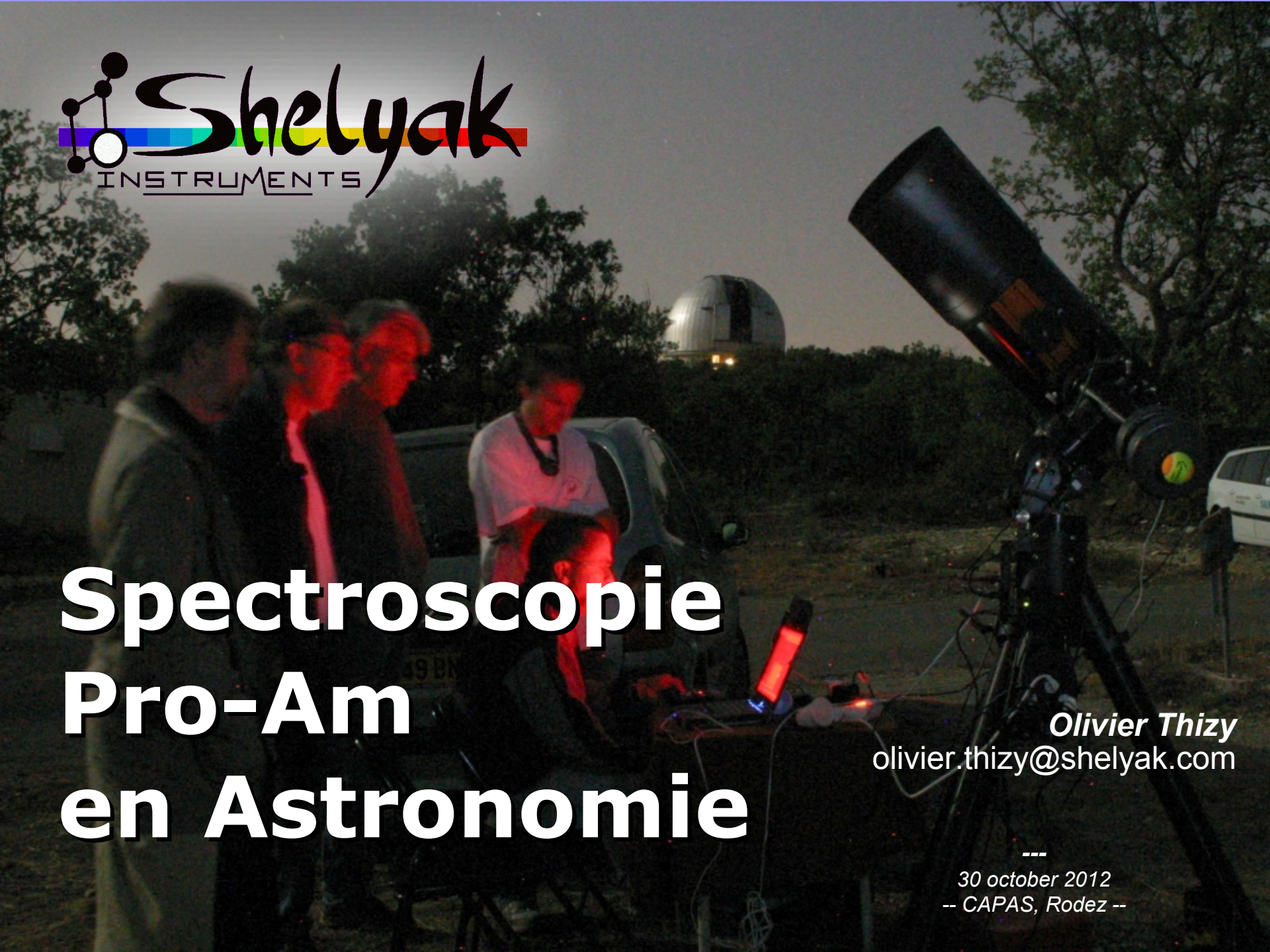
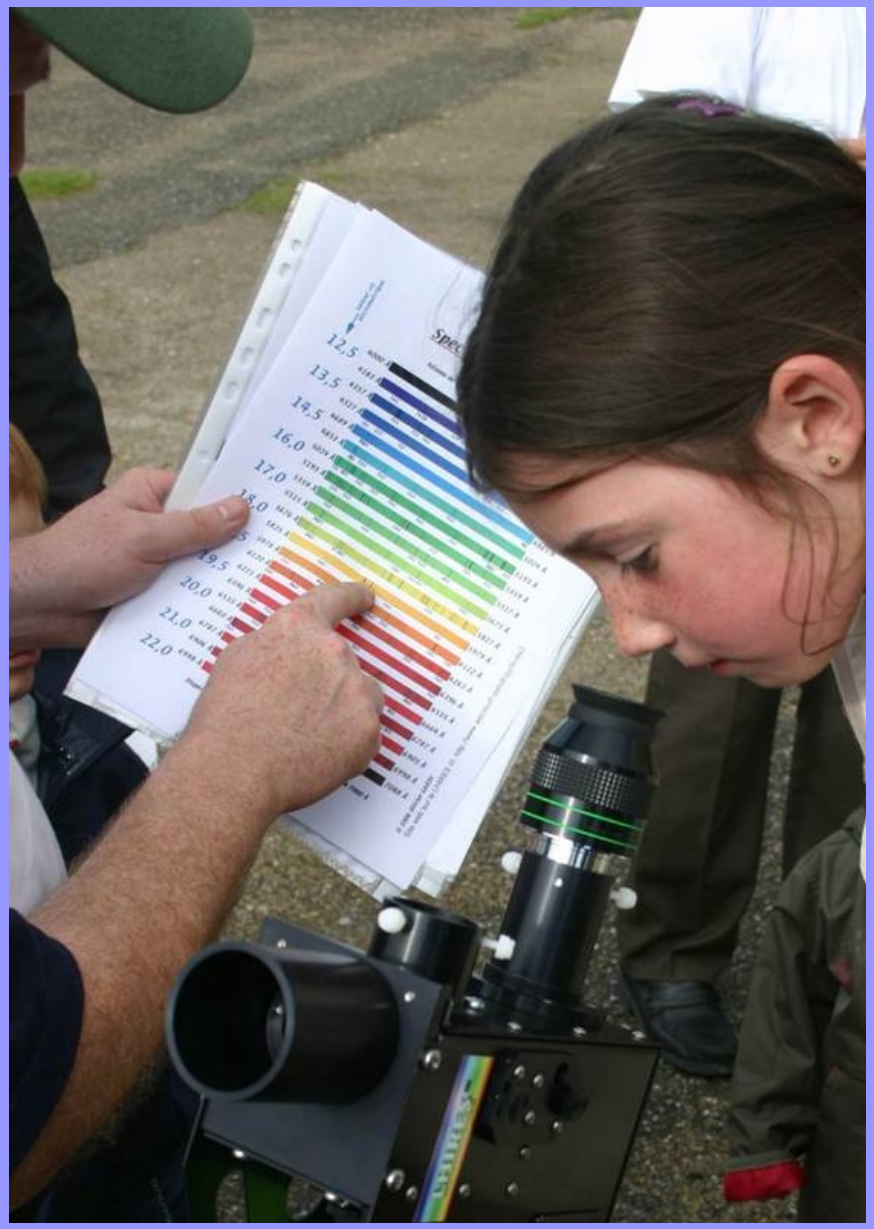


Spectroscopie Pro-Am en Astronomie

Olivier Thizy
olivier.thizy@shelyak.com

---

30 october 2012
-- CAPAS, Rodez --



Sommaire

- **Historique**
- **Equipement**
- **ex. de projets Pro/Am**
  - *Étoiles Be & Herbig Ae/Be*
  - *Campagne Epsilon Aurigae*
    - *& AZ Cas...*
  - *Groupe «covento»*
    - *WR140 (2009)*
    - *WR134/135/137 (2013)*
  - *Autre: SS433, RR Lyrae, active hot stars, cataclysmic variables...*

Un peu d'historique...

Oléron 2003

- **Avant...**
  - **Très peu de collaborations pro/am (atlas étoile Be de C. Buil, Maurice Gavin, Dale Mais) réalisées avec des spectrographes bricolés**

- **Oléron 2003**
  - **École d'Astrophysique pro/am CNRS/AUDE**
  - **Livre des présentations (disponible !)**
  - **Conception du “Lhires”**
  - **Lancement de la liste Spectro-L**
  - **Lancement du site “ARAS”**

La Rochelle: 2006

- **Lancement de la base de données de spectres d'étoiles Be (Be Stars Spectra = BeSS)**
  - **Collection & archivage de spectres**
  - **Définition du format de fichier FITS/Spectres**

- **Atelier pratique sur le Lhires III (souscription AUDE toute fraîche !)**

La Rochelle: 2009

- **10000 spectres amateurs dans BeSS...**
- **Exoplanète: limites repoussée des capacités “amateurs”**
- **Une douzaine de spectroscopistes actifs**

- **==>Les professionnels commencent à demander des observations amateurs !**

La Rochelle: 2012

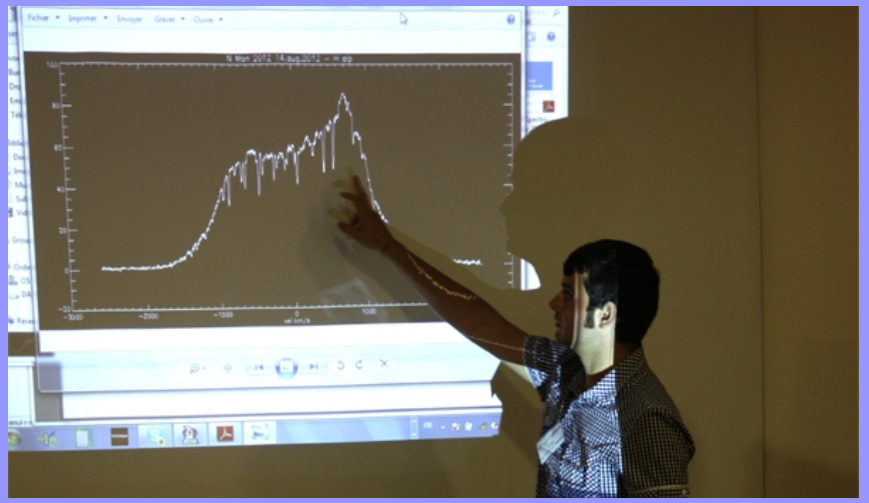
- **26000 spectres / 49 amateurs dans BeSS...**
- **Présentation de la campagne sur les MicroQuasars**

OHP: stages pratiques

- **2004, 2005, 2007, 2008, 2009, 2010, 2011, 2012: un intérêt croissant, participation internationale**
- **30-40 instruments, tous avec des spectrographes**
- **Très pratique avec un zest de théorie**

OHP: ambiance...

OHP 2012 : nova Mon 2012 !



Equipement

	Applications
eShel	Formation des astronomes/astropysiciens Etude des profils de raie (étoiles Be, pulsations...) Abondances, classification stellaire, Binaires spectroscopiques & exoplanètes
Lhires III	(auto) formation avec des résolutions basse/moyenne/haute Classification stellaire Etude des profils de raie (étoiles Be, eps Aur, Wolf-Rayet, Slow Pulsating B stars, Herbig Ae/Be...)
LISA	Pédagogie: lampes, classification, nébuluses, décalage « redshift » des galaxies et quasars... Variables faibles : cataclysmiques, novae, mira... Comètes (classification) Astéroides (classification) ...
Star Analyser	Pédagogie : température des étoiles, classification Novae Etoiles variables faibles Supernovae

Prenez de bonnes Résolutions !

