profile changes (years ?)	Line profile changes (years ?)
Wolf-Rayet		Classification.	1200-2400: line profile changes (years ?) 150-300: classification	
Binary Wolf-Rayet: WR 140...			1200-2400: periastron studies	Periastron studies; orbital elements; spectral changes.
epsilon Aurigae (every 27 years !)			2400: line profile change, KI line change (modified Lhires III)... eclipse folllow up.	Line profile changes.
Cataclysmic variables	Outburst monitoring	Initial classification, monitoring. Line profile changes. Expansion speed.	1200: Line profile changes at initial stage. Expansion speed. 150-600: Initial classification, monitoring.	Line profile changes at initial stage. Expansion speed measurement.
Novae	Initial classification, monitoring	Initial classification, monitoring. Line profile changes. Expansion speed.	1200: Line profile changes at initial stage. Expansion speed. 150-600: Initial classification, monitoring.	Line profile changes at initial stage. Expansion speed measurement.
Mira		Monitoring during all period.	1200: at maximum brightness. 150: follow up. during (almost) all period.	At maximum brightness.
Pulsating stars (RR Lyrae, BW Vul, SPB...)			600-1200: RV of absorption lines.	RV changes of absorption lines.
Supernovae	Initial classification (SN type)	Initial classification (SN type)		

in summary...

- Spectroscopy reveals hidden details from the stars
- Equipment is available off-the-shelf
- Educational projects are numerous and fun
- Pro/Am collaboration is increasing
  with more amateur contributing
  with more professionals requesting support

==> join us !!!

Some useful links



Groupe ARAS: **http://www.astrosurf.com/aras/**

Liste Spectro-L: **http://groups.yahoo.com/group/spectro-l/**

SAS: http://www.socastrosci.org/

CDS Strasbourg http://cdsweb.u-strasbg.fr/

ADS (articles) http://adsabs.harvard.edu/abstract_service.html

Shelyak Instruments **http://www.shelyak.com/**

Stars won't look the same :D

Thank You !!!

DEMO tonight !!!

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