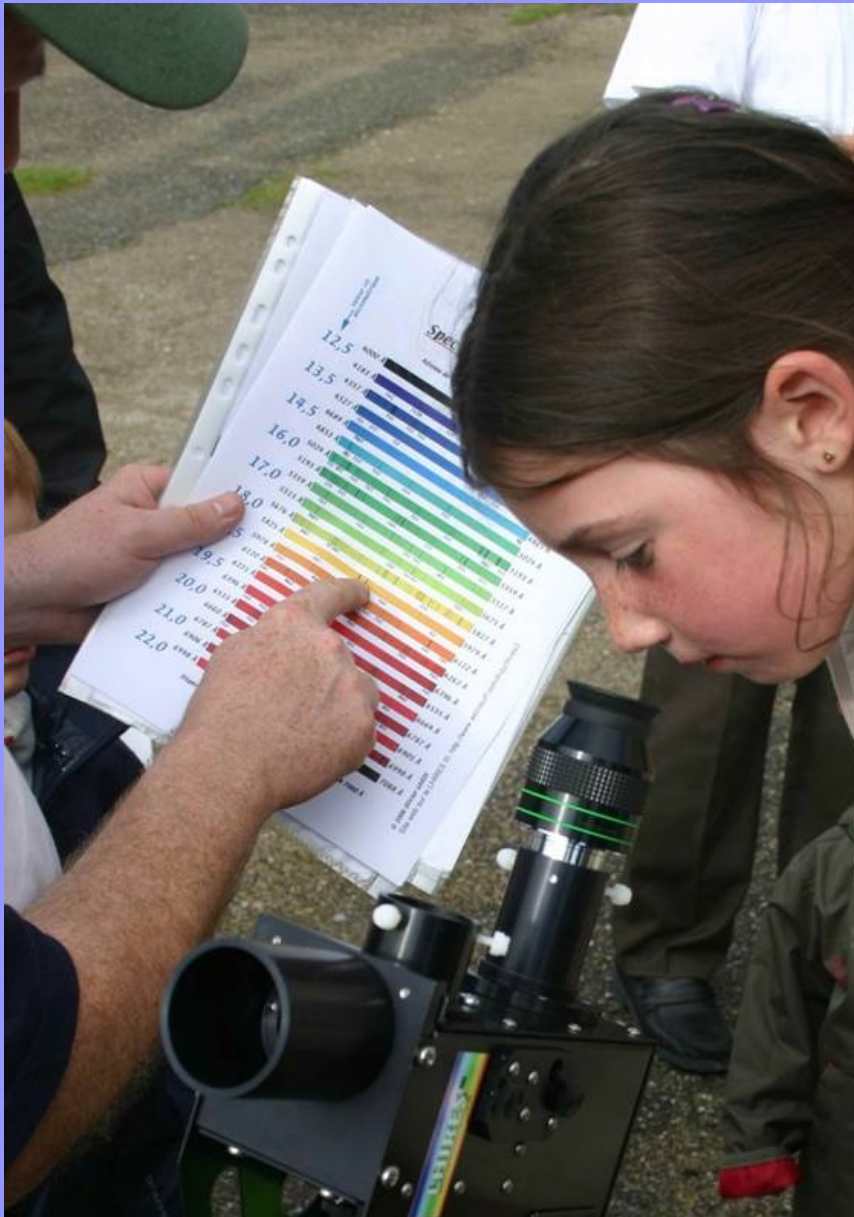


High-Resolution Spectroscopy of Classical Be stars

Olivier Thizy
olivier.thizy@shelyak.com

MAF
September 20th, 2009
-- Denmark --



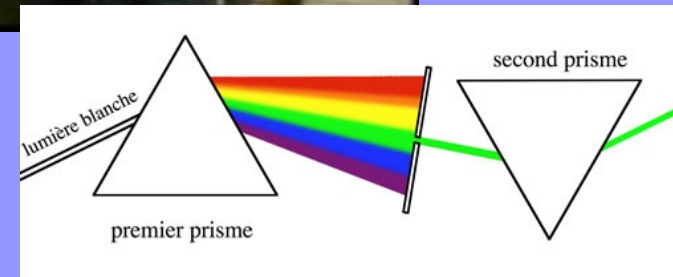
the “menu”...

- historical background and some theory about spectroscopy
- Be stars: astrophysical context
- focus on β Lyrae
- pro/am collaboration
- Time for action
- conclusion



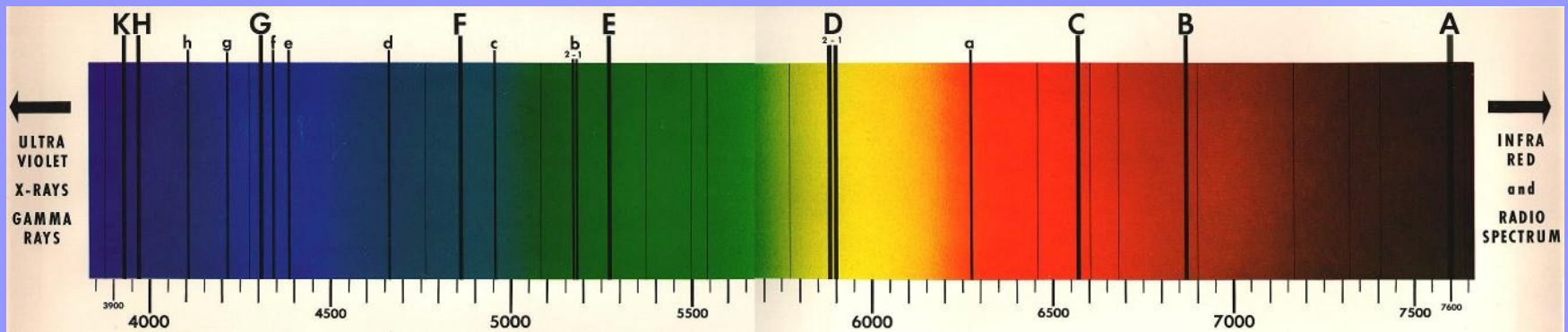
Reminder on spectroscopy

Light & colors



- **Isaac Newton (1642-1726)**
 - a pionnier
 - 1670: prisme's experience
 - Circular “slit” of 6mm:
 $\lambda/\Delta\lambda \sim 10$!

Solar spectrum



- **William Wollaston (1766-1828)**
 - ~150 years after Newton !
 - First observation (in 1802) of dark lines
 - Demonstrated the importance of the slit width
- **Joseph Fraunhofer (1787-1826)**
 - Manufacturer of high quality glasses
 - A, B ($H\alpha$), C, D (sodium doublet)... H, K (Calcium) lines
 - Catalog of ~600 raies in 1814
 - Also observed planets and some stars !
- **Edmon Becquerel (1820-1891)**
 - First photography of the solar spectrum (June 13th, 1842)

Chemical analysis & spectroscopy

- **Léon Foucault (1819-1868)**

- **Comparison between spectra on Earth and solar spectrum (sodium lines, 1849)**

- **Gustav Kirchhoff**

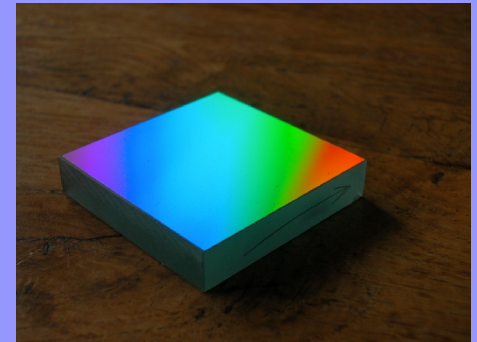
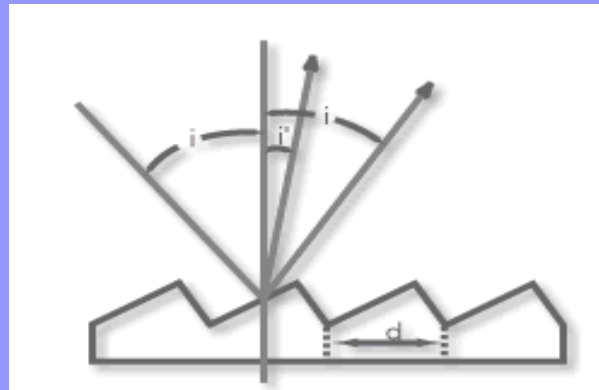
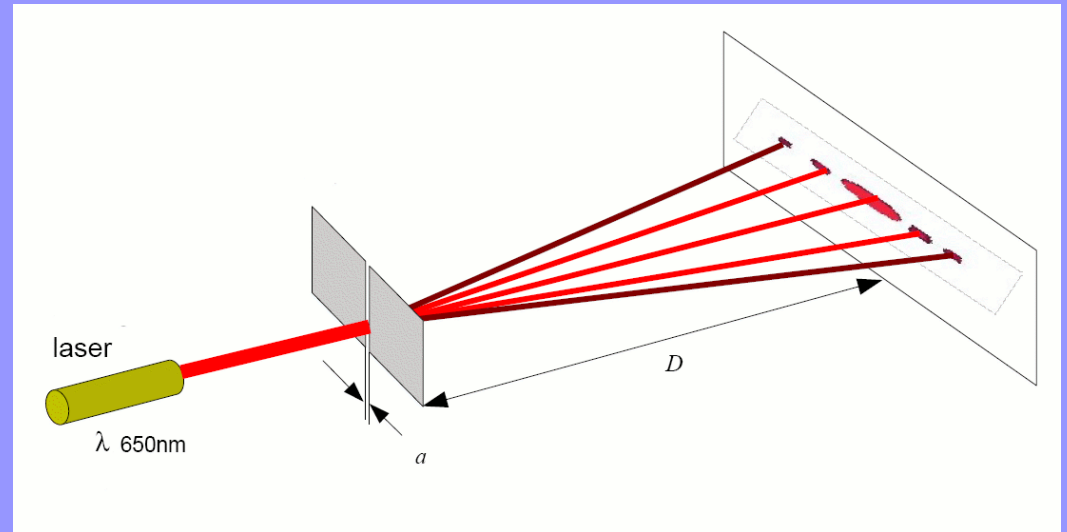
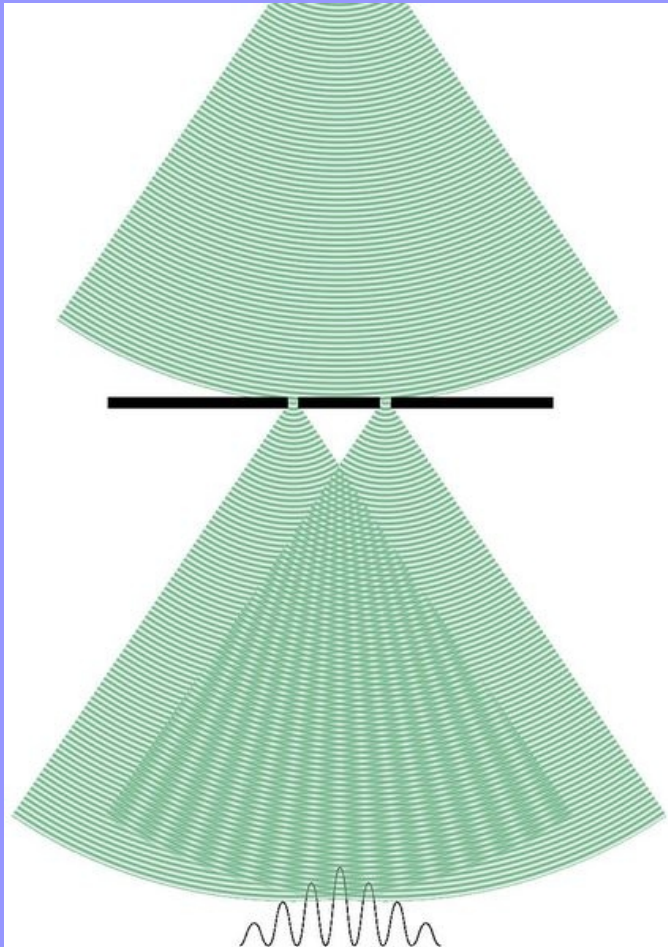
- **In parallel, he made the experiment with salt and published in 1859 that sodium should exist on solar atmosphere!**
 - **A key theoretical result: Kirchhoff laws**

- **Robert Bunsen (1811-1899)**

- **Heidelberg university like Kirchhoff**
 - **Together, they published in 1860 a paper on « chemical analysis by spectroscopic observation », then in 1861-1863 the analysis of several chemical elements and their work on the solar spectrum**

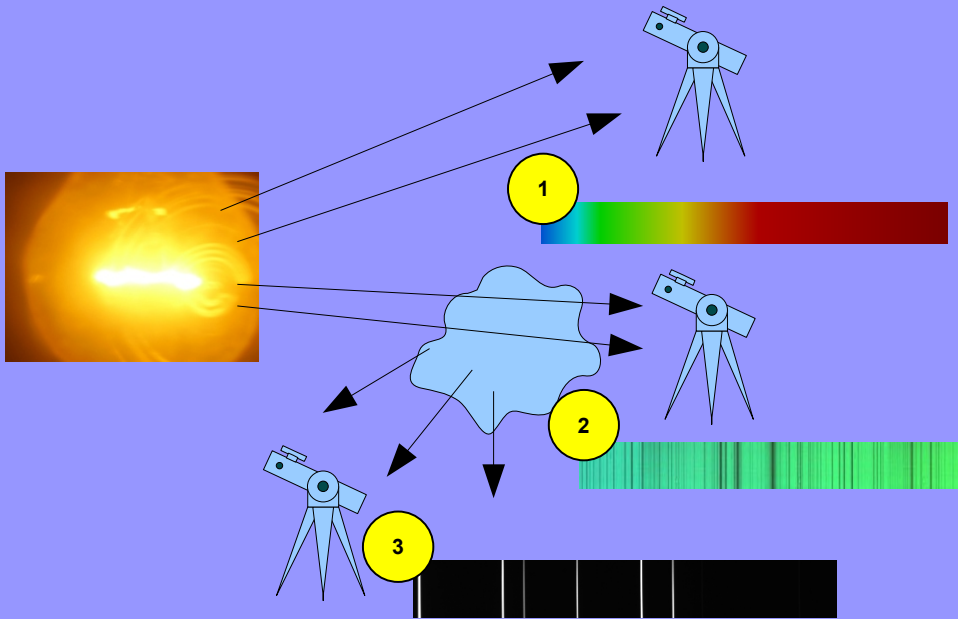
- **...Spectroscop was born...**

Light is a wave



- Thomas Young (1773-1829)
 - Wave interpretation of light (1801)
 - Worked with grating with 20 grooves/mm

Kirchhoff's laws



1

A **continuous spectra** is emitted by any solid or gaseous body under high pressure and high temperature. Stars are, under first approximation, like black body whose continuous spectra has a shape which depends on its surface temperature;

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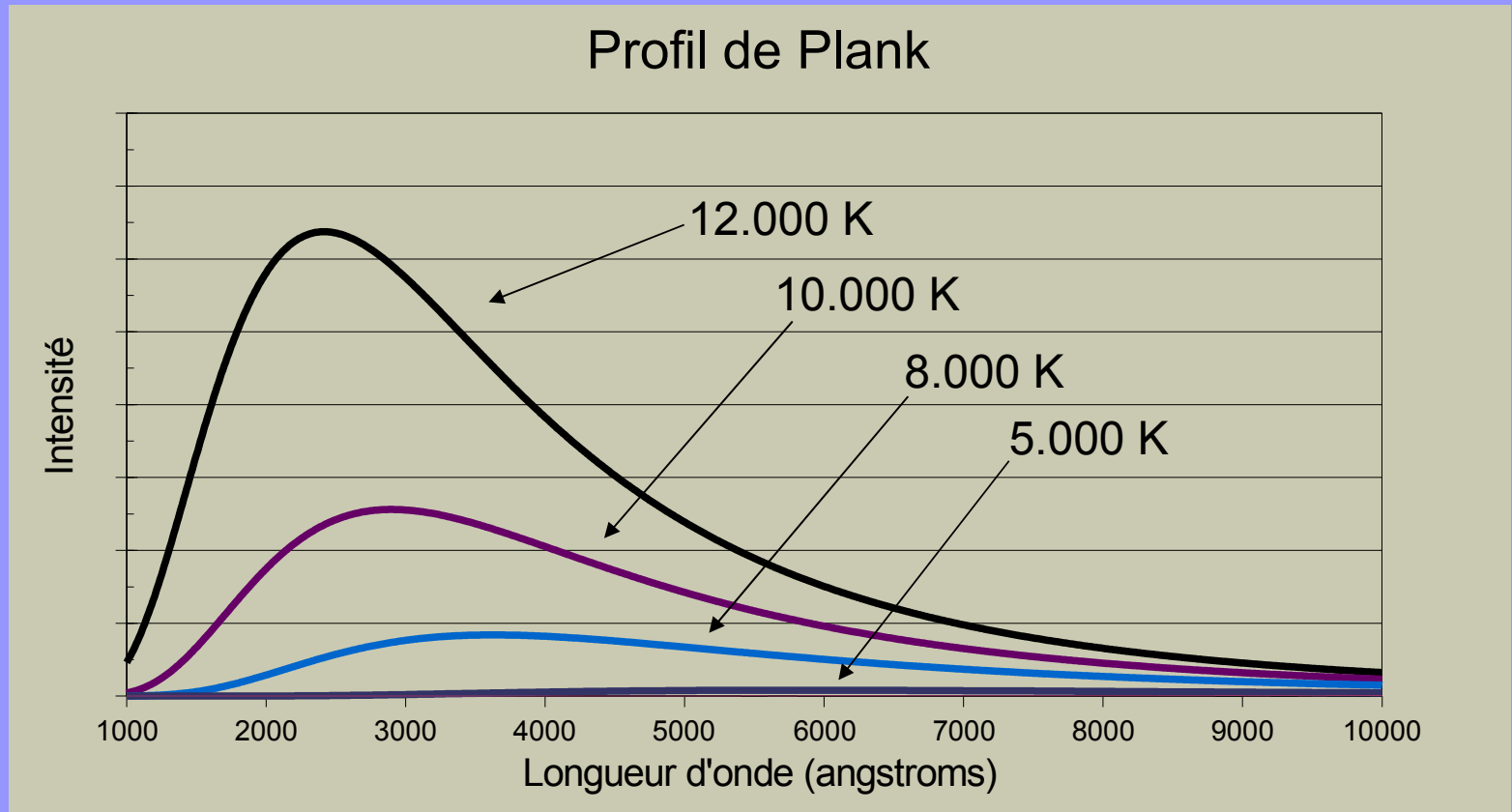
Absorption line spectra: a low pressure low temperature gas crossed by a continuous light absorbs some photons. Spectra then shows dark lines in front of the continuous spectra;

3

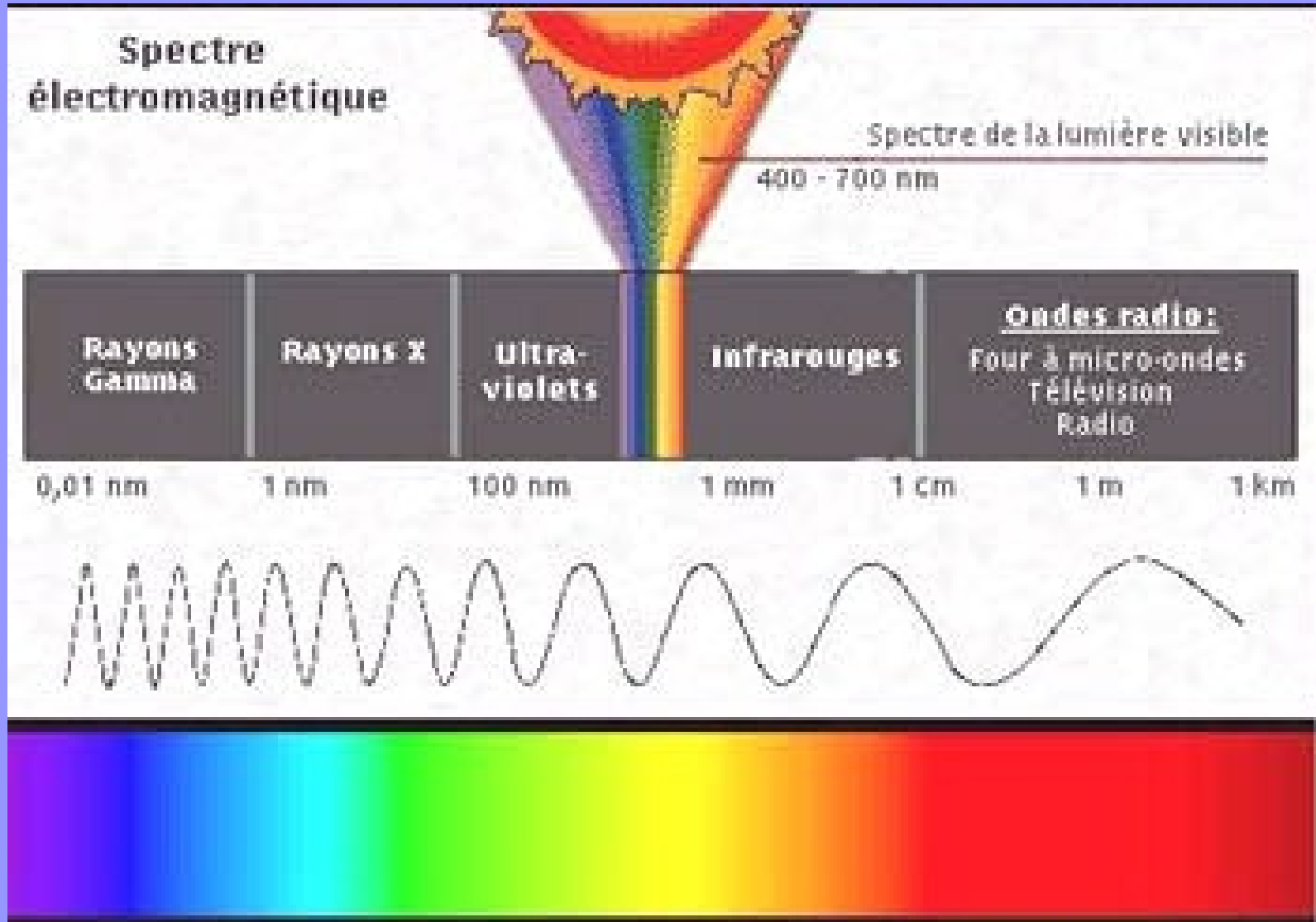
Emission line spectra: a low pressure high temperature gas emits a light made of few radiations, characteristics of the atoms that constitutes this gas. Each chemical element has its own line spectra, true identity card of its composition and state.

