

# Spectroscopy of Classical Be stars

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**BAA Spectroscopy Workshop**  
October 10, 2015  
-- Norman Lockyer Observatory, UK --

# the “menu”...



- **Be stars**  
**astrophysical context**
- **Pro/Am collaboration**
  - ***ARAS***
  - ***BeSS database***
  - ***ARASBeAm***
- **Time for action**
- **Conclusions**

# Be stars



# Be stars



- Discovered in 1866/1867 by father Secchi:
- gamma Cassiopae
- beta Lyrae

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Nr. 1612.

64

Schreiben des Herrn Prof. Secchi, Dir. der Sternwarte des Collegio Romano, an den Herausgeber.

Dans ma dernière je vous annonçais la grande facilité d'observer les spectres stellaires avec la nouvelle construction de spectroscopie que j'ai réussi à combiner. Bientôt j'espère de pouvoir vous envoyer une liste des objets examinés, mais pour le moment je ne pourrais différer davantage à vous signaler une particularité curieuse de l'étoile  $\gamma$  Cassiopée, unique jusqu'à présent. Celle-ci est que pendant que la grande majorité des étoiles blanches montre la raie  $f$  très-nette et large, et comme  $\alpha$  Lyre, Sirius etc.,  $\gamma$  Cassiopée a à sa place une ligne lumineuse très-belle et bien plus brillante que tout le reste du spectre. La place de cette raie est, autant que j'en ai pu prendre des mesures, exactement coïncidente avec celle de  $f$ , et on peut très-bien en faire la comparaison avec l'étoile voisine  $\beta$  Cassiopée. La mesure je l'ai prise en plaçant une pointe de repère dans le chercheur et couvrant la raie dans la grande lunette avec la pointe micrométrique du spectroscopie: si les deux lunettes sont portées de l'étoile  $\gamma$  à l'étoile  $\beta$  et placées de la même manière sur l'une et sur l'autre on

trouve que la position de la raie luisante de la première correspond à la raie obscure de la seconde. J'espère pouvoir faire ces mesures d'une manière plus exacte encore. En comparant ainsi l'étoile  $\beta$  Pégase on trouve que la  $f$  tombe sur une région noire des bandes que cette étoile présente. Du reste la bande luisante que montre  $\gamma$  Cassiopée, n'est pas unique, il y en a plusieurs autres, mais assez plus petites, et je ne les ai pas mesurées. Cette étoile présente donc un spectre inverse de celui du type ordinaire des étoiles blanches.

Pour vous donner une idée pratique de l'effet de cette bande je vous dirai que cette ligne brille sur le reste du spectre comme le groupe du magnésium brille sur le fond lumineux du spectre lorsqu'on brûle ce métal.

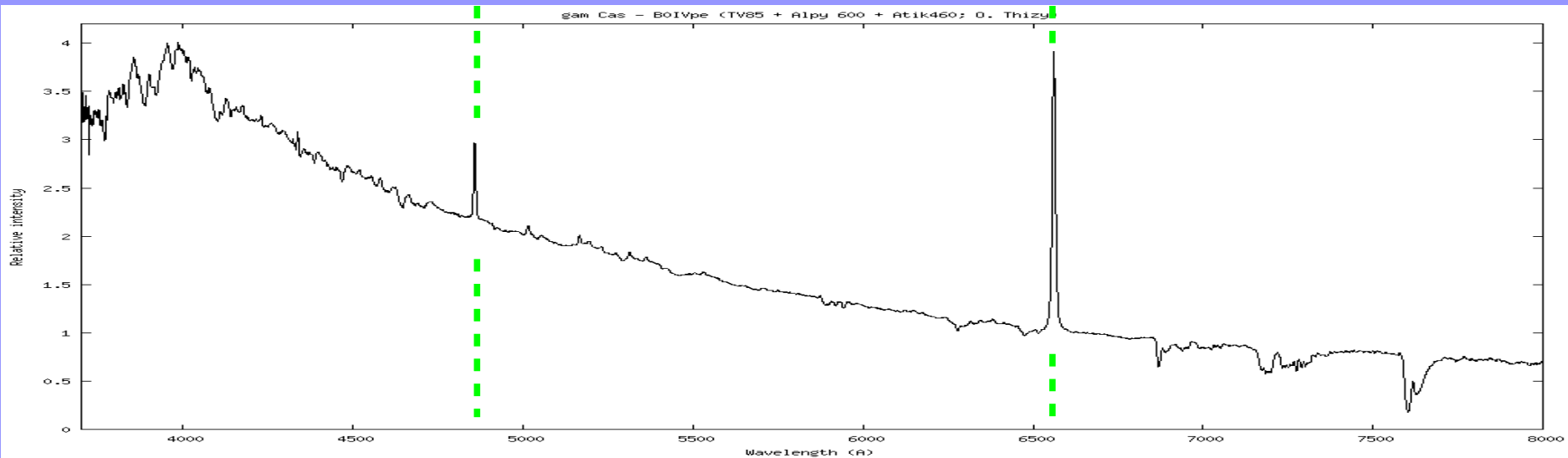
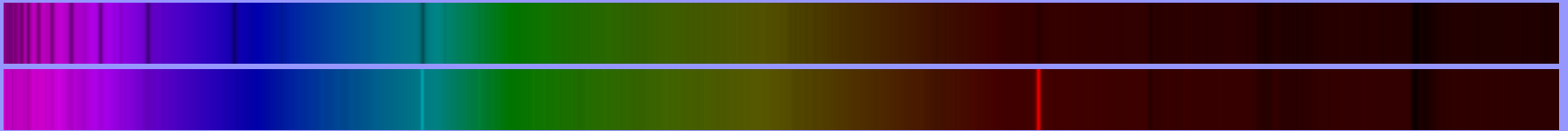
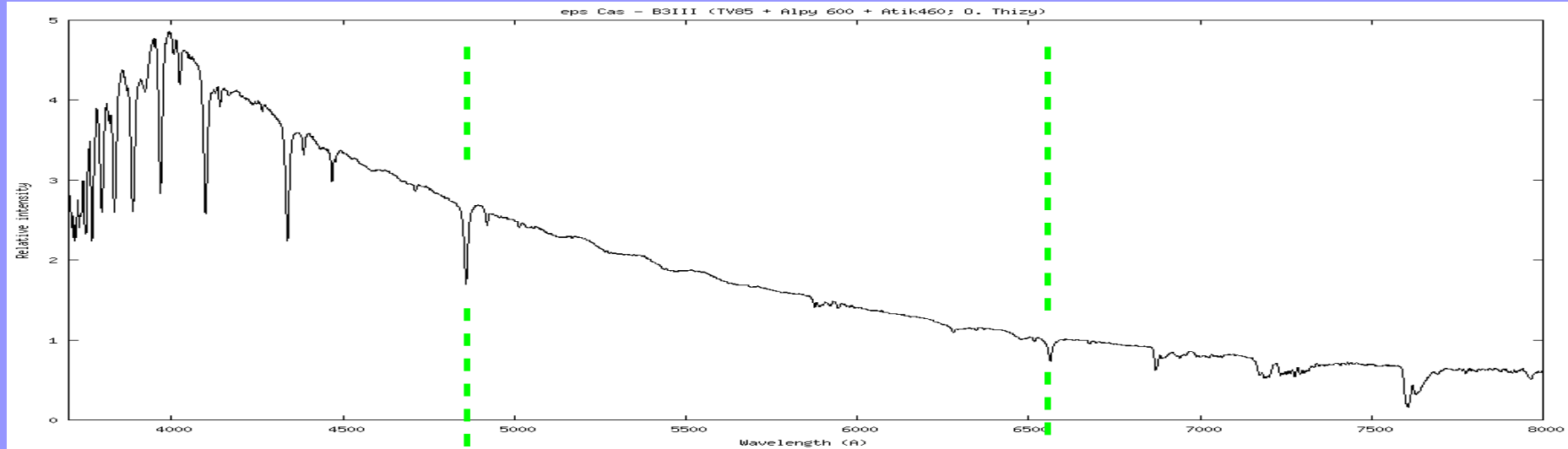
Dans une autre lettre les détails des autres étoiles. — M. Respighi a vérifié ces résultats et a même vu avec sa lunette de 5 pouces seulement plusieurs beaux spectres avec l'usage de ma combinaison.

Rome, 1866 Août 23.

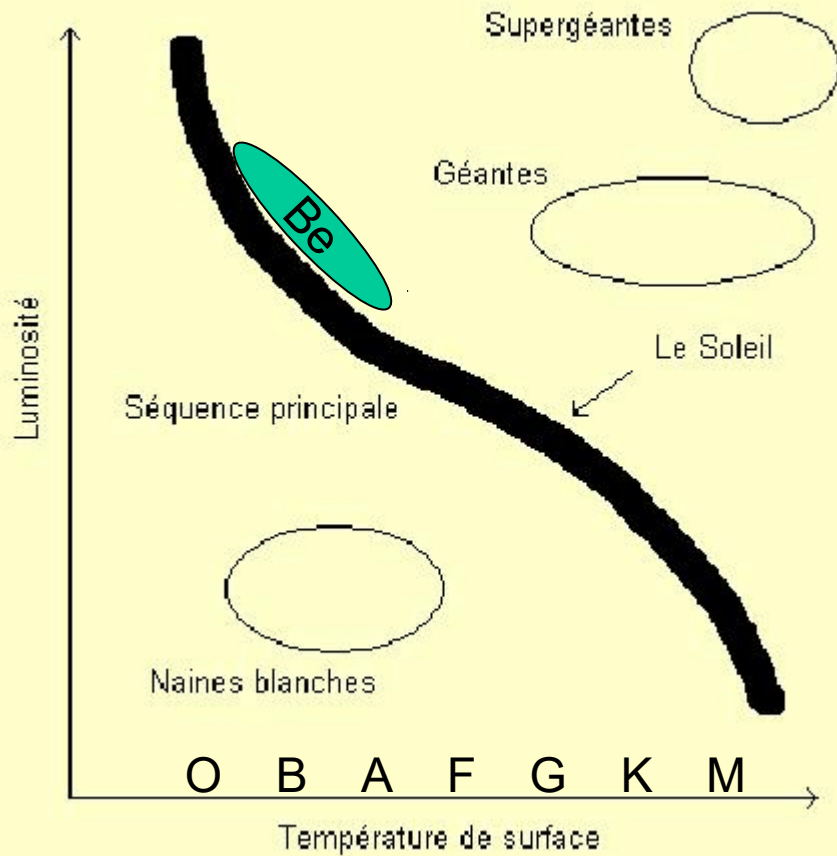
A. Secchi.



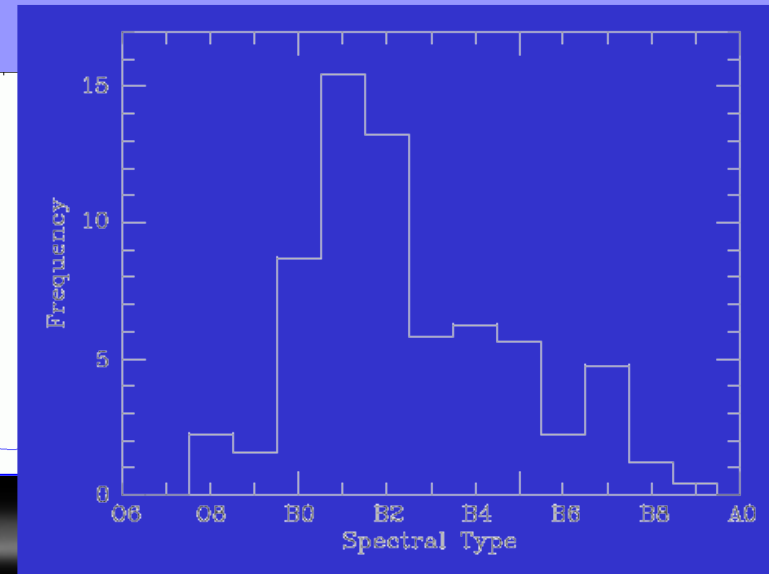
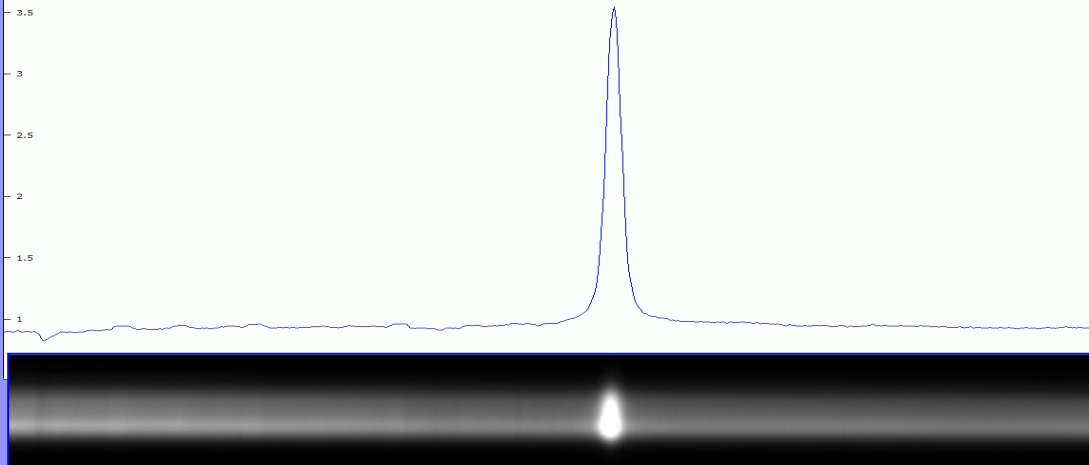
# B versus Be stars



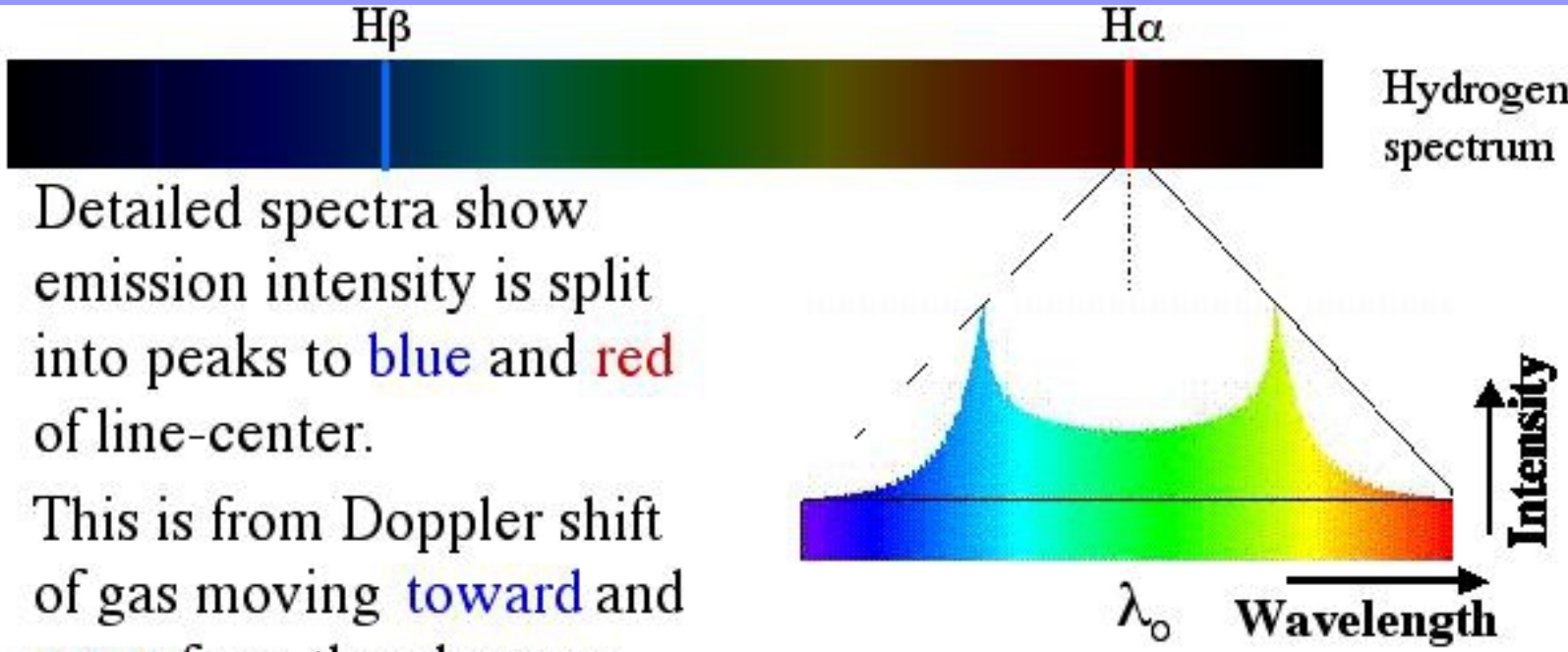
# Be stars

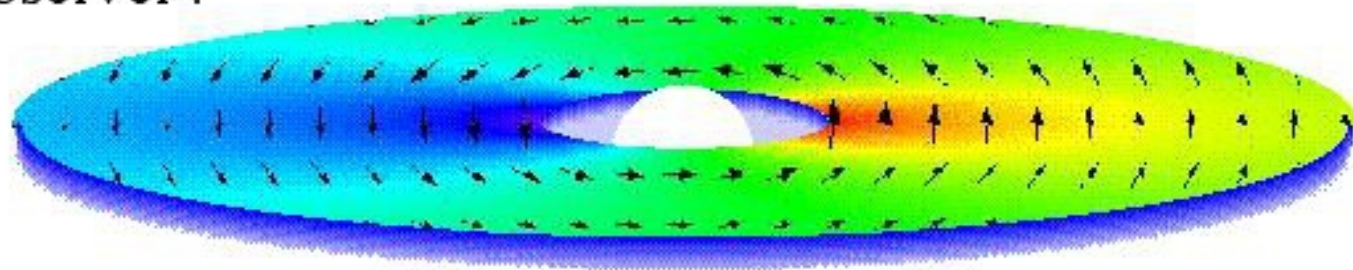


- B stars:  $T \sim 20\,000\text{K}$  ( $4 \times \text{Sun}$ )
- Non super-giants  
(ie: P Cygni is not a Be star!)
  - Masses  $\sim 8 \times \text{Sun}$
  - Size  $\sim 6 \times \text{Sun}$
- Show (or have shown) emission line (H $\alpha$ ...)
- $\sim 10\%-20\%$  of B stars are Be



# Be star: lord of the ring !

- 
- The diagram shows a horizontal bar representing the visible spectrum, with a blue line labeled  $H\beta$  and a red line labeled  $H\alpha$ . Below the  $H\alpha$  line, a detailed plot shows Intensity on the y-axis and Wavelength on the x-axis. The plot features a central dip at  $\lambda_0$  and two symmetric peaks on either side, colored with a gradient from blue on the left to red on the right. A vertical dashed line connects the  $H\alpha$  line to the central dip in the intensity plot.
- Detailed spectra show emission intensity is split into peaks to blue and red of line-center.
  - This is from Doppler shift of gas moving toward and away from the observer.