Résolution
R = λ / Δλ

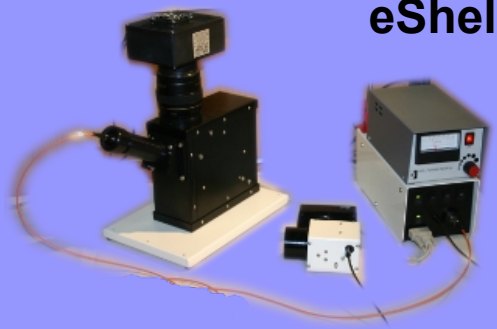
20000

10000

1000

100

Lhires III



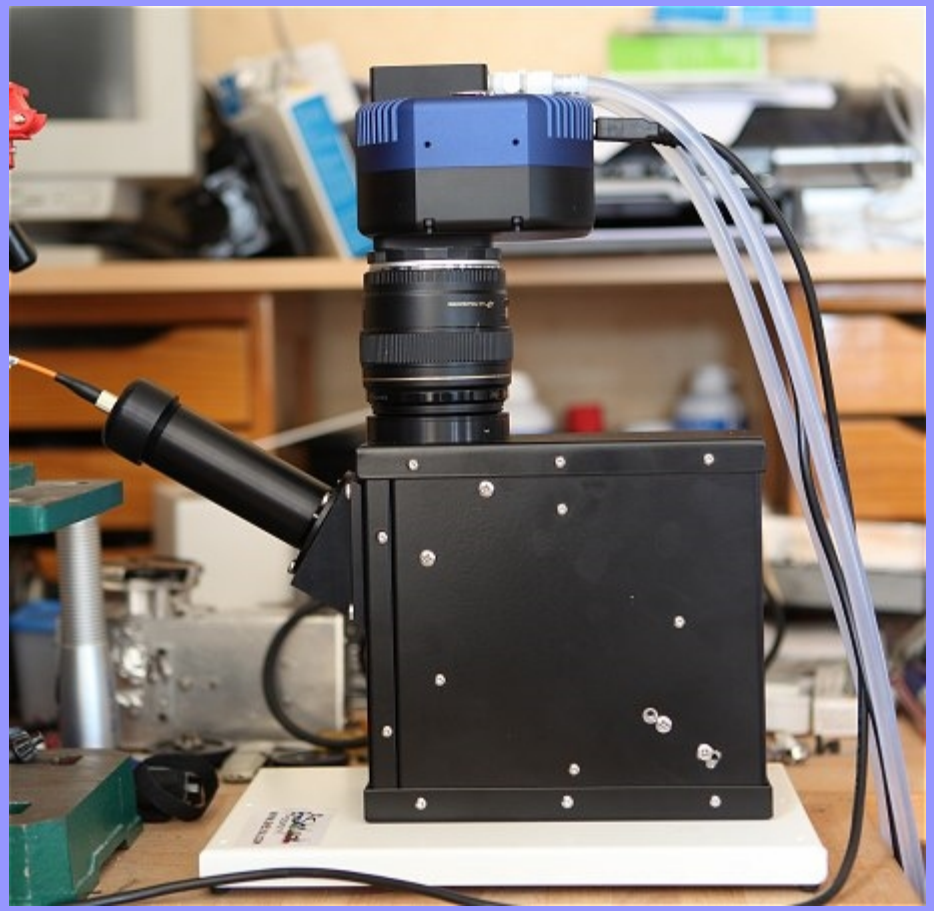
eShel

LISA

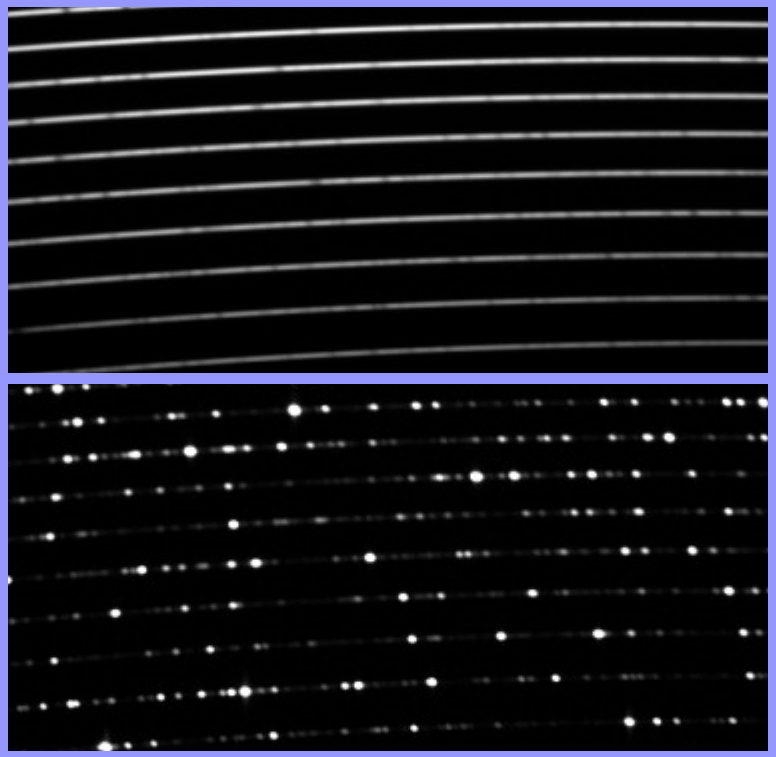
Star Analyser

Couverture du domaine spectral

eShel: un outil pour les vitesses radiales



Exoplanète tau Boo avec un eShel

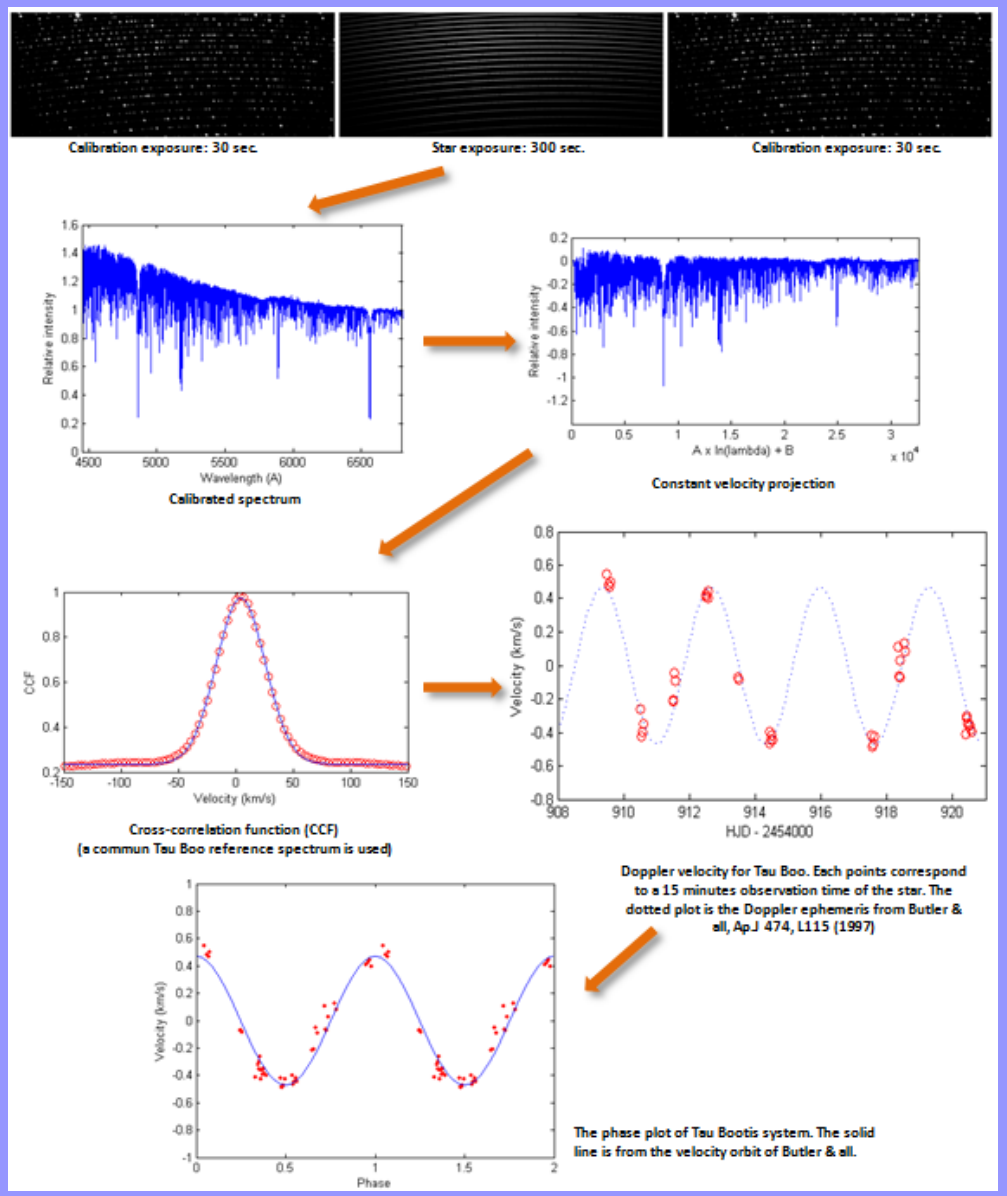


La CCF est calculée sur le domaine spectral 4400-6445 A (excluant Halpha).

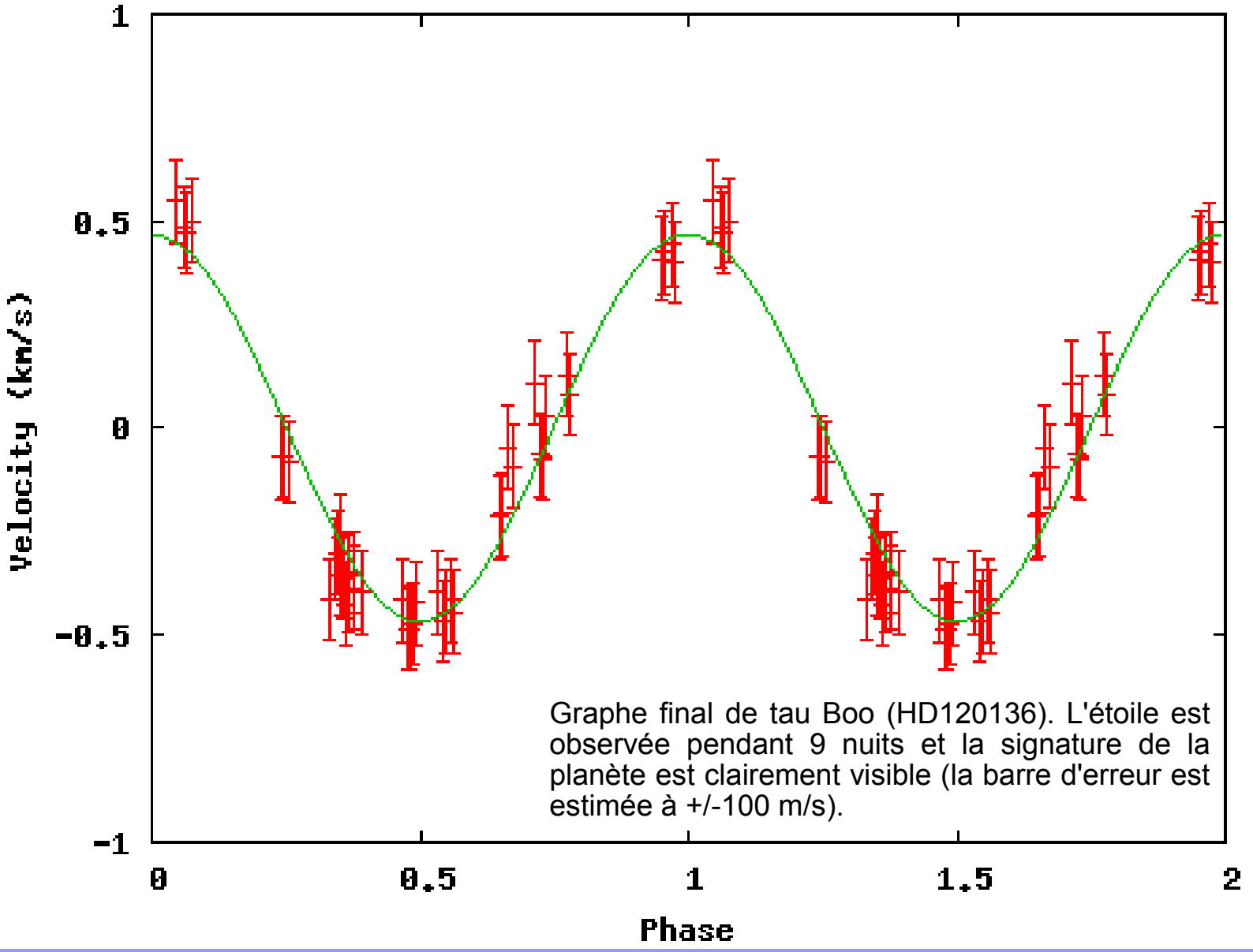
L'amplitude de décalage spectral ne représente que 1/25ème de la résolution spectrale du spectrographe !

Données collectées entre 19 mars et 29 mars 2009.

Christian Buil

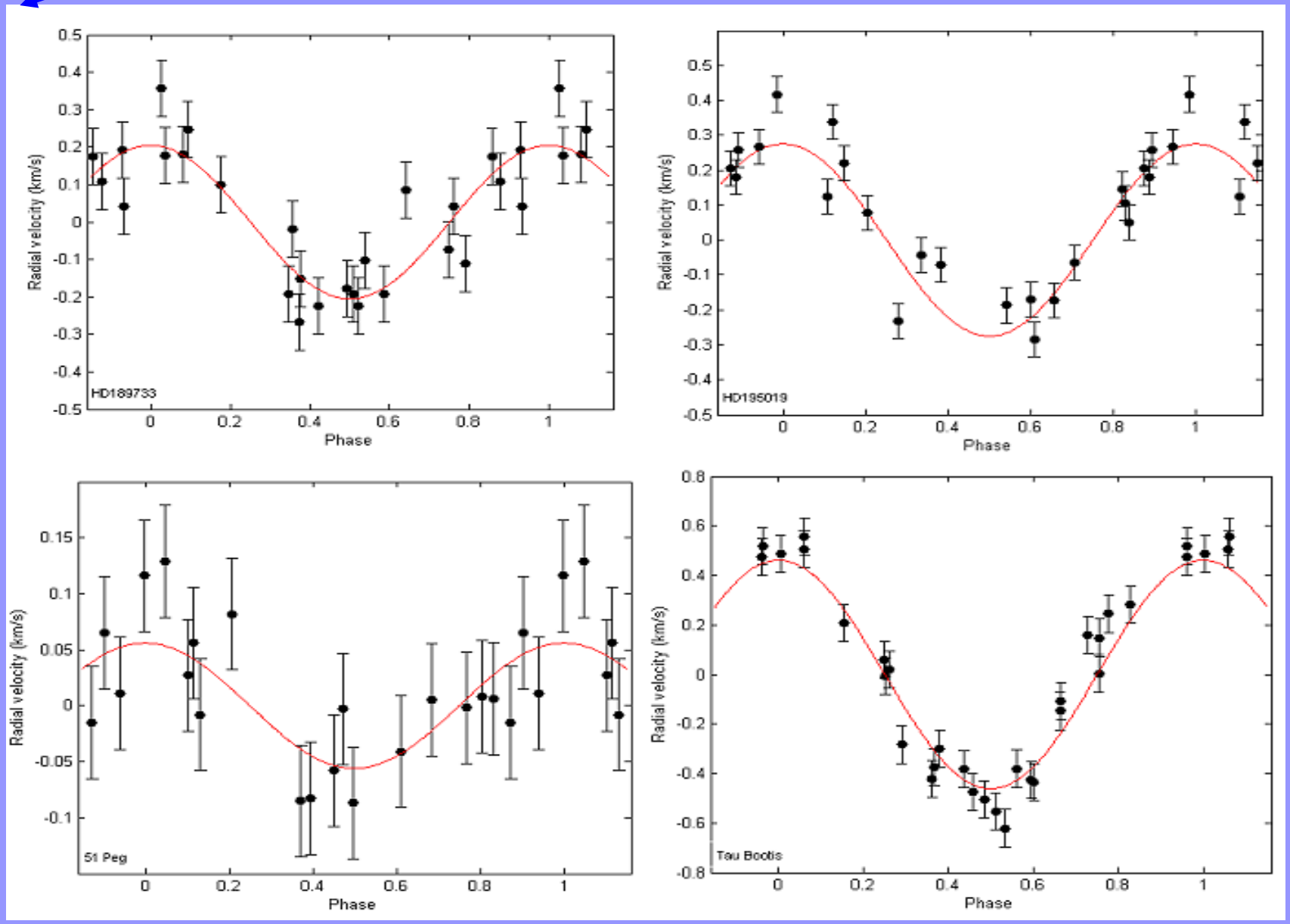


Exoplanet tau Boo with eShel



Graphe final de tau Boo (HD120136). L'étoile est observée pendant 9 nuits et la signature de la planète est clairement visible (la barre d'erreur est estimée à +/-100 m/s).