1

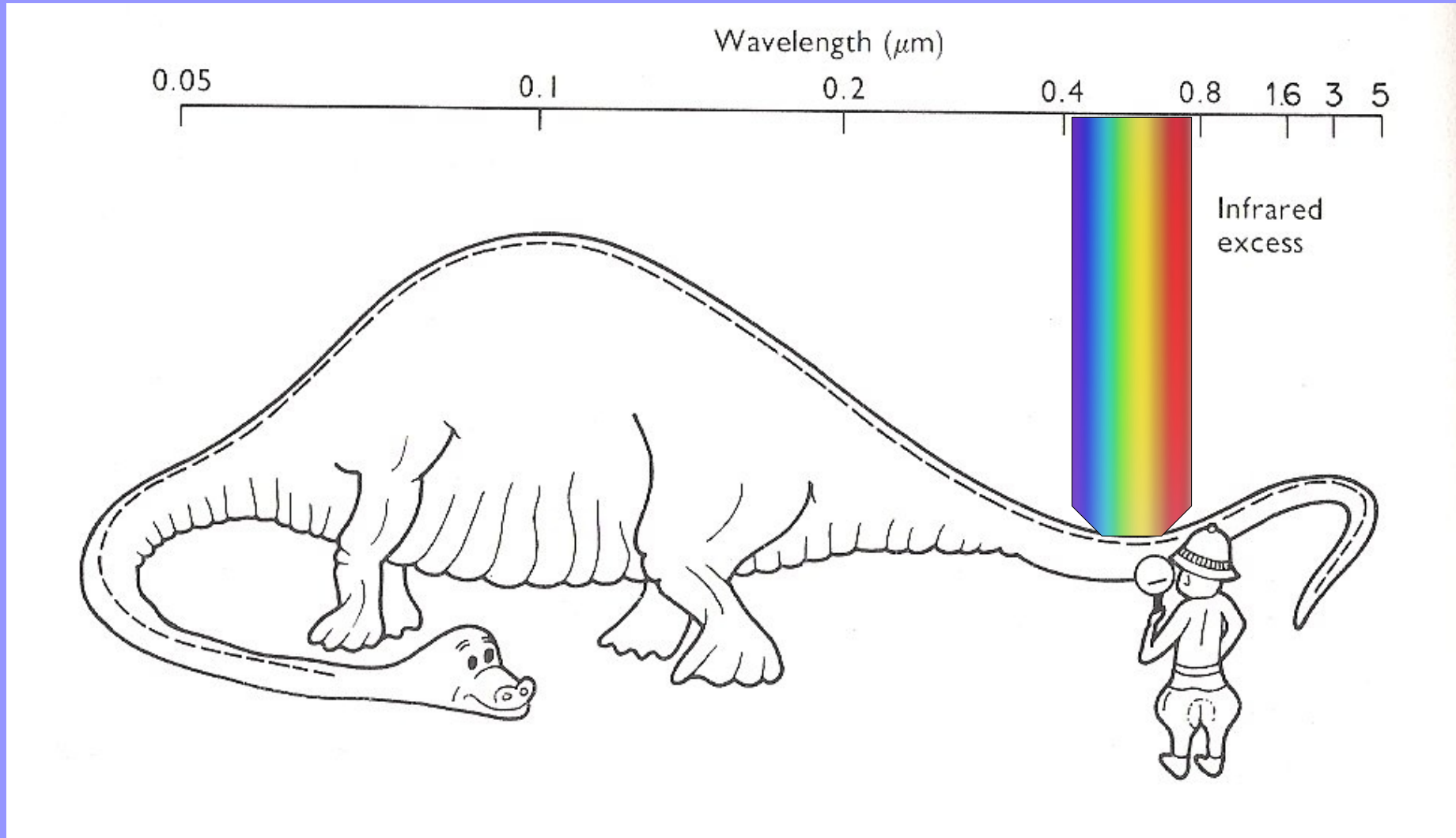
Black body profile



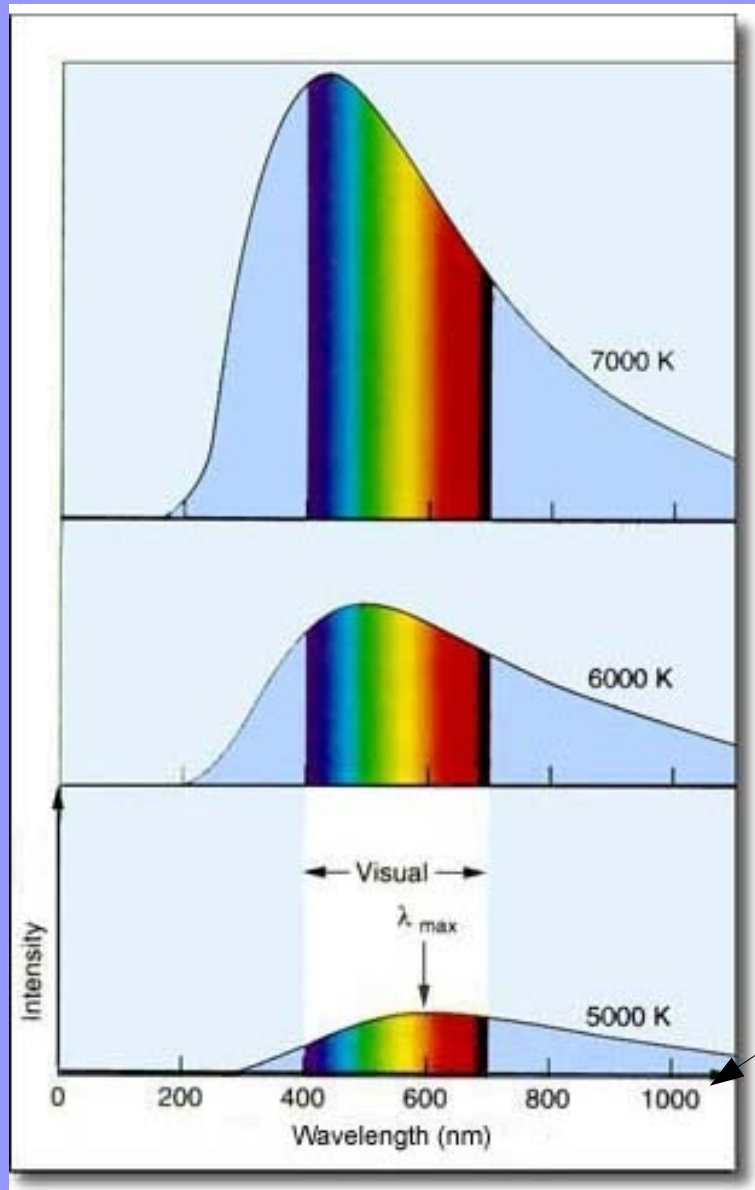
Electromagnetic spectrum



Visible: a small window



Informations from Planck profile



➤ **Stefan's law:**

Intensity (below the curve) =
Constant * T^4

➤ **Wien's law:**

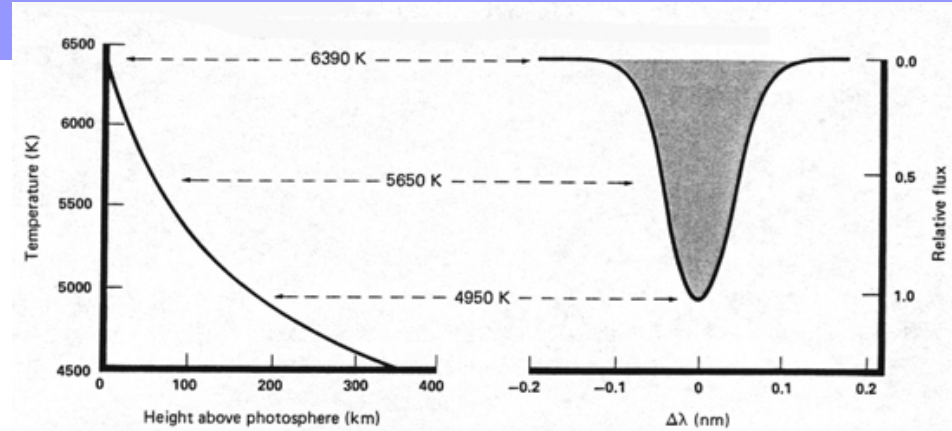
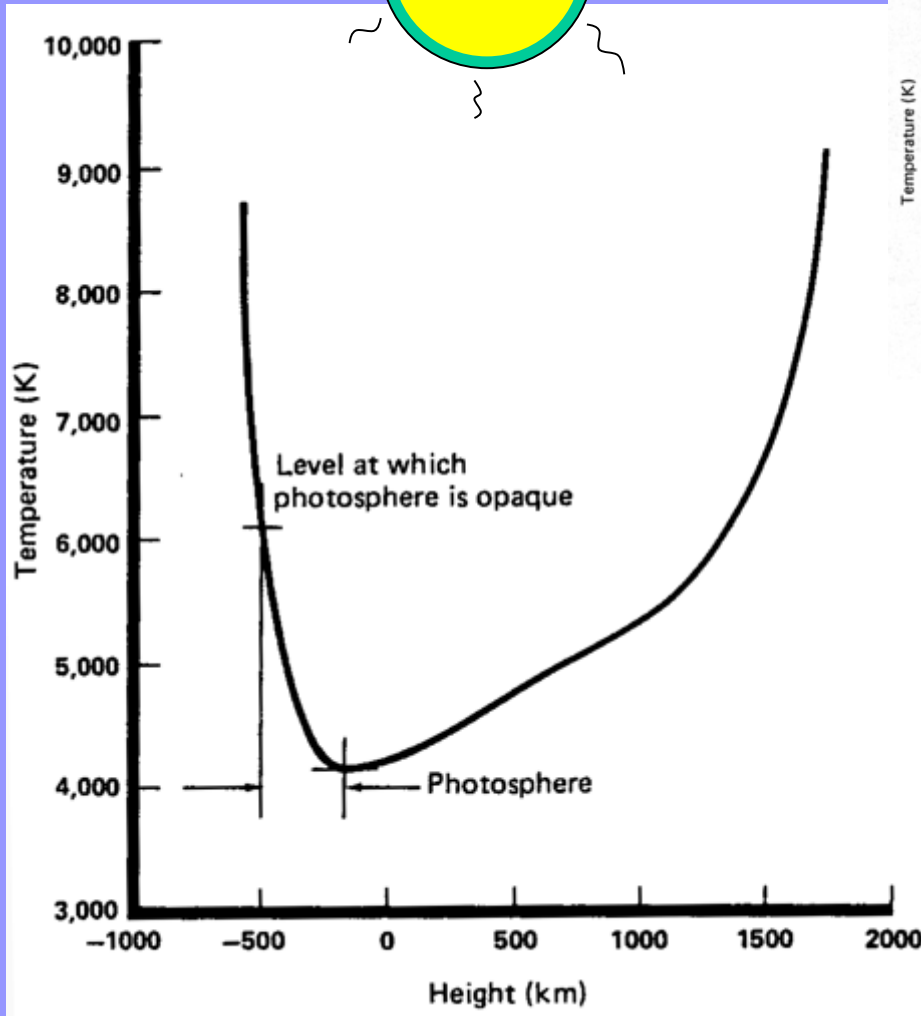
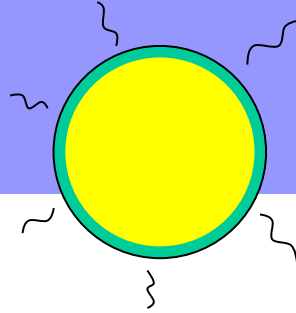
$\lambda_{\text{max}} * \text{Temperature} = \text{Constant}$
(2900 $\mu\text{m.K}$)

==>Temperature = Color !!!

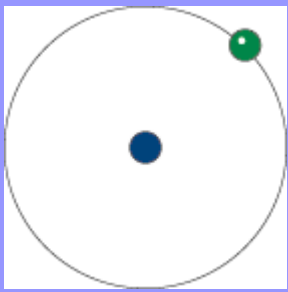
Visible domain

= 400-700nm (4000A-7000A)

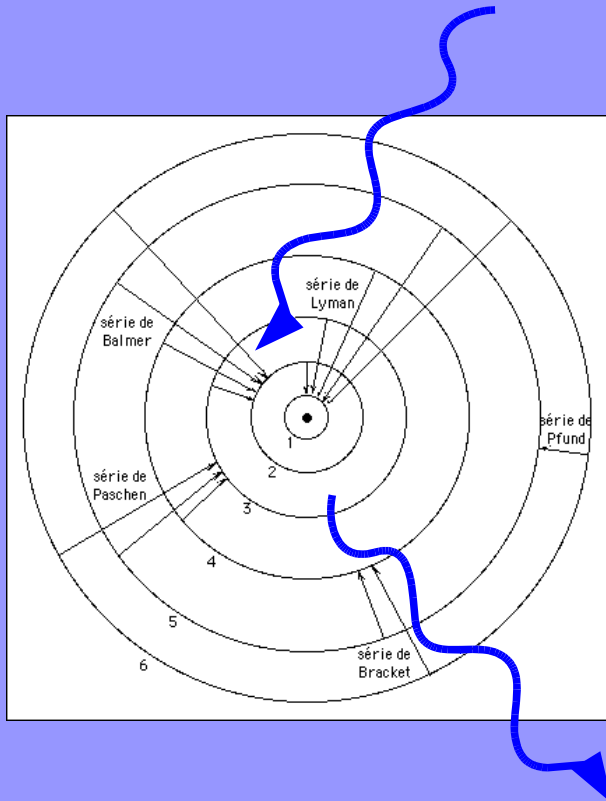
Absorbtion lines



- *The photosphere is actually very thin*
- *The « wings » of spectral lines come from deeper layers than the « core »*



Absorbption/Emission lines



$$\Delta \text{Energy} = h * \nu = h * c / \lambda$$

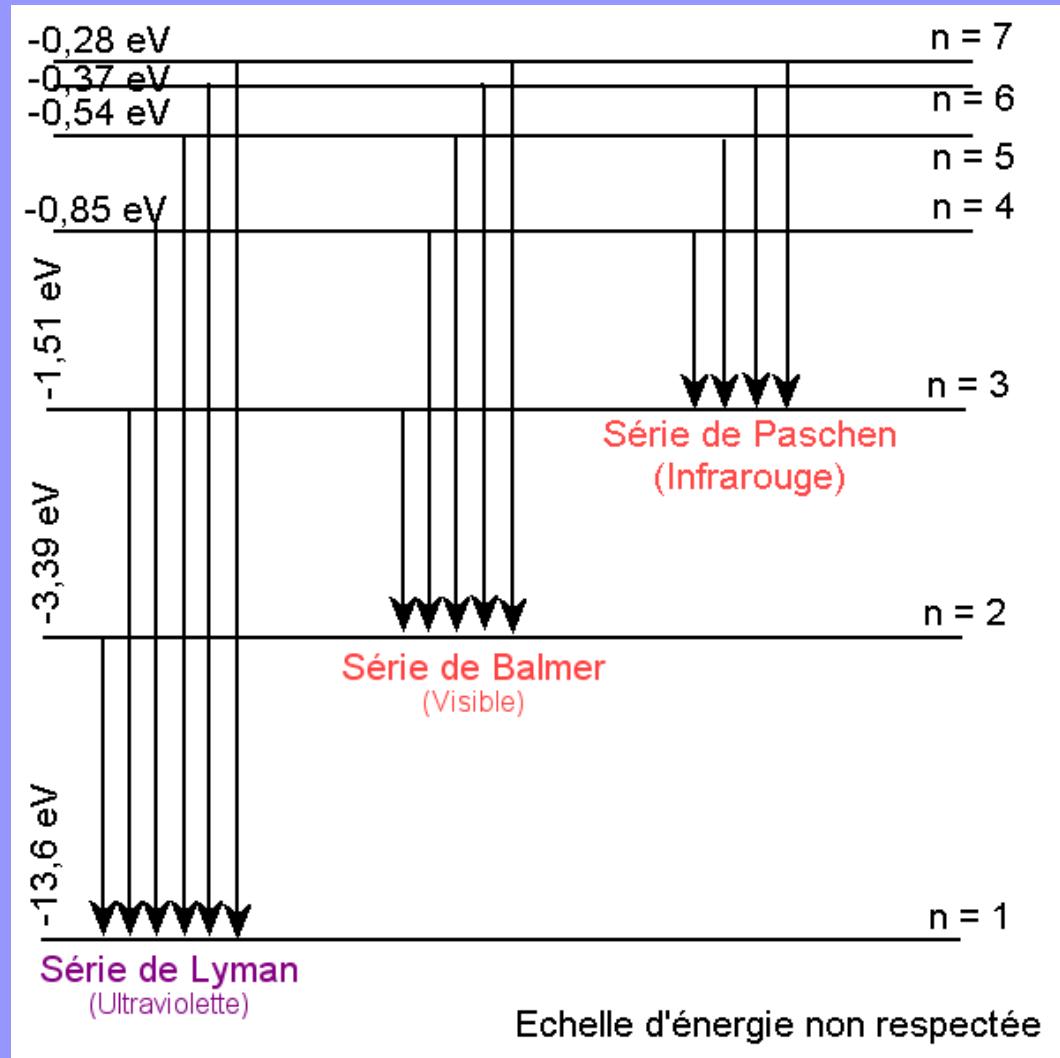
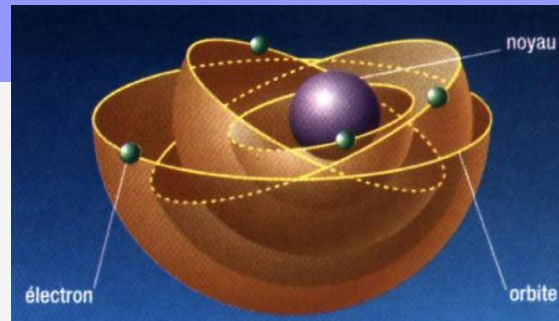


Table of elements



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Be

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Na

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Mg

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K

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Ca

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Sc

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Ti

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V

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Cr

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Mn

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Fe

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Co

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Ni

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Cu

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Zn

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Ga

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Ge

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As

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Se

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Br

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Kr

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Sr

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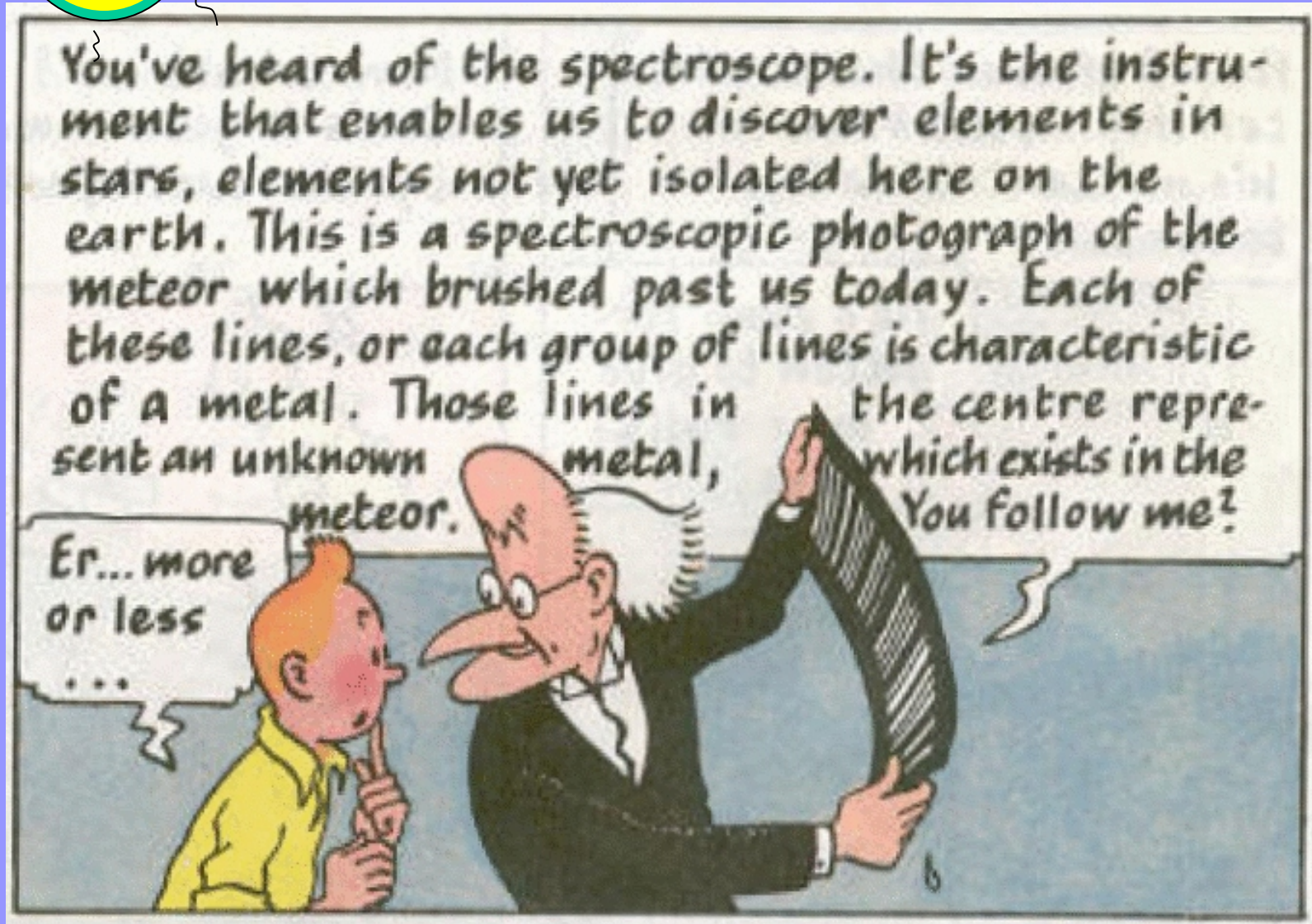
*Lanthanide