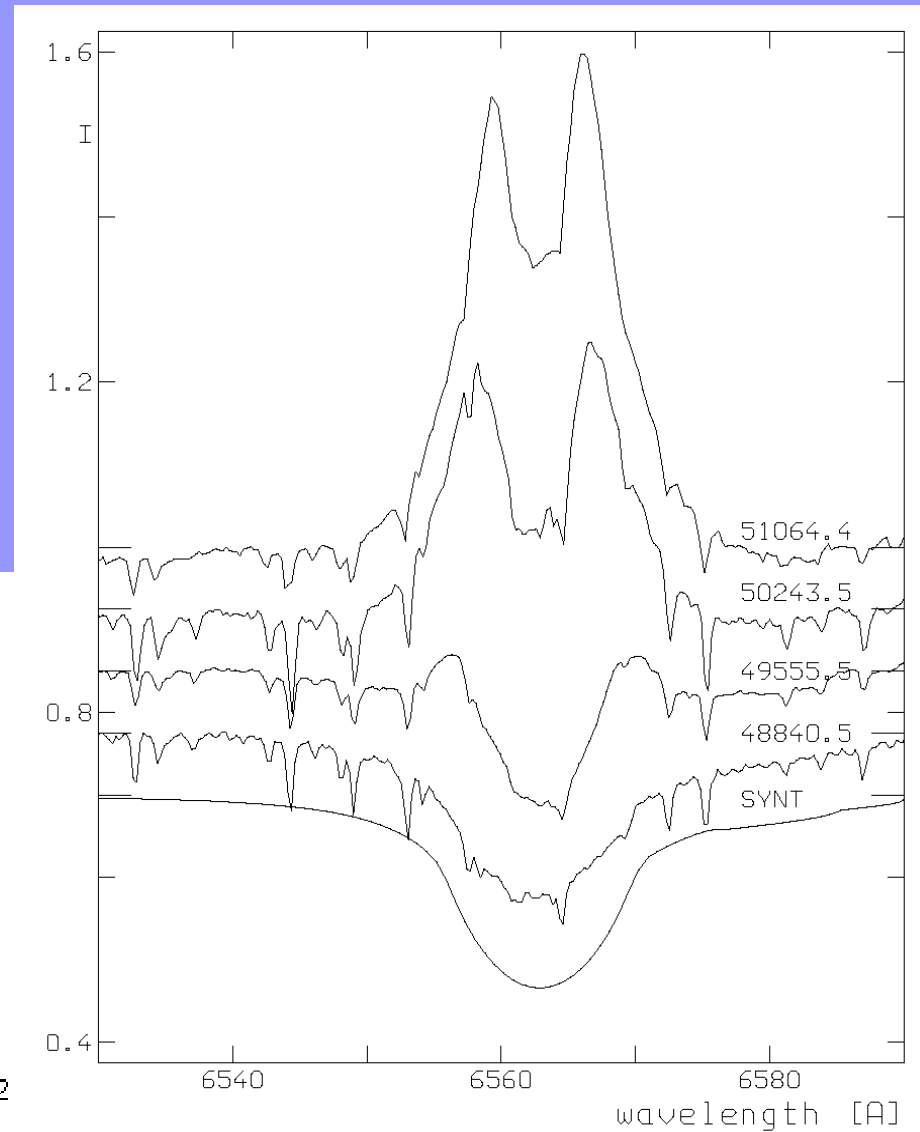
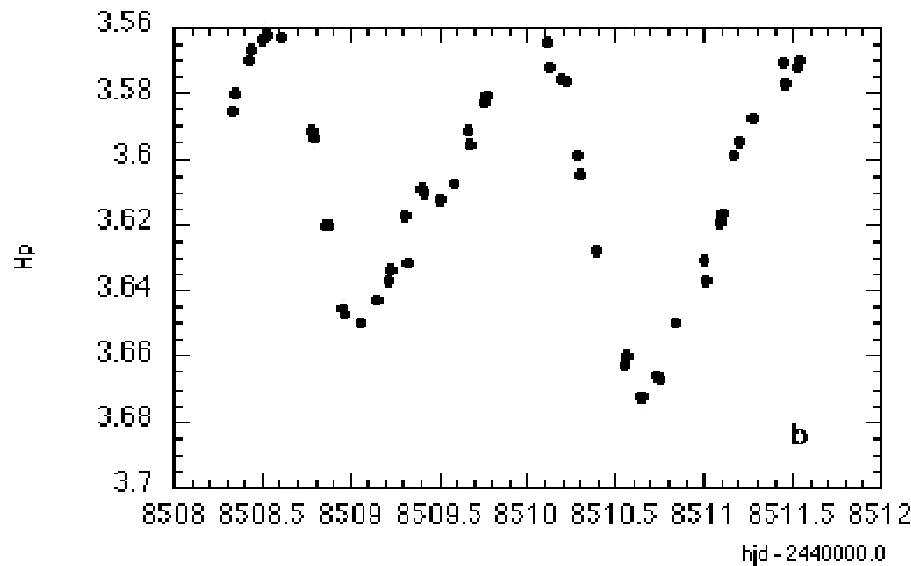


- Indicates a disk of gas orbits the star.

# Be stars are variable stars

› Evolution over different time scales (hours to years)

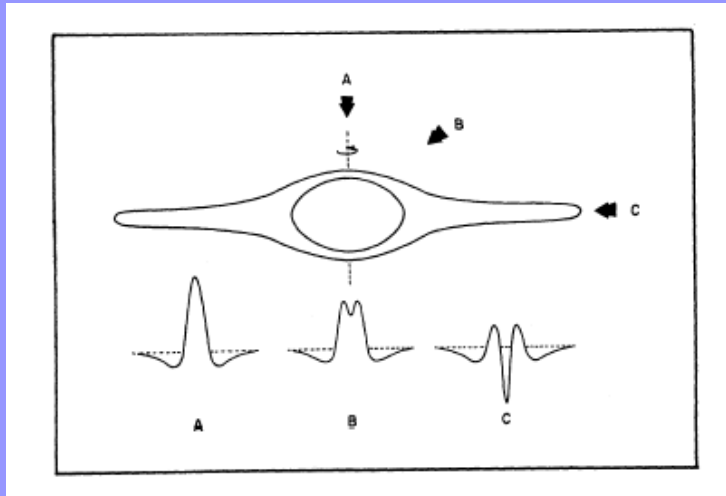
› Cycle B-→Be-→B-→Be... ?



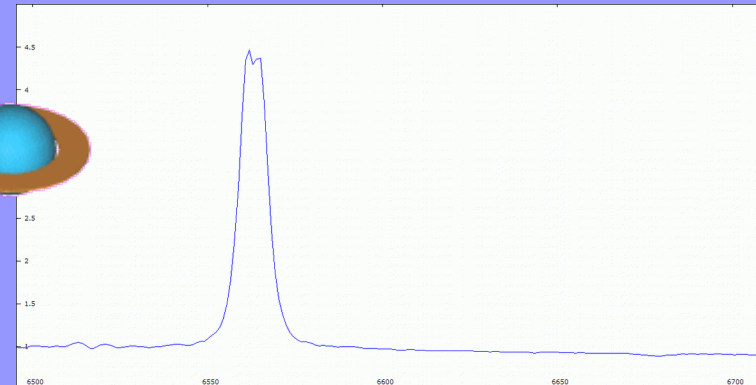
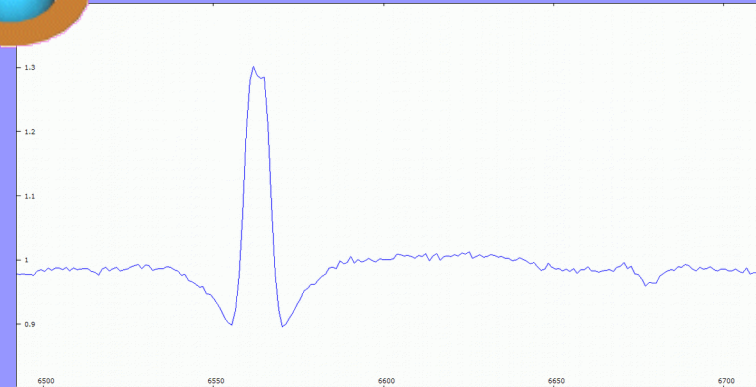
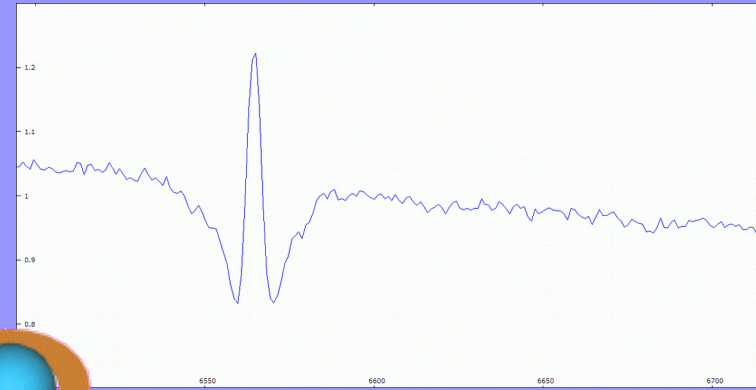
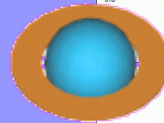
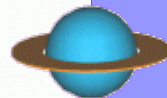
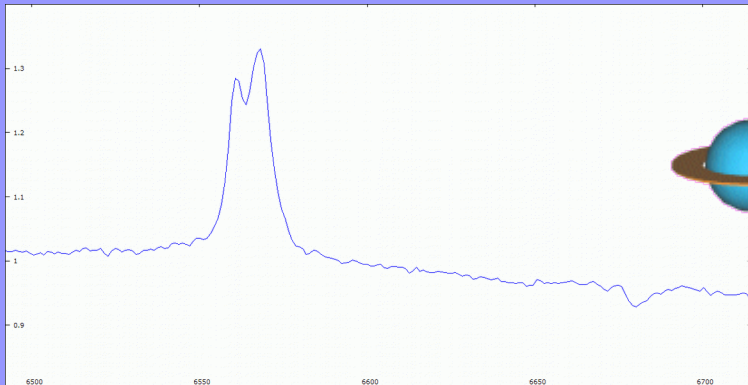
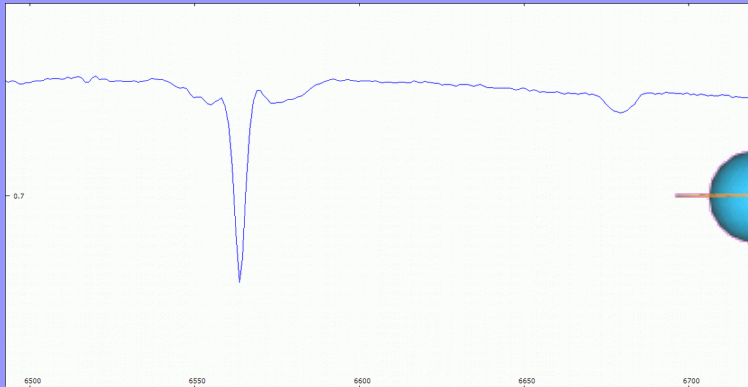
# Circumstellar Disks of Be Stars

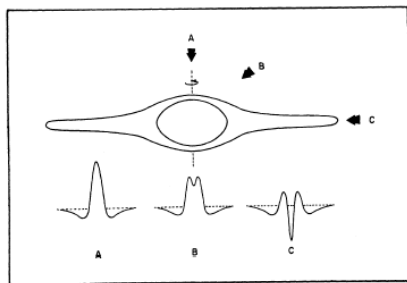
- Disk is close to the star
- Disk thickness increases outward from the star
- Density drops with distance from the star as  $r^{-n}$ 
  - Density exponent  $n \sim 2.5-4.0$   
(simplified models)
- Disk is temporary  
(can be present for decades)
- Disk can suddenly appear or disappear
- Disks can add to the continuum brightness  
(up to 70% in the optical region)

# Line profiles

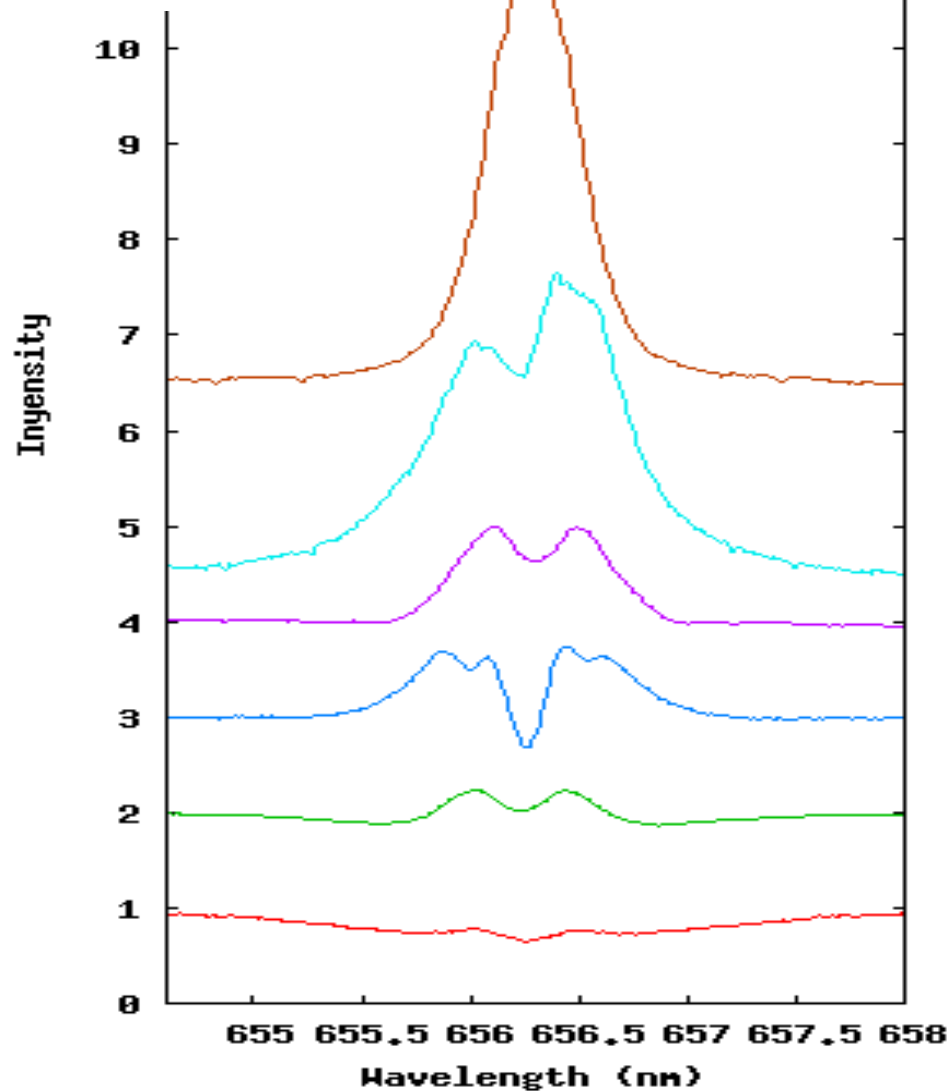


B star

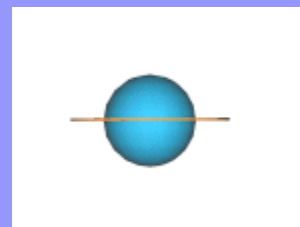
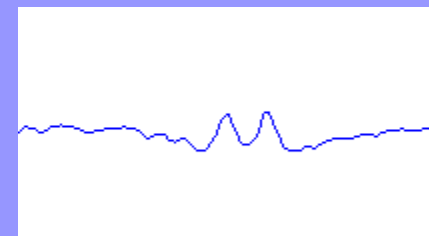
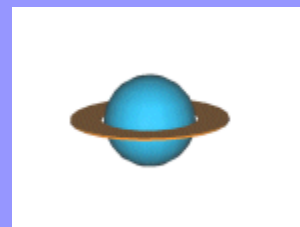
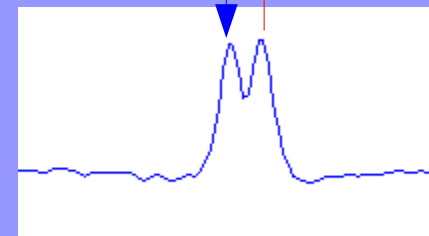
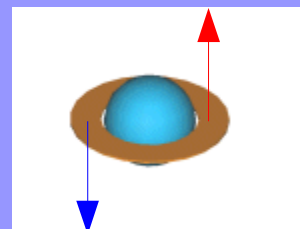
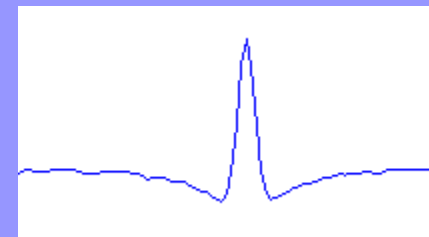
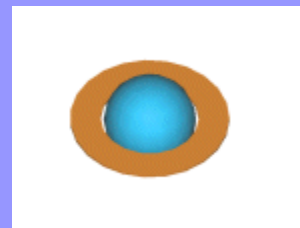