Exoplanètes: et de 4 avec le eShel



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/

Exoplanètes pro-am ?

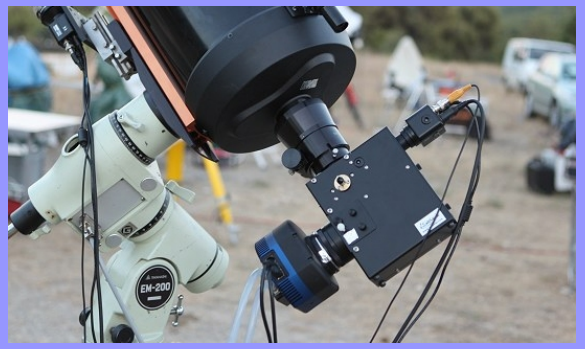
- **Exoplanètes connues: affiner les éléments orbitaux**
- **Découvertes possibles autour d'étoiles de type A où la résolution est limitée par l'étoile elle-même ==>demande beaucoup de temps télescope !**

- **Contact: Claire Moutou (Observatoire de Marseille) (cf présentation à La Rochelle 2009)**

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

LISA: un nouvel outil pour les variables

...où quand les spectroscopistes & variabilistes se rencontrent



Exposition : 1 heure (6 x 600 sec)
Rapport Signal/Bruit = 10 (@ Halpha)
Etoiles type A0V
CCD KAF-8300 (Binning 1 x1)

Altitude 0 m - Suburban

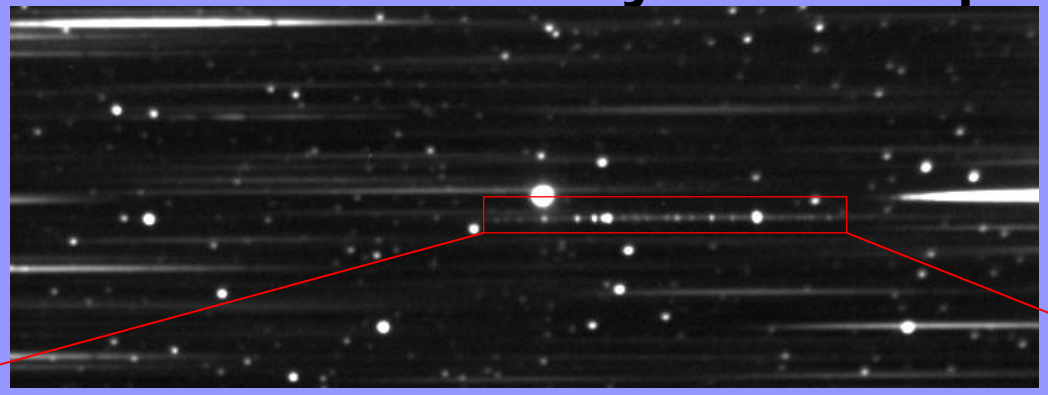
	Slit 23 µm R = 1100	Slit 50 µm R = 600	Slit 100 µm R = 290
D = 12.8 cm F/D = 8	12.5	13.1	13.4
D = 28 cm F/D = 6.8	13.6	14.6	15.0
D = 35 cm F/D = 6.8	13.9	14.9	15.4
D = 50 cm F/D = 6.0	14.4	15.5	16.2
D = 100 cm F/D = 6.0	15.2	16.3	17.2

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

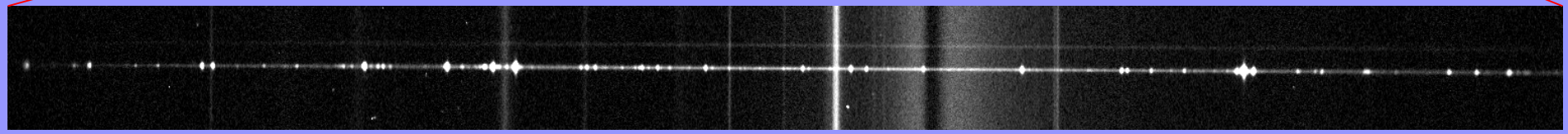
KAF3200: push 0.5 mag further...

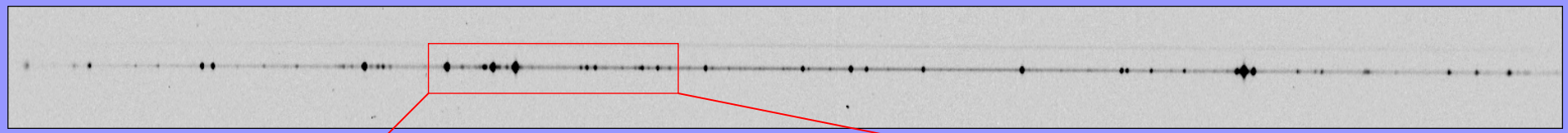
Aspect typique d'un spectre LISA 2D
Etoile symbiotique *V1016 Cyg*



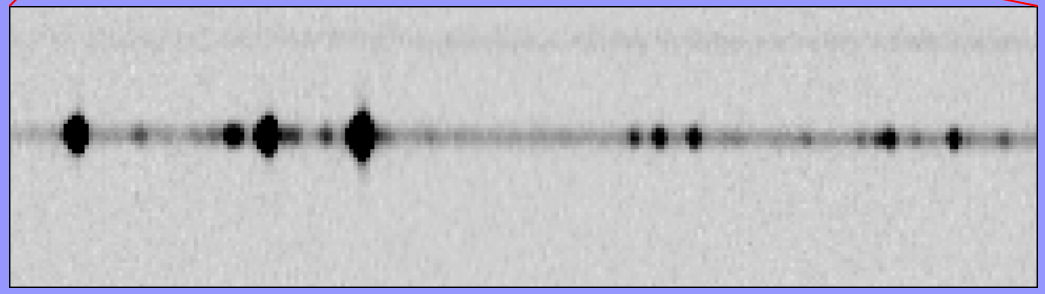
Star Analyser

Spectre 2D avant élimination du fond de ciel (23 µm slit)





Spectre 2D après soustraction du fond de ciel



© C. Buil

Projets Pro/Am

Exemple de collaborations pro/am

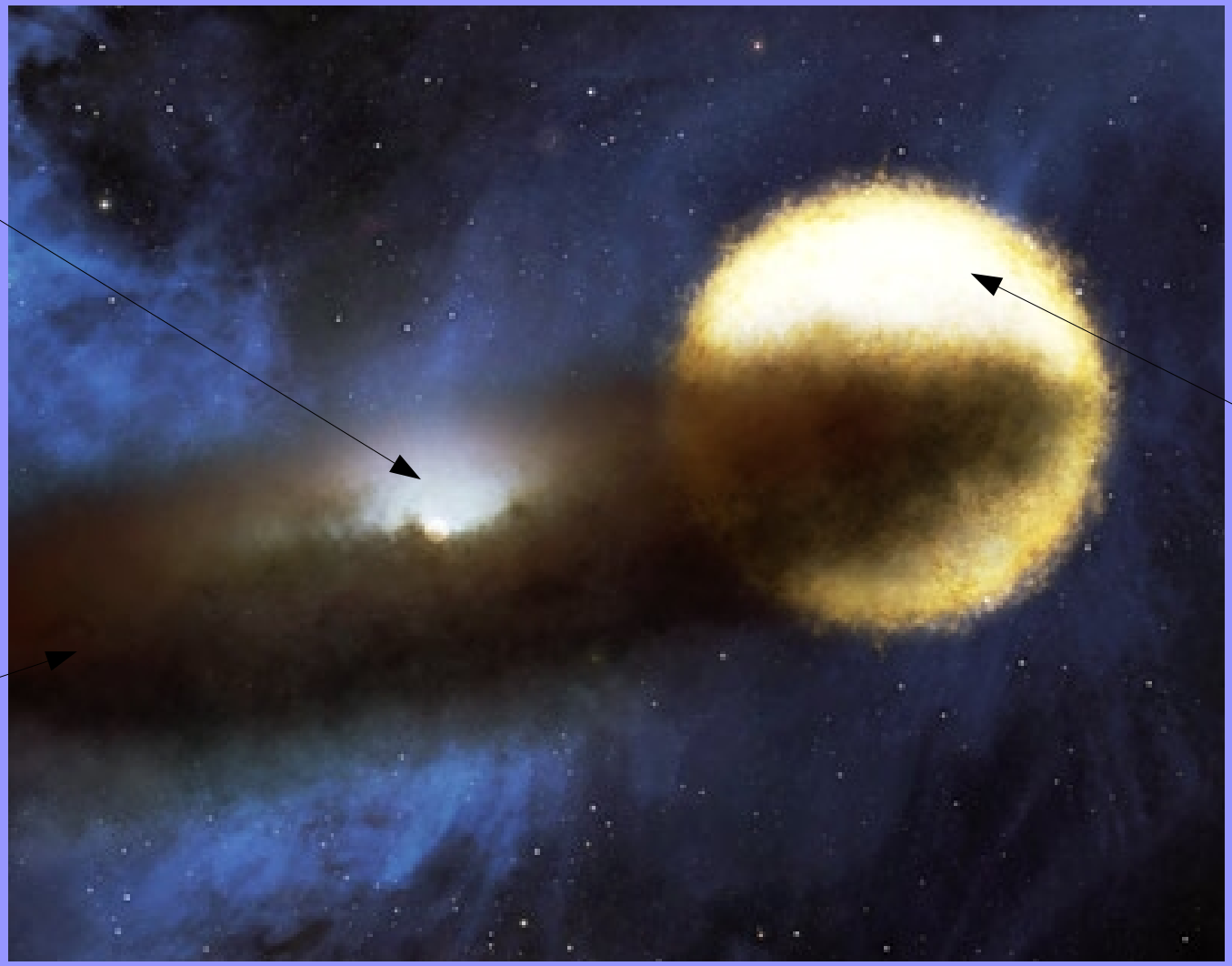
- **Etoiles Be & Herbig Ae/Be, BeSS, ARAS BeAm**
  -des amateurs observent dans leur jardin de temps en temps
  -prototype d'une étude long-terme avec l'aide d'amateurs
  -des campagnes spécifiques (delta Sco...) → cf F.Cochard

- **Eclipse 2010-2012 d'epsilon Aurigae**
  - ***Une collaboration pro/am mais aussi spectro/photométrie réussie !***
  - ***Ensuite? Éclipse AZ Cas à suivre (2012-2014) !!!***

- **Groupe «Covento»: étoiles Wolf-Rayet**
  Périastre WR140 en 2009: observé dans un obs. professionnel
  WR134/135/137: 17 mai → 17 sept. 2013, campagne au Tenerife

- ***Autres***
  - ***MicroQuasars, SS433 : suivi long-terme***
  - ***RR Lyrae, étude spectroscopque de l'effet Blazhko***
  - ***Etoiles chaudes actives: P Cygni, Deneb, Rigel...***
  - ***Variables Cataclysmiques, étoiles symbiotiques, novae...***