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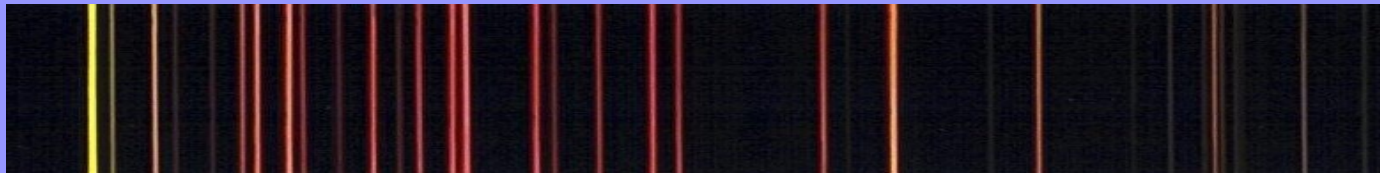
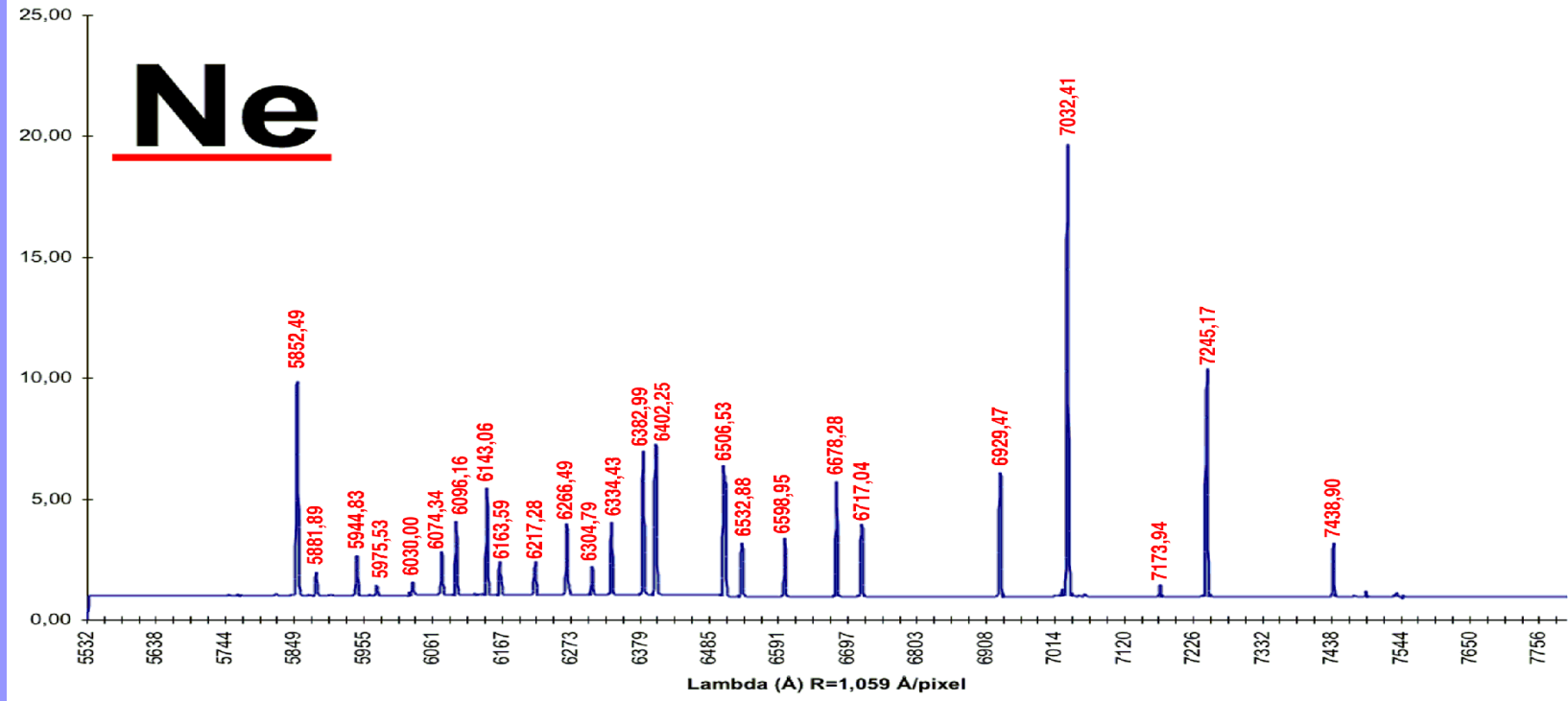
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

2

Absorbtion lines



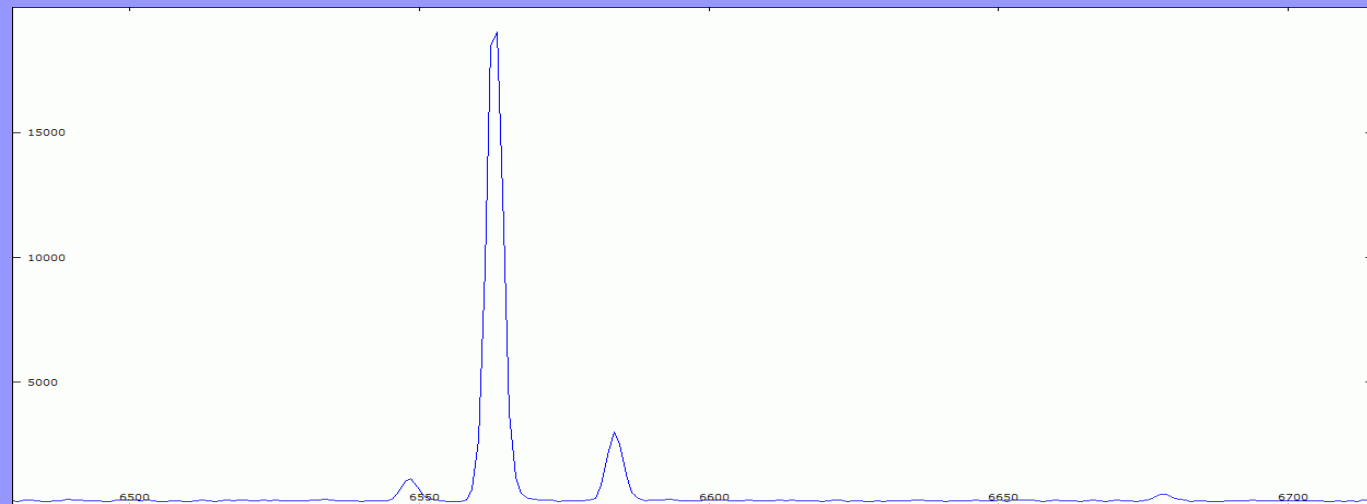
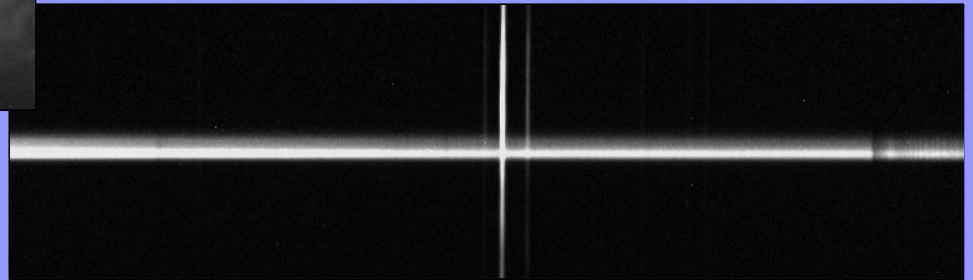
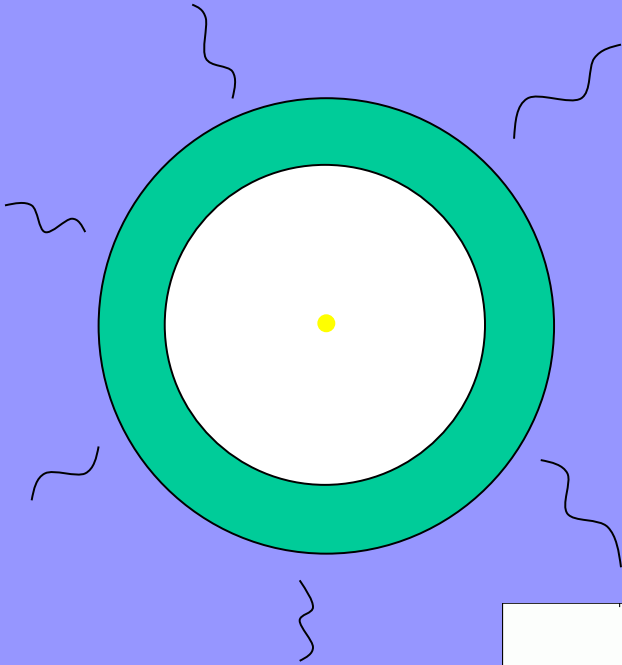
Emission lines



- Calibration lamp (here: internal neon lamp of a Lhires III spectrograph) create emission spectra

Example of emission line

- Spectrum of a planetary or diffuse nebula is in emission*



Stellar classification

- **Some pioneers: Lewis Rutherfurd (1816-1892), Angelo Secchi (1818-1878), William Huggins (1824-1910), Hermann Carl Vogel (1841-1907)**
- **A key work: Henry Drapper catalog from Harvard**
 - **Edward Pickering (1846-1919) and his team (of women!); created AAVSO**
 - **Williamina Fleming (1857-1911): type A...Q; 26000 spectra**
 - **Antonia Maury (1866-1952): type I...XX; first to put O type before A type in Flemming classification**
 - **Annie Cannon (1863-1941)**
 - **“OBAFGKM” types**
 - **sub-divisions (B0..9)**
 - **~400000 spectra of her own !!!**



A.J. Cannon

Stellar classification

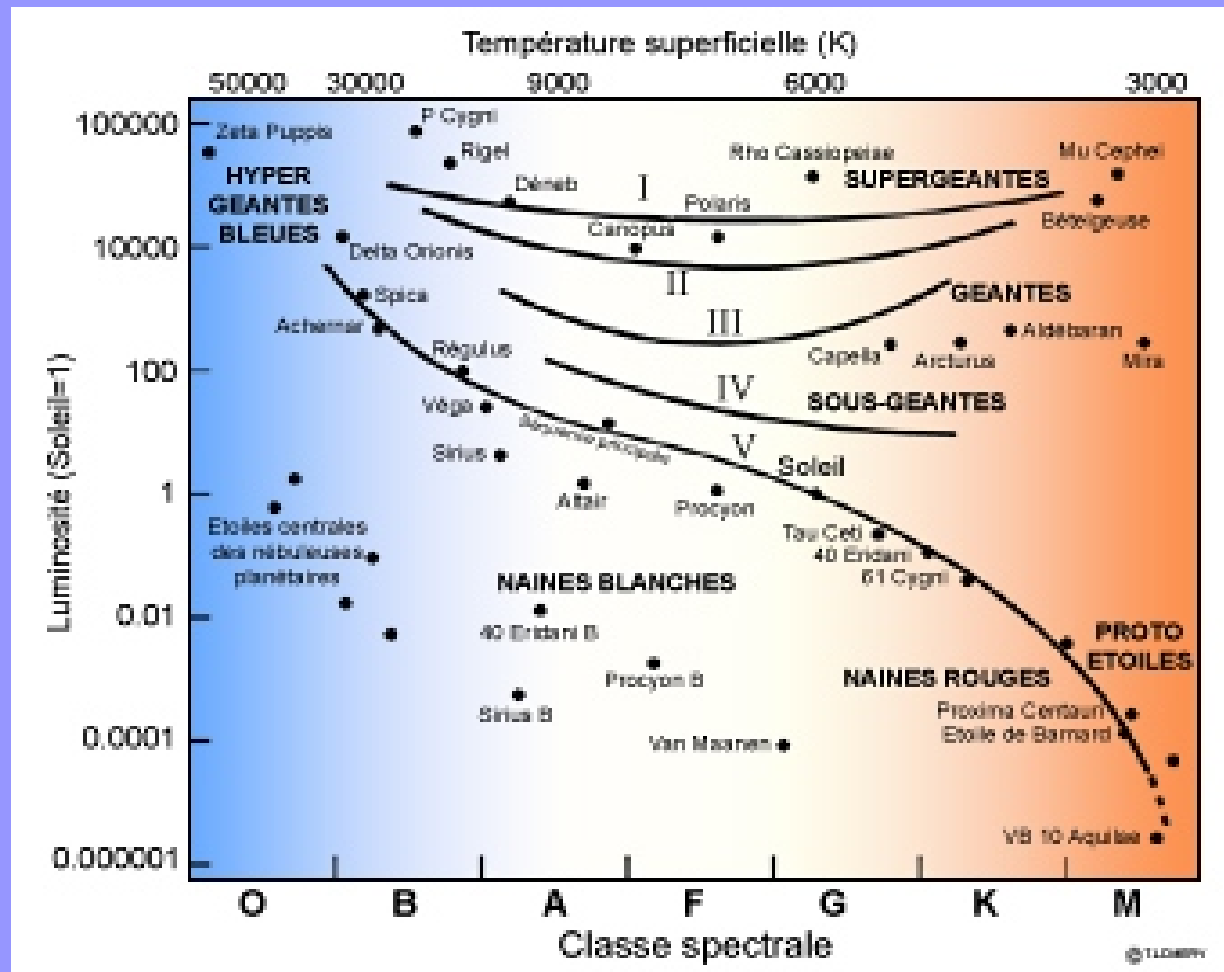
- 1890: Drapper catalog of stellar spectra
- 1911-1915: 225300 stars reviewed by A.J. Cannon
- 1918-1924: HD (Henry Drapper) catalog published
- 1949: HDE: HD catalog extension
- 1943: “Atlas of Stellar Spectra” by William Morgan, Philip Keenan, & Edith Kellman [MKK]
 - Spectral type from HD catalog (Temperature): OBAFGKM
 - Introduced class of luminosity I...V



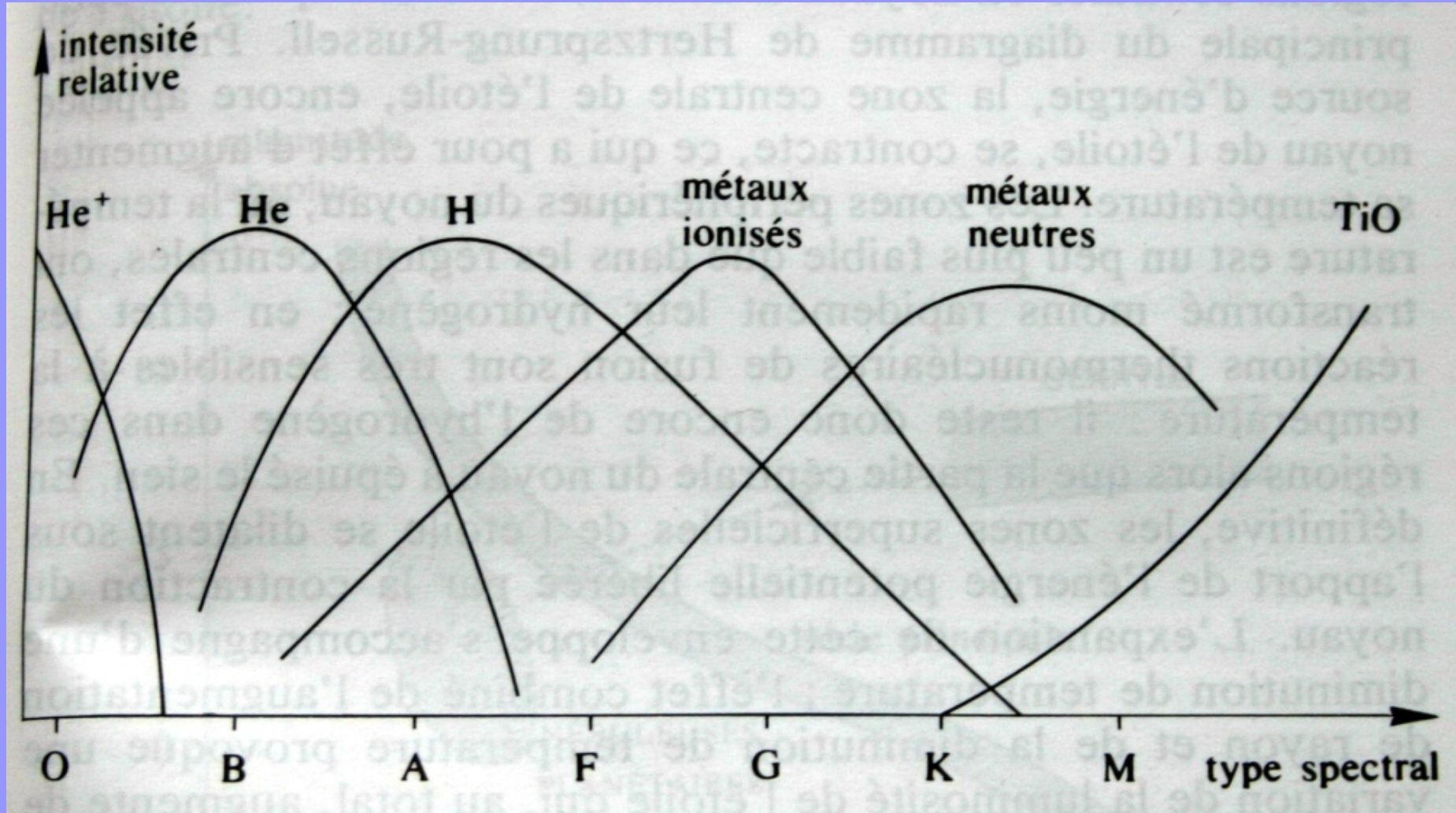
E. Pickering team (all women!) in 1913.

Beginning of Astrophysics

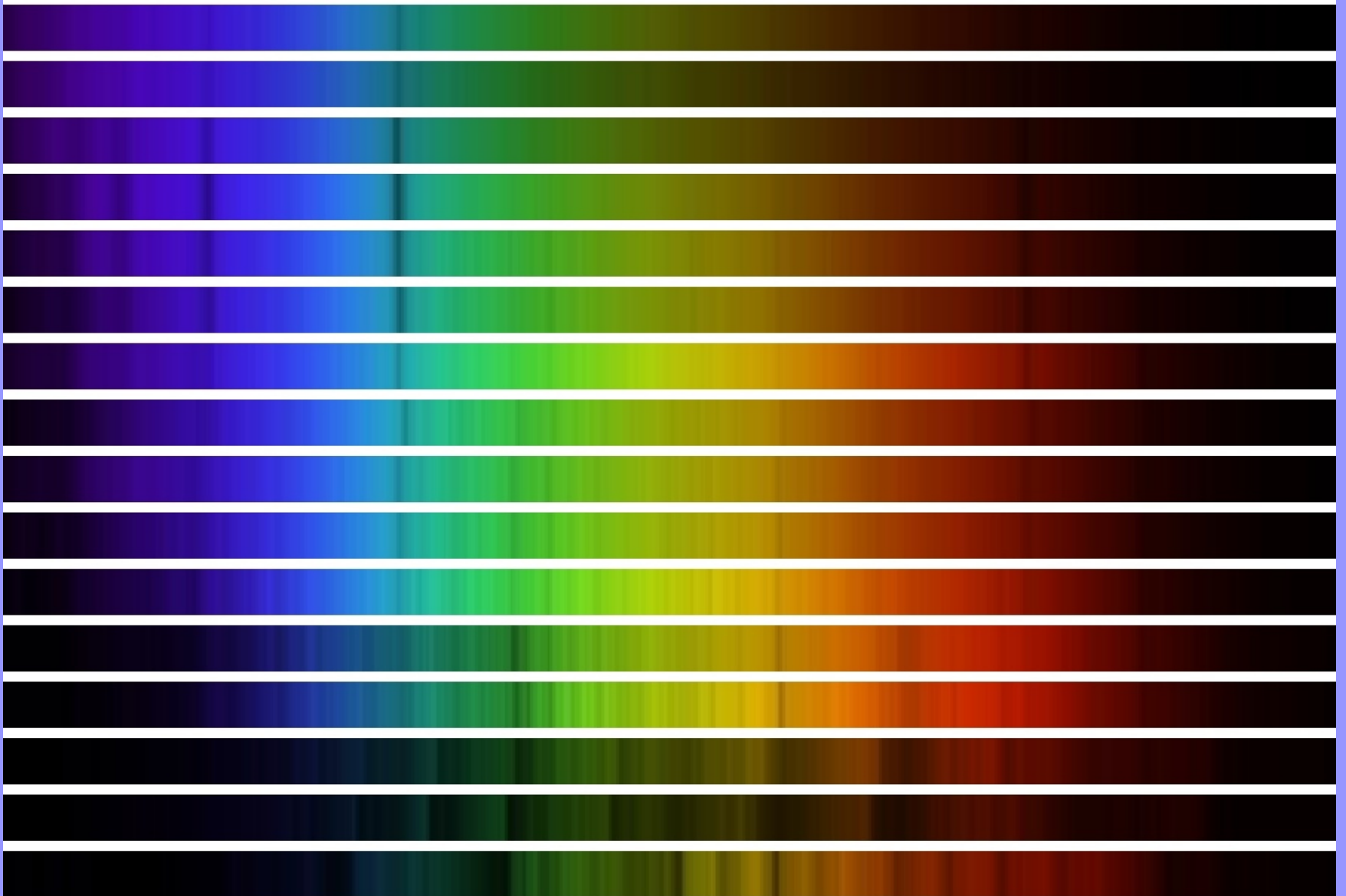
- Einar Hertzsprung (1873-1967) & Henry Russell (1877-1957)
- Color/Luminosity (first published in 1911)



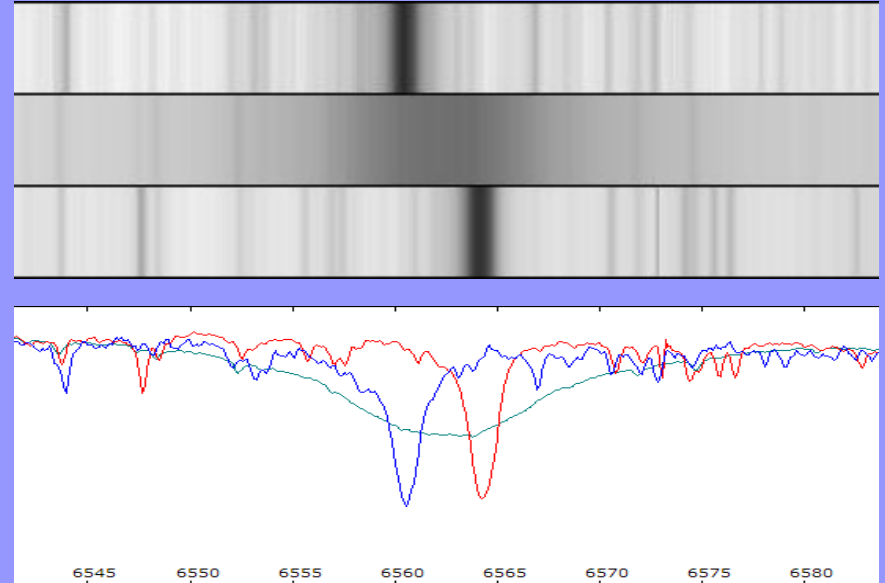
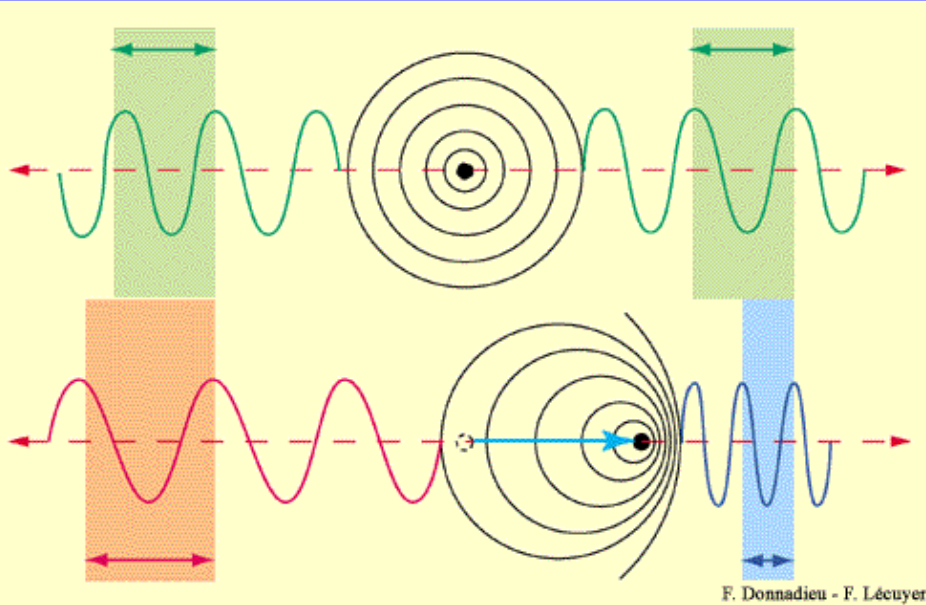
Relative intensity per elements



From ABC... to OBAFGKM !