tet	Ari	—
23	Tau	—
BU	Tau	—
one	Ori	—
phi	Per	—
32	Peg	—

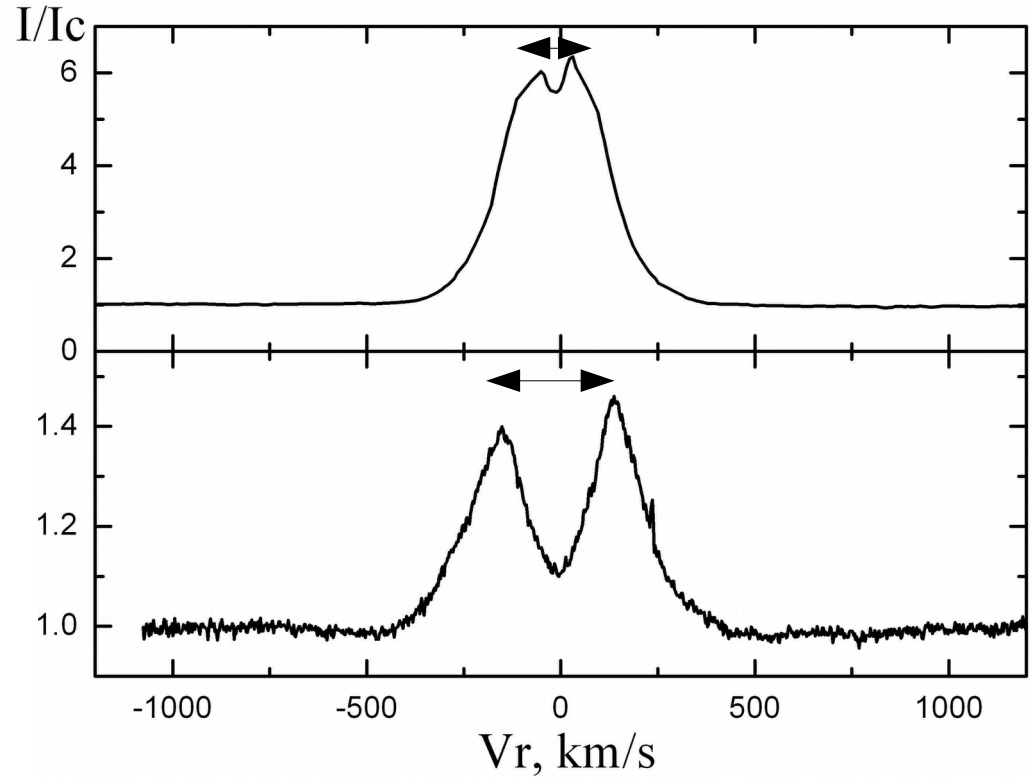
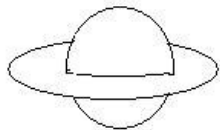
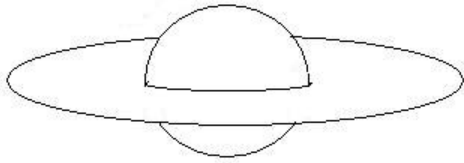


# Line profiles

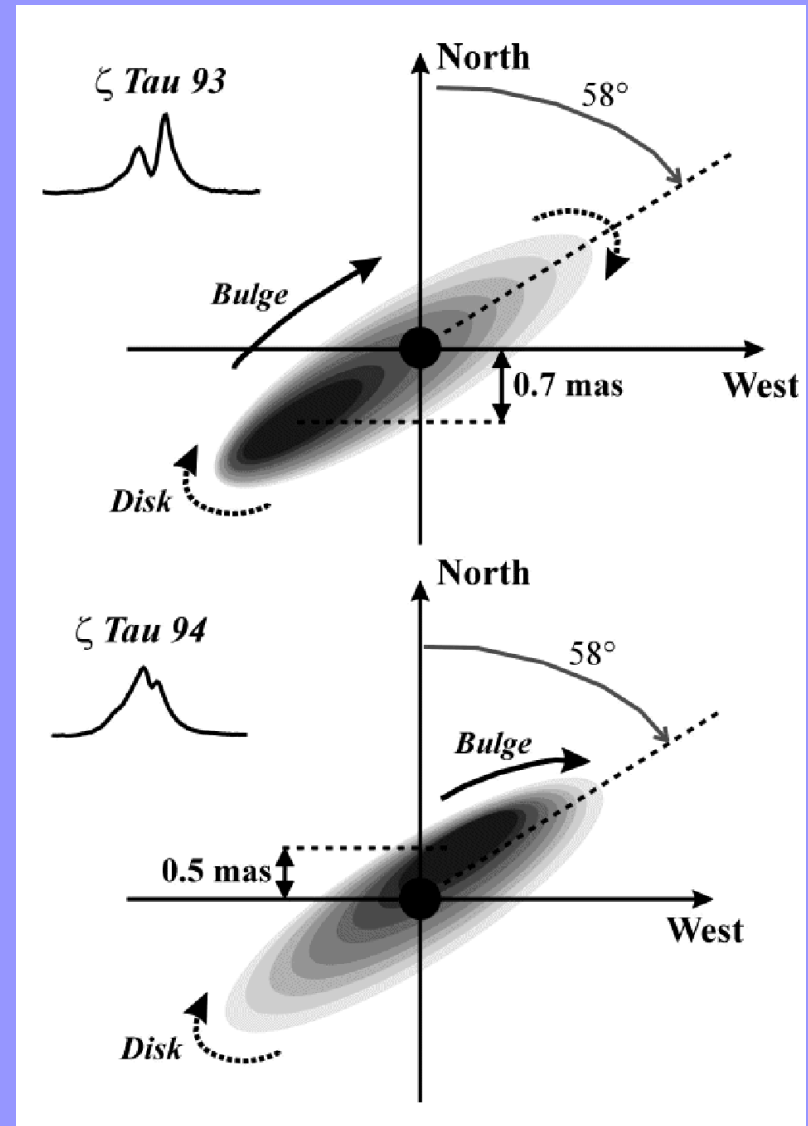
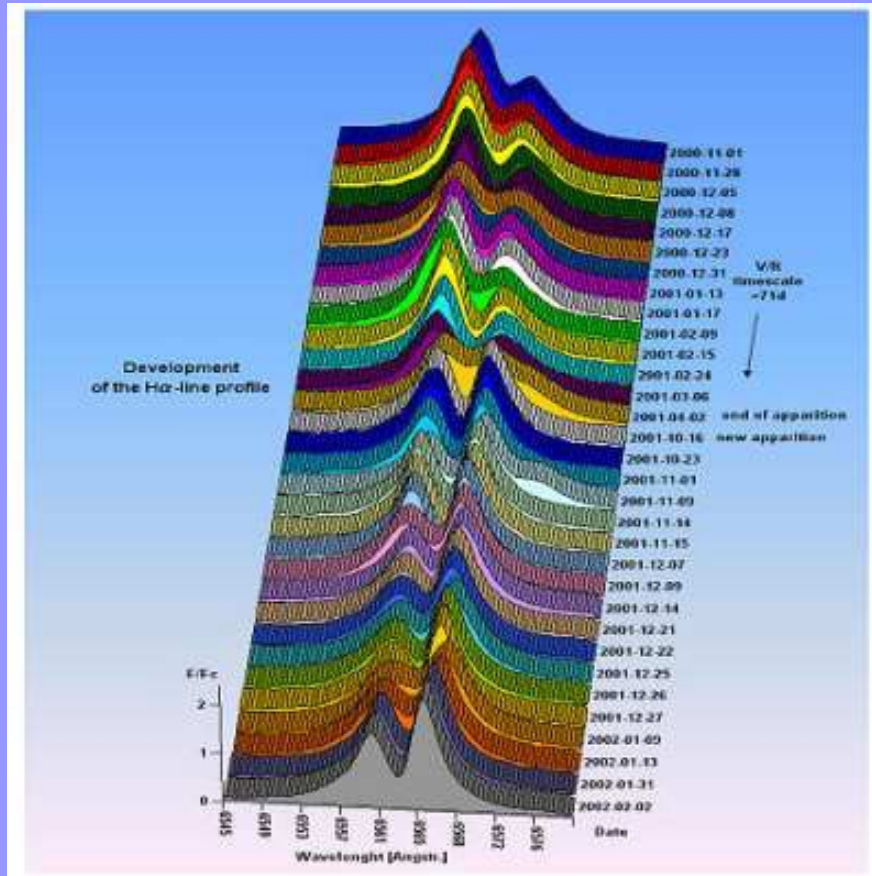




# Disk size effect

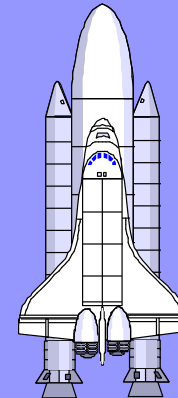
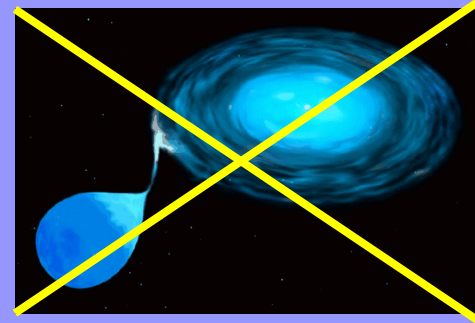
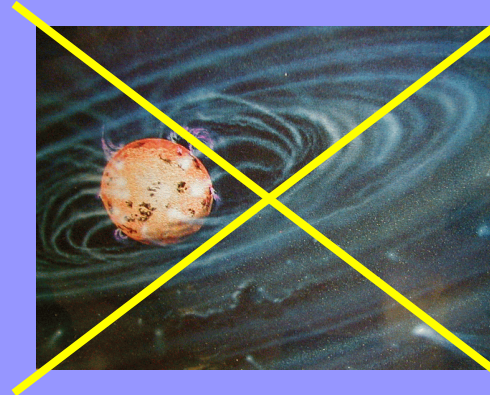


# System's geometry



# Where does the disk come from ?

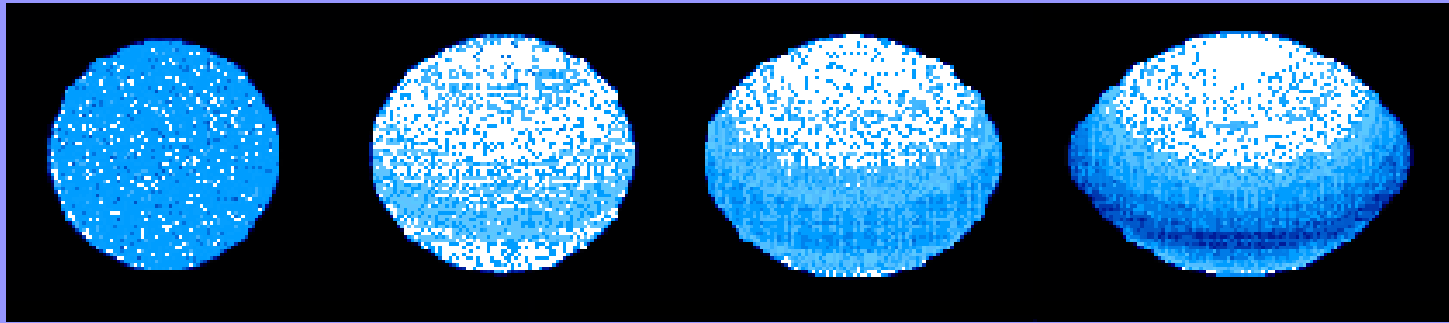
- Disk is decretion and not accretion
- Be are on main sequence ==> disk is not a proto-disk
- Most Be stars are not binaires so material doesn't come from a companion
- Disk must then be created by matter ejected...



# Ejection of material ?

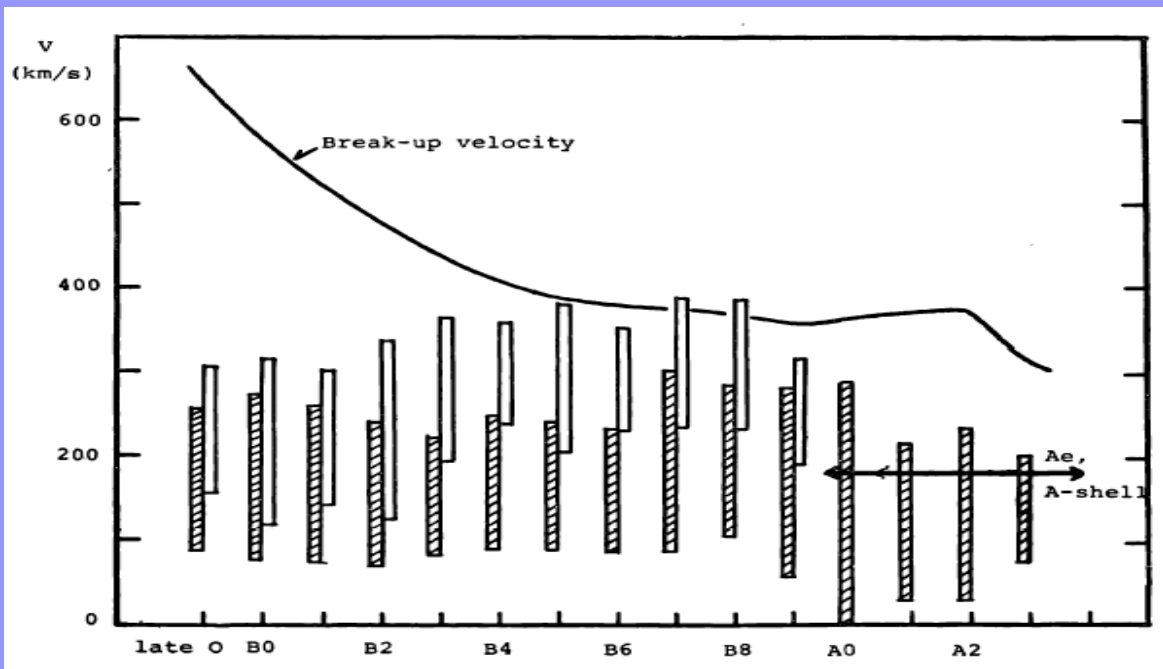
- rotation of the star alone is not enough to eject material
- A magnetic field could bring some additional angular momentum to eject material
- non radial pulsations could help this ejection and is currently thought as the main mechanism
- Strong stellar wind would constraint into disk
- ...but there is still lot to learn and it is an active field of work where more observations are required over long period of time so theory can be finetuned !