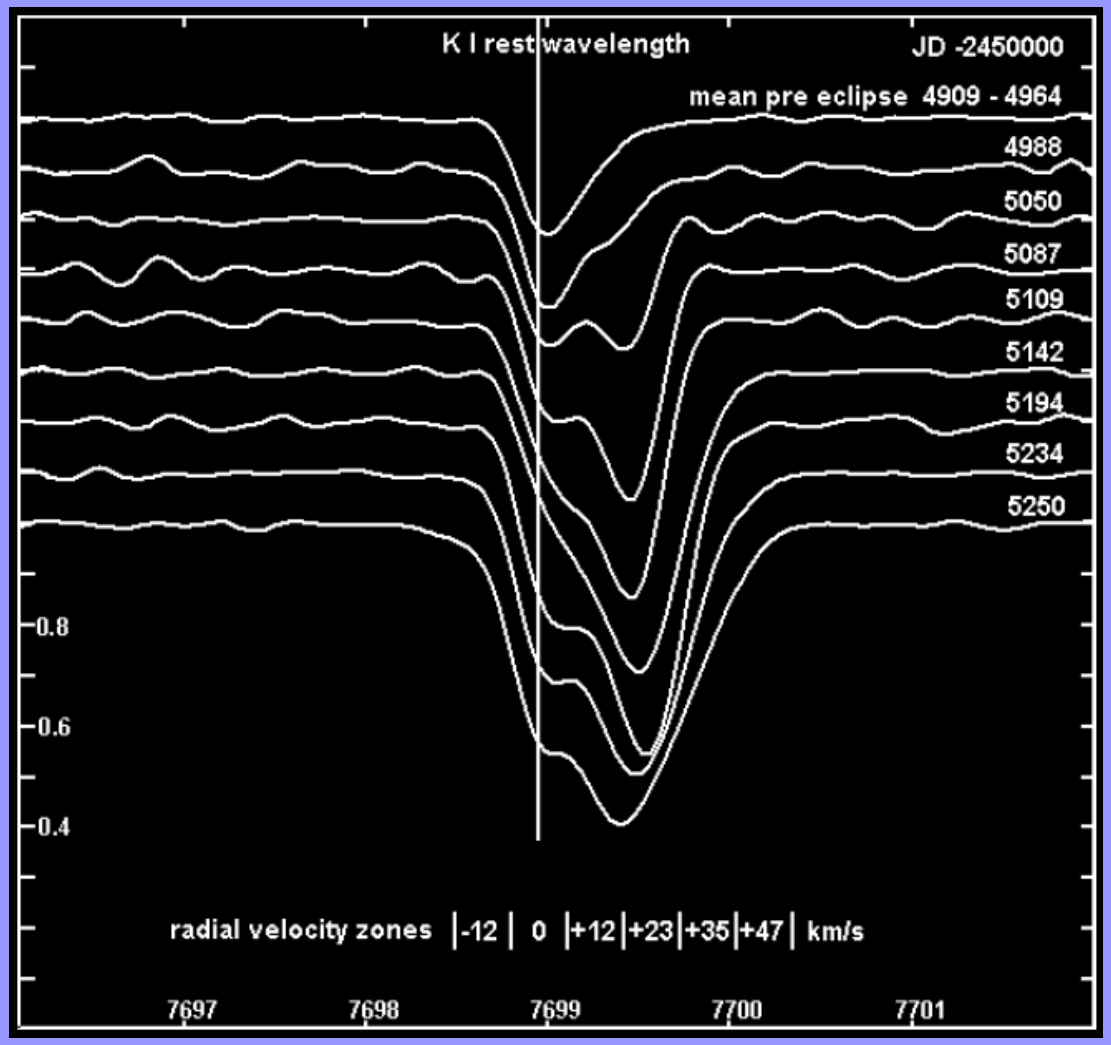
Eclipse eps Aurigae



- Eclipse tous les 27 ans...
- 25 amateurs ont pris des spectres entre 2005 & 2012
- 900 spectres collectés

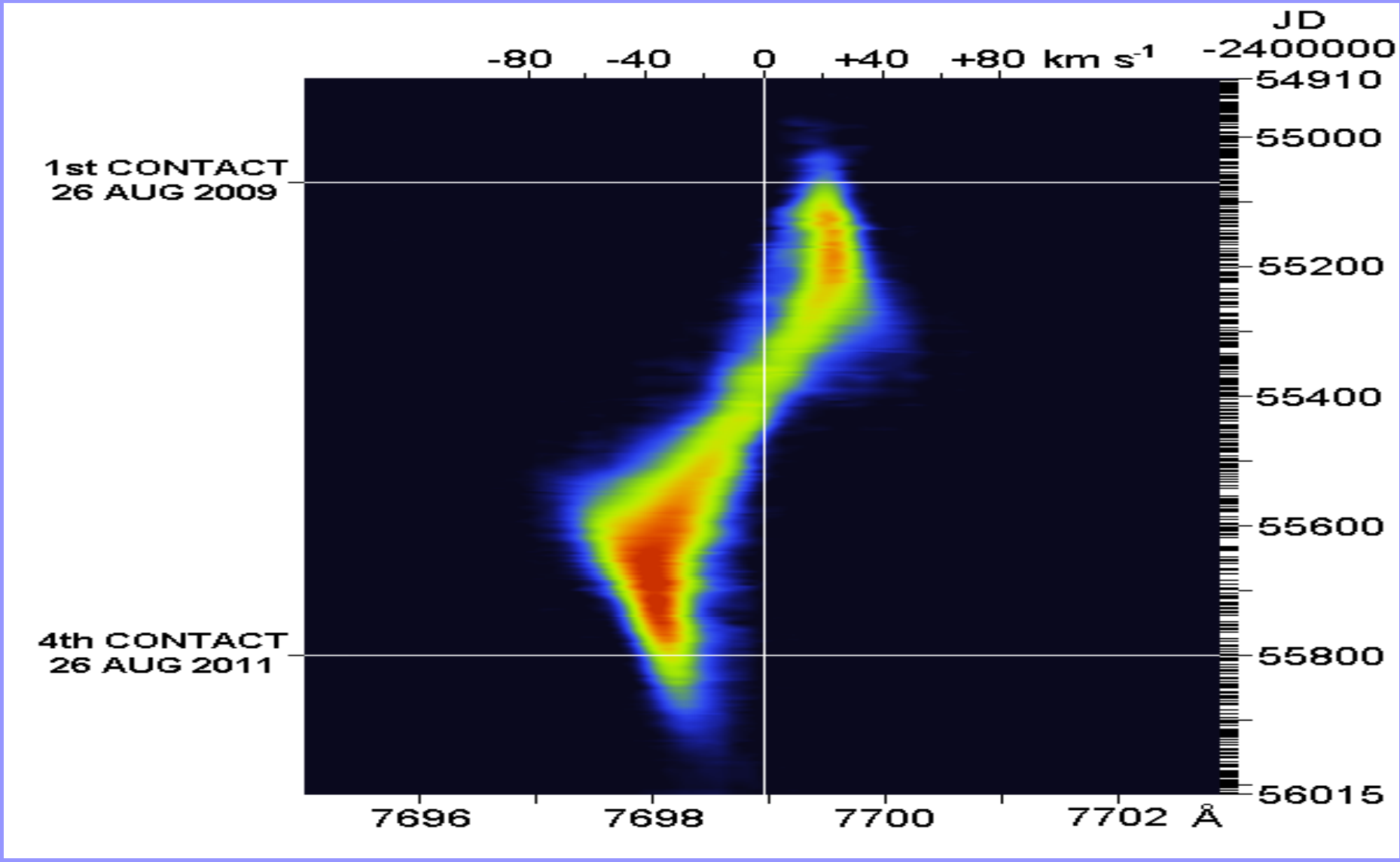
Robin Leadbeater

Eps Aurigae : raie du Potassium KI 7699



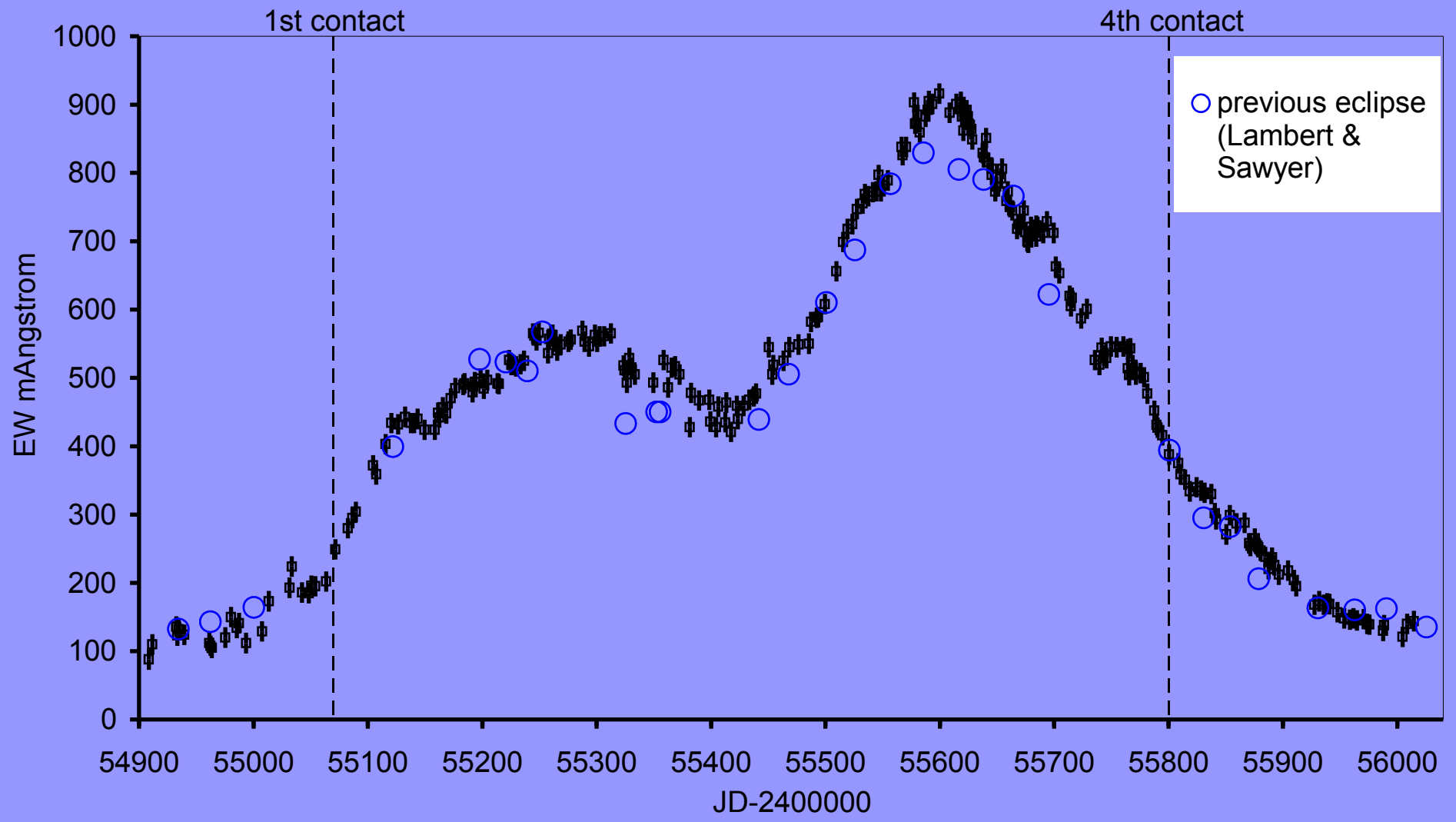
- Une nouvelle raie apparaît !

Robin Leadbeater (Lhires III), Bob Stencel



Robin Leadbeater (Lhires III), Bob Stencel: évolution de la raie du potassium neutre 7699A après soustraction de la partie interstellaire observée en dehors de l'éclipse.