Doppler Effect



Expansion of galaxies
=
red shift

$$\frac{(\Delta \lambda)}{\lambda} = \frac{v}{c}$$

In summary...

Light from the stars gives us information on:

- Their **temperature** [overall profile]
- **composition** and **physical conditions** of excitation and ionization (ie temperature) [visible lines]
- quantitative chemical composition (**abundance**), **pressure**, **gravity** [line intensity and shape]
- **movements** [Doppler effect]
 - *radial velocity*
 - *rotation*
 - *expansion*

Some books...



Some useful links

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

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

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

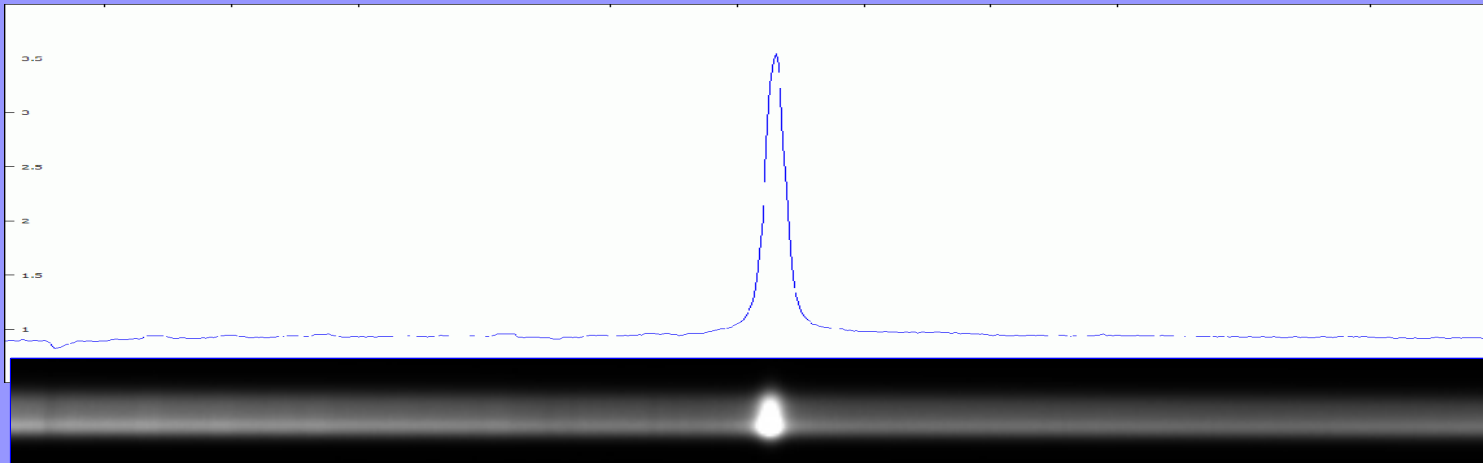
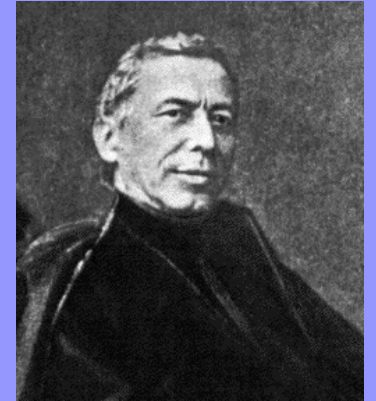
ADS (articles) http://adsabs.harvard.edu/abstract_service.html

Shelyak <http://www.shelyak.com/en/resources.html>

Be stars

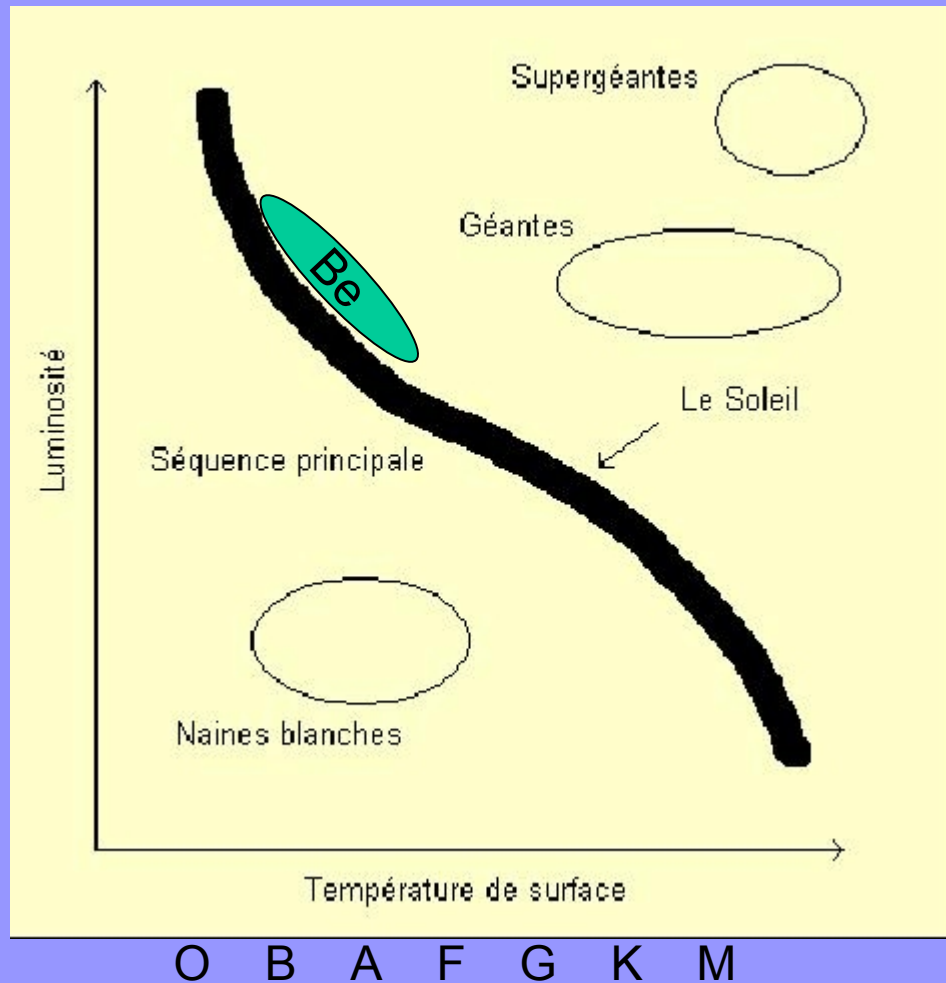


Be stars

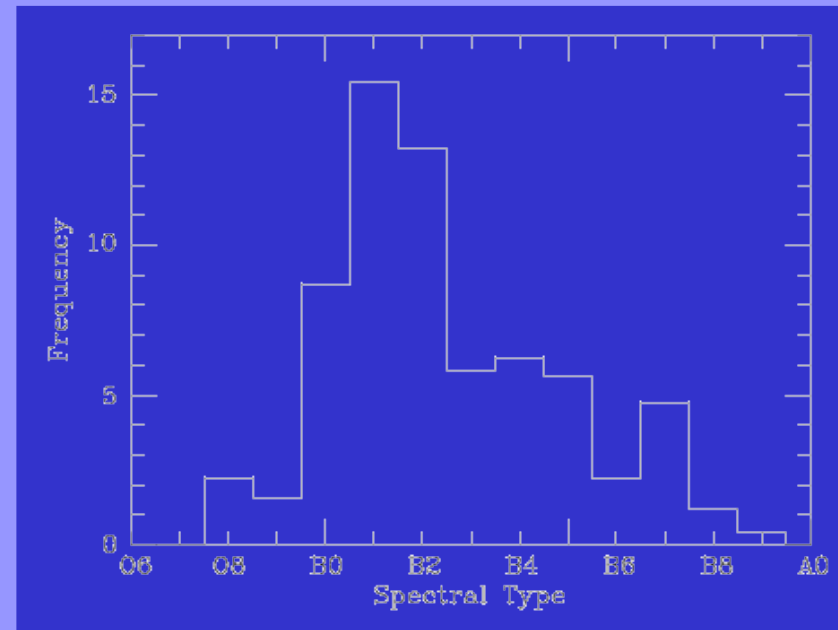


- Discovered in 1866/1867 by father Secchi:
 - gamma Cas
 - beta Lyr

Be stars



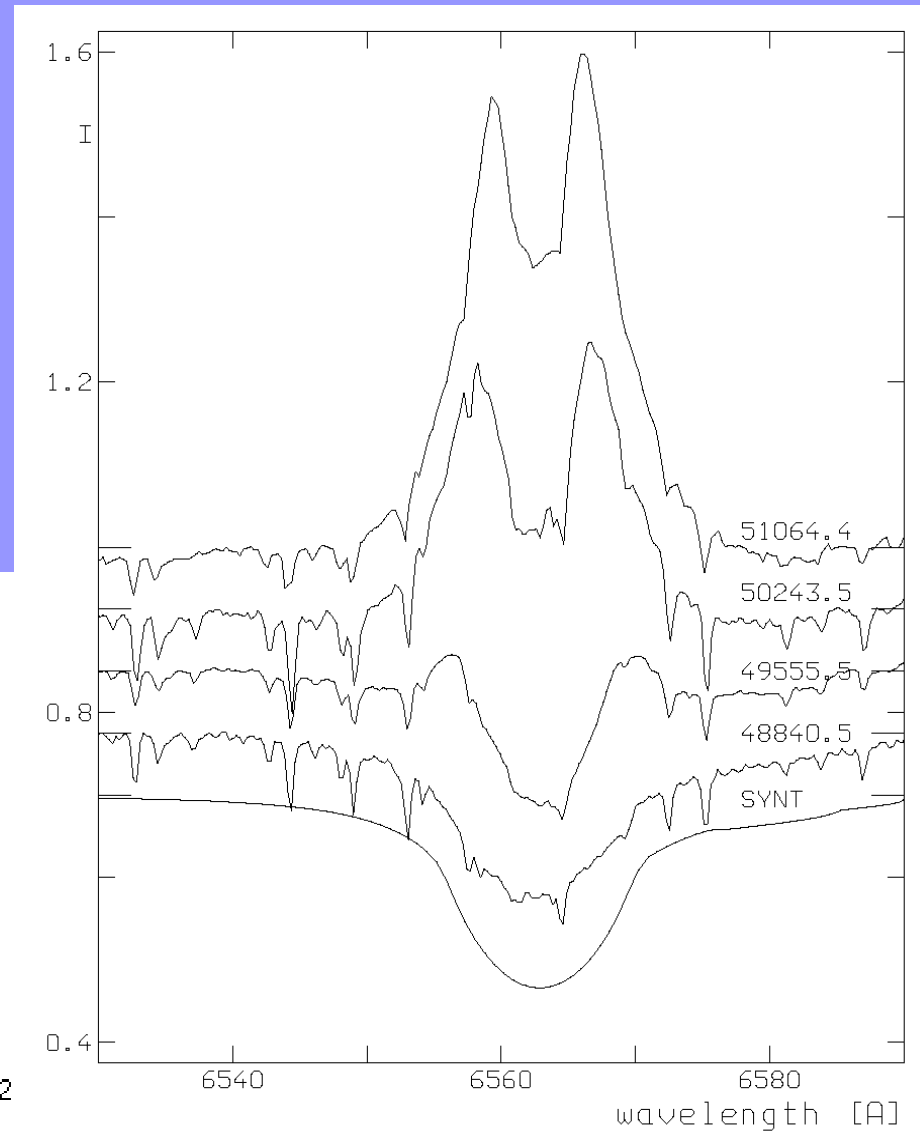
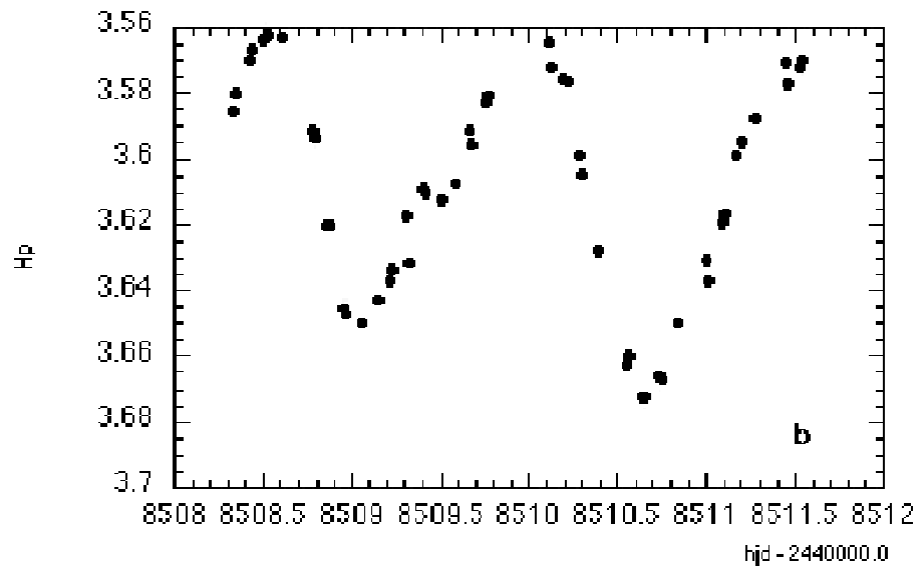
- $T=20\,000\text{K}$ ($4 \times \text{Sun}$)
- Non super-giants (ie: P Cygni is not a Be star!)
- $M=8 \times \text{Sun}$
- $R=6 \times \text{Sun}$
- $\sim 10\%-20\%$ of B stars are Be



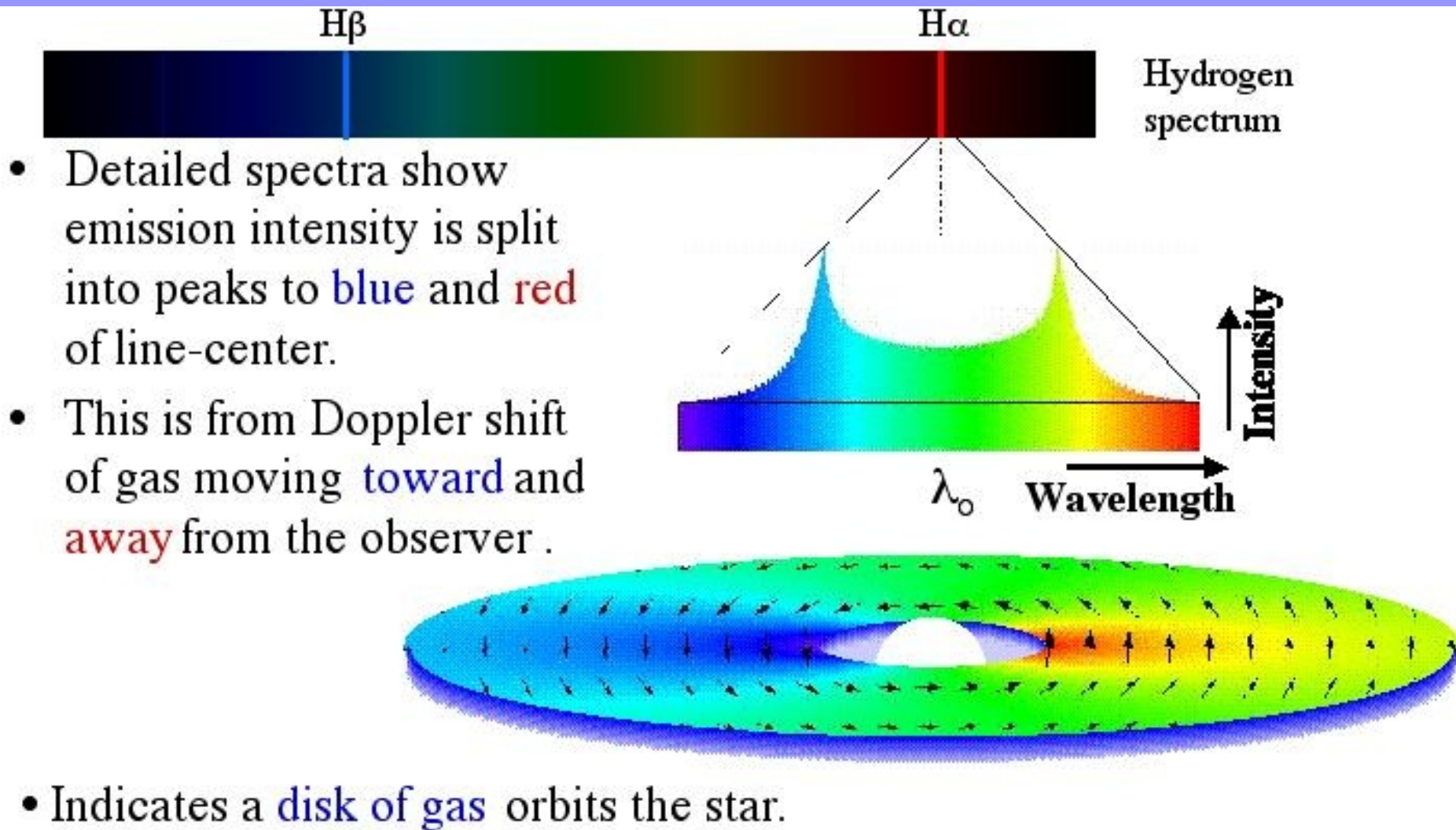
Be stars are variable stars

➤ Evolution over different time scales (hours to years)

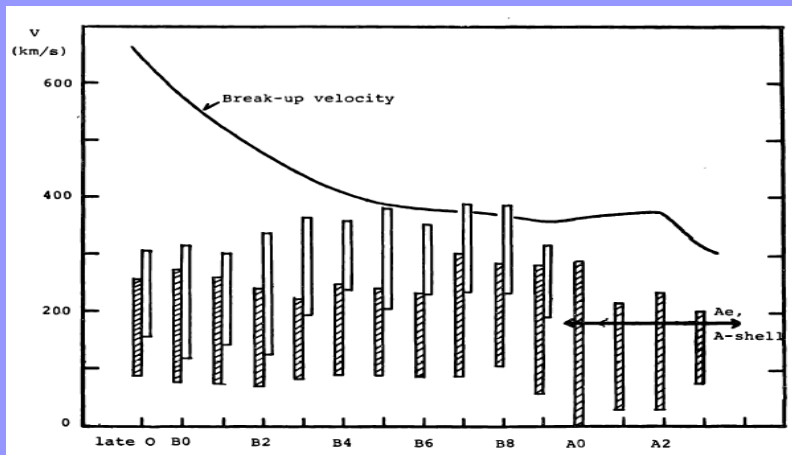
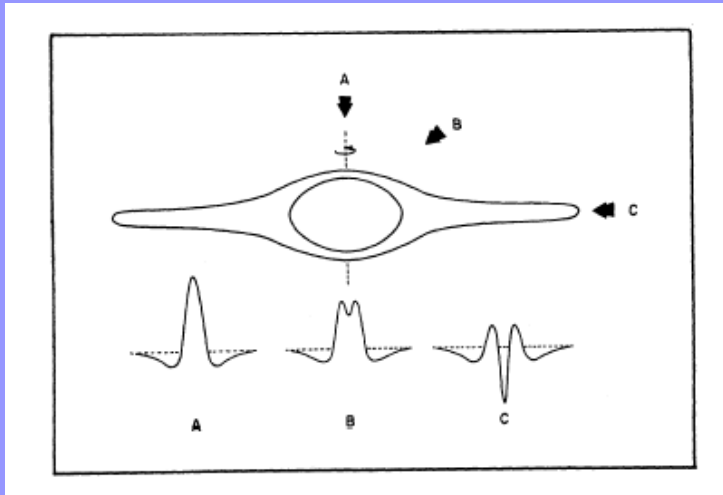
➤ Cycle B-→Be-→B-→Be... ?



Be star: lord of the ring !



Be star: lord of the ring !



- Temporal evolution
 - 'outburst'
- Géométrical
- But the origin of the disk is still debated
 - Non Radial Pulsations
 - Magnétique impulses
 - Rotational speed
 - Others...
- Correlation between photometry & spectroscopy is key !!!