# Turn Forrest... Turn !



$V=0$

$V \rightarrow$



➤ Be stars have higher average rotational speed than B stars

➤ Not fast enough to eject material

➤ Binary can help but lot of Be stars are not binaries

# Magnetic field detection

- Direct detection by spectro-polarimetry (Zeeman effect) is very hard:
  - very few lines in hot stars
  - expected magnetic field is very low
  - pulsations are modifying line profiles
  - line profiles broaden by rotation



80" telescope  
at Pic du Midi  
(Narval spectrometer)

Source vidéo: H Henrichs



# One detection ?

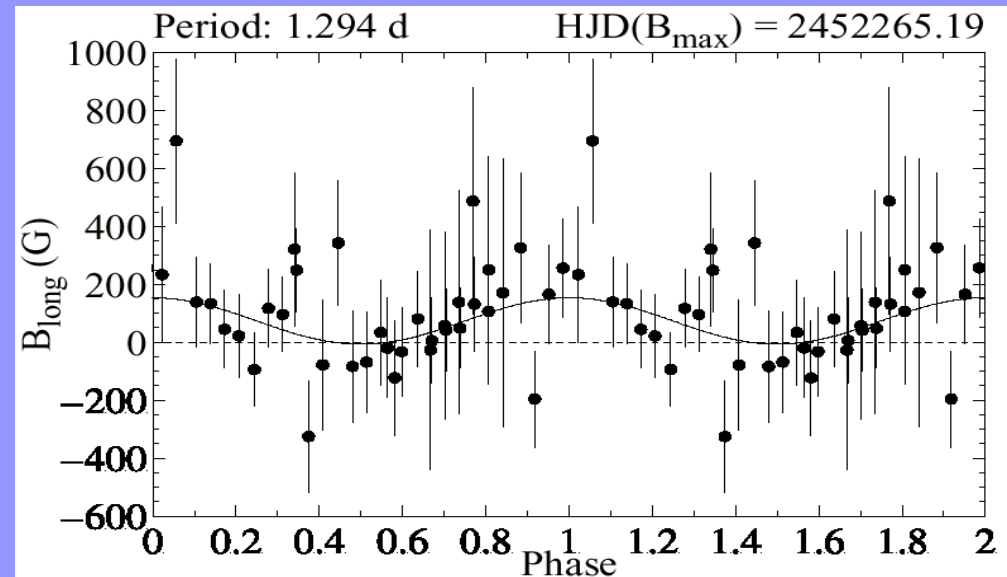
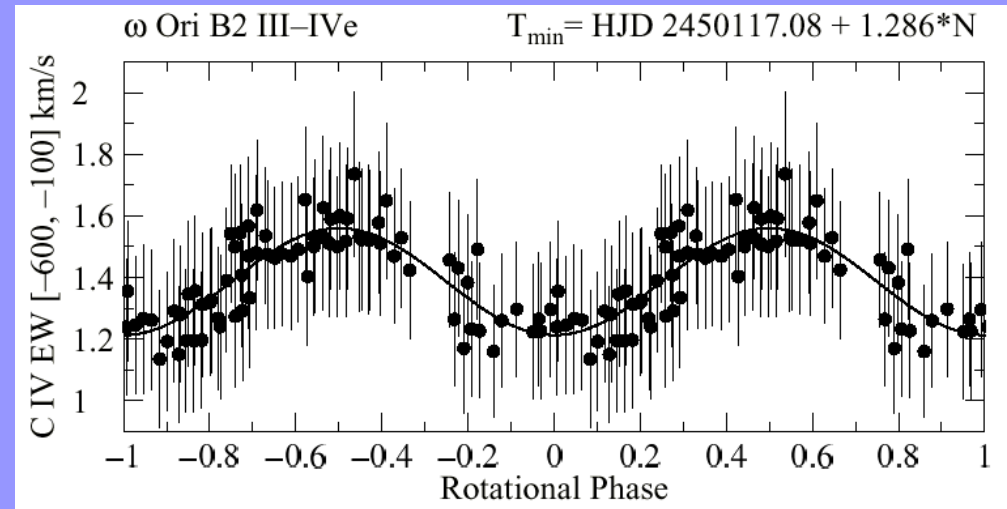
- $\beta$  Cep, prototype of  $\beta$  Cep stars, also a Be star but rotating slowly...

- ... with a magnetic field (Henrichs et al. 2000)...

- ...turns out two stars on same line of sight!

- $\omega$  Ori, a fast rotating classical Be star...

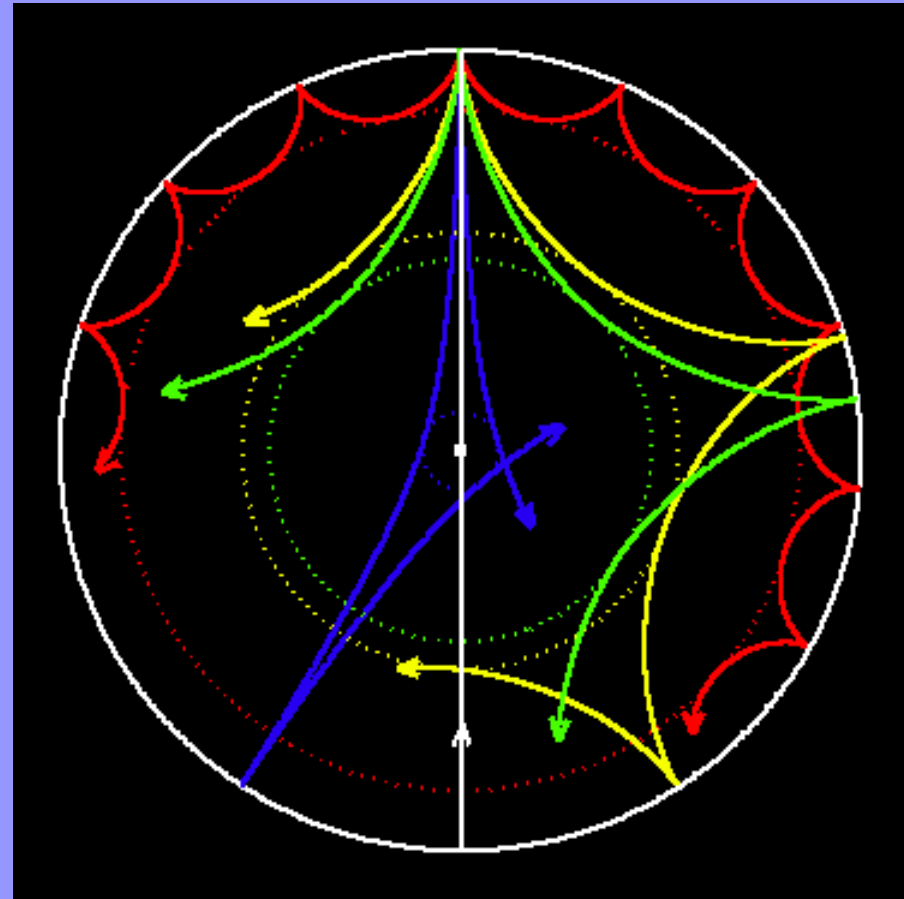
- ... with a magnetic field (Neiner et al. 2003)



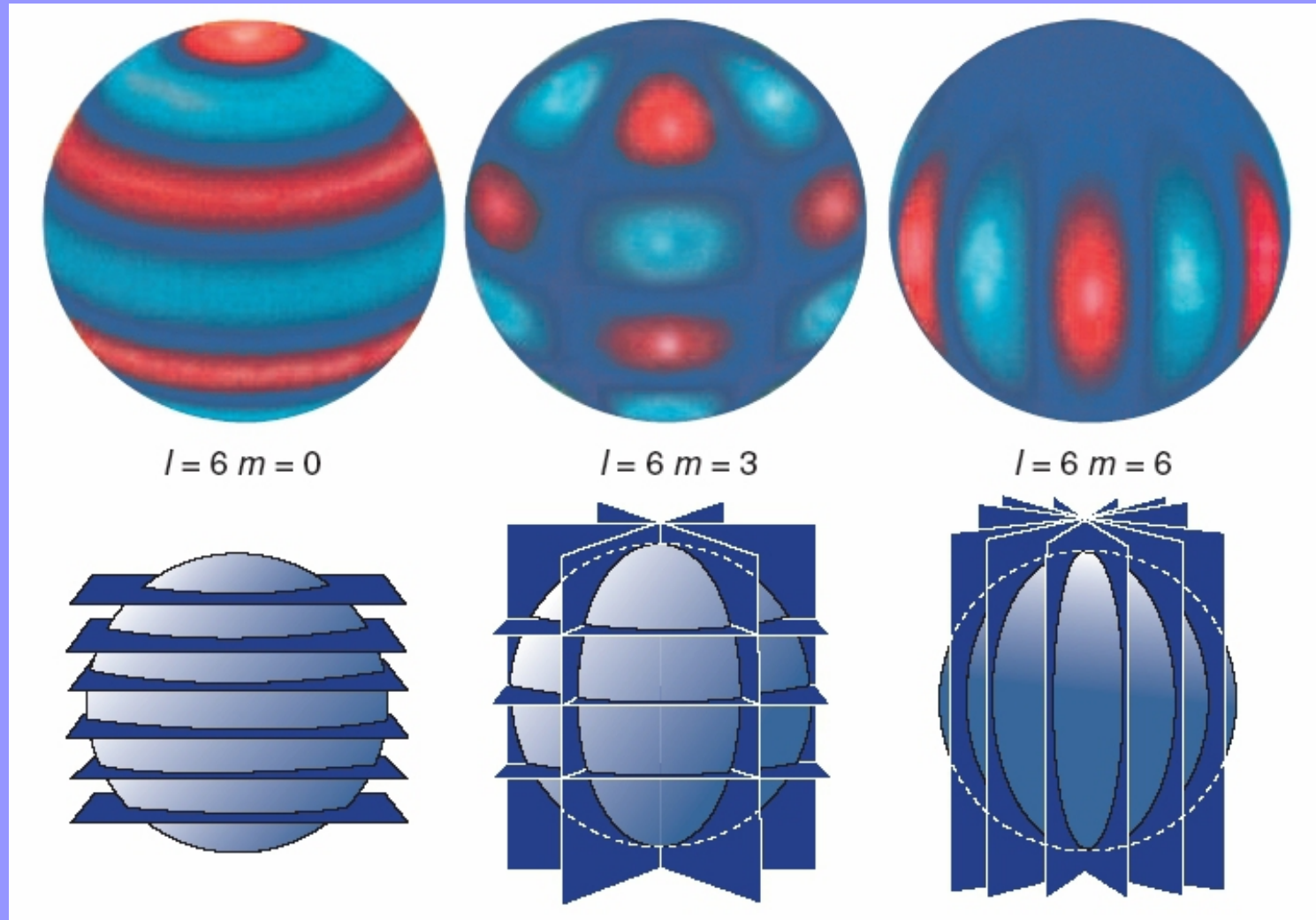


# Non Radial Pulsations

- Sonic waves internal to the star, curved by changes in speed of sound
- Wave trajectory depends on internal structure of the star
- NRP (Non Radial Pulsations) mode