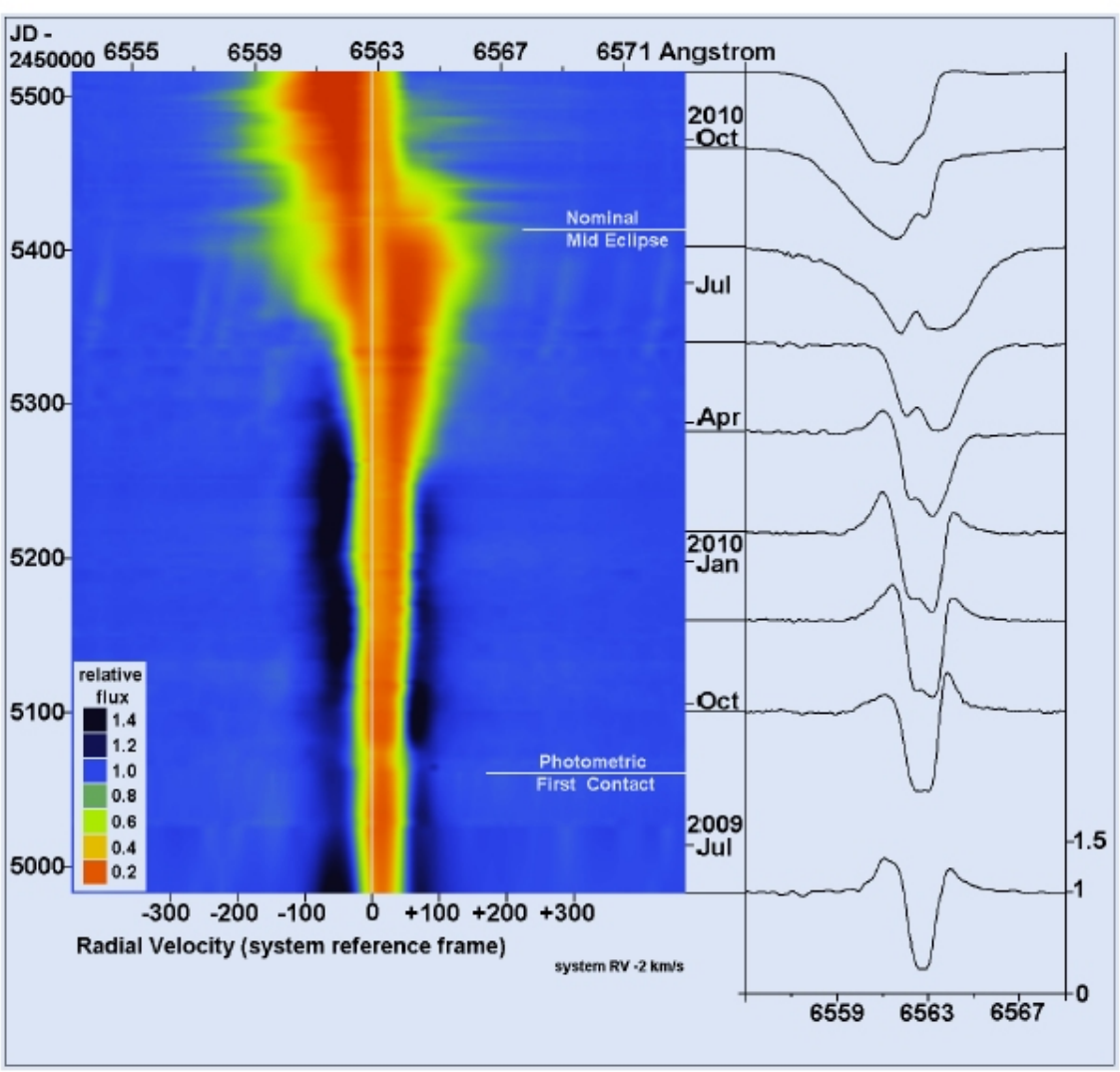
Eps Aurigae : KI 7699 line

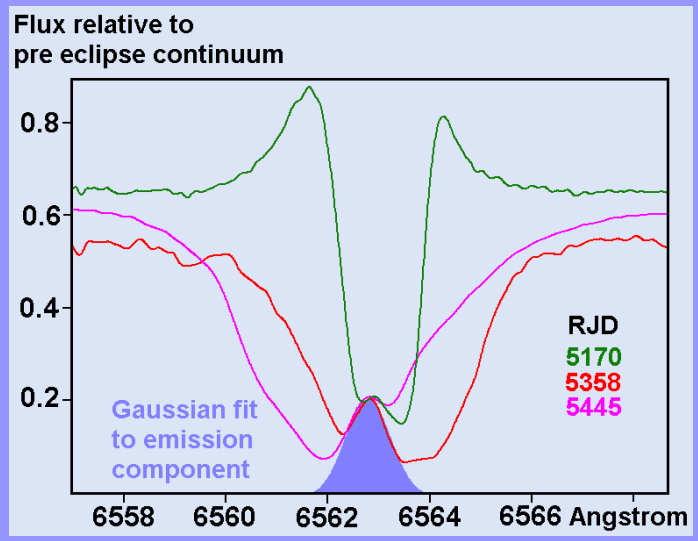


Largeur équivalente de la raie KI 7699 (avec composante interstellaire)
Comparée avec l'éclipse de 1983 décalée de +9896 days. Des anneaux ?

Robin Leadbeater, Bob Stencel

Eps Aurigae : raie Halpha





<u>Composante “cachée”?</u>
Une émission stable est visible à la position centrale de la raie.

Robin Leadbeater, Bob Stencel: évolution de la raie Halpha depuis le premier contact jusqu'à 100j après la mi-éclipse environ. 159 spectres de plusieurs observateurs.

Campagne pro/am eps Aurigae

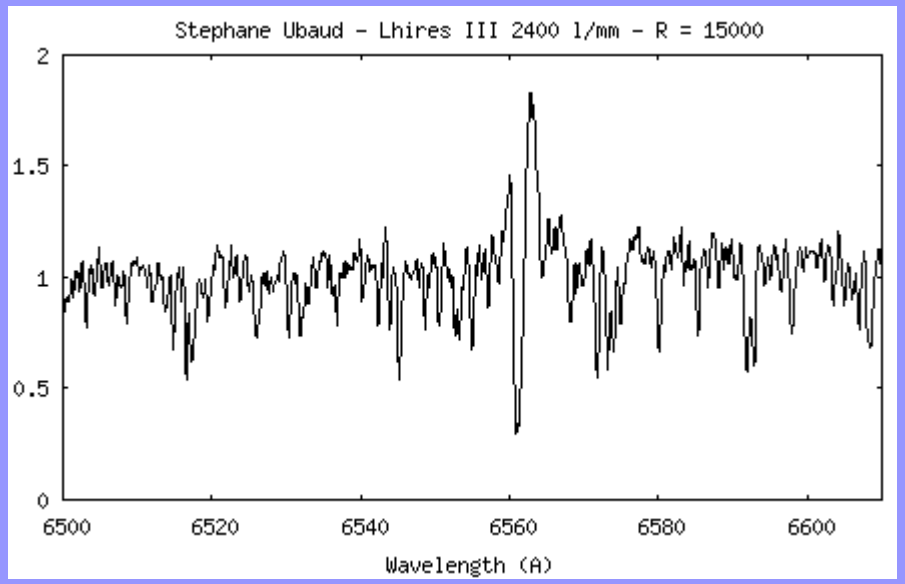
- **Observations complementaires photometrie / spectroscopie**
- **Environ 900 spectres collectés (et ça continue hors éclipse...) !**

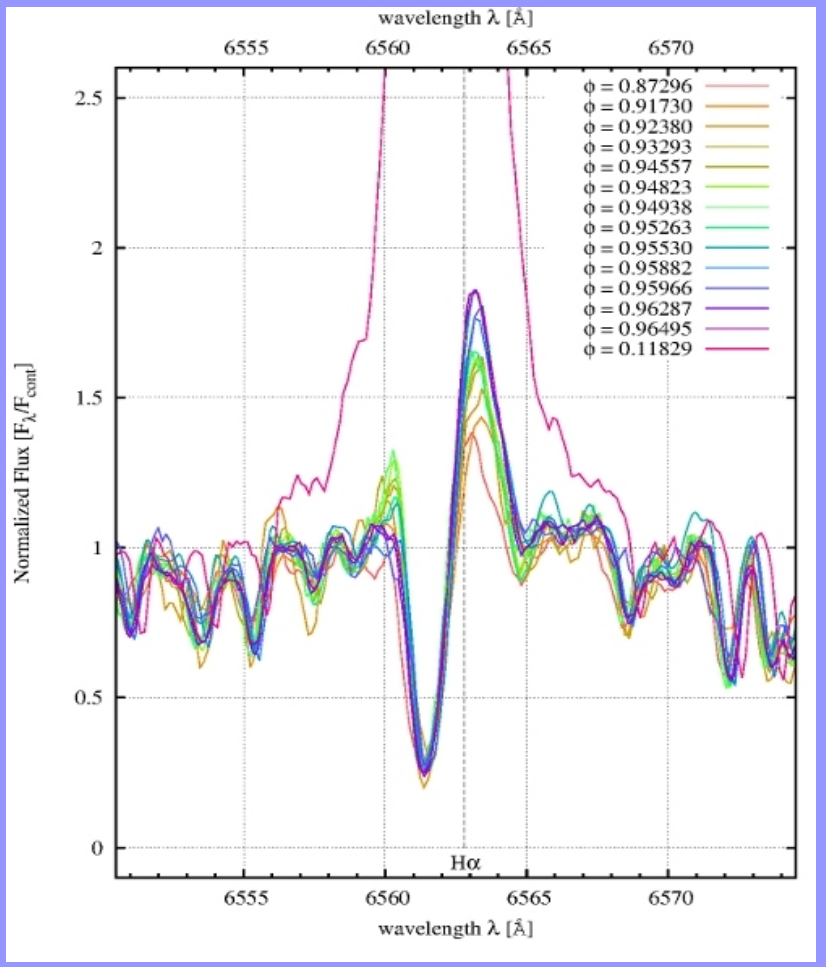
- **Contacts: Robert 'Bob' Stencel (Denver, USA)**
  Jeff Hopkins (amateur; responsable photometrie)
  Robin Leadbeater (amateur; resp. spectroscopie)

- **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 dans la revue Sky & Telescope !
  - http://arxiv.org/abs/1206.6754: JAAVSO vol. 40 #2 – special eps Aurigae!

Ensuite ? Eclipse AZ Cas (2012-2014) !

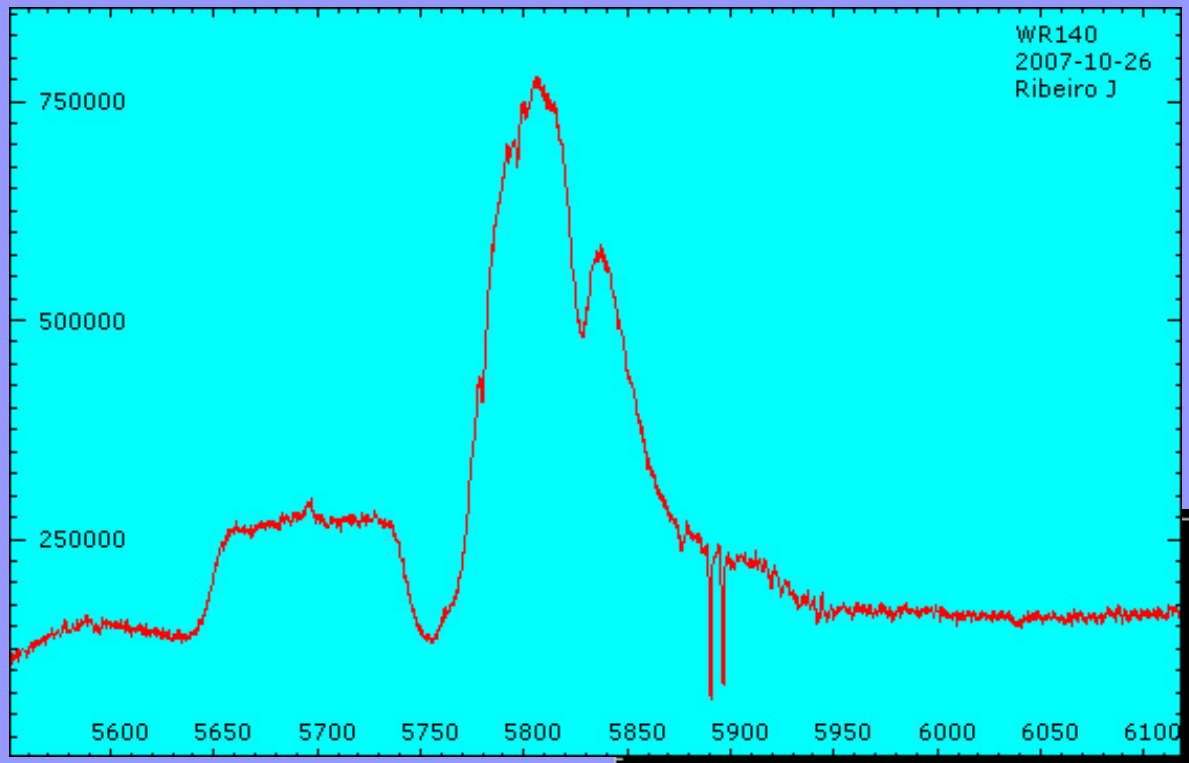
- Cible facile pour l'hémisphère Nord
- Mag V 9.2-9.5; type spectral Moelb

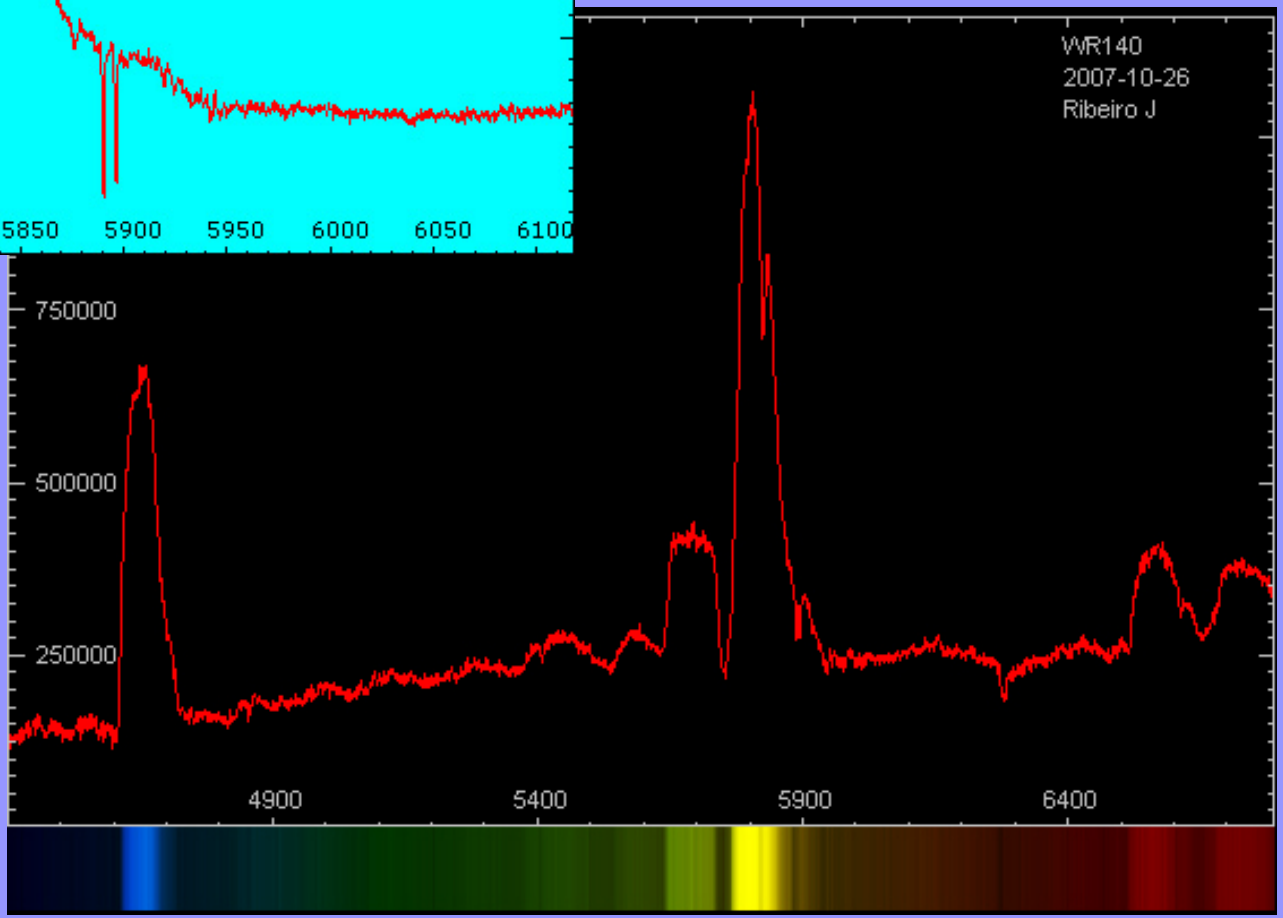




- http://www.astrosurf.com/aras/surveys/azcas/index.htm
- http://www.astri.uni.torun.pl/~cgalan/AZCas/