Circumstellar Disks of Be Stars

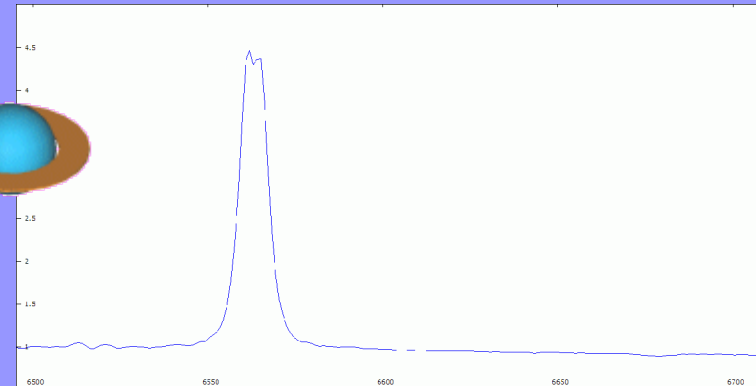
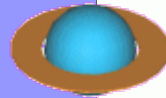
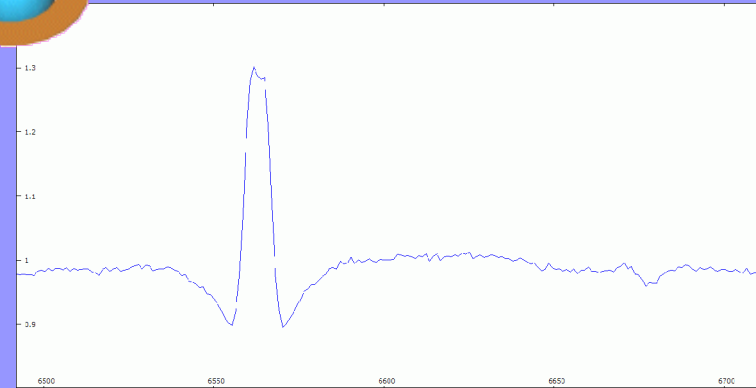
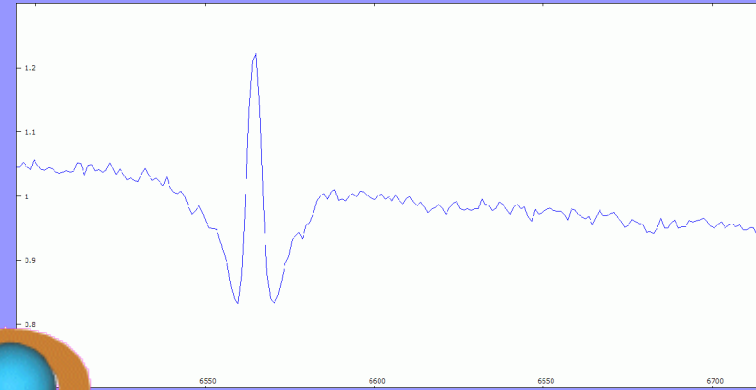
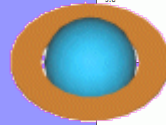
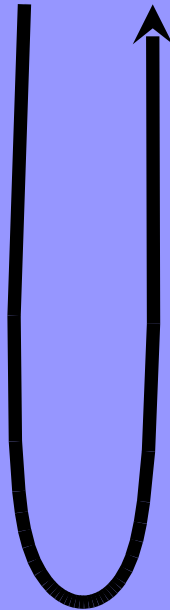
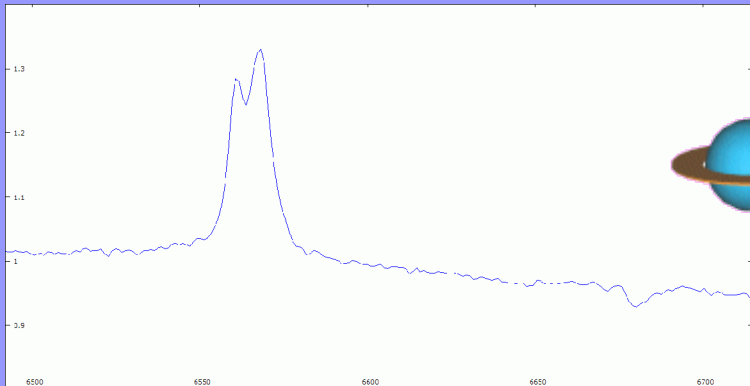
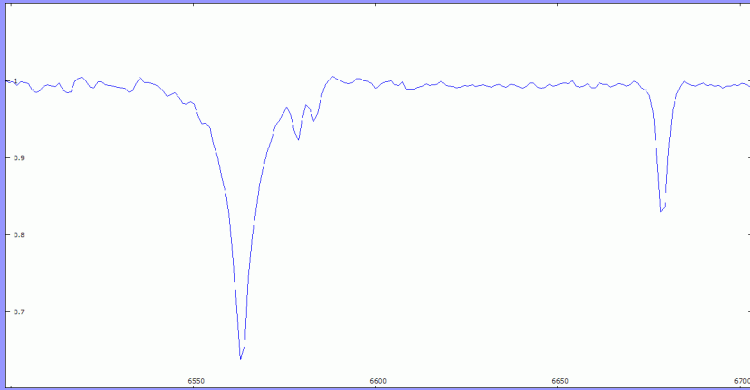
- Flat near the star
- Disk thickness increases outward from the star
- Density drops with distance from the star as r^{-n}
- Density exponent $n \sim 2.5-4.0$ (simplified models)
- Disks are temporary (can be present for decades)
- Disks can suddenly appear or disappear
- Disks can change into rings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

Which emission lines to see ?

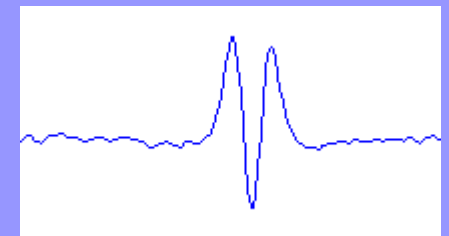
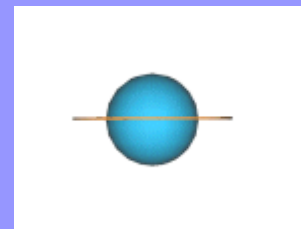
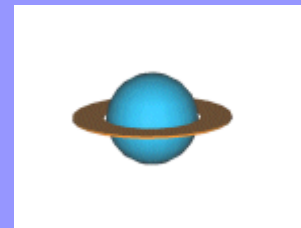
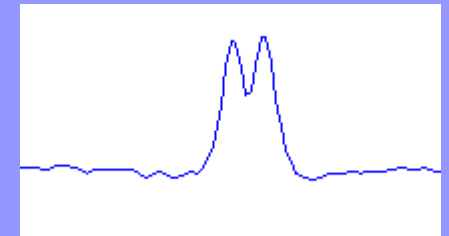
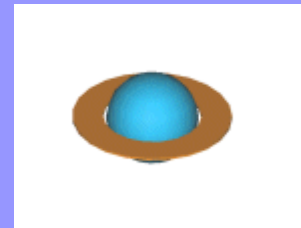
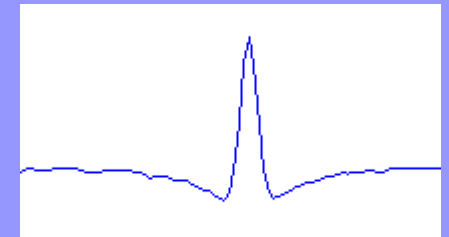
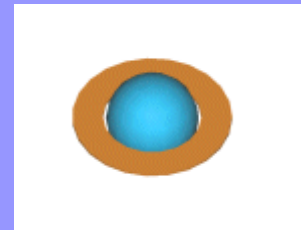
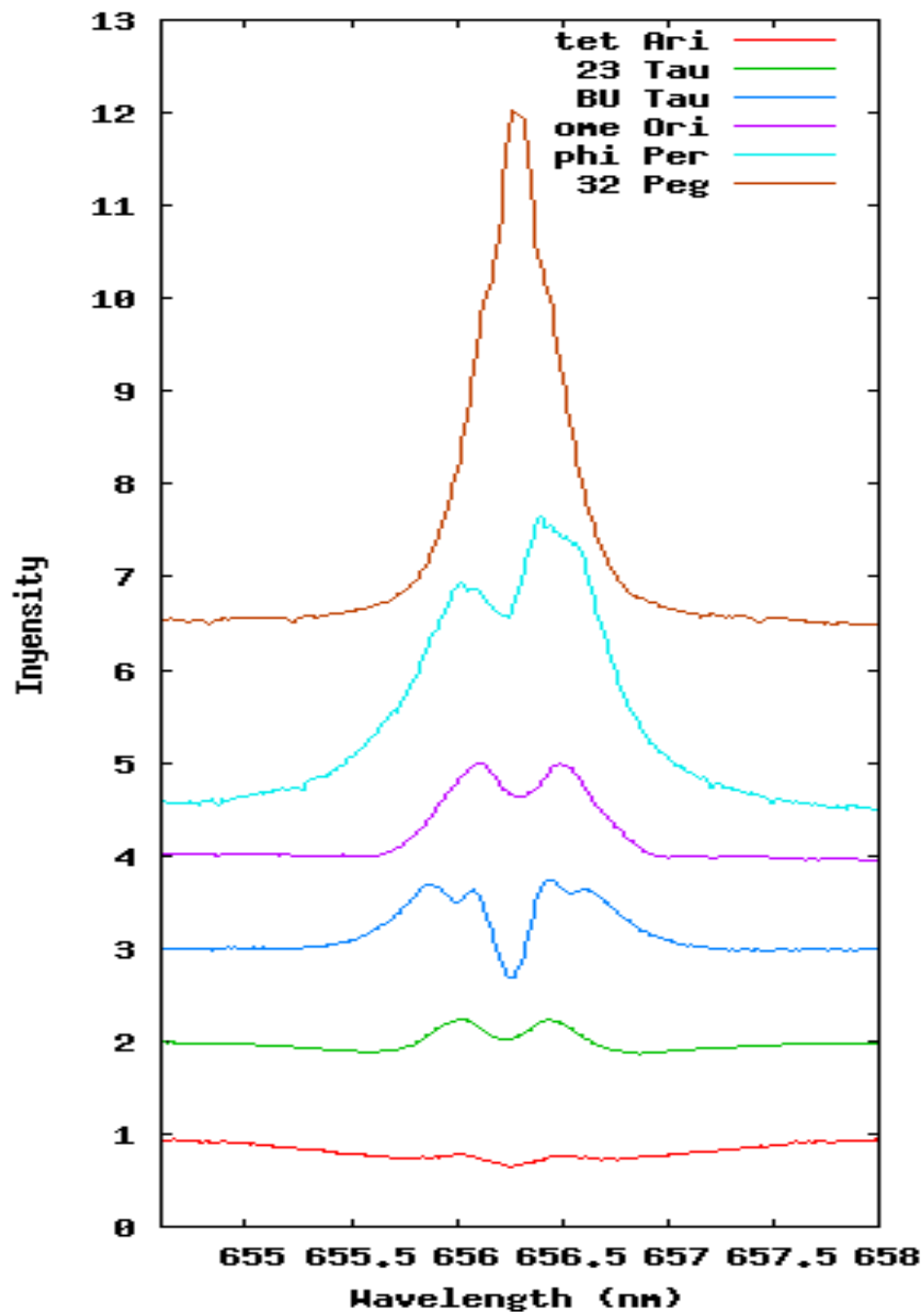
- Hydrogene lines are the most prominent ones
 - $H\alpha$ 6562.8, $H\beta$ 4861.3, $H\gamma$ 4340.5, $H\delta$ 4101.7, $H\epsilon$ 3970.1
 - If the star is in a Be phase, there will be emission in $H\alpha$. Depending on disk density, there will also be $H\beta$ emission, possibly $H\gamma$. $H\delta$ 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...

Line profiles

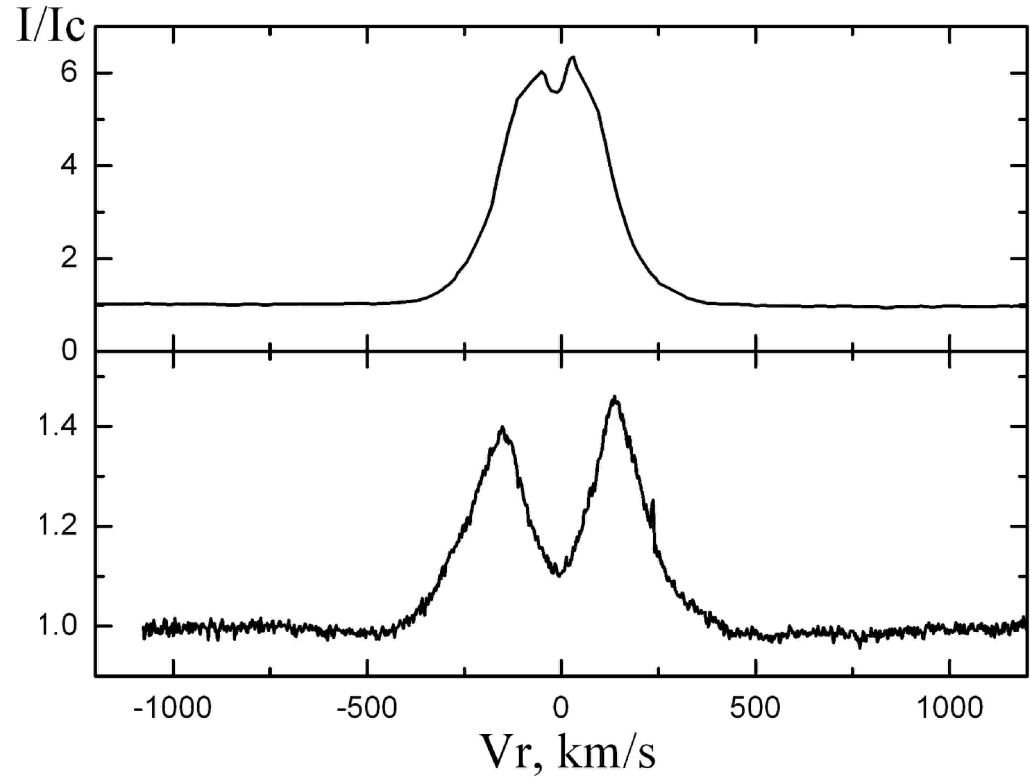
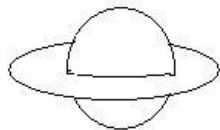
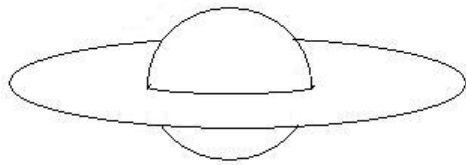
B star



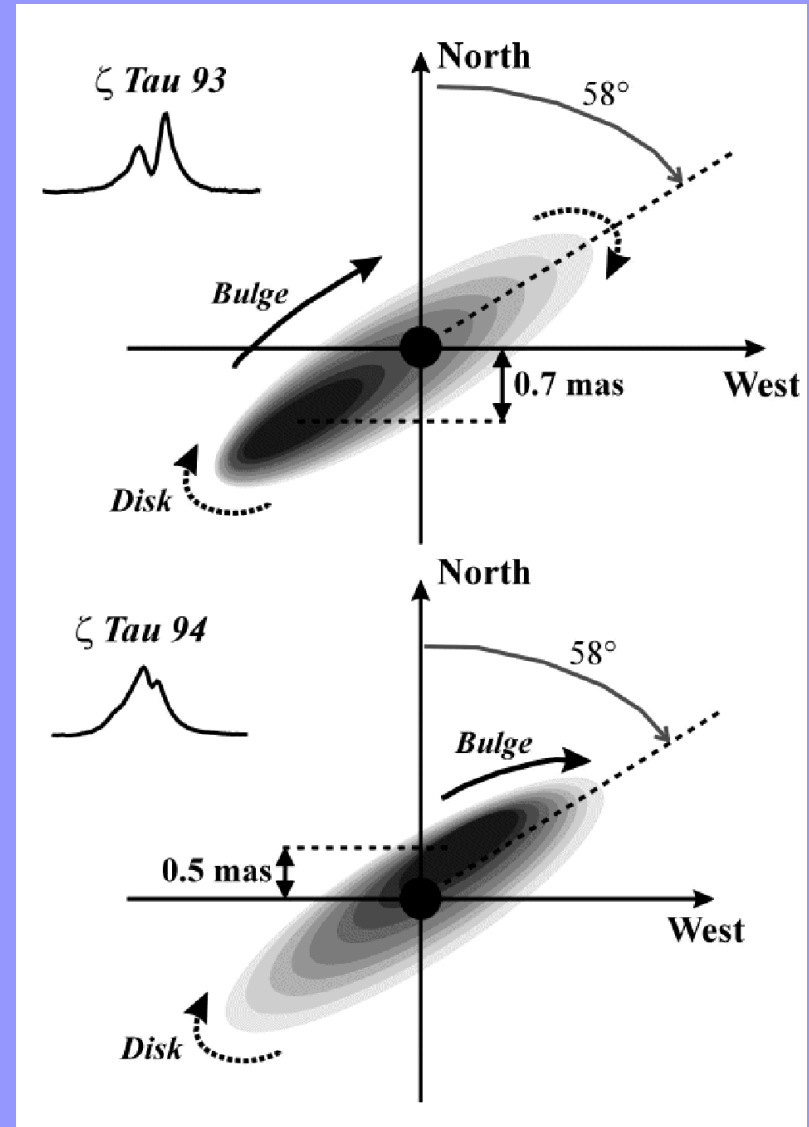
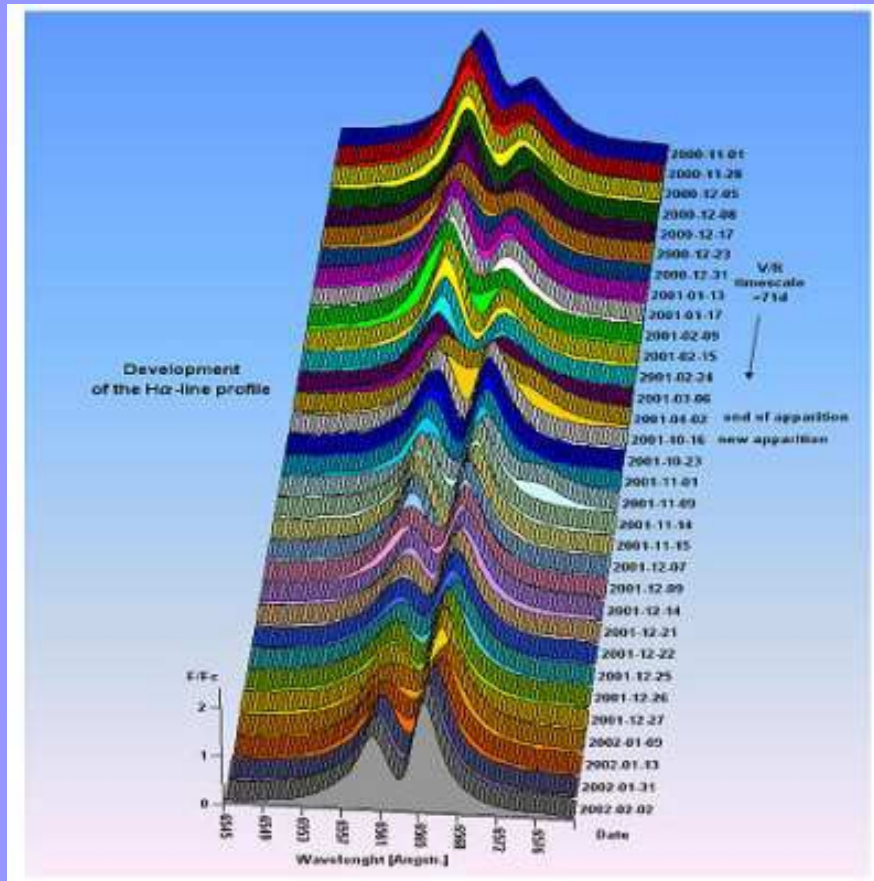
Line profiles



Disk size effect

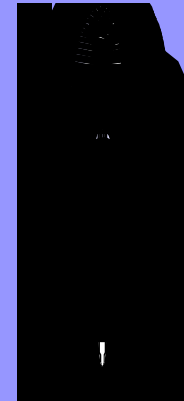
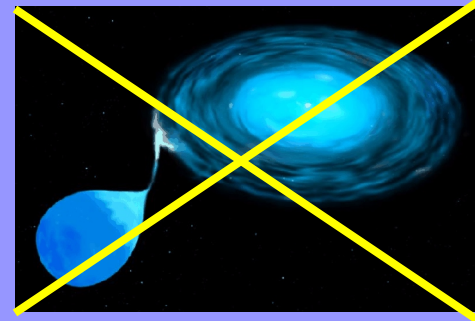
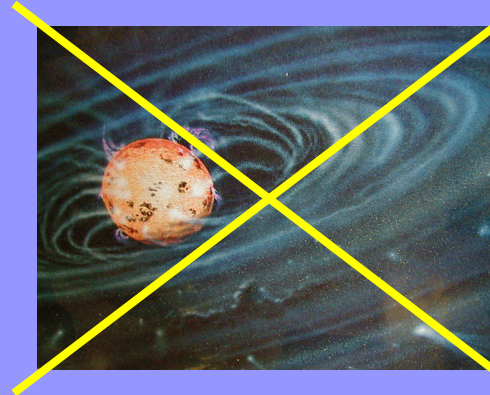


System's geometry



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 binaries
- Disk must then be created by matter ejected...

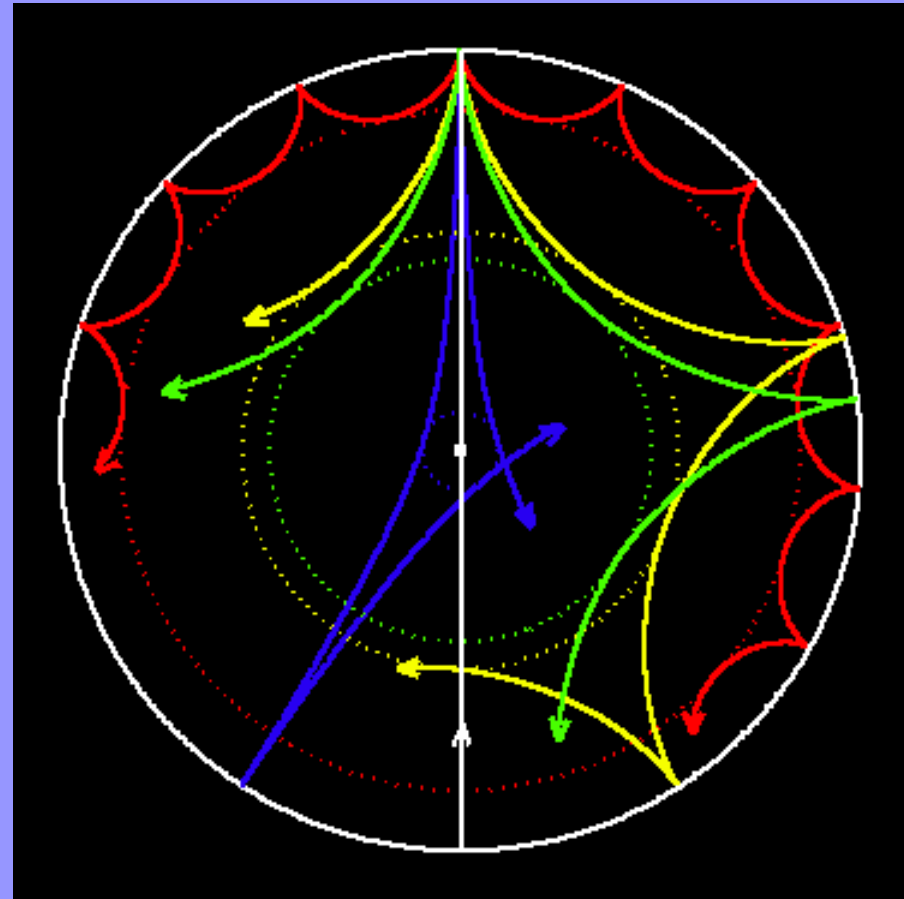


Ejection of material ?