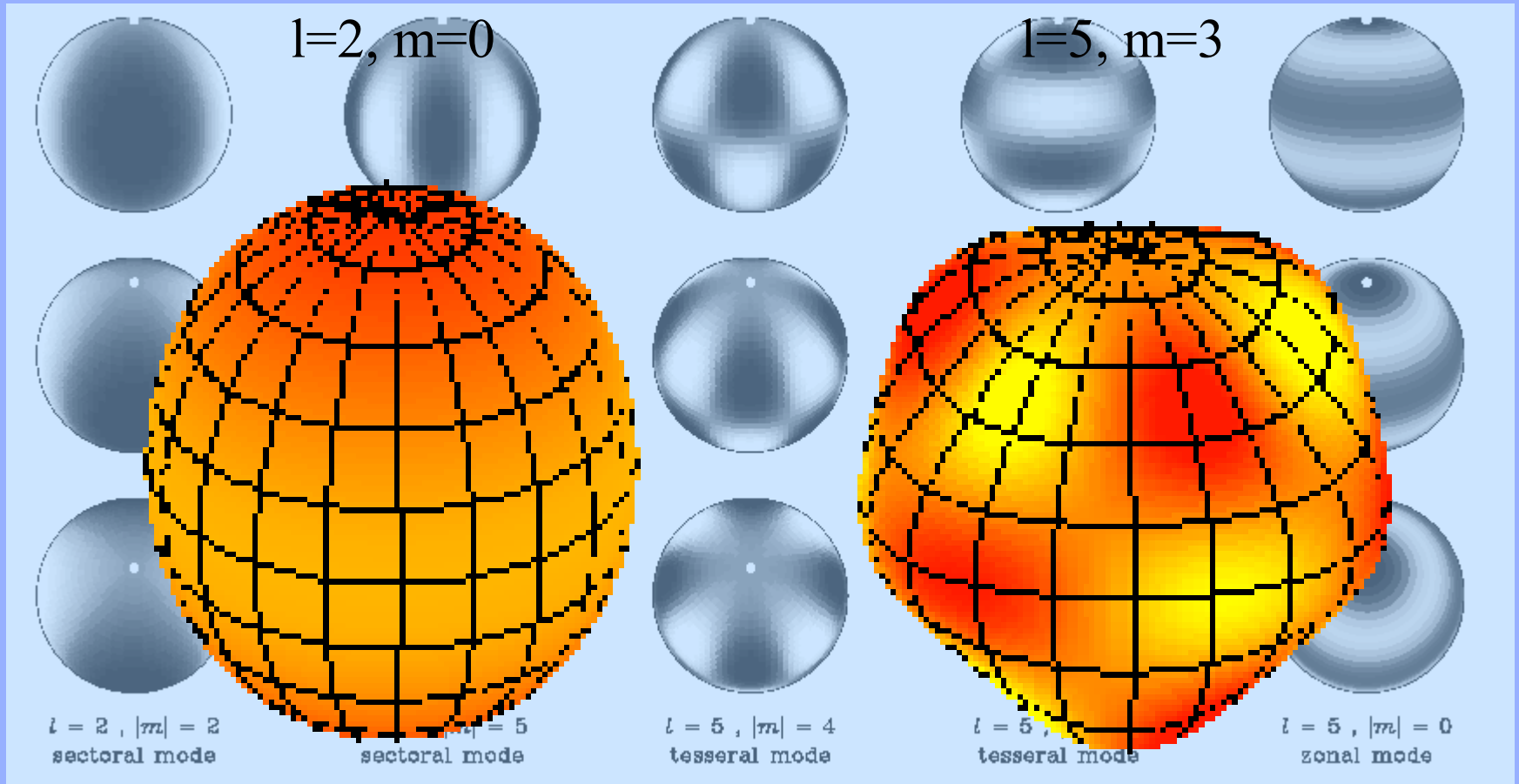


# Non Radial Pulsations



$l$  = nb of lines in longitude /  $m$  = nb de lines in latitude

# Non Radial Pulsations



$l$  = nb total de lignes séparatrices

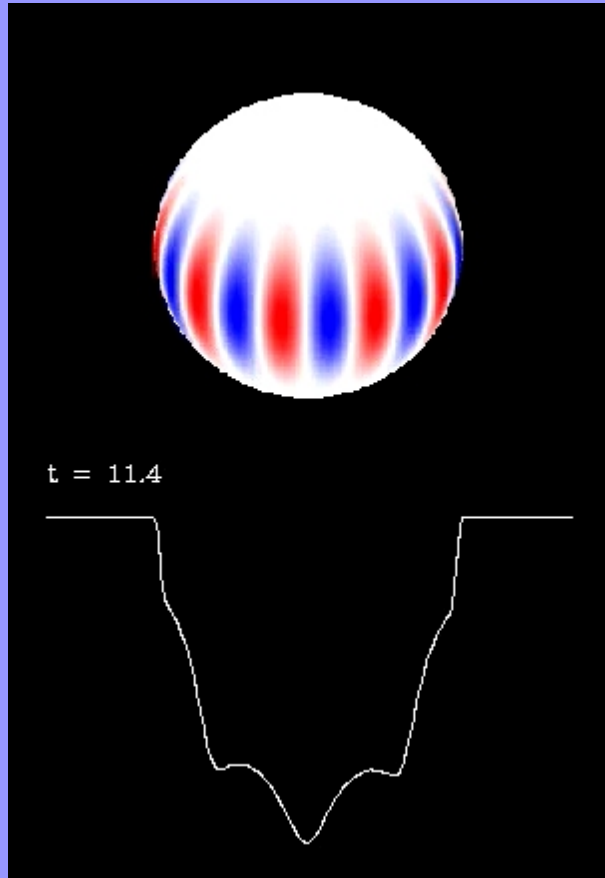
$m$  = nb de lignes en latitude

Schrijvers 1999

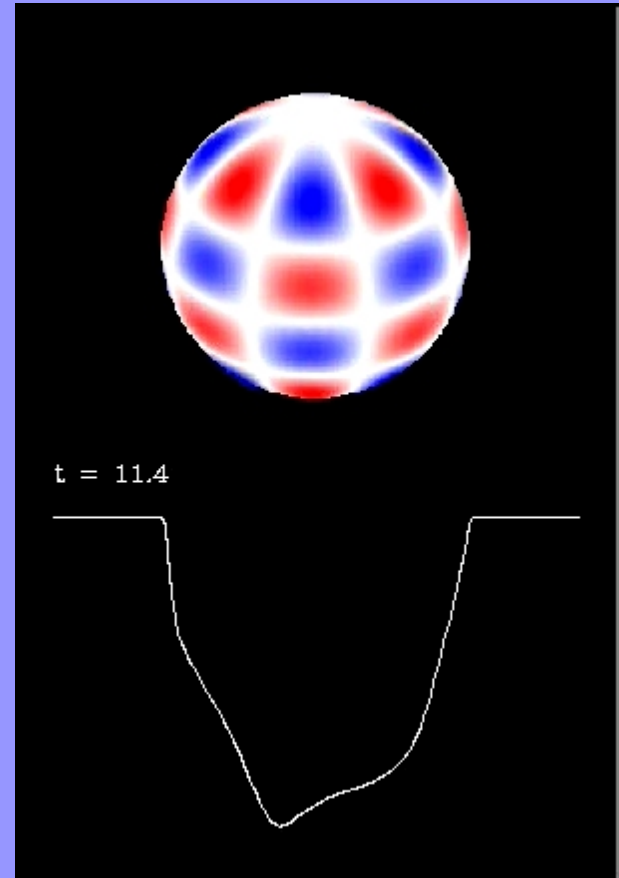
From: C. Neiner

# NRP spectral changes

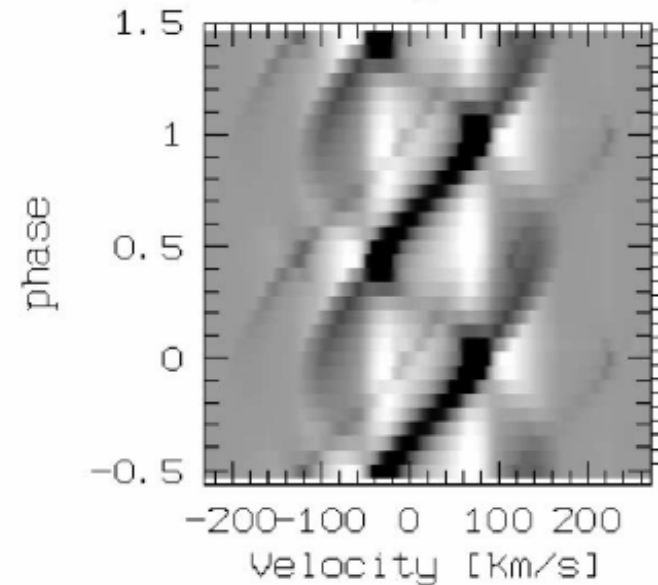
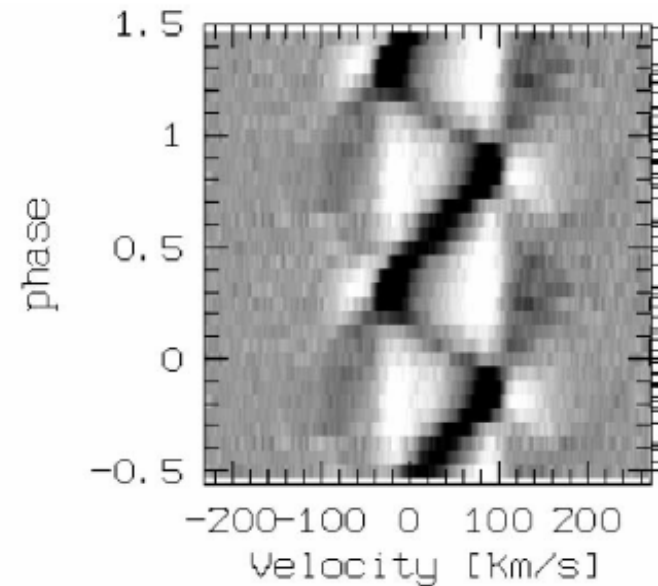
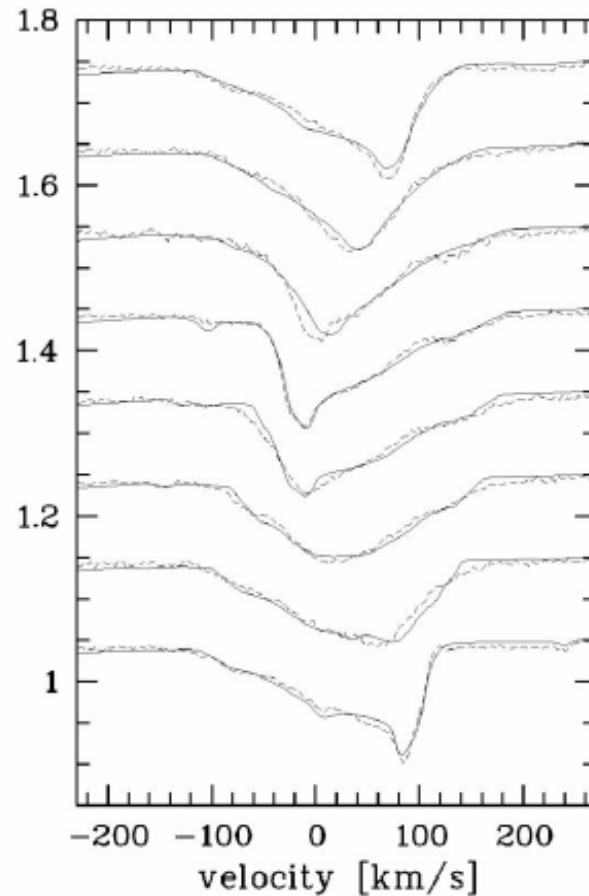
$l=10, m=10$



$l=7, m=4$

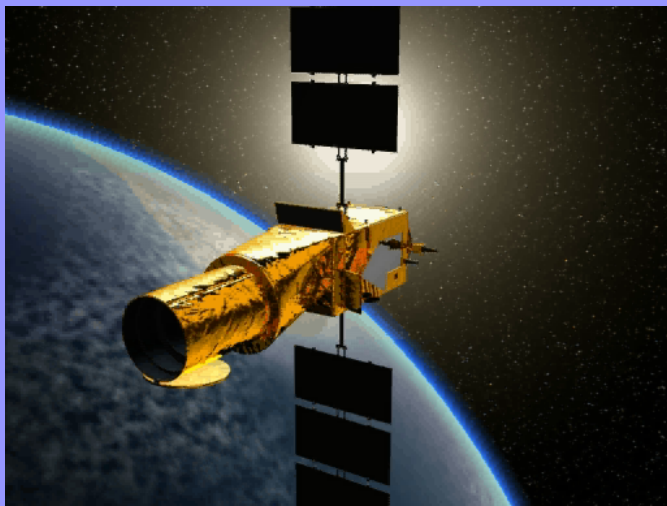


# Example of spectral changes



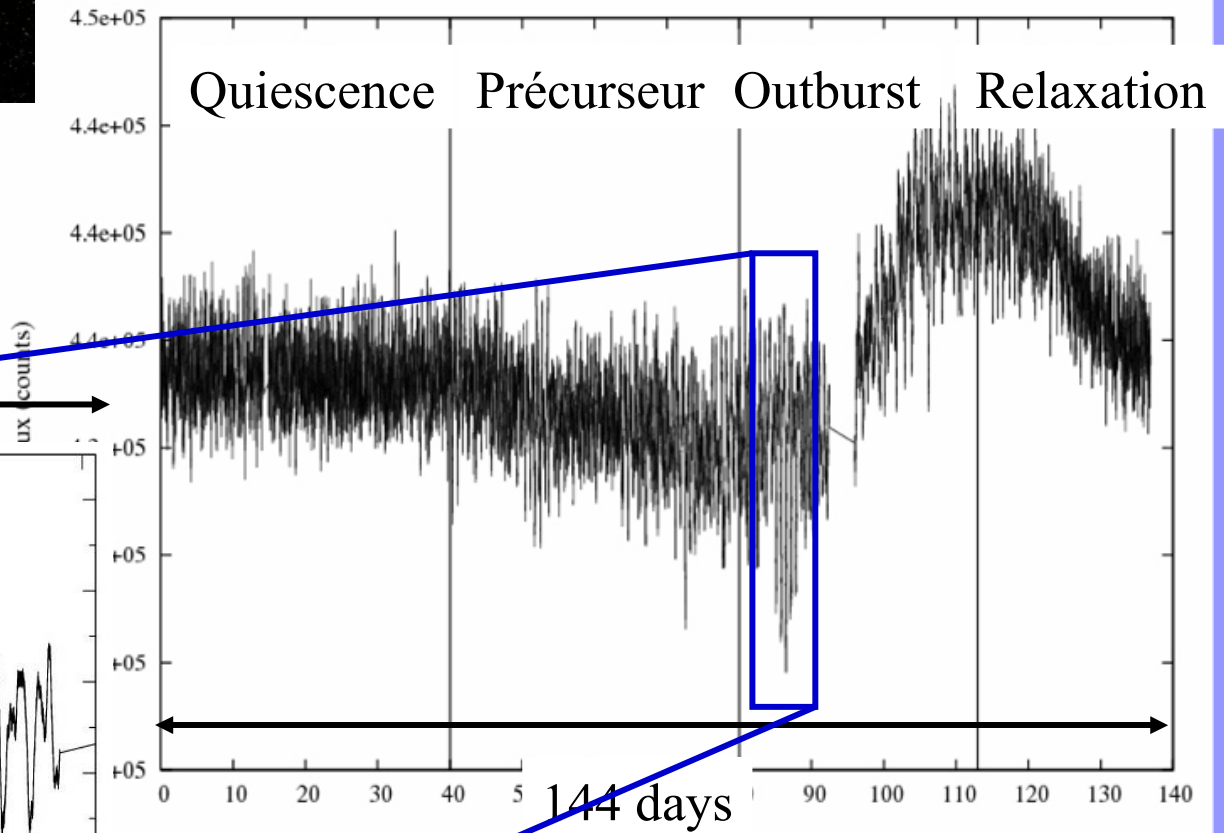
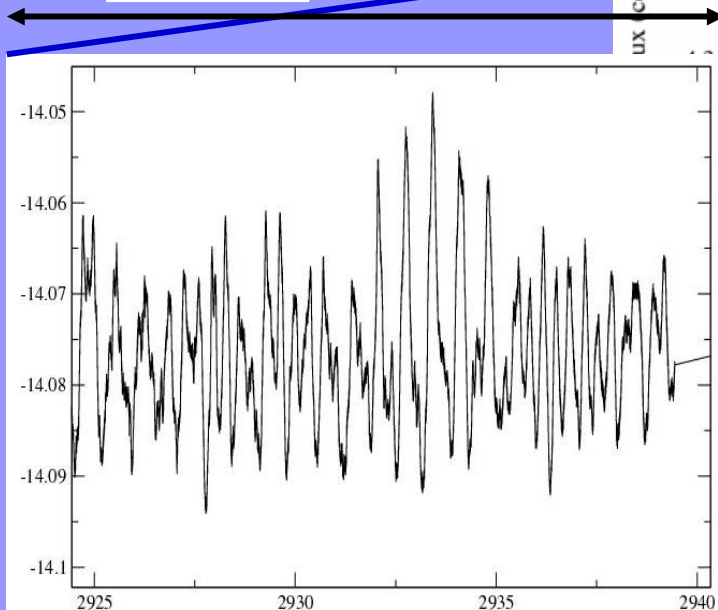
# HD 49330 outburst

- >300 frequencies détected
- 30 independant frequencies



CoRoT photometry

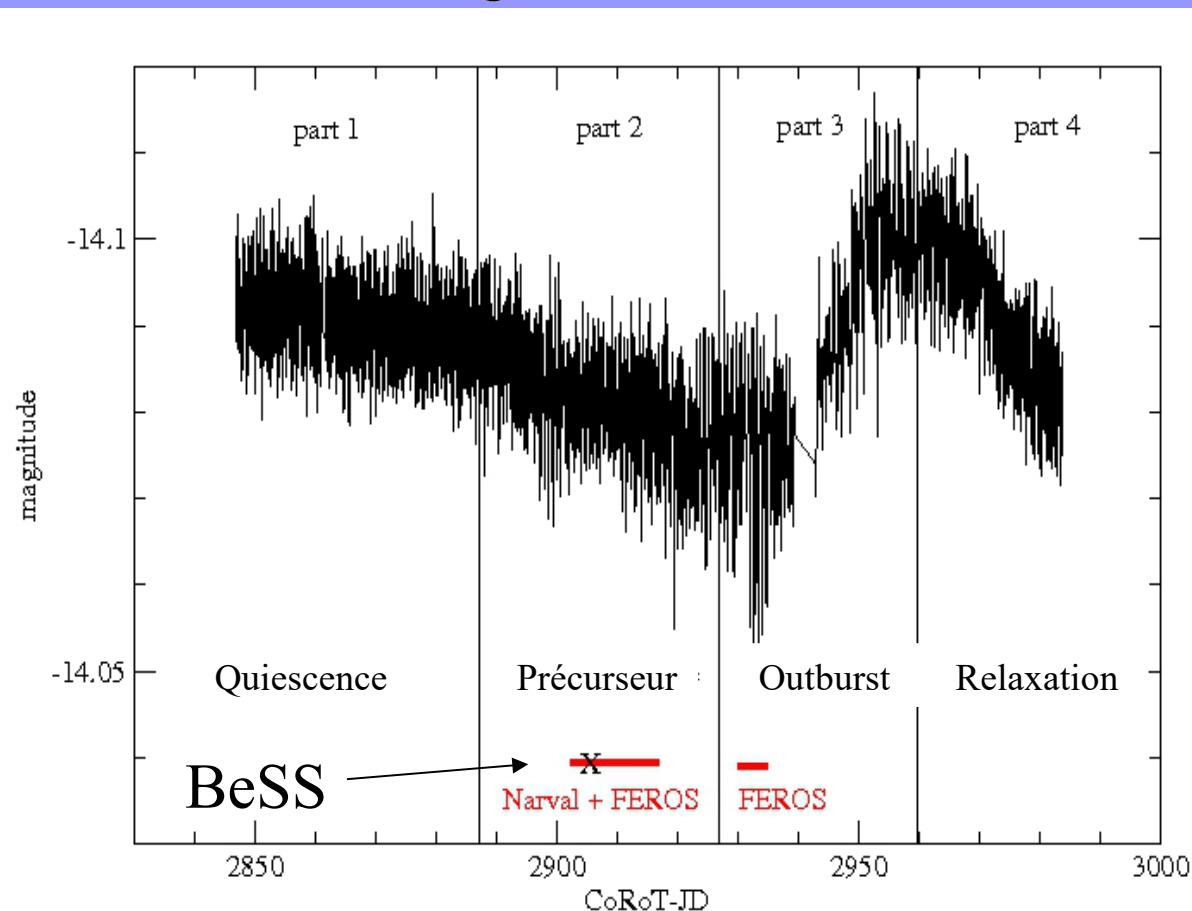
15 days



(Huat et al., 2009)

# HD 49330 outburst

- FEROS at La Silla, Chili (18-28 dec 2007 & 10-14 jan 2008)
  - Narval at TBL, Pic du Midi, France (12-19 dec 2007)
  - Some amateur spectra from BeSS...
- lucky as just before & during outburst!



(Floquet et al. 2009)



# Current status ?

- Clear ***correlation*** between pulsations & material ejection
  - **BUT...** are the ***pulsations triggering*** outburst or ***outburst exciting pulsations*** modes ?
- need to create a model of internal Be star structure and pulsations...
- need more data (amateur observations !)





**Pro/Am collaboration**





# ARAS group

- 2003: Oléron pro/am school (CNRS)
  - need identified for an higher resolution spectrograph → Lhires
  - need for a common portal (->ARAS) and discussion group (->**Spectro-L**)
- 2004 & 2005: Practical spectro camps at OHP observatory
- 2006
  - Standard high resolution spectrograph Lhires III available
  - la Rochelle, second pro/am school
- 2007 & 2008
  - Setup of BeSS database
  - Practical spectro camp at OHP observatory
- 2009
  - Setup of ArasBeAm front-end
  - La Rochelle third pro/am school; OHP spectro camp
- 2010... 2015: OHP practical workshop (**11<sup>th</sup> in 2015**)
- 2012: pro/am symposium (**next: nov 11-15, 2015, near Geneva**)
- 2013: ARAS forum created: **<http://www.spectro-aras.com/forum/>**

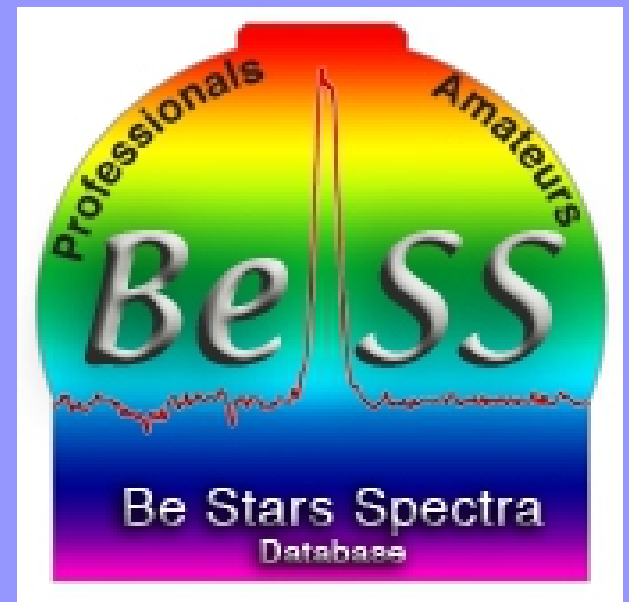
# OHP spectro camps



# BeSS database

- Be Star Spectra: a data base dedicated for Be star spectra
- Specs defined by professionals and amateurs
- Programmation done by GEPI team (Paris-Meudon obs.)
- Started end of 2007
- Support VO requests

- URL: **<http://basebe.obspm.fr>**




# BeSS database

Fichier Édition Affichage Historique Marque-pages Outils ?

BeSS Database

basebe.obspm.fr/basebe/Accueil.php?flag\_lang=en

Rechercher



Professionals Amateurs

BeSS

Be Star Spectra Database

l'Observatoire de Paris

LESIA

**Menu**

- Home
- Be stars
- Spectra
- Records
- Registrations
- Tools
- Help
- Statistics
- Publications
- Credits

**Member Zone**

Observer  
othizy

Password  
●●●●●●●●

Validate Erase

This page allows you to query the catalogue of Be stars for informations.  
Warning: when a parameter (e.g. vsini) is used in a query, only stars for which this parameter is defined in BeSS are returned.