WR140

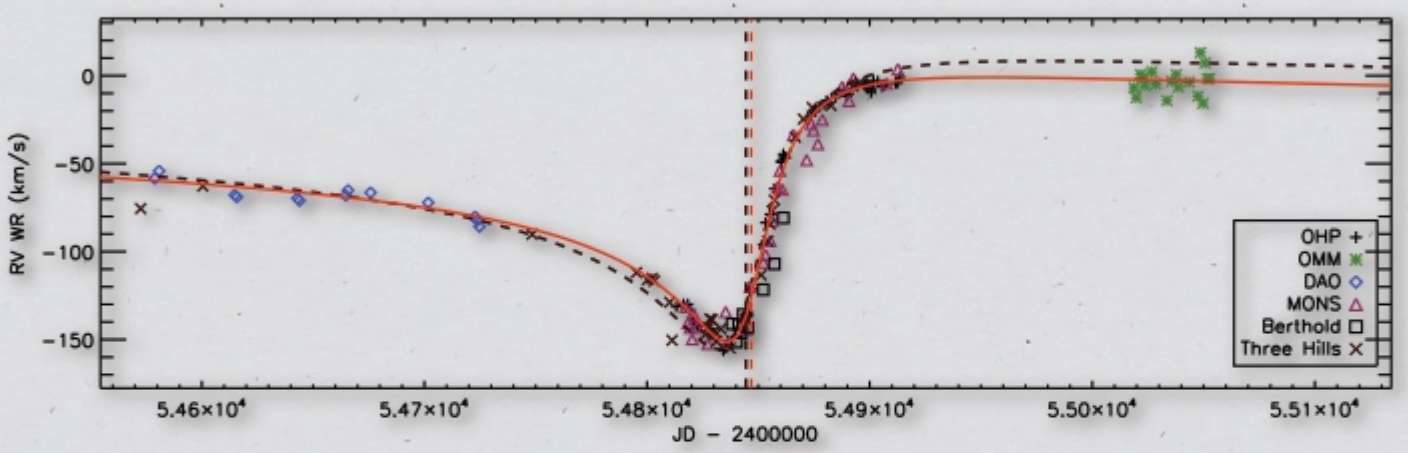


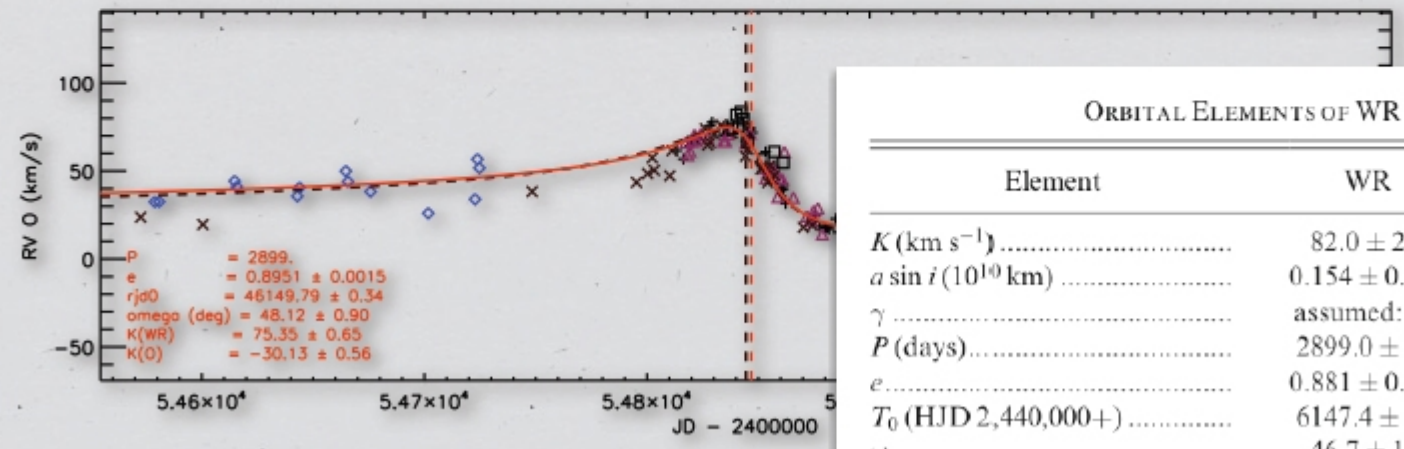


Jose Ribeiro

WR140 / périastre 2009

Radial Velocities



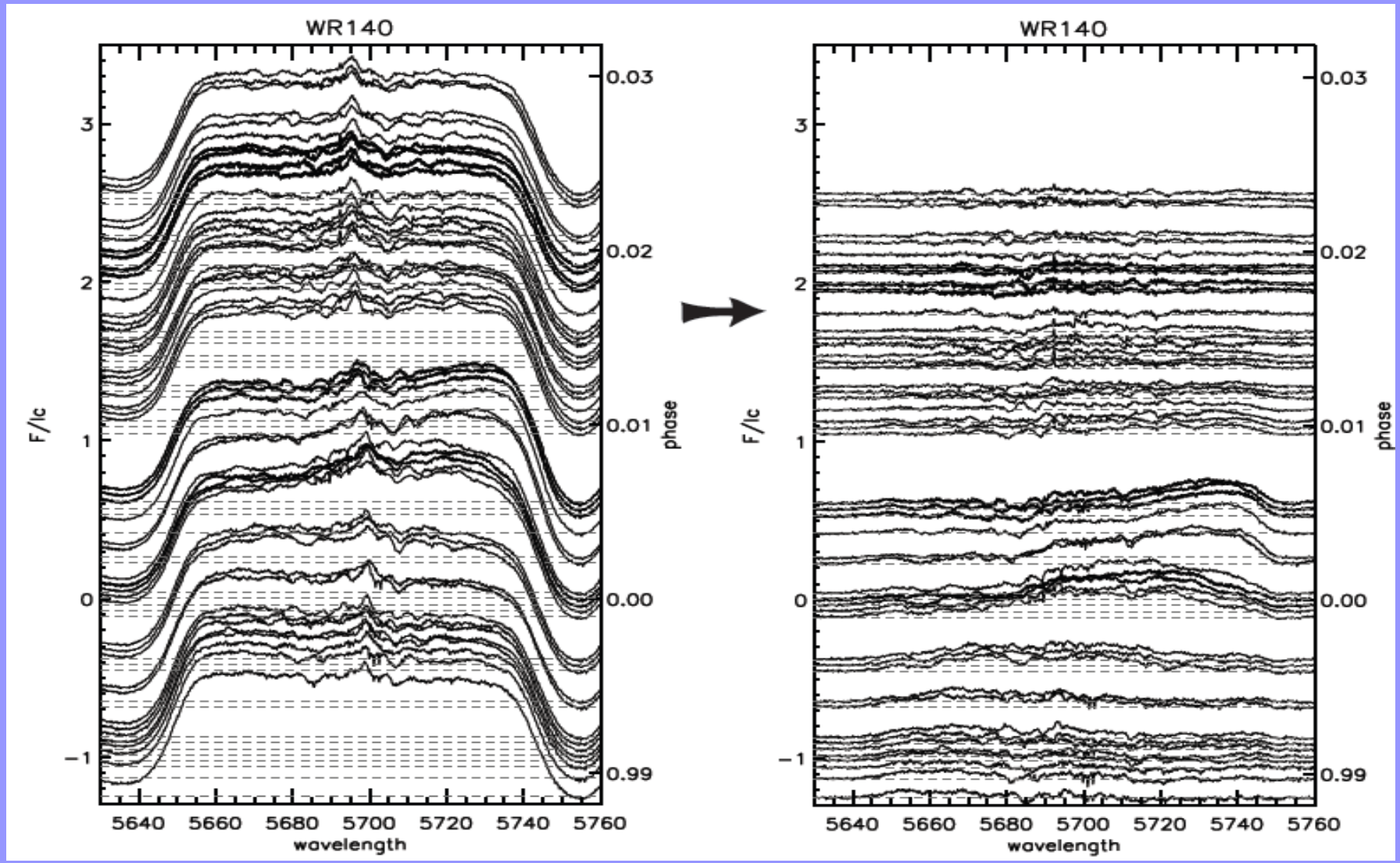


ORBITAL ELEMENTS OF WR 140

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 / périastre 2009



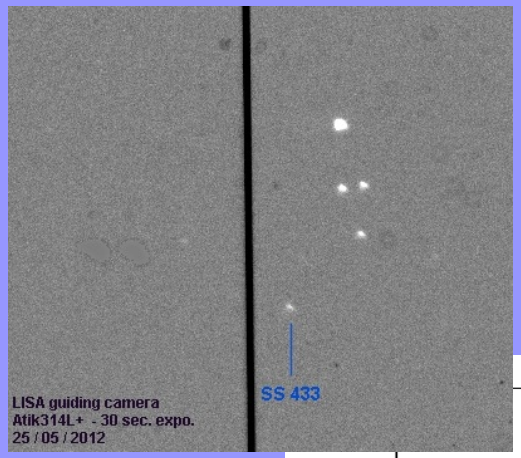
Rémy Fahed et al.: le plat de la raie CIII 5696 en fonction de la phase / émission en excès

Groupe COVENTO: prochaine campagne

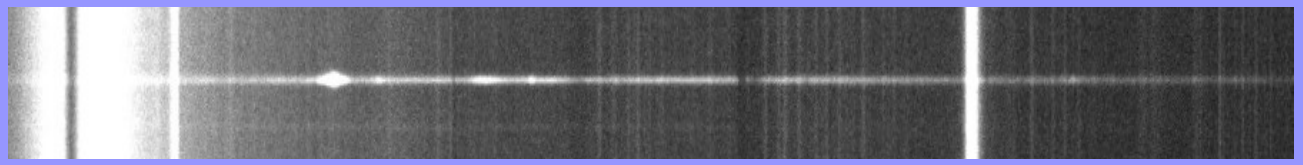
- Wolf-Rayet **WR134/135**
  17 mai au 17 septembre 2013
  Télescope IAC80 à Tenerife + eShel