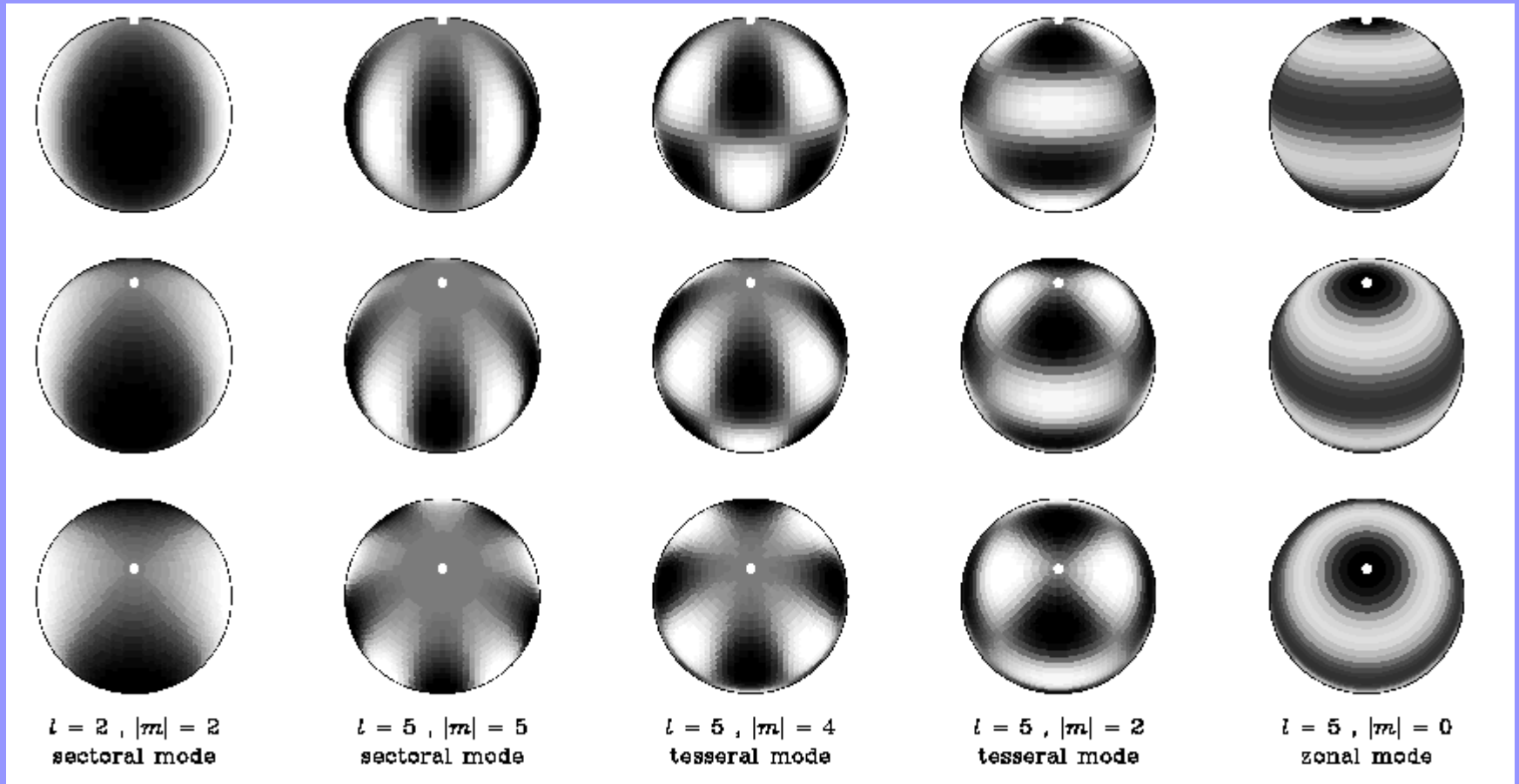
- rotation of the star alone is not enough to eject material
- non radial pulsations could help this ejection
- A magnetic field could bring some additional angular momentum to eject material
- ...but there is still lot to learn and continuous observations are required!

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

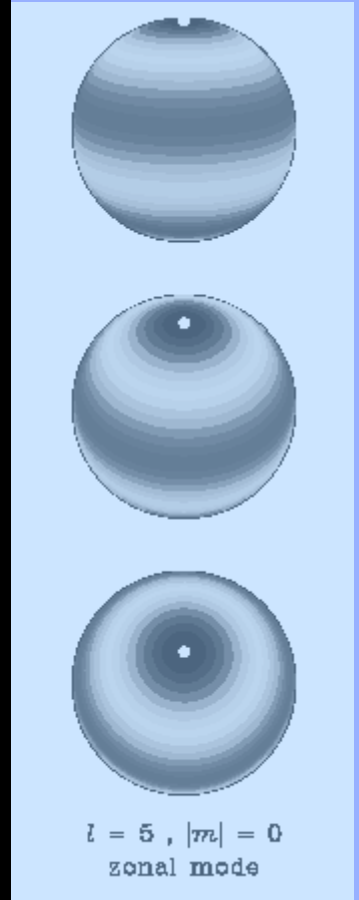
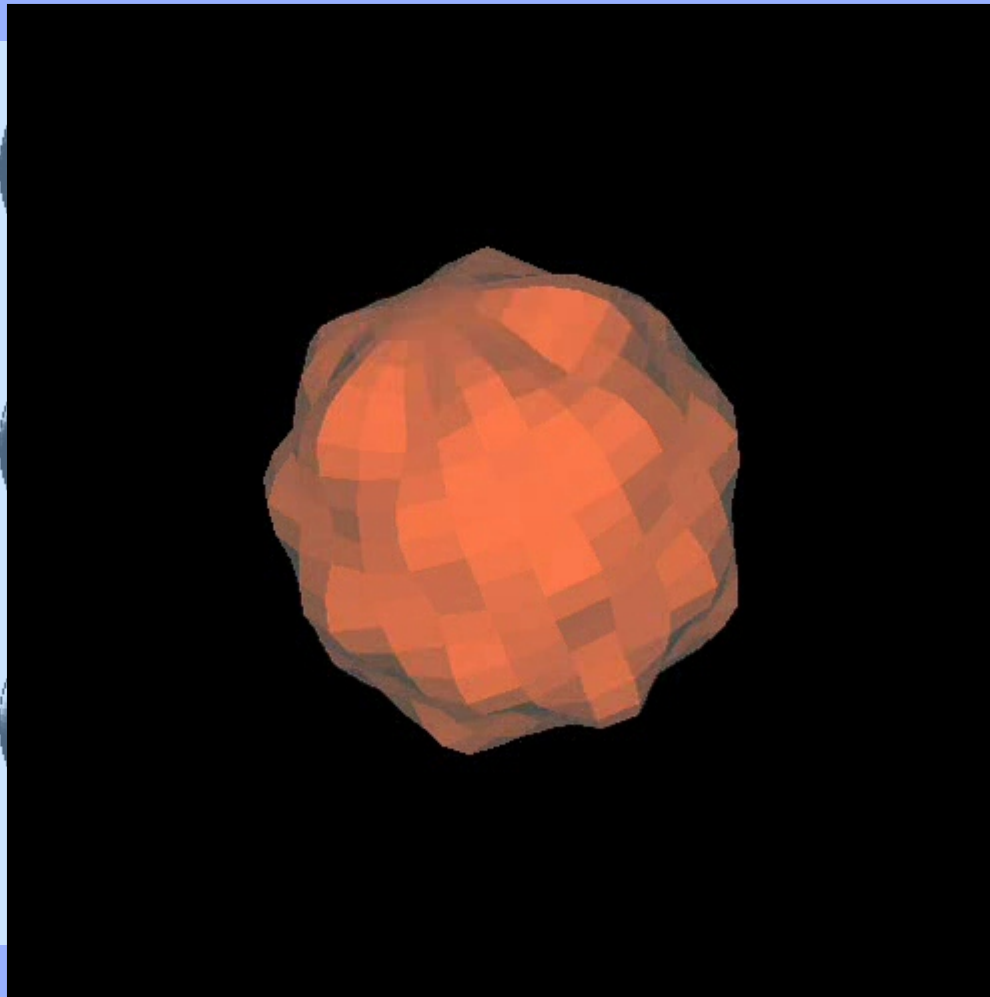
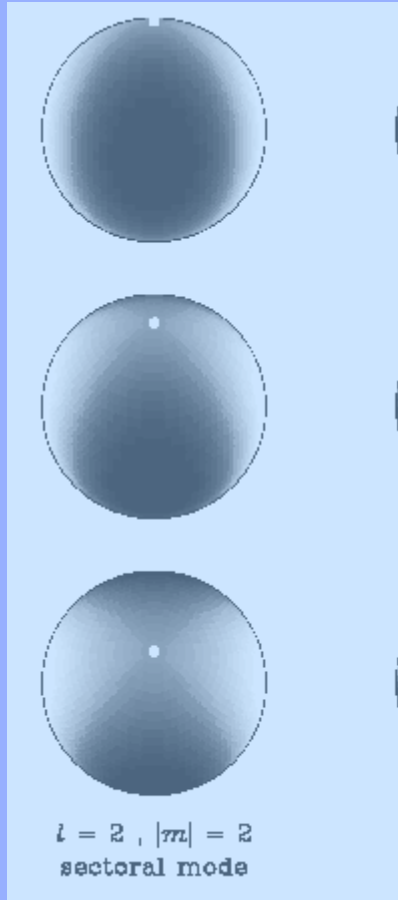


l = nb of lines in longitude

m = nb de lines in latitude

Schrijvers 1999

Non Radial Pulsations



l = nb total de lignes séparatrices

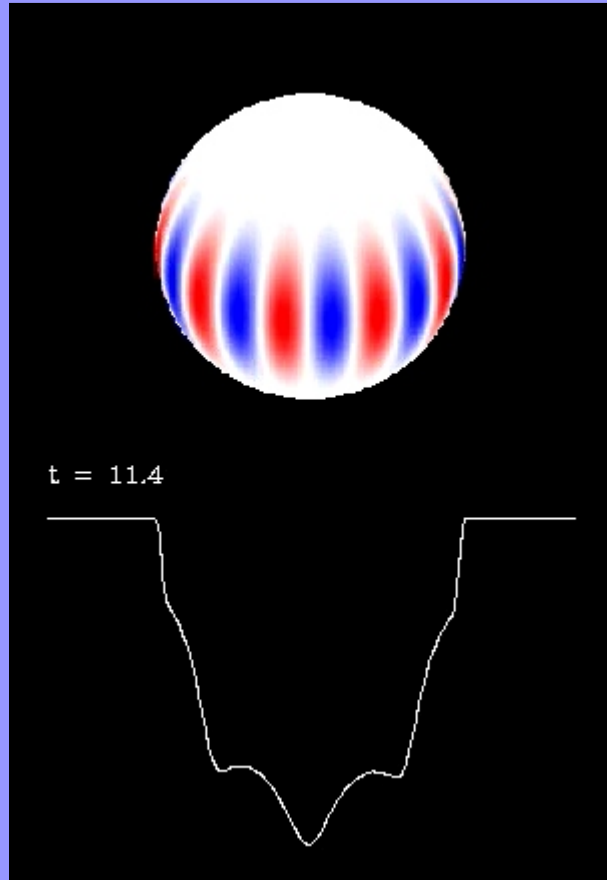
m = nb de lignes en latitude

$l=9, m=5$

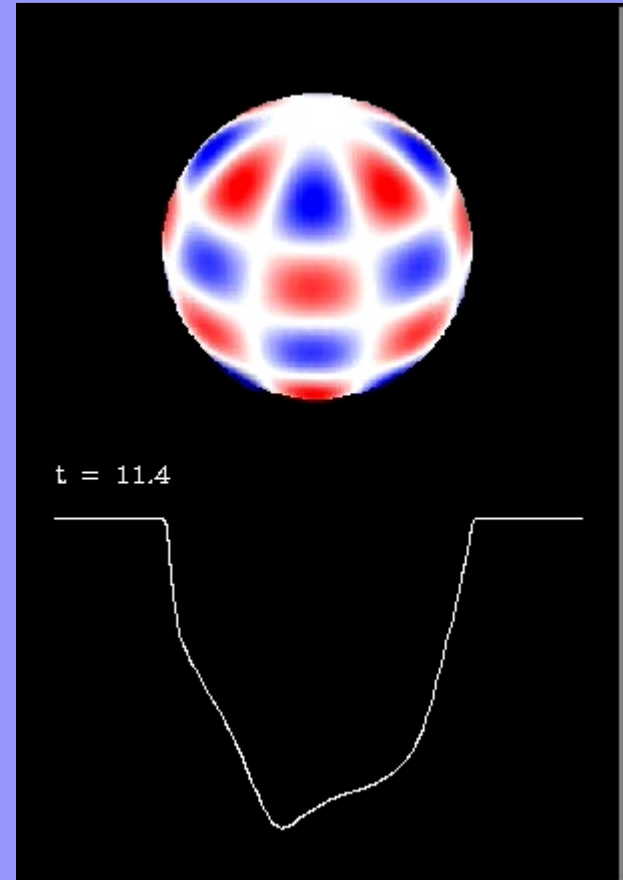
Animation: C. Ormerod

NRP spectral changes

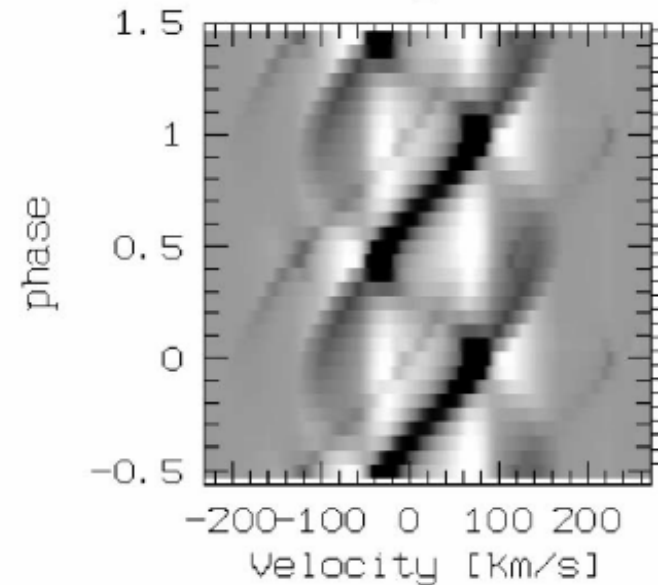
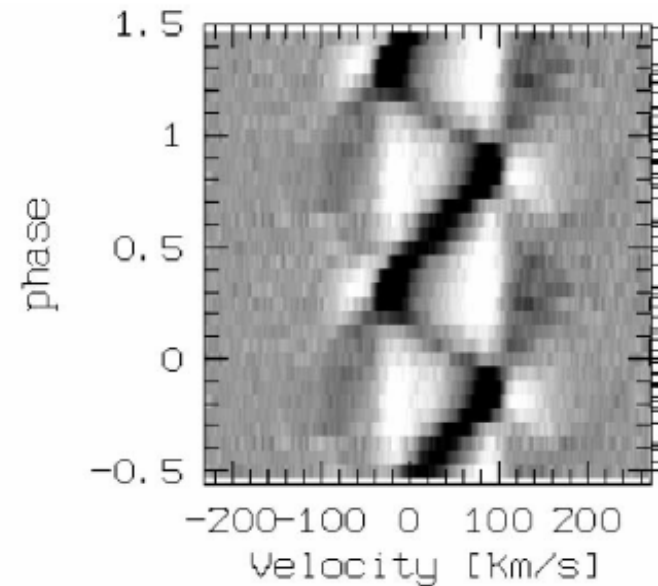
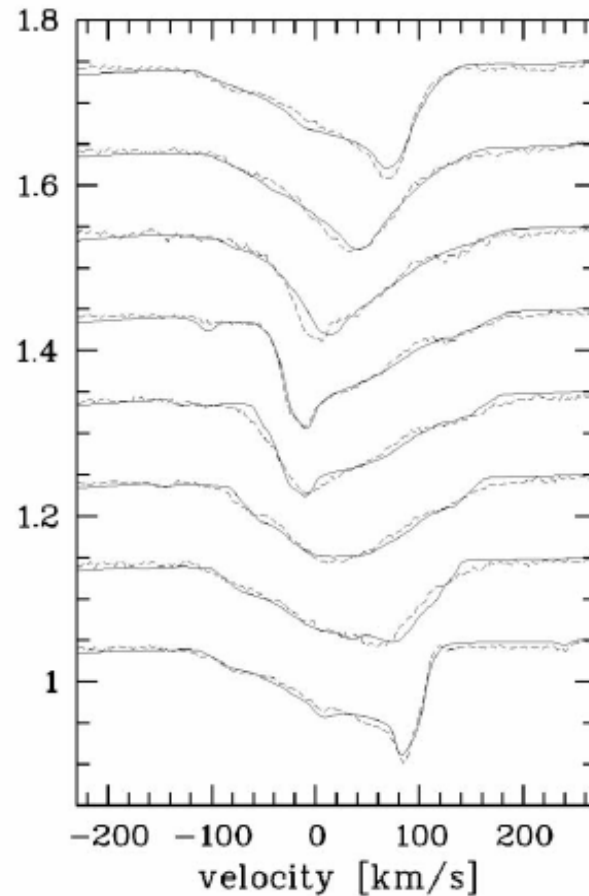
$l=10, m=10$



$l=7, m=4$



Example of spectral changes



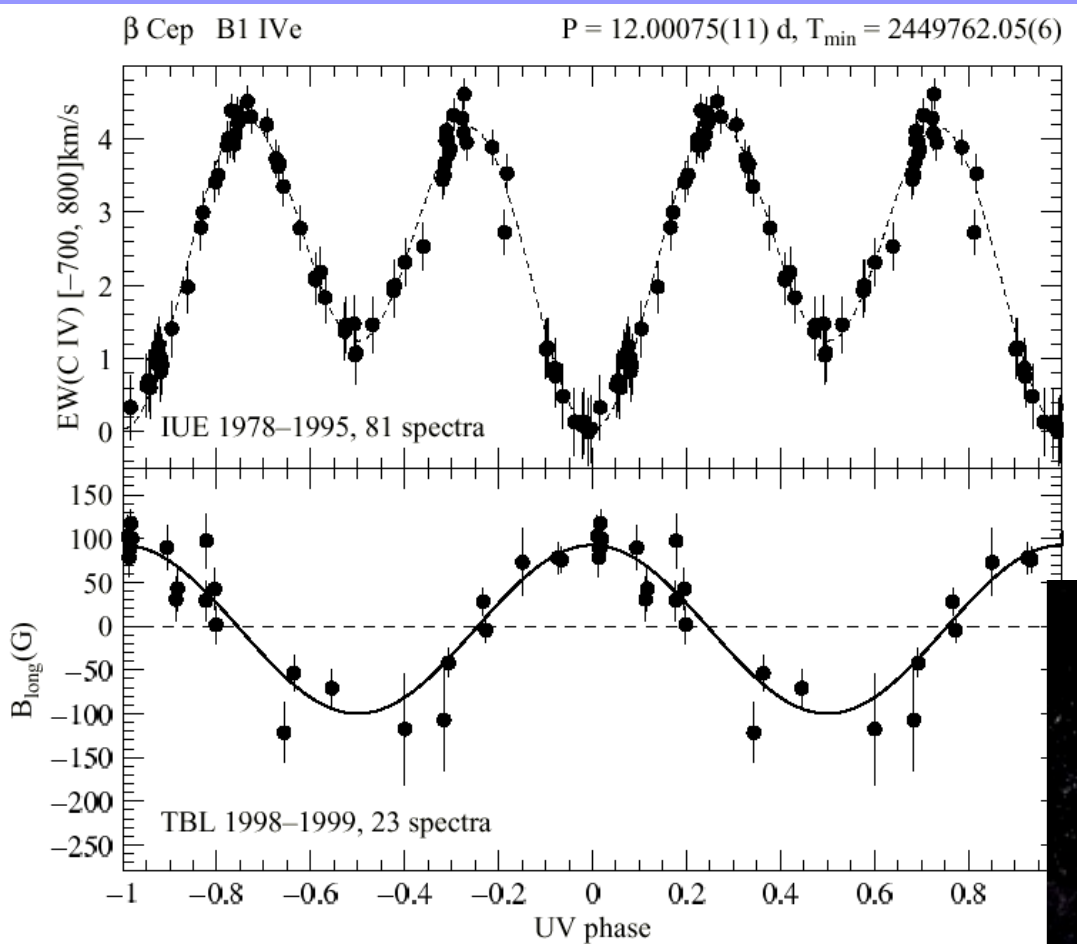
Magnetic field detection

- Direct detection by spectro-polarimetry (Zeeman effect) is very hard:
 - too 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)



One detection: β Cep



- β Cep, prototype of β Cep stars, also a Be star but rotating slowly...

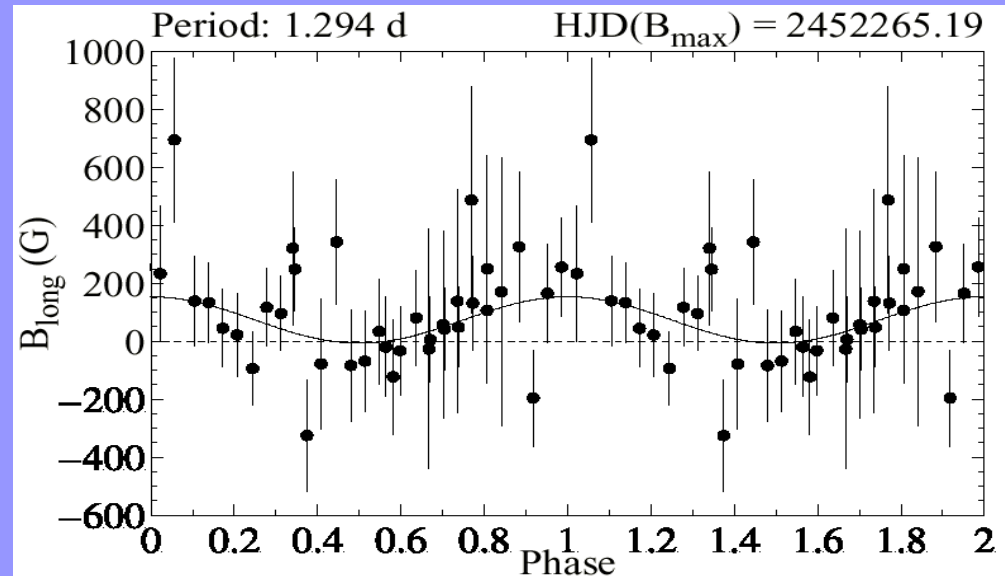
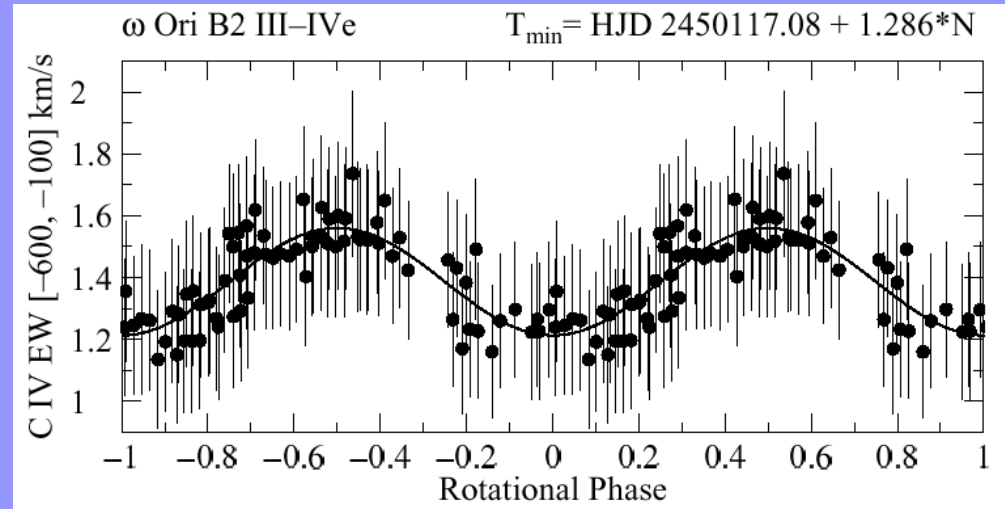
... with a magnetic field (Henrichs et al. 2000)



...and a classical Be star !