**Be stars query**

There are currently 2320 Be stars in the BeSS catalogue

Be star

RA ( $\alpha$ ) J2000  h  m  s

DEC ( $\delta$ ) J2000  d  '  "

Stellar type

V magnitude between  and

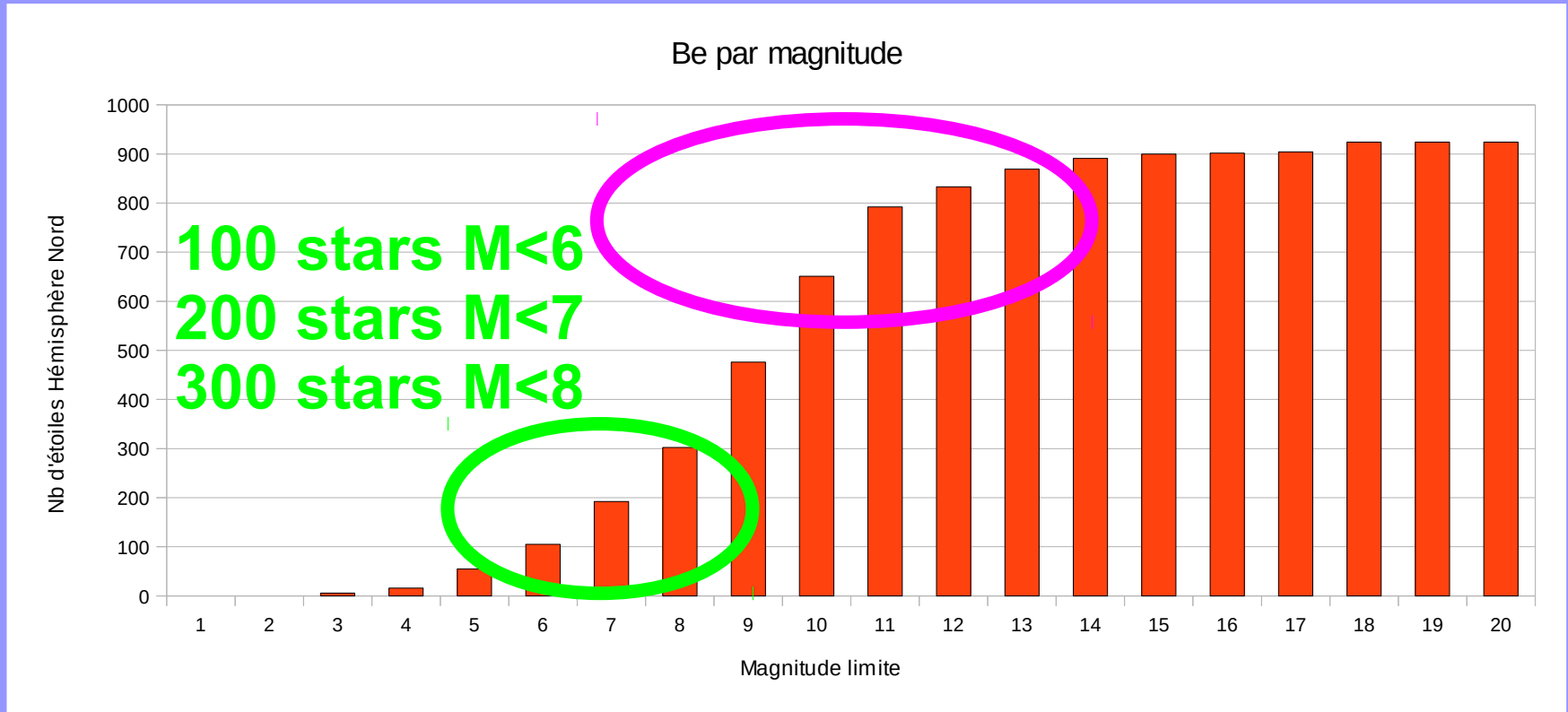
Spectral type between  and

Vsini between  and  km/s

*Note : BeSS also includes Herbig Ae/Be stars now*



# BeSS catalog: 2320 stars



⇒ Lot of targets to « play » with !

- *High resolution (Lhires III, eShel...)*
- *Low resolution (LISA, Alpy 600...)*



# BeSS spectra

- Currently 104070 spectra (or “orders”) in BeSS
  - 55727 from professional (by batches)
- Over 2320 stars in catalog, 1049 (45%) have a spectrum
- Rate is ~10000 spectra/orders per year
- All in «BeSS» FITS format
  - use this file format for your spectra!

Number of spectra inserted in BeSS in 2007: 30754

Number of spectra inserted in BeSS in 2008: 8037

Number of spectra inserted in BeSS in 2009: 7277

Number of spectra inserted in BeSS in 2010: 4028

Number of spectra inserted in BeSS in 2011: 7859

Number of spectra inserted in BeSS in 2012: 25527

Number of spectra inserted in BeSS in 2013: 9136

Number of spectra inserted in BeSS in 2014: 11016

# BeSS spectra

# 48 000

- Currently 14071 spectra for “orders” in BeSS
  - 55727 professional (by chance)
- Over 2320 stars in catalog, 1049 (45%) have a spectrum
- Rate is ~10000 spectra/orders per year
- All in `BeSS.FITS` format
  - use the file format for your telescope

# Amateur

# Spectra !!!

Number of spectra inserted in BeSS in 2007: 50754

Number of spectra inserted in BeSS in 2008: 8037

Number of spectra inserted in BeSS in 2009: 7217

Number of spectra inserted in BeSS in 2010: 4018

Number of spectra inserted in BeSS in 2011: 7859

Number of spectra inserted in BeSS in 2012: 25527

Number of spectra inserted in BeSS in 2013: 9136

Number of spectra inserted in BeSS in 2014: 11016

# BeSS amateur observers

- 68 amateurs (+10 in one year; ~50% on regular basis)
- 80% with Shelyak spectrographs contributing to 98% spectra
- Amateurs contribute to >80% of Halpha spectra !

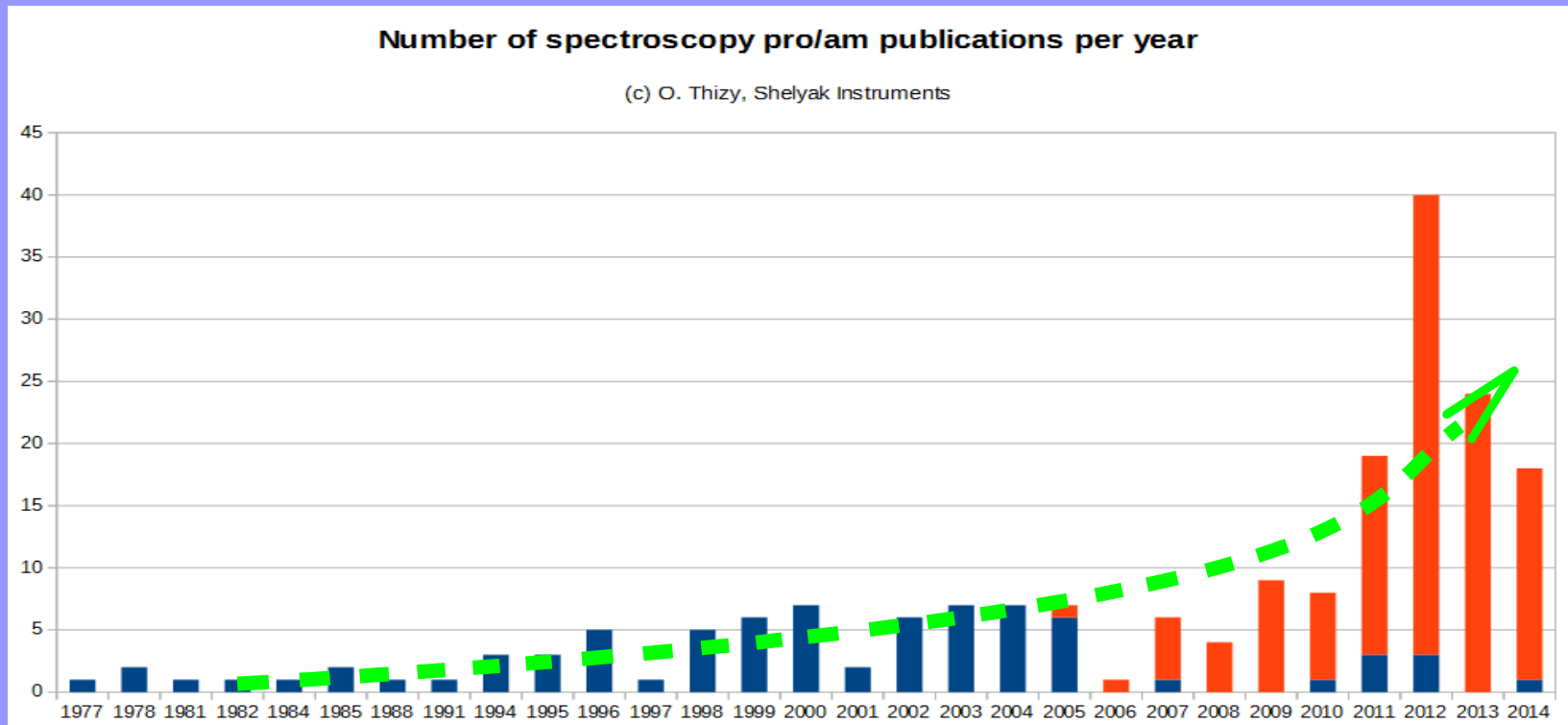
Amateur insomniacs top ten

Spectra	Observer
14573	Thierry GARREL
14156	Christian Buil
4335	Olivier Thizy
3121	Michel Pujol
2230	Joan Guarro Fló
1705	Stephane Charbonnel
1212	Olivier GARDE
930	Valerie Desnoux
909	Bernard Heathcote
720	Ernst Pollmann

Instruments (BeSS)	Spectra	Obs.
Shelyak eShel	40640	8
Shelyak Lhires III	7803	43
Shelyak LISA	479	2
<i>Home Made</i>	380	7
<i>Spectra L-200</i>	228	5
<i>Grating</i>	30	1
Shelyak Alpy 600	20	1
<i>SBIG SGS</i>	2	1
<b>TOTAL</b>	<b>49582</b>	<b>68</b>
incl. Shelyak Instruments	48942	54

# Pro/Am publications

- 87 articles published since 2012 (all subjects, Cf poster)  
(Monthly eruptive stars letter & BeSS report not included - yet)
- 17 with BeSS data
- First A-Tel in 2014: amateur should learn how to publish and make more Am/Pro publications ! :-)



# ARAS BeAm: an amateur tool

Fichier Édition Affichage Historique Marque-pages Outils ?

[ArasBeAm]

arasbeam.free.fr/spip.php?page=beam\_belist2&lang=en

Rechercher

[Workshop in medium H-alpha V/R time behavior in  \$\pi\$  Aqr](#)  
[Monitoring the radial velocity of  \$\zeta\$  Tauri](#)  
[H-alpha radial velocity observations of  \$\gamma\$  Cas](#)  
[Periodic behavior of the H \$\epsilon\$ 6678 emission in  \$\delta\$  Sco](#)

**Be datasheets**  
[H \$\alpha\$ -emission and V-correlations as probes of Be stars disks](#)  
[Short report of the delta Sco periastron passage campaign 2011](#)  
[Zet Oph litterature history](#)  
[SHELIAK litterature and history](#)  
[Bet Mon A: historical evolution](#)

**Links**  
[BeSS](#)  
[ARAS website](#)

List of Be stars with Magn lower than 9  
Max declination : 90°  
Min declination : -25°

## High Resolution Program: H $\alpha$ (6563 Å), R > 5000

Recently observed	To be observed soon	To be observed immediately	Intensive observation required
-------------------	---------------------	----------------------------	--------------------------------

495 objects

Star	HD #	RA	DEC	Magn.	Sp. type	Tot. nb	1 year	2 months	Last	Obs Period
+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
<a href="#">HD 224905</a>	224905	+00 01 38.6	+60 26 59.7	8.47	B1Vne	4	1	0	2014-11-16 21:23:59	365
<a href="#">HD 225095</a>	225095	+00 03 27.1	+55 33 03.2	7.95	B2IVne	7	1	0	2014-10-23 20:18:30	365
<a href="#">2 Cet</a>	225132	+00 03 44.4	-17 20 09.6	4.54	B9IVne	21	2	0	2014-12-14 04:09:05	365
<a href="#">10 Cas</a>	144	+00 06 26.5	+64 11 46.2	5.57	B9IIIe	28	3	0	2014-11-02 22:09:02	365
<a href="#">V742 Cas</a>	698	+00 11 37.1	+58 12 42.6	7.08	B5IIe	20	2	0	2014-10-05 22:10:04	365
<a href="#">BD+61 39</a>	0	+00 20 17.4	+62 27 49.9	8.85	B0.5IVe	4	1	0	2014-12-05 01:24:34	365
<a href="#">HD 2789</a>	2789	+00 32 02.8	+67 09 40.1	8.36	B3Vne	10	1	0	2014-09-11 23:05:08	365
<a href="#">omi Cas</a>	4180	+00 44 43.5	+48 17 03.7	4.48	B5IIIe	51	8	0	2015-02-07 21:05:37	365
<a href="#">HD 4931</a>	4931	+00 52 15.5	+60 05 23.8	8.72	B8Ve	5	1	0	2014-12-21 01:04:02	365
<a href="#">gam Cas</a>	5394	+00 56 42.5	+60 43 00.3	2.47	B0IVpe	741	111	8	2015-04-02 19:23:49	30
<a href="#">V442 And</a>	6226	+01 03 53.4	+47 38 32.3	6.82	B2IVe	64	18	1	2015-03-05 23:44:15	30
<a href="#">HD 6343</a>	6343	+01 05 53.0	+65 58 15.8	7.26	B8e	13	3	0	2014-10-30 19:36:59	365
<a href="#">phi And</a>	6811	+01 09 30.1	+47 14 30.5	4.25	B7Ve	62	8	2	2015-03-08 19:43:01	365
<a href="#">V764 Cas</a>	7636	+01 17 26.3	+57 37 55.5	6.89	B2IIIe	24	2	0	2014-10-03 21:48:15	365
<a href="#">HD 7720</a>	7720	+01 18 27.1	+61 53 34.5	8.86	B5IIe	6	1	0	2014-12-20 02:24:45	365
<a href="#">BD+62 271</a>	0	+01 34 49.1	+63 37 35.8	8.58	B8Ve	3	0	0	2013-11-22 22:41:44	365
<a href="#">HD 9709</a>	9709	+01 36 03.1	+47 06 52.1	7.07	B9e	13	1	0	2014-09-06 01:11:57	365

# ArasBeAm: new spectra

Resultats

arasbeam.free.fr/spip.php?page=beam\_splist2&etoile=lam Eri&lang=en

Rechercher

H-alpha V/R time behavior in  $\pi$  Aqr

Monitoring the radial velocity of  $\zeta$  Tauri

H-alpha radial velocity observations of  $\gamma$  Cas

Periodic behavior of the H $\epsilon$ 6678 emission in  $\delta$  Sco

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**Links**

BeSS

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### Available spectra for this star :

Common name	QR Vul
HD #	HD192685
RA	+20 15 15.9
DEC	+25 35 31.1
Magnitude	4.759
Spectral type	B3Ve
Expected observation period	30

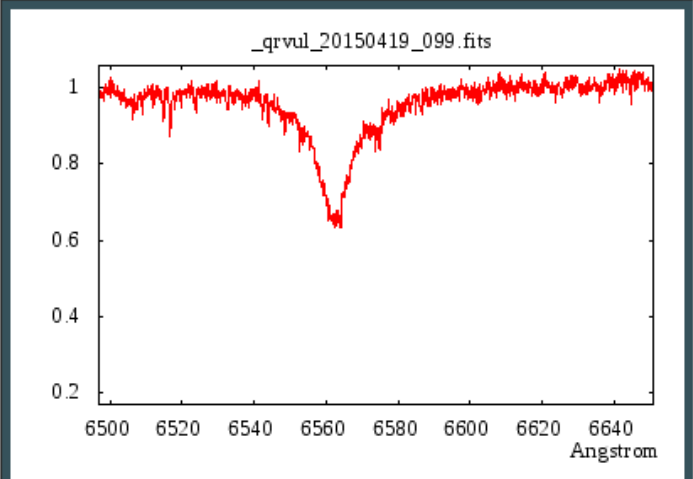
**High resolution spectra ( $R \geq 5000$ )**

**Low resolution spectra ( $R < 5000$ )**

200 available spectra.  
View of spectra 1 - 100.  
[Next page](#)

# 111347

\_qrvul\_20150419\_099.fits



Angstrom

Obs. date : 2015-04-19 02:22:03

Instrument : C9 LHIRE53\_2400 ATIK460EX

Observation duration : 2727 s.