- Lien: **http://www.stsci.de/convento/**

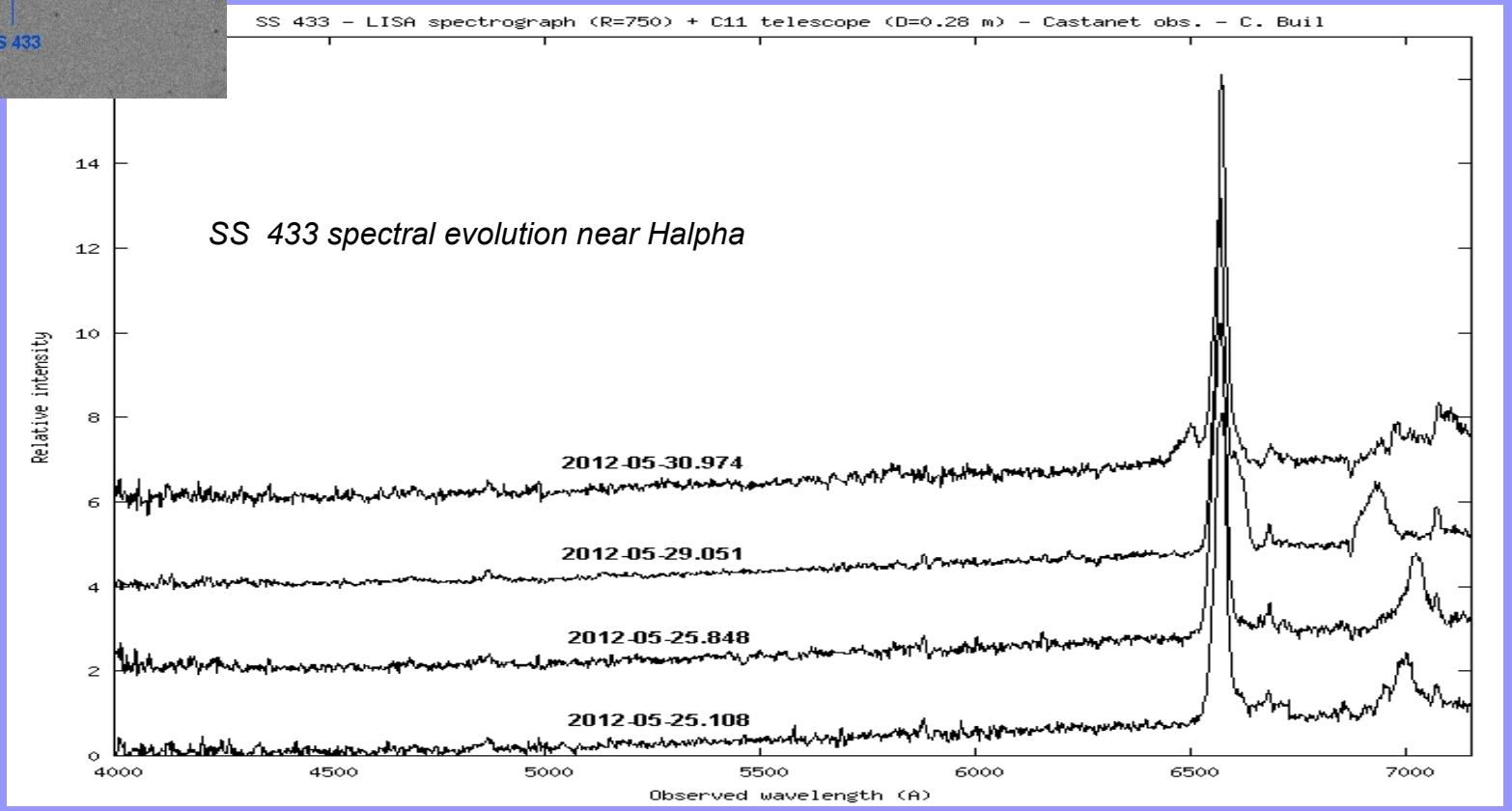
Autre: MicroQuasars, SS433



LISA guiding

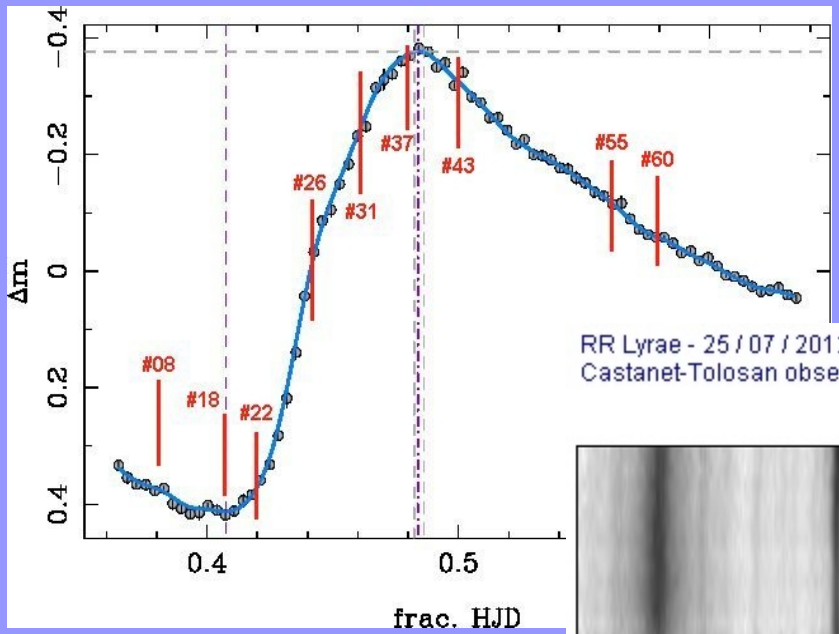


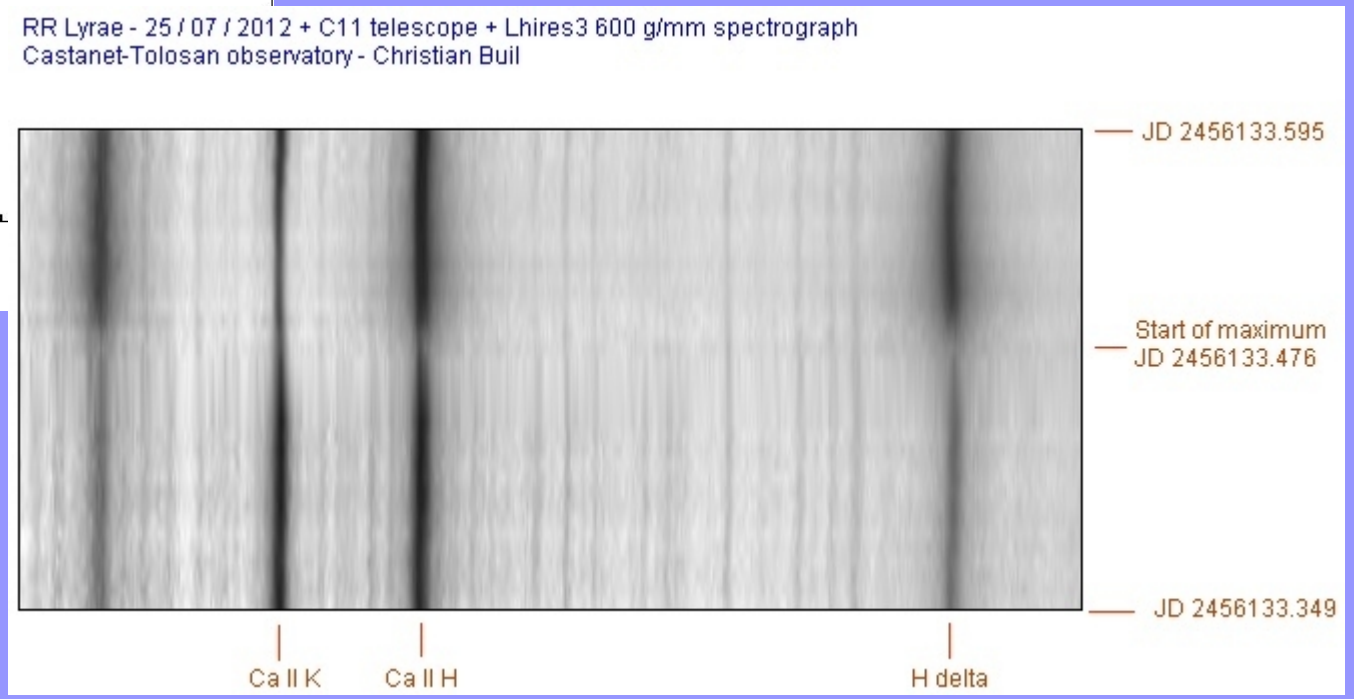
Near IR spectrum of SS 433 (C. Buil)



- Suivi des jets à très haute vitesse (Oxford university)
- http://www.astrosurf.com/buil/microquasars/obs.htm

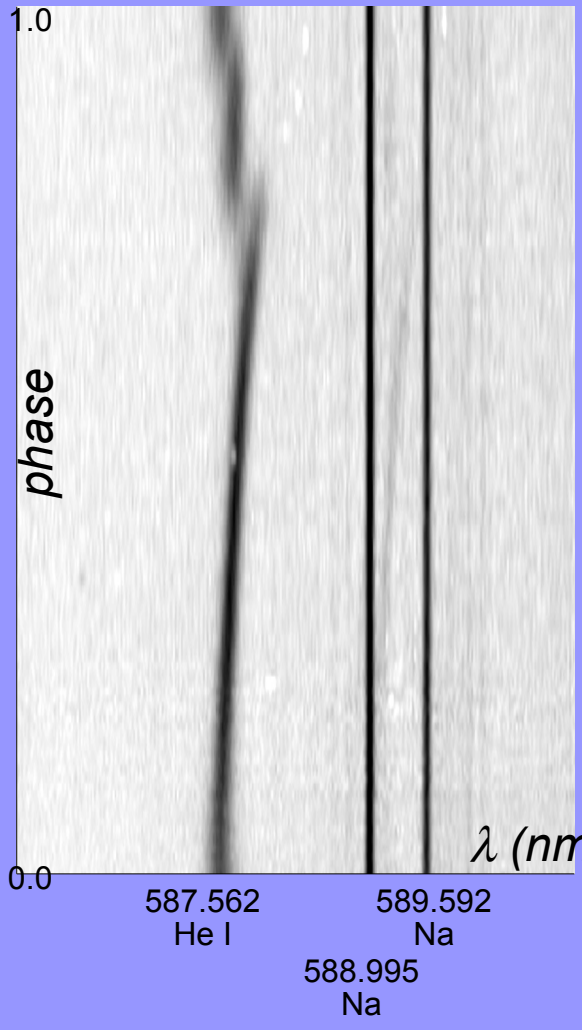
Autre: RR Lyrae / effet Blazhko



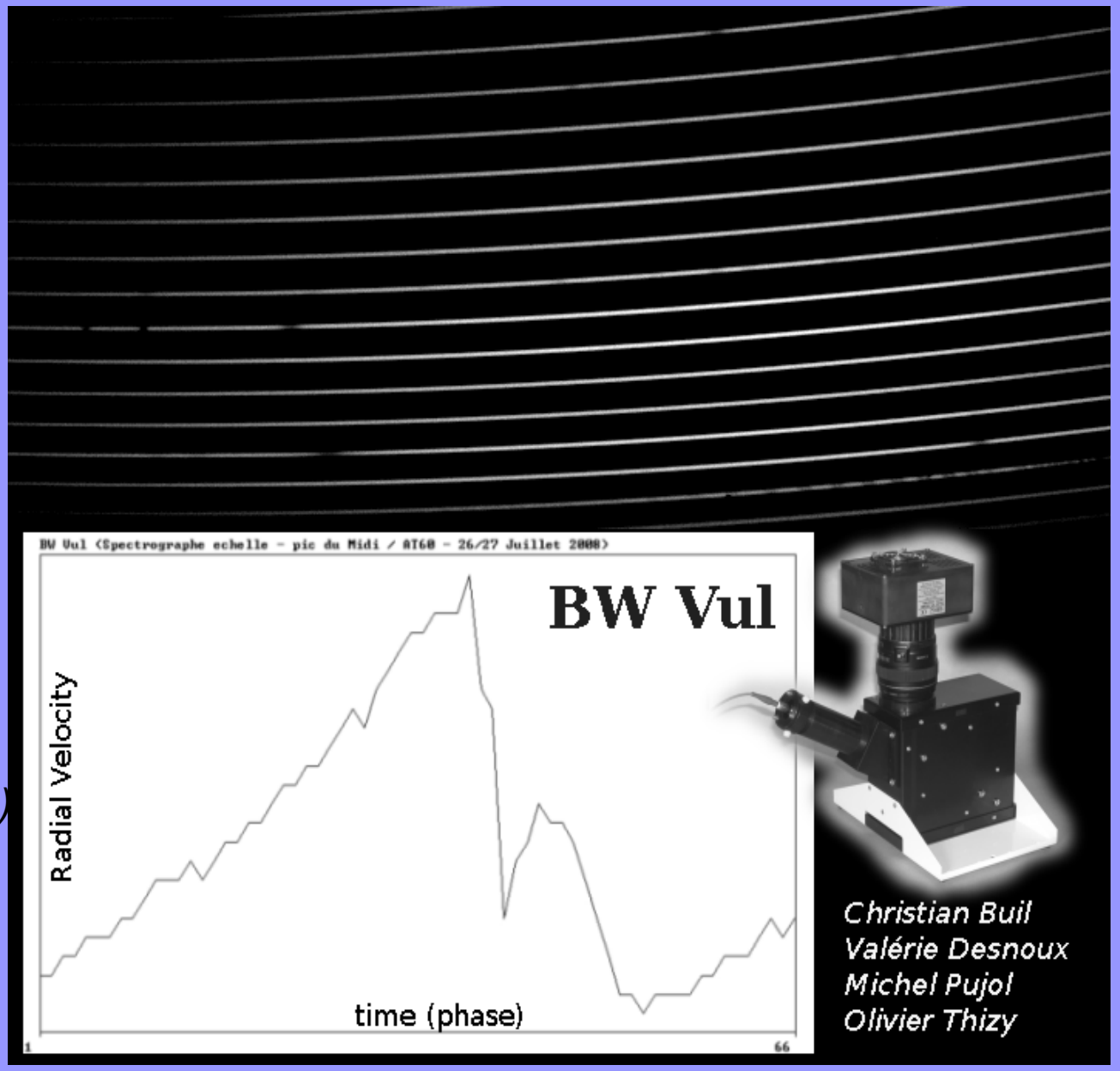


- http://www.astrosurf.com/buil/rrlyr2/rrlyr_campaign.htm
- OHP2012 (D.Gillet): http://www.shelyak.com/dossier.php?id_dossier=36&lang=2