▪ ω Ori, a fast rotating classical Be star...

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



Some useful links

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

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

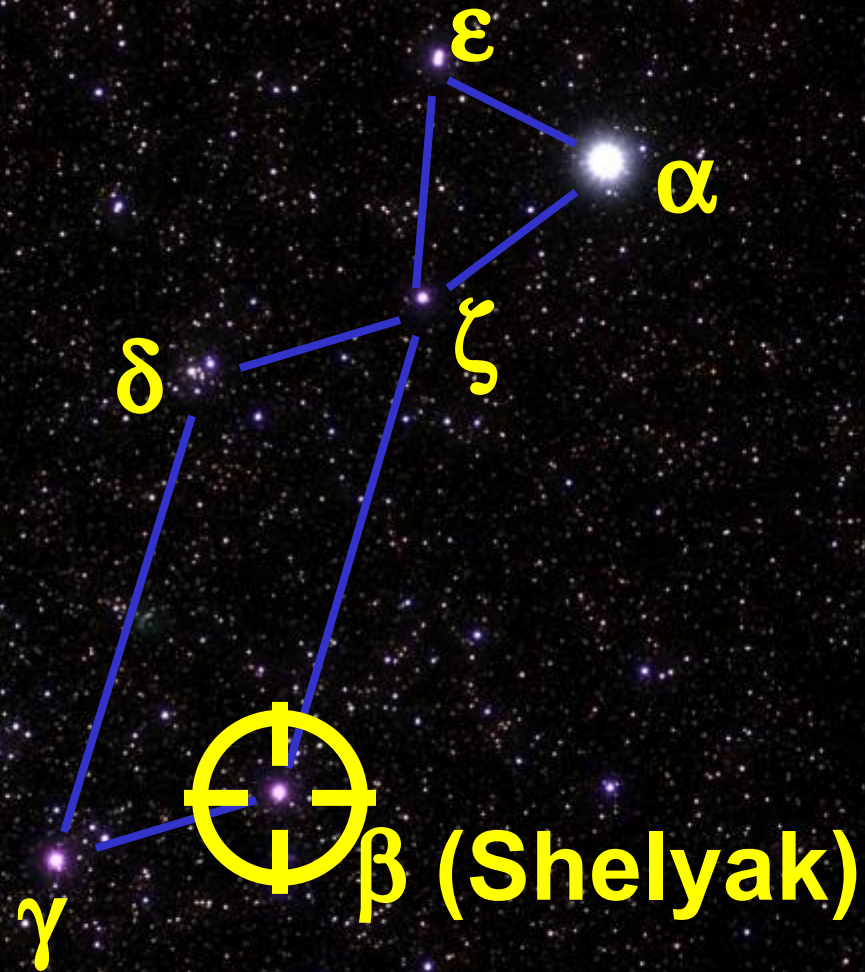
CDS Strasbourg <http://cdsweb.u-strasbg.fr/>

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

Shelyak http://www.shelyak.com/en/be_stars.html

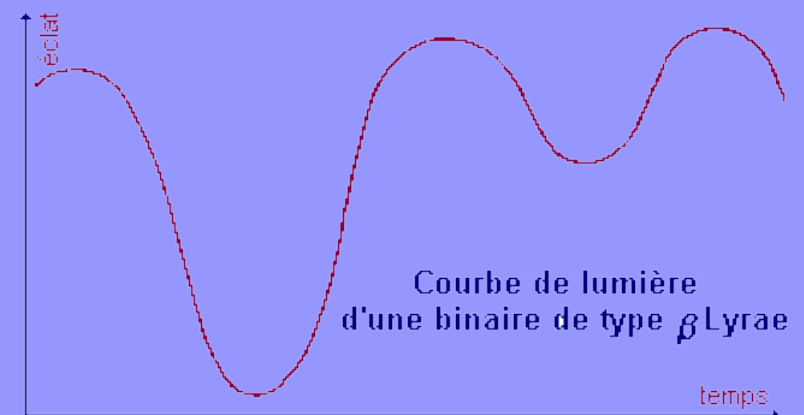
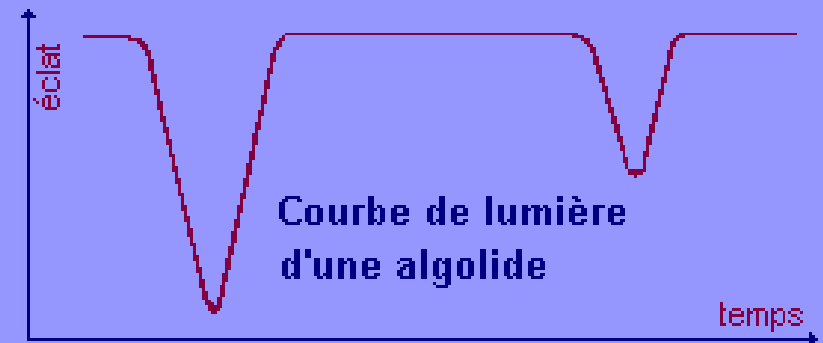
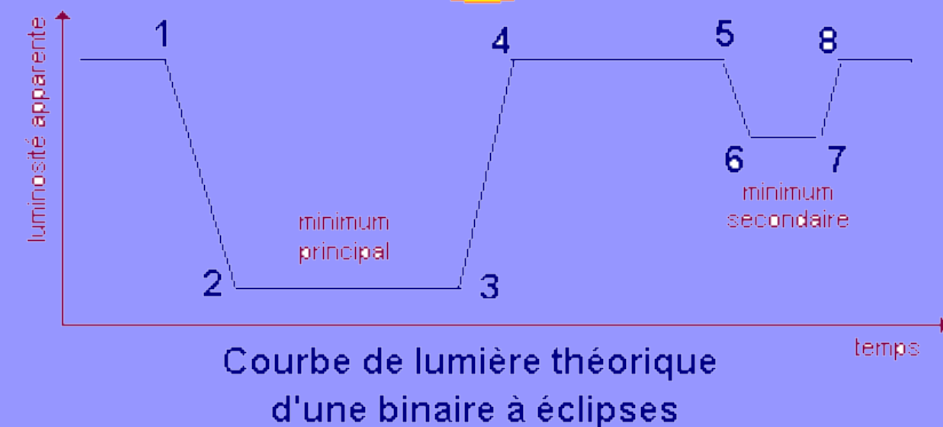
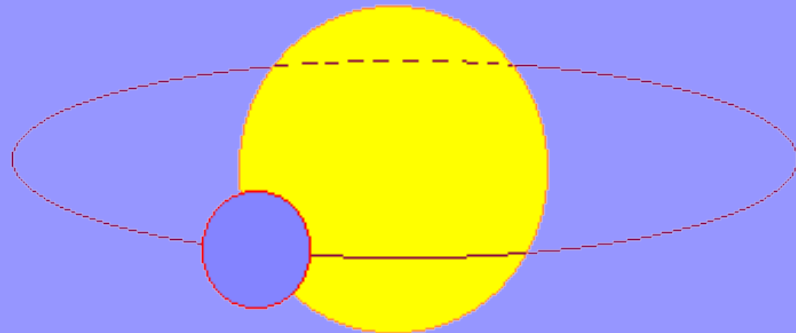
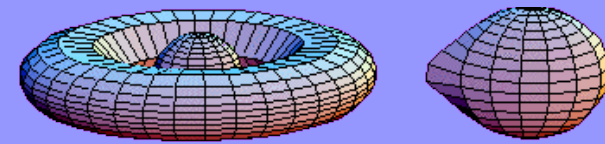
Some key articles (cf ADS):

- 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



β (beta) Lyrae

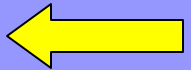
Eclipsing binaries



Bright eclipsing binary Be stars

- 7 eclipsing binary Be bright stars are visible from our location:

RA	Dec	HR	name	HD	V	Sp
5.3660	-02.4431	1788	eta Ori	35411	3.36	B1V+B2e
18.8039	33.3046	7106	beta Lyr	174638	3.45	B7Ve+A8p
22.9937	42.0574	8762	omicron And	217675	3.62	B6IIIIpe+A2p
21.9207	63.3875	8383	VV Cep	208816	4.91	M2Iaep+B8Ve
21.2979	58.4119	8164		203338	5.66	M1Ibep+B2pe+B3V
5.8238	19.8551	2030		39286	6.06	B8III+G2IIIe
6.8695	-01.6936	2577		50820	6.21	B3IVe+K2II

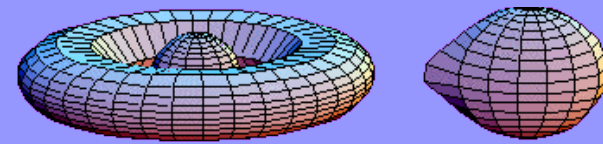


from Huib Henrichs

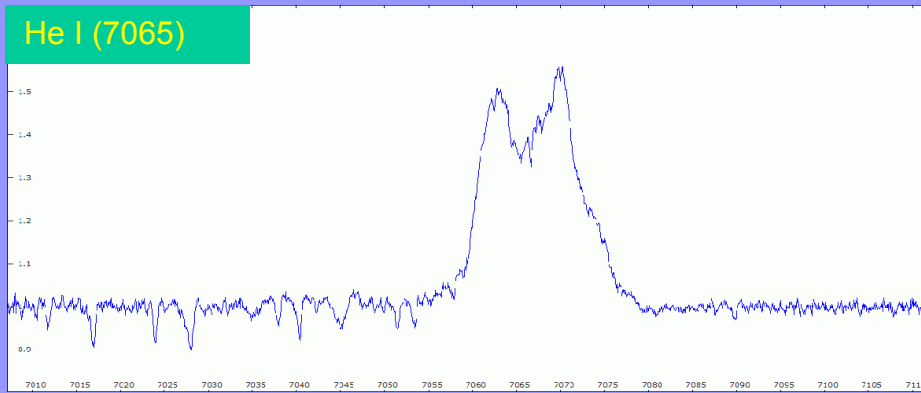
History of beta Lyrae

- 1794: Goodricke discovered her variability
 - $P = 12.9\text{d} (+19\text{sec/year})$
 - Minimum = 1mag
 - Second minimum = 0.5mag
 - Distance of ~ 270 parsecs
 - $V = -17\text{km/sec}$
- 1867: Spectrum observed by Secchi
- 1892: first calibrated spectrum by Belopolsky
 - Full RV (radial velocity) amplitude = 370km/sec

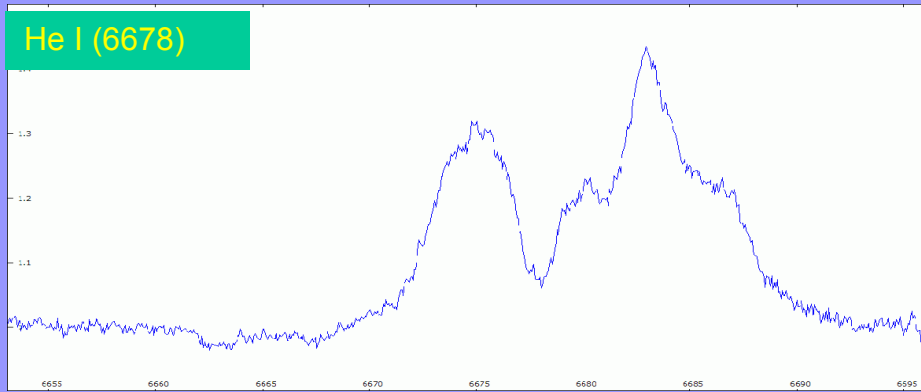
β Lyrae (19/9/2004)



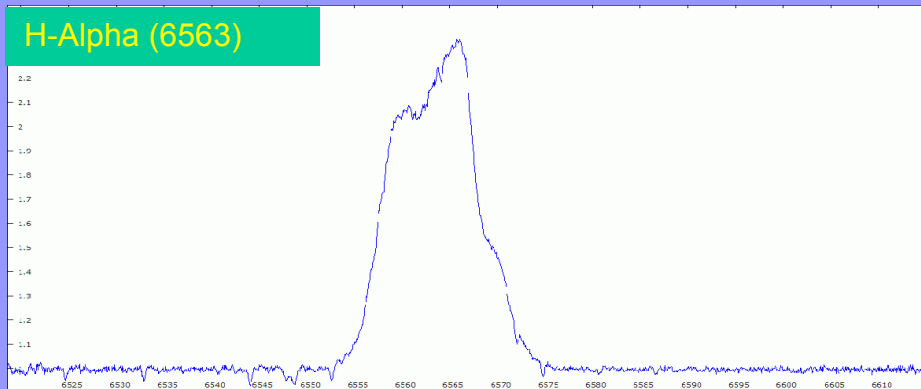
He I (7065)



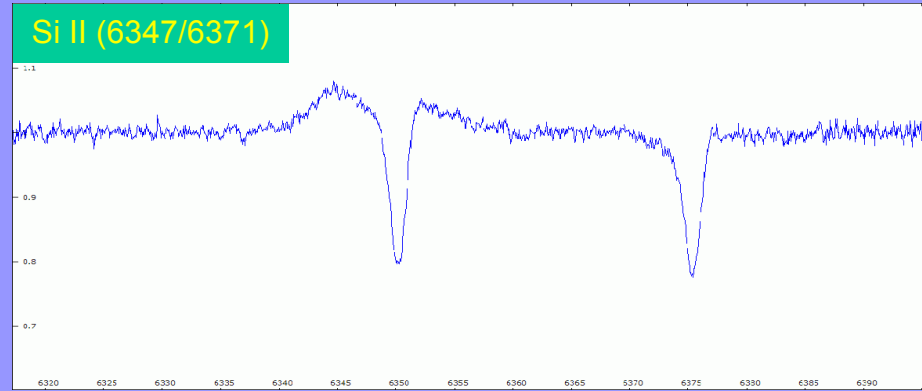
He I (6678)



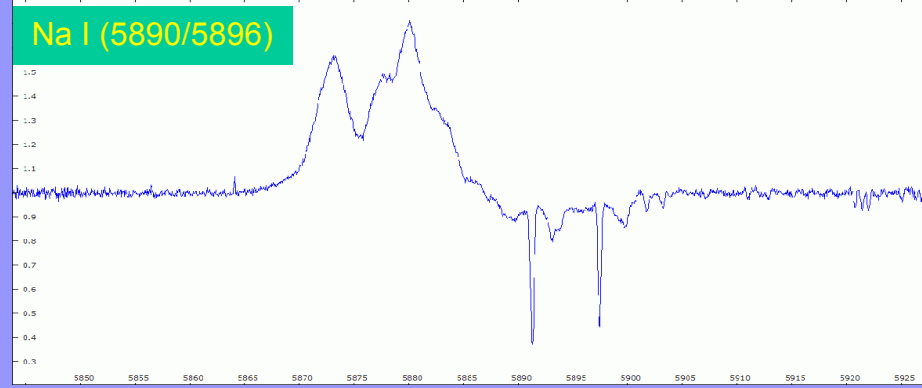
H-Alpha (6563)



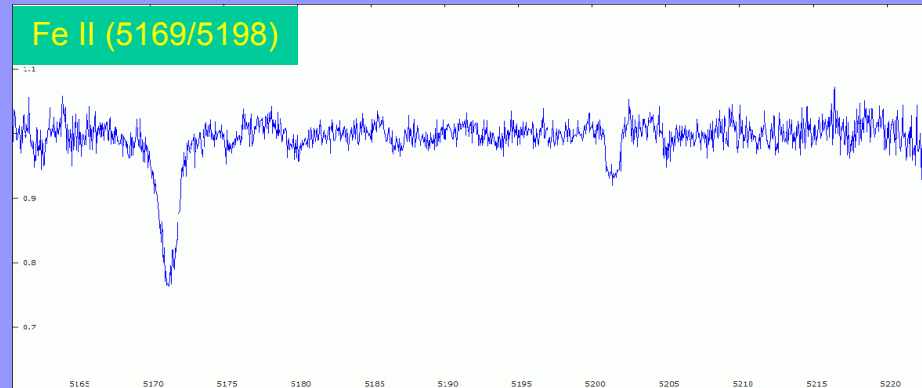
Si II (6347/6371)



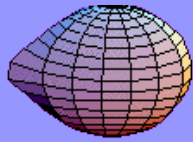
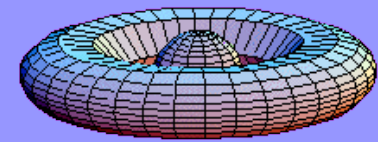
Na I (5890/5896)



Fe II (5169/5198)

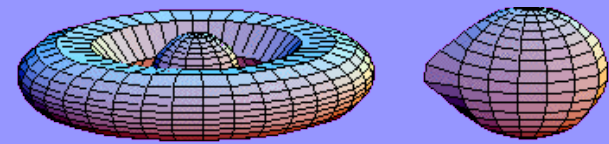


Am/Am Collaboration !!!

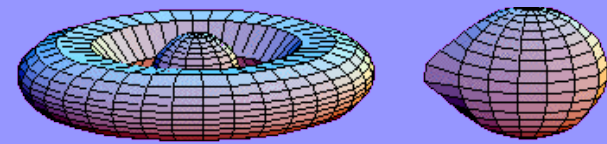


- Teams from two astronomical club collaborated at the same observatory for a continuous 2 weeks monitoring (13 clear nights!)
- Contribution from 6 different instruments total
- Comment from a professional astronomer:
 - « beta Lyrae is a very interesting star to monitor but I have to warn you that spectra analysis will be very difficult as, on top of emission, this binary system includes an accretion disk, polar jets, mass transfer... well, you will have fun! »

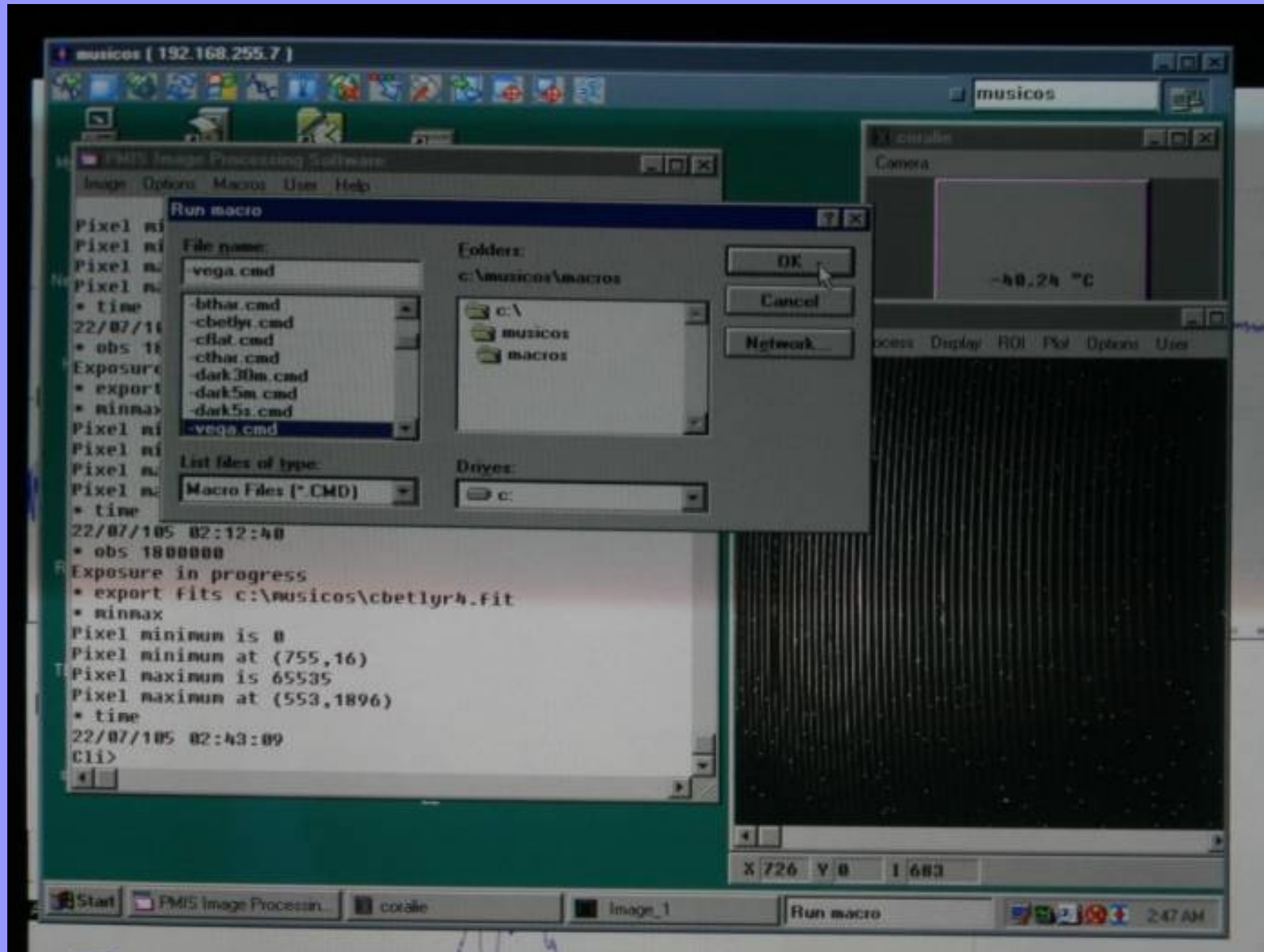
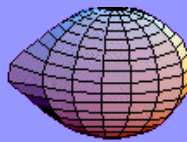
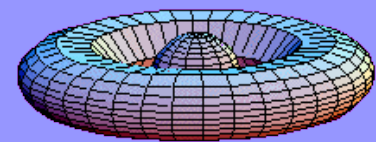
Saint Véran observatory