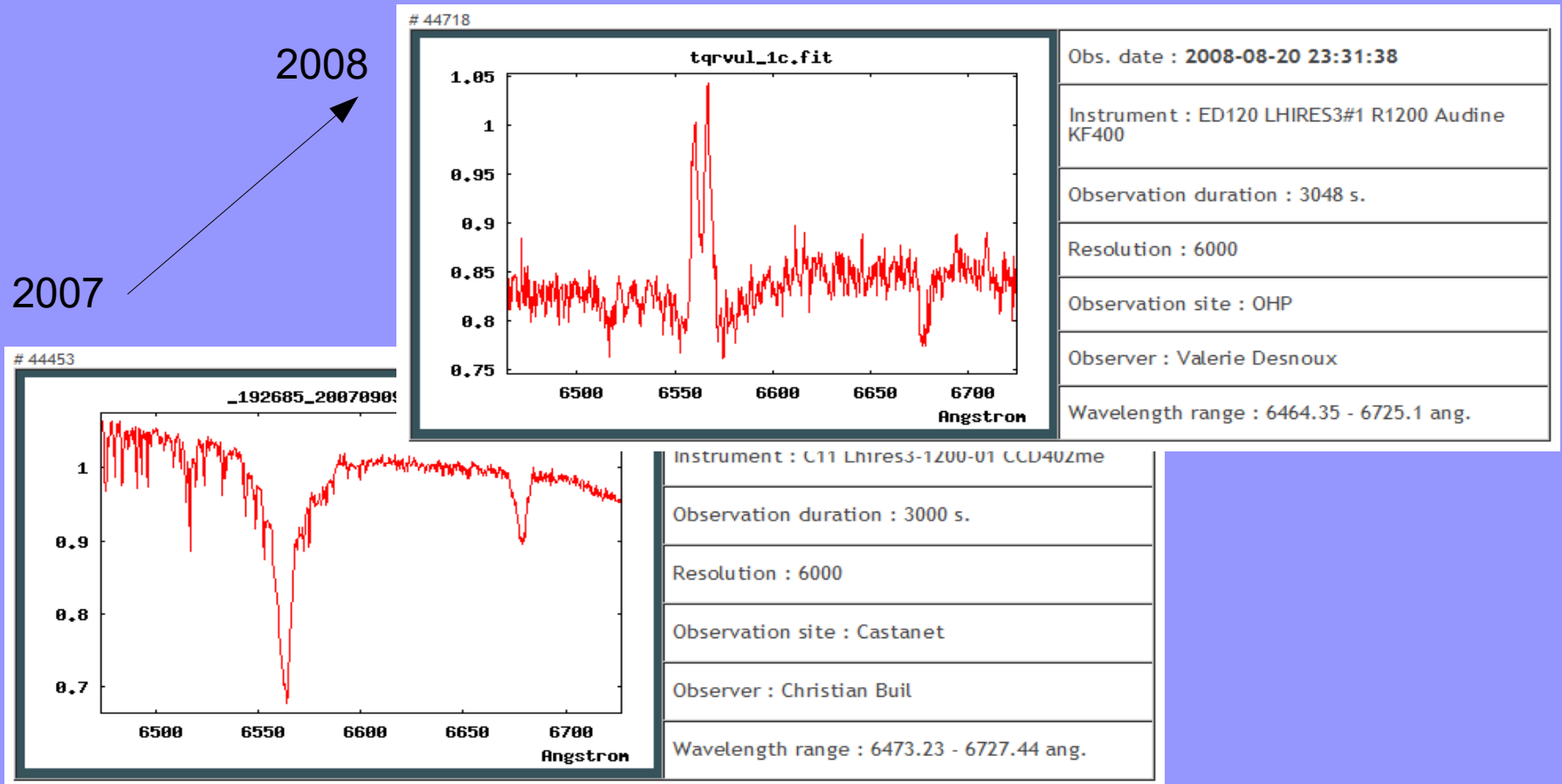
Resolution : 15000

Observation site : Paris Saint-Charles

Observer : Valerie Desnoux

Wavelength range : 6496.88 - 6650.88 ang.

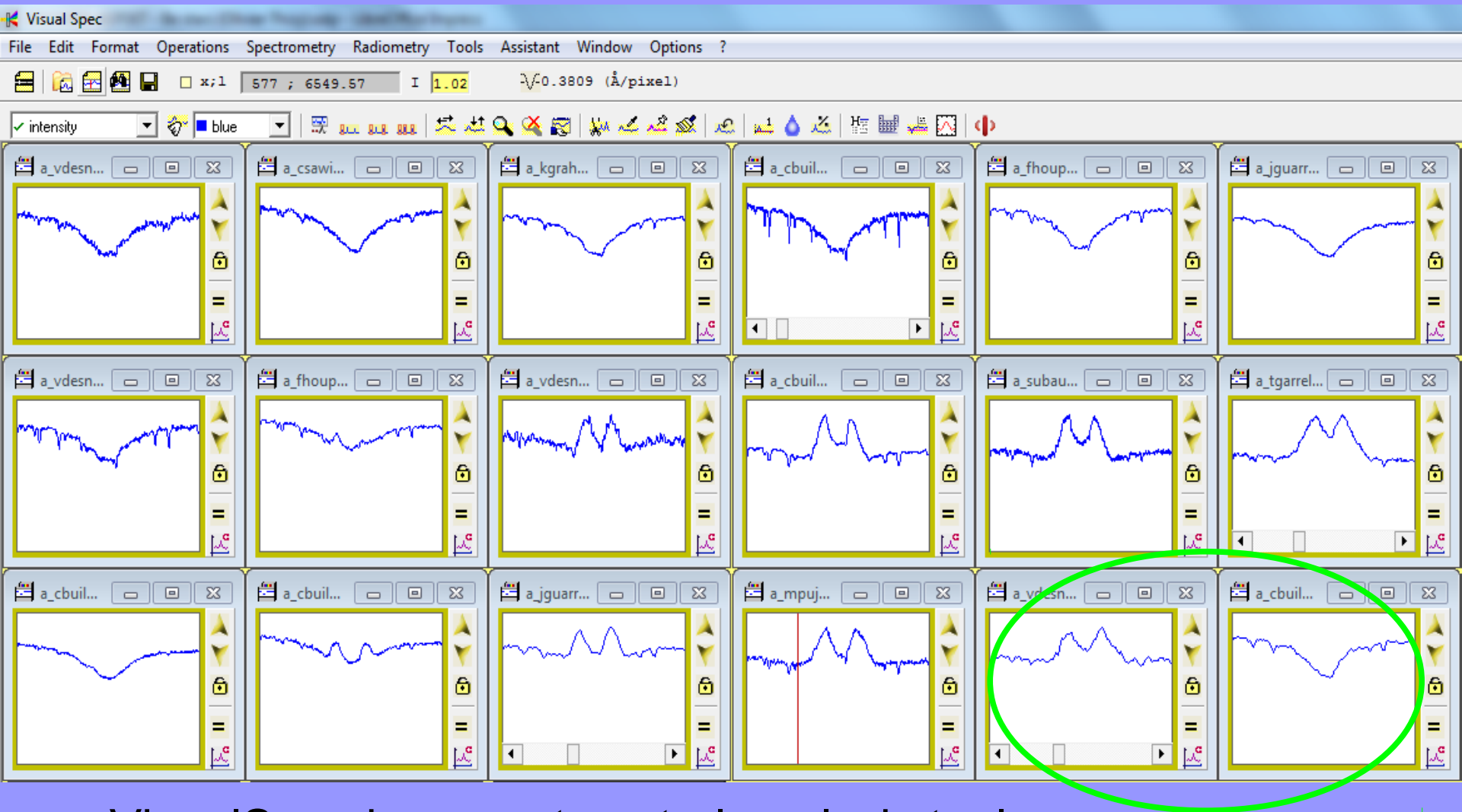
# Example of QR Vul



- QR Vul outburst detected in august 2008 by Valérie Desnoux using a small 12cm refractor during OHP spectro. workshop
- More than 30 outbursts detected + several «evolutions» on all Be stars monitored by amateurs...



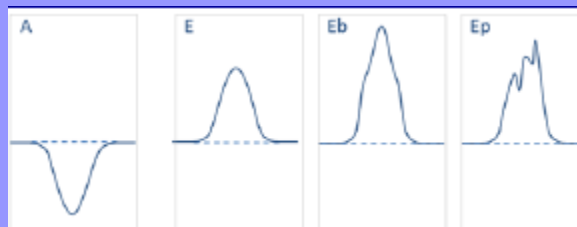
# VisualSpec tools



- VisualSpec is a great spectral analysis tool with direct link to BeSS database

# Spectra profiling

- Effort done last few years to catalog the stars based on their profile and look for evolution
- 1st letter :
  - A (absorption)
  - E (emission)
- 2nd letter : if a second line is visible (upper/lower case depending if it crosses the previous line base)



# Profile evolution study

- Work in Progress !

Etoile	HD	RA	DEC	Mag	Période	Profil	Variabilité
<a href="#">2 Cet</a>	225132	+00 03 44.4	-17 20 09.6	4.54	365	Aea	Aea-Aea
<a href="#">10 Cas</a>	144	+00 06 26.5	+64 11 46.2	5.57	365	AEa	
<a href="#">V742 Cas</a>	698	+00 11 37.1	+58 12 42.6	7.08	365	Ep	
<a href="#">omi Cas</a>	4180	+00 44 43.5	+48 17 03.7	4.48	365	E	
<a href="#">gam Cas</a>	5394	+00 56 42.5	+60 43 00.3	2.47	30	Ep	Ep
<a href="#">V442 And</a>	6226	+01 03 53.4	+47 38 32.3	6.82	7, 30	Ea	A-Ea-A-Ea
<a href="#">HD 6343</a>	6343	+01 05 53.0	+65 58 15.8	7.26	365	AE	
<a href="#">phi And</a>	6811	+01 09 30.1	+47 14 30.5	4.25	365	Ae	
<a href="#">V764 Cas</a>	7636	+01 17 26.3	+57 37 55.5	6.89	365	Eb	
<a href="#">HD 9709</a>	9709	+01 36 03.1	+47 06 52.1	7.07	365	AEa	
<a href="#">HD 9612</a>	9612	+01 37 22.2	+74 18 03.4	6.59	365	AEa	
<a href="#">phi Per</a>	10516	+01 43 39.6	+50 41 19.4	4.09	365	Ep	Ea, V/R
<a href="#">eps Cas</a>	11415	+01 54 23.7	+63 40 12.4	3.34	365	A	
<a href="#">V777 Cas</a>	11606	+01 55 42.9	+59 16 24.4	7.02	365	Ea	
<a href="#">V787 Cas</a>	13590	+02 15 13.0	+64 01 28.0	7.9	365	Ea	Ea
<a href="#">tet Ari</a>	14191	+02 18 07.5	+19 54 04.2	5.58	365	AeA	
<a href="#">HD 17505</a>	17505	+02 51 08.0	+60 25 03.9	7.1	365	A	
<a href="#">HD 18552</a>	18552	+03 00 11.9	+38 07 54.3	6.12	365	Ea	
<a href="#">V801 Cas</a>	19243	+03 08 54.2	+62 23 04.5	6.5	365	Eb	
<a href="#">HD 20134</a>	20134	+03 16 59.8	+60 04 03.0	7.47	90	A	A-Ae-AE-Aea-A
<a href="#">BK Cam</a>	20336	+03 19 59.3	+65 39 08.3	4.73	365	Ea	
<a href="#">HD 21362</a>	21362	+03 28 52.3	+49 50 54.2	5.58	365	AEa	A 2001, AEa 2008
<a href="#">HD 21455</a>	21455	+03 29 26.3	+46 56 16.3	6.23	365	AEa	
<a href="#">HD 21650</a>	21650	+03 31 15.7	+41 43 35.2	7.33	365	Ea	
<a href="#">HD 21620</a>	21620	+03 31 29.3	+49 12 35.2	6.28	365	AeA	
<a href="#">HD 21641</a>	21641	+03 31 33.1	+47 51 44.7	6.77	365	AEa	
<a href="#">psi Per</a>	22192	+03 36 29.4	+48 11 33.5	4.31	365	Ea	V/R
<a href="#">CT Cas</a>	22238	+03 38 01.0	+55 10 15.1	7.69	120	Ea	
<a href="#">HD 22780</a>	22780	+03 41 07.9	+37 34 48.7	5.54	90	AEa	Aea-AeA-A-AEa
<a href="#">13 Tau</a>	23016	+03 42 18.9	+19 42 00.9	5.68	365	AeA	
<a href="#">ELECTRA</a>	23302	+03 44 52.5	+24 06 48.0	3.71	120	AeA	Aea - AeA
<a href="#">MEROPE</a>	23480	+03 46 19.6	+23 56 54.1	4.16	365	Aea	AEa -VR - A increase
<a href="#">ALCYONE</a>	23630	+03 47 29.1	+24 06 18.5	2.87	365	AEa	
<a href="#">HD 23552</a>	23552	+03 48 18.1	+50 44 12.4	6.15	365	AEa	
<a href="#">PLEIONE</a>	23862	+03 49 11.2	+24 08 12.2	5.05	7, 30	EA	Ea-EA
<a href="#">HD 23800</a>	23800	+03 50 25.1	+52 28 54.9	6.98	365	Ea	Ea & A
<a href="#">HD 24479</a>	24479	+03 57 25.4	+63 04 20.1	4.95	365	AeA	AeA - VR - E central rate.

# New campaign: low resolution

Eichier Édition Affichage Historique Marque-pages Outils ?

[ArasBeAm] x +

arasbeam.free.fr/spip.php?page=beam\_belist2&lang=en

Rechercher

H-alpha V/R time behavior in  $\pi$  Aqr  
Monitoring the radial velocity of  $\zeta$  Tauri  
H-alpha radial velocity observations of  $\gamma$  Cas  
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Zet Oph literature history  
SHELIAC literature and history  
Bet Mon A: historical evolution

Links

BeSS  
ARAS website

List of Be stars with Magn lower than 14  
Max declination : 90°  
Min declination : -25°

All Resolutions Program: H $\alpha$  (6563 Å)

Recently observed			To be observed soon			To be observed immediately				
940 objects										
Star	HD #	RA	DEC	Magn.	Sp. type	Tot. nb	1 year	2 months	Last	Obs Period
<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -	<input type="checkbox"/> + <input type="checkbox"/> -
BD+62 2346	0	+00 01 24.7	+63 30 15.7	9.73	B0Ve	2	1	0	2014-11-15 21:54:39	202
HD 224905	224905	+00 01 38.6	+60 26 59.7	8.47	B1Vne	4	1	0	2014-11-16 21:23:59	202
HD 225095	225095	+00 03 27.1	+55 33 03.2	7.95	B2IVne	7	1	0	2014-10-23 20:18:30	202
2 Cet	225132	+00 03 44.4	-17 20 09.6	4.54	B9IVne	24	4	0	2014-12-14 04:09:05	202
10 Cas	144	+00 06 26.5	+64 11 46.2	5.57	B9IIIe	30	3	0	2014-11-02 22:09:02	202
BD+59 2829	0	+00 06 48.3	+60 36 00.8	9.86	B1Ve	1	0	0	2012-10-27 18:20:52	202
BD+62 1	0	+00 07 33.2	+63 04 49.2	10.46	B2IVpe	1	0	0	2012-10-27 19:02:46	202
BD+62 11	0	+00 10 46.9	+63 10 22.6	9.60	B5Ve	4	2	0	2014-11-22 17:20:10	202
V742 Cas	698	+00 11 37.1	+58 12 42.6	7.08	B5IIe	20	2	0	2014-10-05 22:10:04	202
EM* AS 2	0	+00 12 59.2	+66 19 19.4	10.58	B5e	1	0	0	2012-10-29 17:18:53	202
BD+61 39	0	+00 20 17.4	+62 27 49.9	8.85	B0.5IVe	4	1	0	2014-12-05 01:24:34	202
BD+63 48	0	+00 26 40.1	+64 25 55.4	9.26	B1IIInne	2	0	0	2013-08-06 02:16:52	202
BD+55 81	0	+00 28 12.0	+56 23 47.5	10.02	B1.5Vnne	3	2	0	2014-12-22 18:27:51	202
BD+62 89	0	+00 29 49.2	+63 04 04.0	10.25	B0Vpe	1	0	0	2012-10-29 19:21:08	202
BD+61 105	0	+00 31 19.2	+62 25 39.4	9.34	O9Ve	1	0	0	2012-10-29 19:53:19	202
VX Cas	0	+00 31 30.7	+61 58 51.0	11.41	A0e	0	0	0		202

**BeSS coverage rate increased from 28% (2010) to 45% (2015)**

# Automated observation: future ?

- Three amateurs have done automated spectral acquisition
  - Michel Pujol, major author on AudeLA, with Lhires III and eShel spectrographs
  - Thierry Lemoult wrote a large script on PRISM and uses LISA & eShel spectrographs
  - Andrew Smith with The Sky X and LISA
- New projet started a year ago : monitor B stars to detect new emission (new Be stars)
  - data reduction and spectral analysis still require some effort
  - no database for B star, coordination on ARAS forum

Done by Valérie Desnoux !