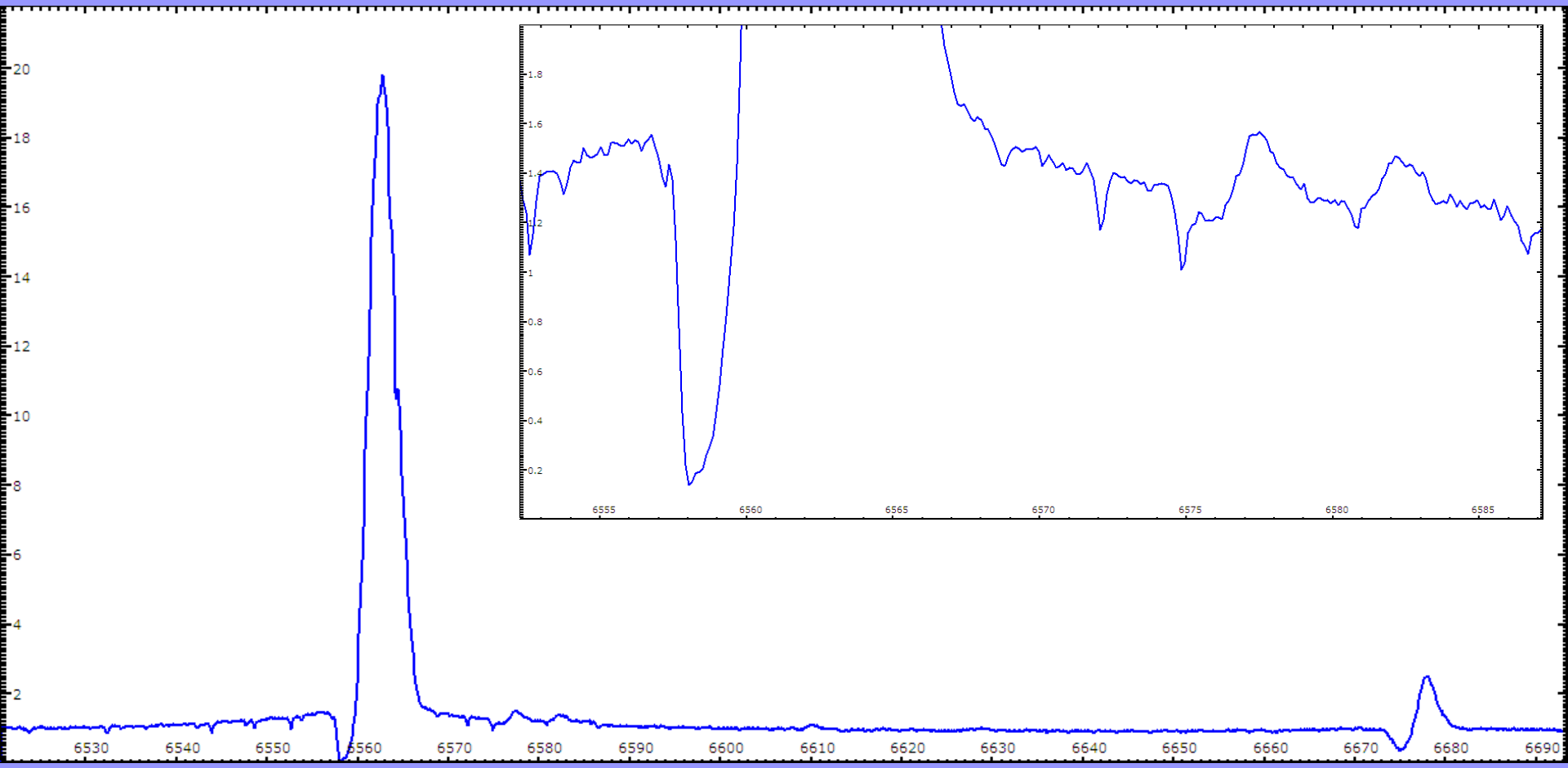
Un autre exemple de pulsations: BW Vul



Spectrogramme du doublet du sodium & HeI / BW Vul (pose 5min, 60cm f/3.5 télescope du pic du Midi)

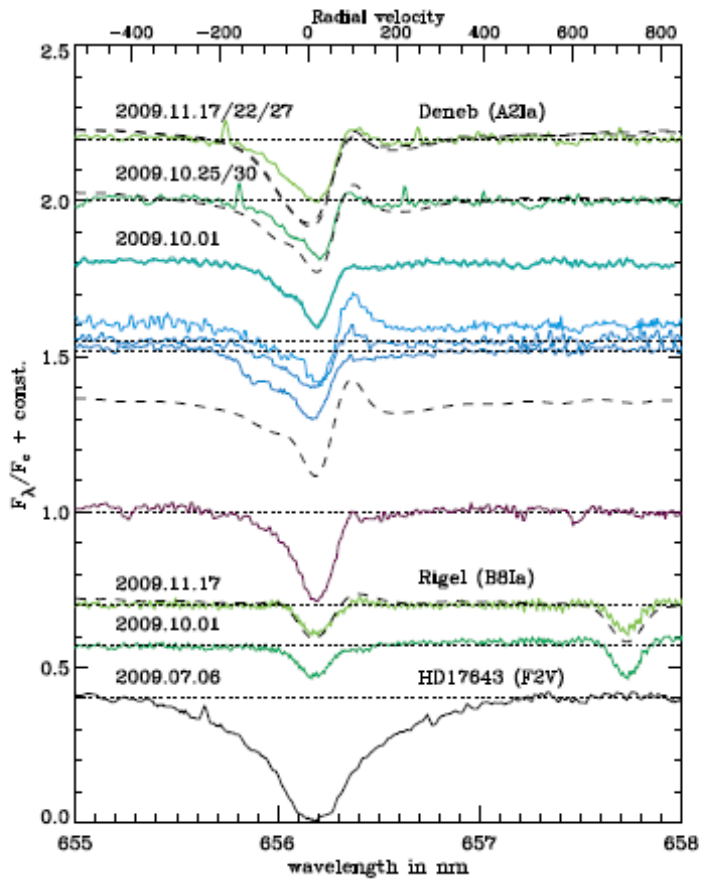


Autre: étoiles chaudes actives (P Cygni)



- Ernst Pollmann: http://www.astrospectroscopy.de/

Autre: étoiles chaudes actives (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

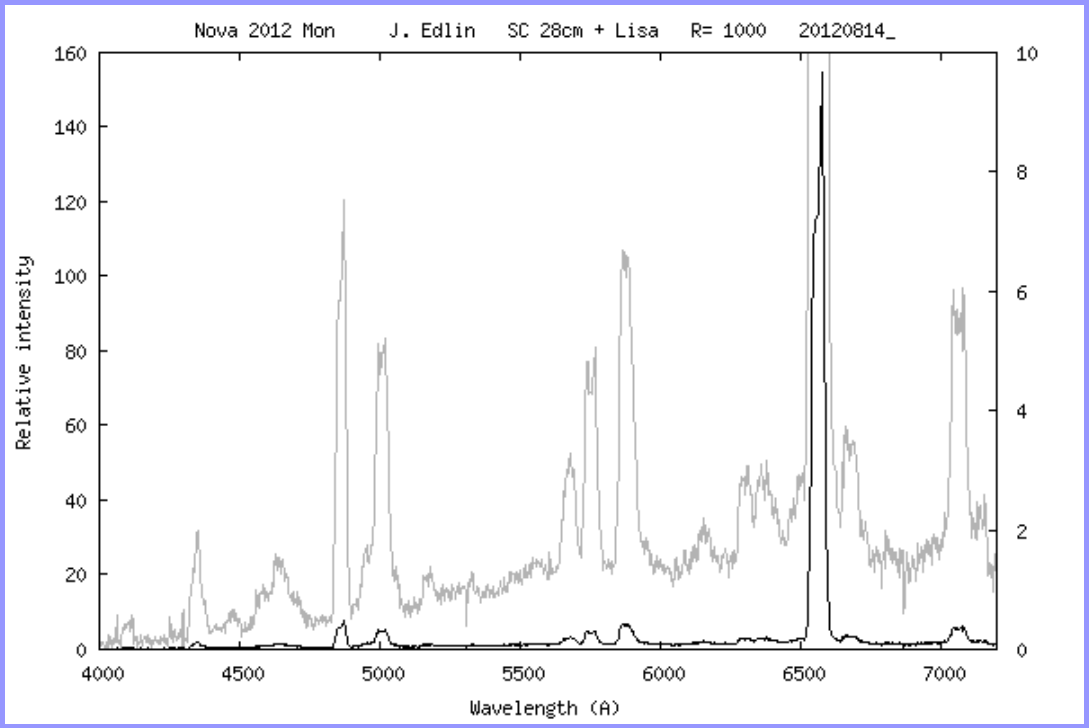
Several Hα spectra were obtained during the same period with the 0.28 m amateur telescope (Celestron 11) located in Castanet-Tolosan (France) equipped with the eShel spectrograph and a QSI532 CCD camera (CCD KAF3200ME). These spectra were used in this study as an indication of the emission level and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

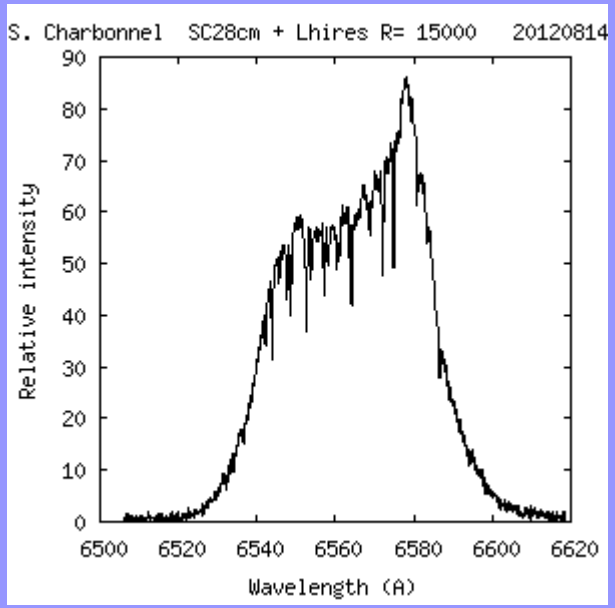
The reduction of these data was performed using the standard echelle pipeline (Reshel software V1.11). H2O telluric lines are removed by means of division by a synthetic H2O spectrum using Vspec software - the telluric-line list was taken from GEISA database (LMD/CNRS). We corrected for the diurnal and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

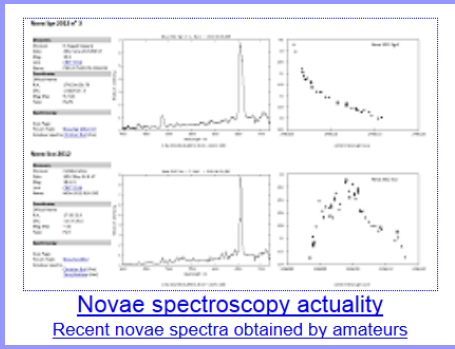
- **Ref:** arXiv:1007.2095v1 : Time, spatial, and spectral resolution of the Halpha line-formation region of Deneb and Rigel with the VEGA/CHARA interferometer

Autre: étoiles cataclysmiques (novae)

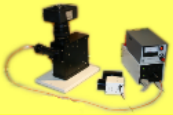
- Accessibles avec le LISA...
  ou Lhires III & eShel (les brillantes)






Novae spectroscopy actuality
Recent novae spectra obtained by amateurs

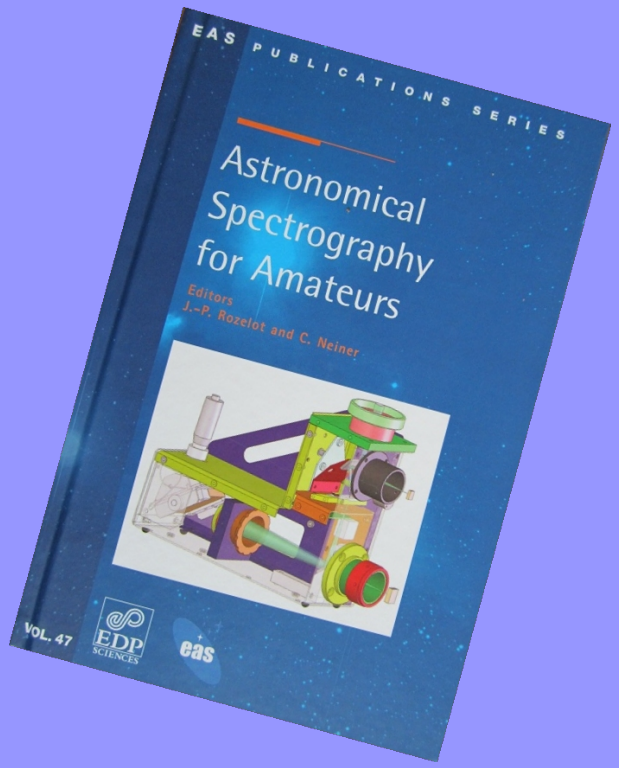
- http://www.astrosurf.com/aras/novae/Novae_Aras.html

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)		

Conclusions

- ***La spectroscopie est en plein essort***
- ***L'équipement est disponible “sur étagère”***
- ***Les collaborations Pro/Am sont de plus en plus nombreuses***
  - ***de + en + de spectroscopistes amateurs contribuant***
  - ***de + en + de professionnels demandent des spectres***
- ***Mais une pièce manque au puzzle: base de donnée générale...***

Quelques liens utiles



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

Forum ARAS **http://www.spectro-aras.com/forum/**

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

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

Shelyak Instruments
Tél.: +33.476.41.36.81
http://www.shelyak.com
Email: olivier.thizy@shelyak.com