# BeSS monthly report

Pour spectro-l@yahoogroups.com ✨, Thomas Rivinius ✨

## BeSS report – October 2014

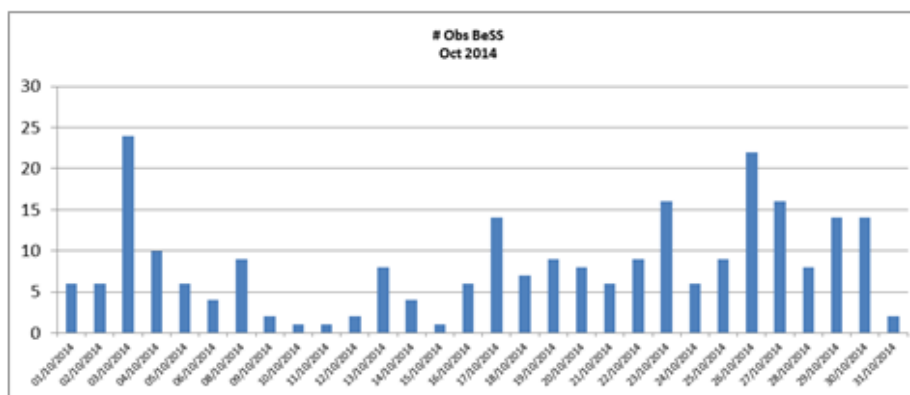
Data compiled by Valérie Desnoux

Do not miss the new section on the Be projects by Ernst Pollmann [here](#)

Observateur	Nb spec
Pujol	100
Buil	42
Guarro Fló	22
Graham	17
Sawicki	16
MontigianiMannucci	12
Fosanelli	8
HOUPERT	7
Bohlson	5
Berardi	4
Pollmann	4
GARREL	4
Heidemann	2
LAILLY	2
Powles	2
Sollecchia	2
Leonardi	1
<b>Total général</b>	<b>250</b>

- 250 H-alpha spectra acquired
- 140 objects observed
- 17 observers contributed

The most observed objects were gam Cas, pi Aqr and V2136 Cyg, lam Cyg, V442 And



## Objects observed

Classique								?	Herbig
pi Aqr	HD 6343	HD 205060	kap Aql	KX And	28 Cyg	V2163 Cyg	10 Cas	V594 Cas	V1578 Cyg
gam Cas	18 And	NN CMa	AX Mon	V868 Ara	HD 21641	LQ And	HD 196712		AB Aur
phi Per	omi And	HD 44996	11 Cam	HD 205551	16 Peg	43 Ori	HD 61224		
V442 And	eps Cas	V1150 Tau	HD 37352	HD 223387	HD 50820	bet Psc	HD 50658		
lam Cyg	zet Tau	20 Vul	HD 13867	V378 And	tet Ari	HD 232590	HD 20017		
V2136 Cyg	HD 17505	HD 21650	V549 Per	lam Eri	EW Lac	iot Lyr	ALCYONE		
PLEIONE	V1369 Ori	HD 23800	psi Per	HD 206773	120 Tau	HD 21620	HD 71072		



# BeSS team: thanks to them !







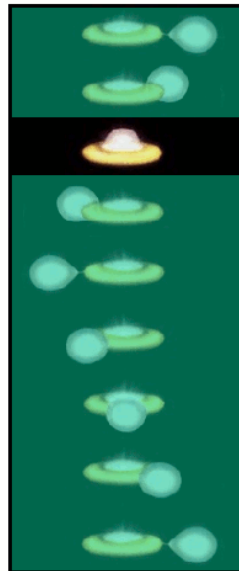
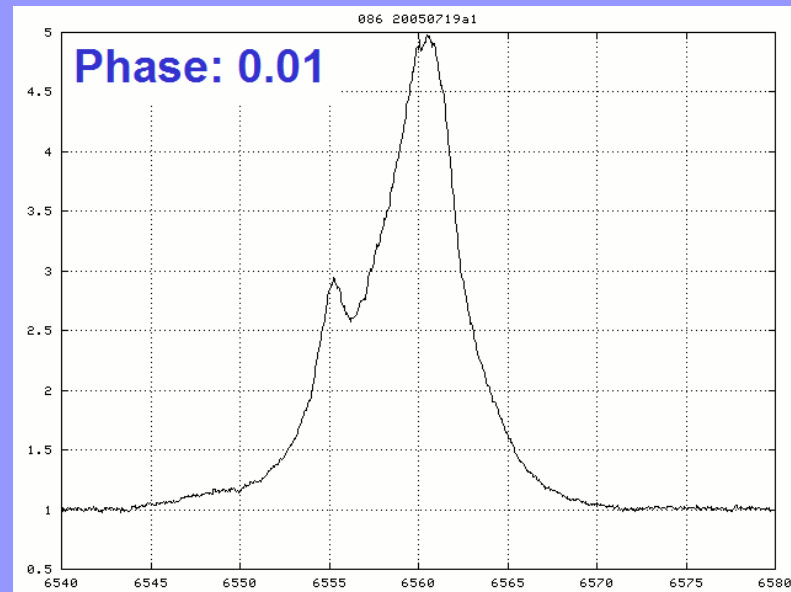
**Time for Action ...**



# Practice and learn

- gamma Cassiopae
  - *bright, easy to find, circumpolar, strong emission*
  - *reduce your data (ISIS)*
  - *compare with BeSS latest spectra*
  - *format into BeSS FITS file*
  - *upload your first spectrum on BeSS*

- beta Lyrae  
(Shelyak !)
  - Look for night after night changes on H $\alpha$  (~13 days period)





# Which emission lines to see ?

- Hydrogene lines are the most prominent ones
  - $H\alpha$  6562.8,  $H\beta$  4861.3,  $H\gamma$  4340.5,  $H\delta$  4101.7,  $H\epsilon$  3970.1
  - If the star is in a Be phase, there will be emission in  $H\alpha$ .  
Depending on disk density, there will also be  $H\beta$  emission, possibly  $H\gamma$ .  $H\delta$  and  $H\epsilon$  are usually not seen in emission.
- Neutral helium HeI can be found
  - for exemple at 4009.3, 4026.2, 4143.7, 4387.9, 4437.5, 4471.5, 4713.1, 4921.9, 5875.6, and 6678.2
- Other lines can be visible in Be stars
  - CII (3920, 4267, 4738, 4745, 6578, 6583...), NII (3995, 4630...), OII (4119, 4367, 4415, 4642, 4649, 4662...), MgII (mainly 4481), SiIII (4552, 4568 & 4575 triplet; several lines around 3800; also at 3924, 4338, 4813, 4829 & 5740), SiII (3856, 3863, 4128, 4131, 5041, 5056, 6347, 6371), and sometimes iron FeII lines...

# Contribute !

- ARAS BeAm
  - *Look for “red” status for your telescope range*
  - *Look for stars with short observation period requested*
- Spectro-L & ARAS forum
  - Join the discussion group and follow campaign launched
  - Look for alert on outbursts
  - Publish your results
- Other campaigns?
  - Of course! Expand to other campaigns: P Cygni, bright novae, Wolf-Rayet, pulsating stars, etc...

# Some Be stars of interest...

- **delta Sco** is a key binary system with very strong variable emission... very interesting star!
- **48 Lib**: very interesting, V/R ratio is growing since few years; to monitor
- **beta CMi**: late Be star, symmetrical V/R but radial velocity to monitor. ~700 days period? Need more data there to constraint a period...
- **phi Per**: Equivalent Width changing over time
- **66 Oph**: double peak spectrum, more southern but interesting to look at. Peak separation changed between the 1990's and now. Is disk dissipating?

# Some Be stars of interest...

- **omi Cas**: no emission lines in 1970's; Intensity around 4 in 1990's and now around 6. Is the emission single-peak or triple?

Concentration of material in a Roche lobe with presence of a companion? EW went from 20 in the 1990's to 40Å

- **pi Aqr**: single peak in 1982, double peak after, then in 1996 absorption line with a single line swinging with a period of 84 days. It is worth to continuous monitor this star now

- bright Be binary candidates to monitor (with EW in bracket): EW Lac (46), V777 Mon (20-45), V695 Mon (45), HD206773 (0-43), 105 Tau (42), HD208682 (41), phi Per (30-40), HD 202904, DX Eri, nu Gem

- And more: V442 And, 14 Lac, lam Eri, V2136 Cyg, FF Cam, HL Lib, lam Cyg, OT Gem, CX Dra, eta Ori, QR Vul, V696 Mon, Pleione, V341 Sge, etc...



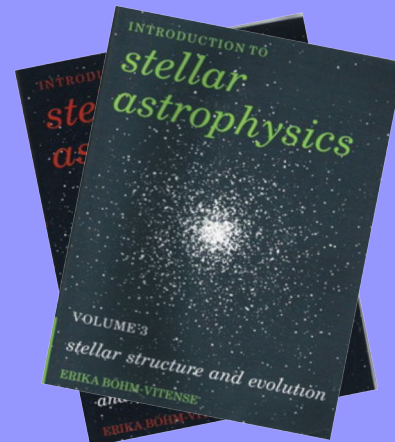
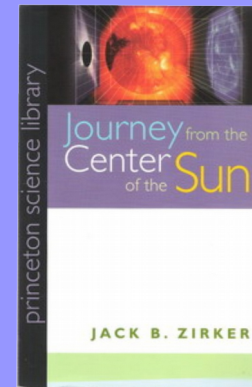
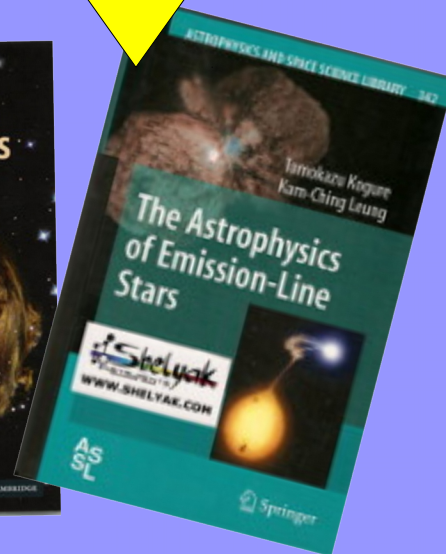
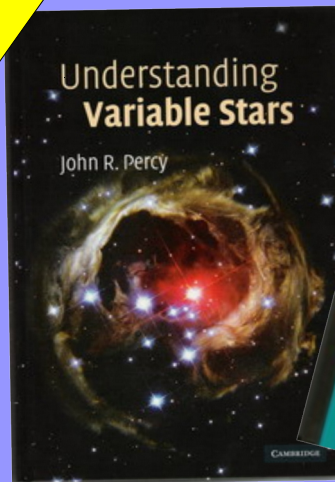
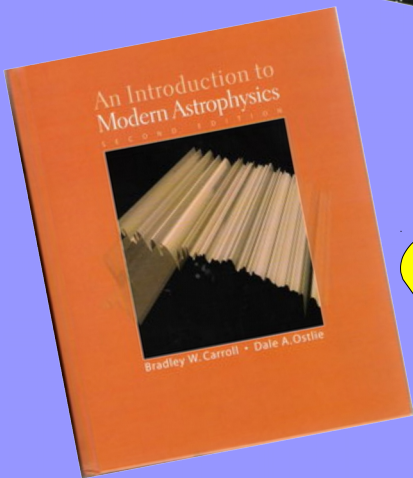
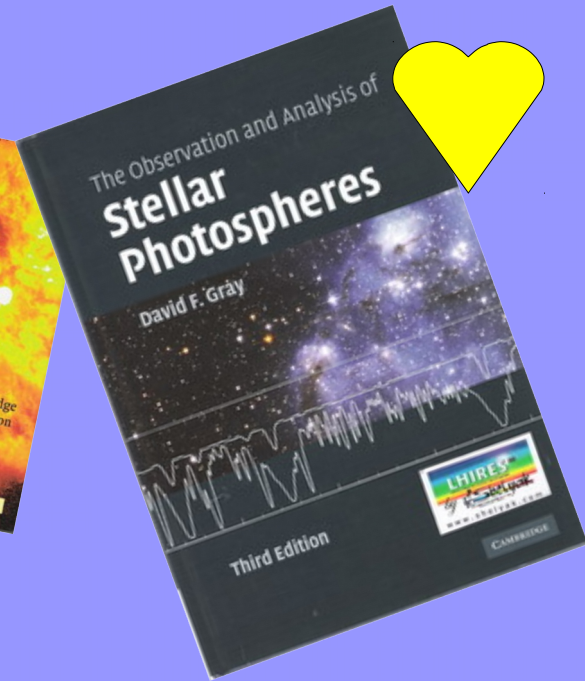
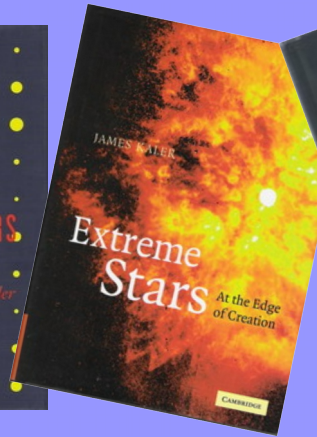
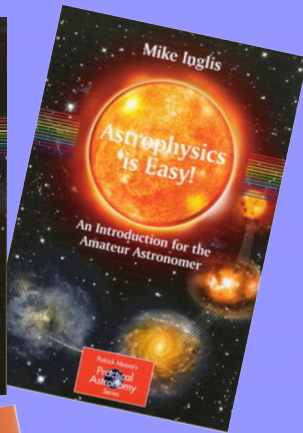
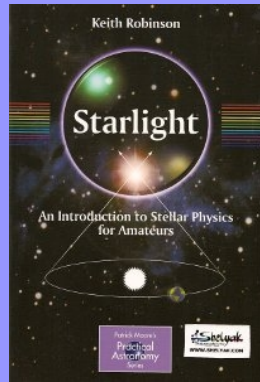
# Conclusions

- Be Stars = ***fun*** and ***exciting*** project  
Ideal to ***learn*** spectroscopy
- Then join ***other campaigns***  
while continuing to observe Be stars:
  - P Cygni
  - VV Cep
  - Wolf-Rayet
  - Active Massive Hot stars in general
  - Eruptive stars, novae...
  - RR Lyrae, BW Vul, other pulsating stars
  - Spectroscopic binaries
  - exoplanets...



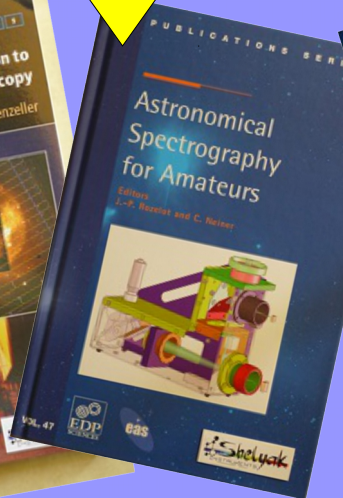
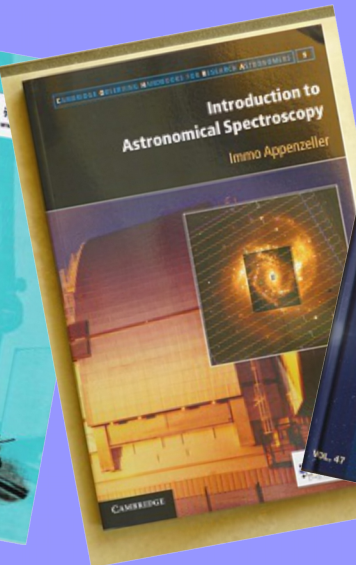
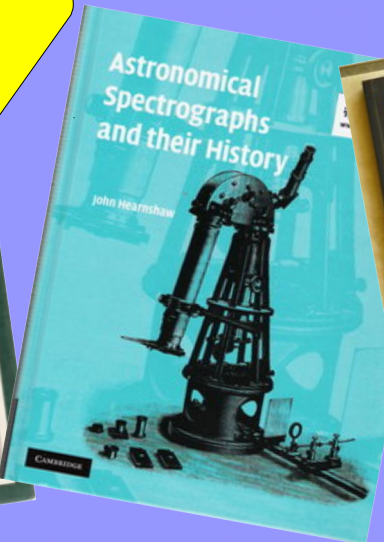
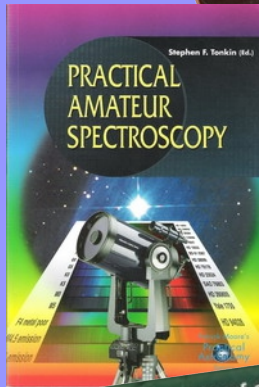
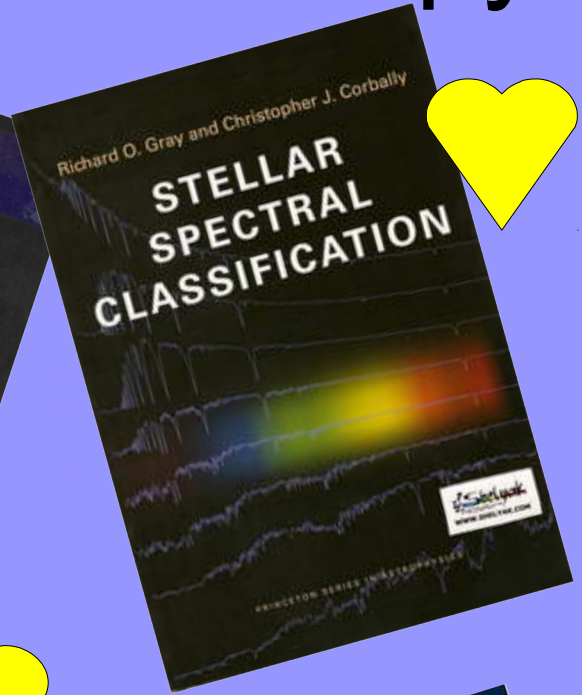
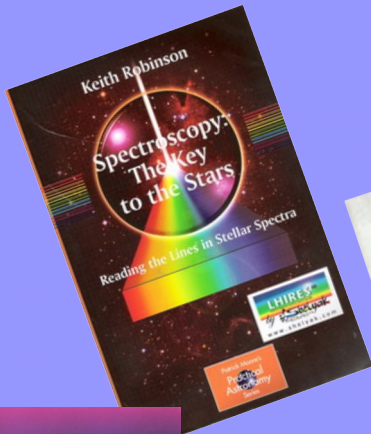
**JOIN US !!!**

# Some books on Astrophysics





# Some books on Spectroscopy



# Some useful links

Groupe ARAS: <http://www.astrosurf.com/aras/>

Liste Spectro-L: [http://groups.yahoo.com/group/\*\*spectro-l\*\*/](http://groups.yahoo.com/group/spectro-l/)

ARAS forum: [http://www.\*\*spectro-aras.com/forum\*\*/](http://www.spectro-aras.com/forum/)

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

ADS (articles) [http://adsabs.harvard.edu/abstract\\_service.html](http://adsabs.harvard.edu/abstract_service.html)

Shelyak [http://www.\*\*shelyak\*\*.com/dossier.php?id\\_dossier=24?lang=2](http://www.shelyak.com/dossier.php?id_dossier=24?lang=2)

Some key articles (cf ADS):

- Slettebak, A. 1988, Publication of the Astronomical Society of the Pacific (PASP), 100, 770-784
- Porter, J. M., Rivinius T., 2003. Publications of the Astronomical Society of the Pacific, 115:1153–1170
- Proceedings IAU Symposium No. 272, 2010 (introduction by Baade et al; Be star population by Martayan et al.; etc...)



Stars won't  
look the same o

**Thank You !!!**



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