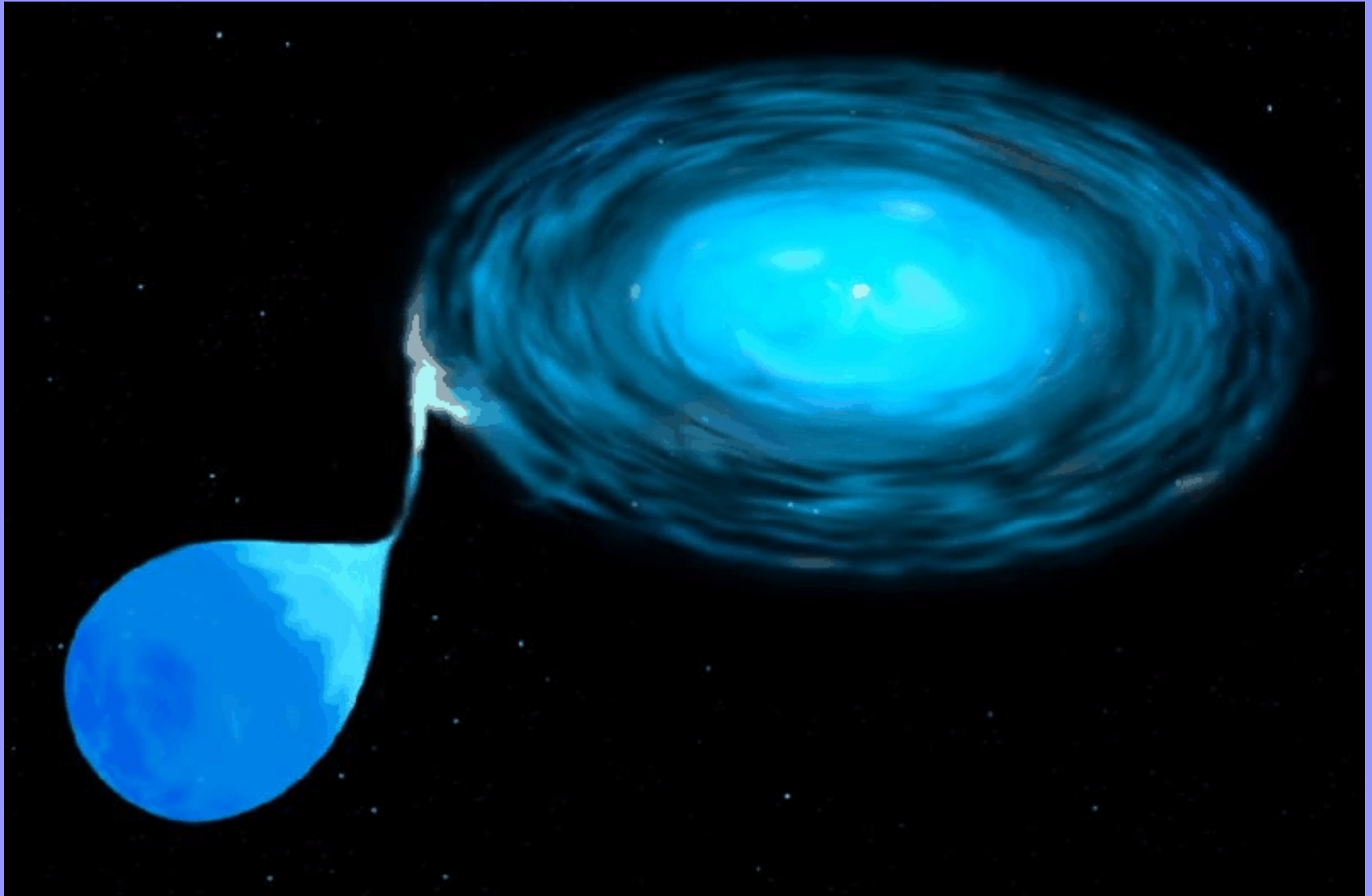
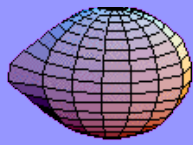
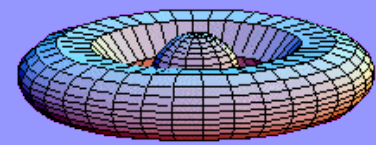
Acquisitions (1/2)



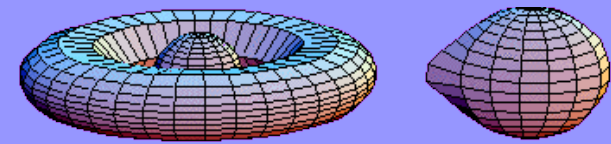
Acquisitions (2/2)



How does it look like ?



β Lyrae – Model (1/5)



Primary:

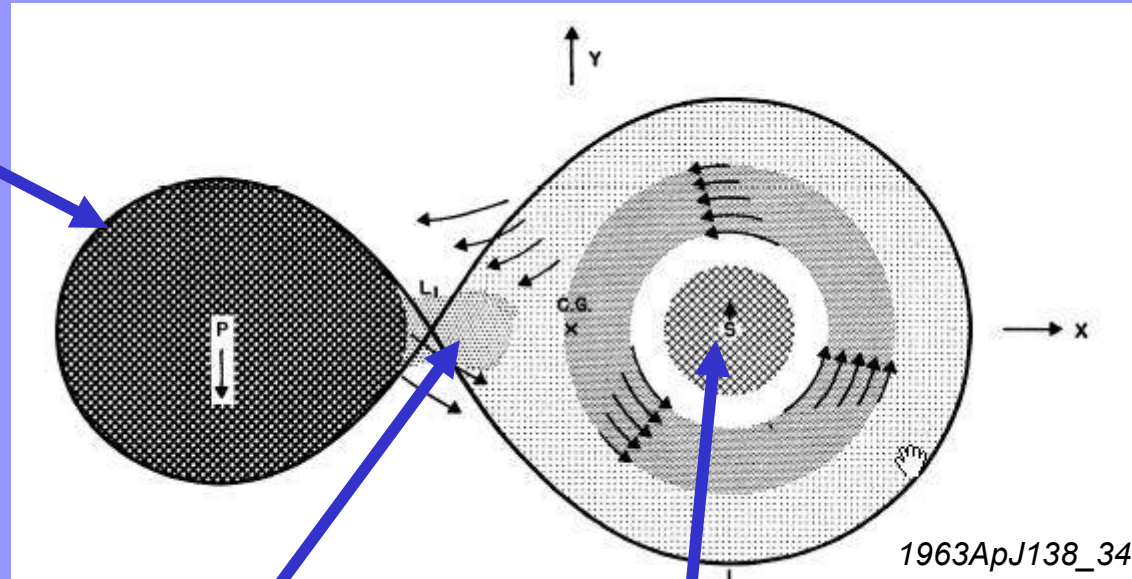
B6-B8II

$3 M^*$

$T=12000\text{K}-13000\text{K} ?$

$v \cdot \sin(i) = 50-60\text{km/sec}$

Seems more luminous



Mass transfer $\sim 20 \cdot 10^{-6} M^*$

Secondary:

B0-B2Ve

$13 M^*$

$6.7 R^*$

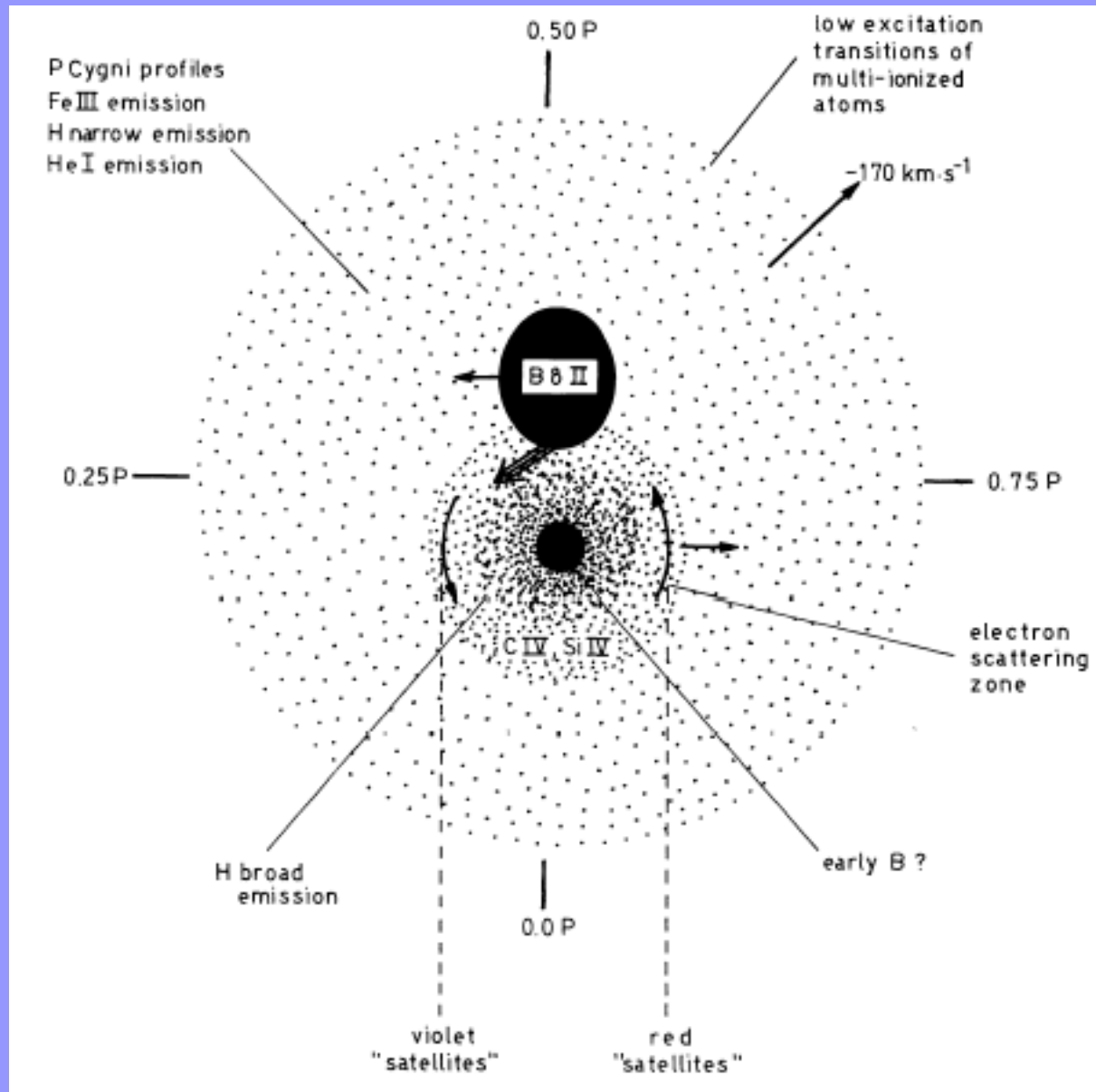
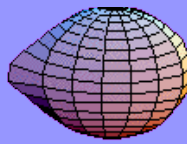
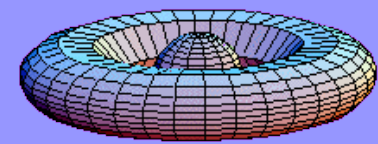
Disk covering 26%
of the star's sky

Polar jets

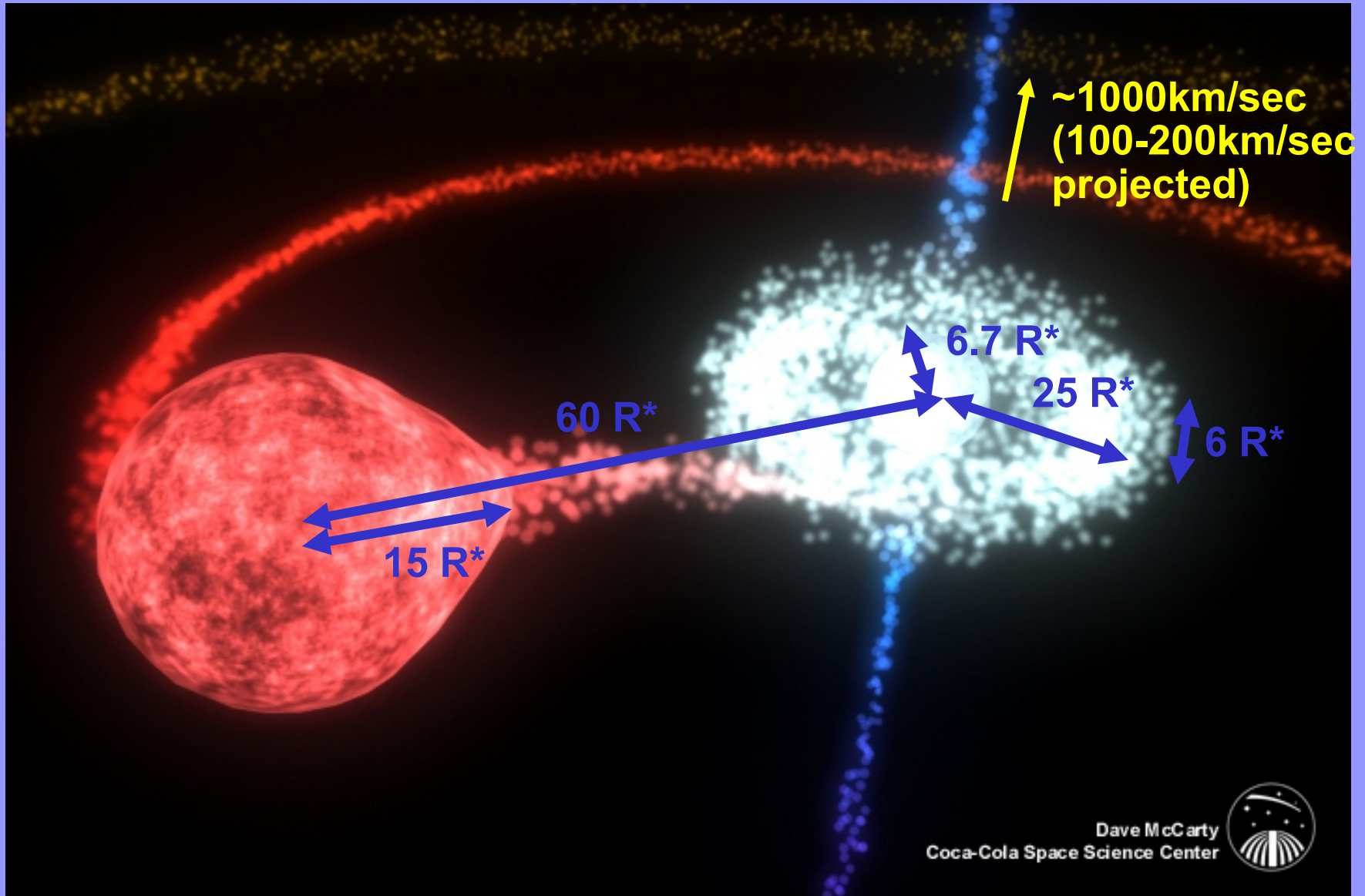
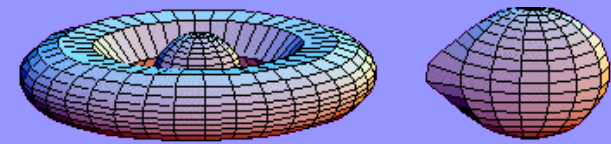
System inclination $\sim 80^\circ-85^\circ$

$q = M(\text{secondary}) / M(\text{primary}) = 4.8-5.6$

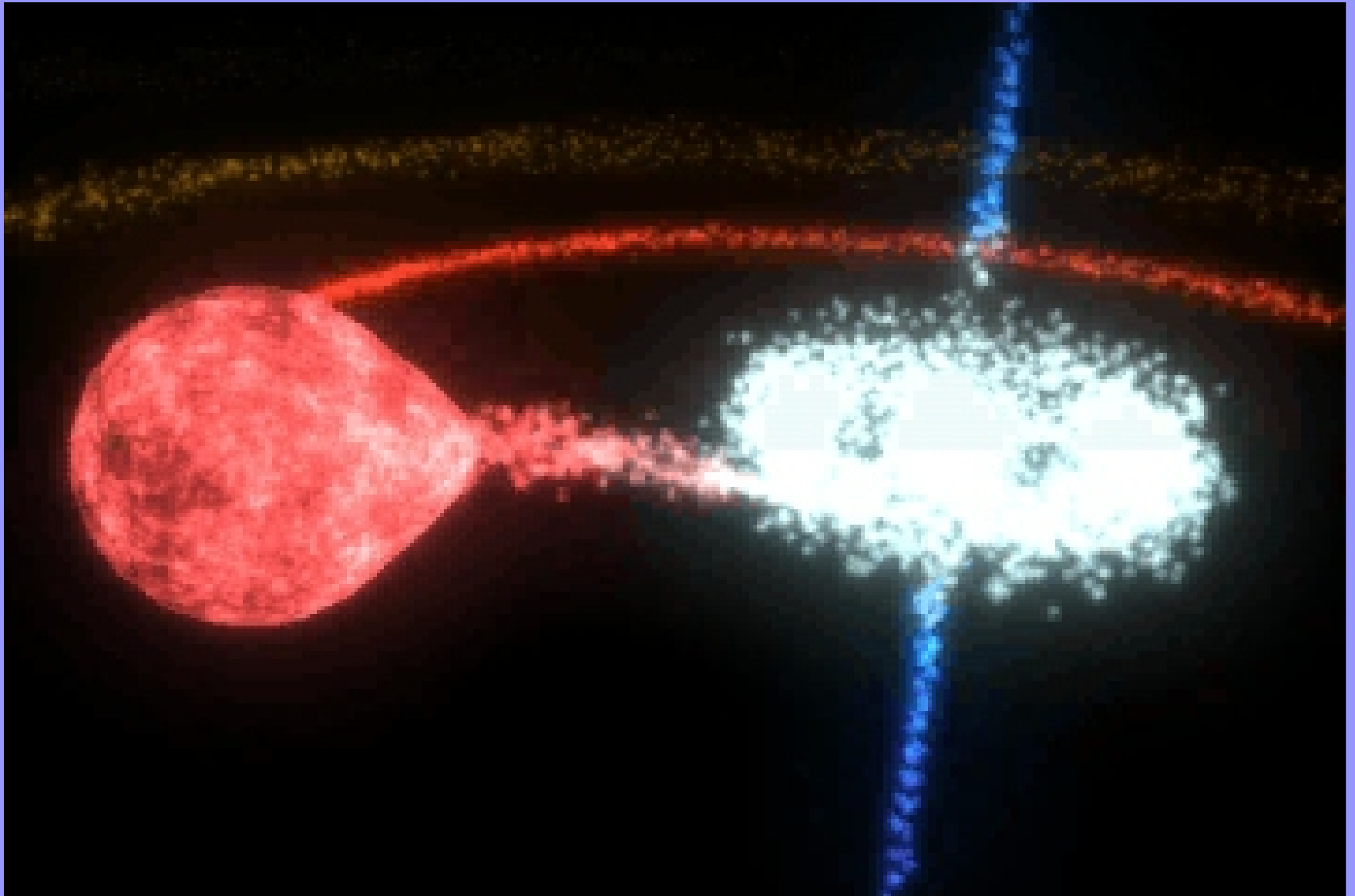
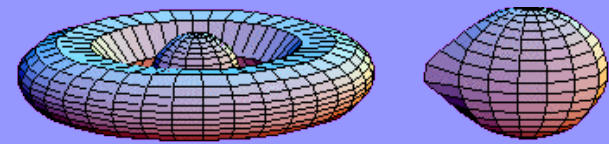
β Lyrae – Model (2/5)



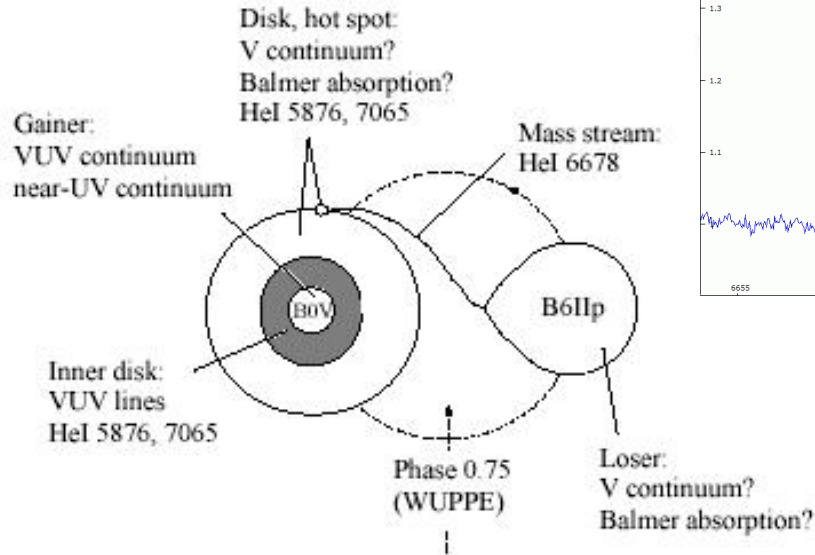
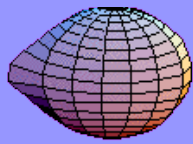
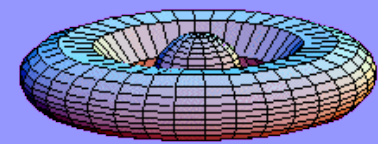
β Lyrae – Model (3/5)



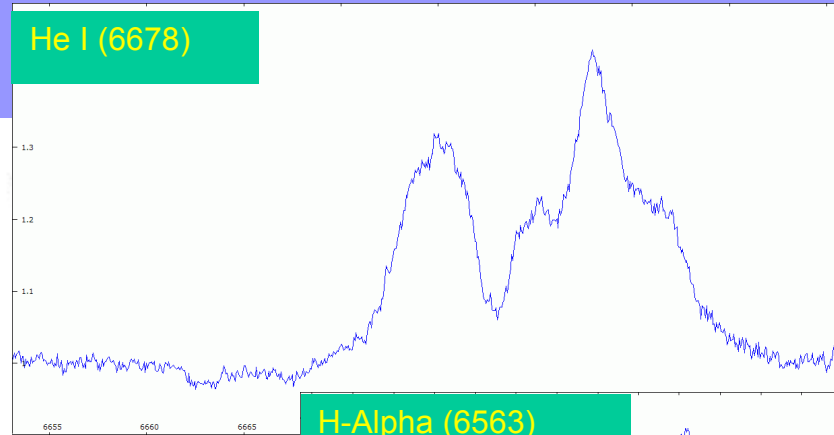
β Lyrae – Model (4/5)



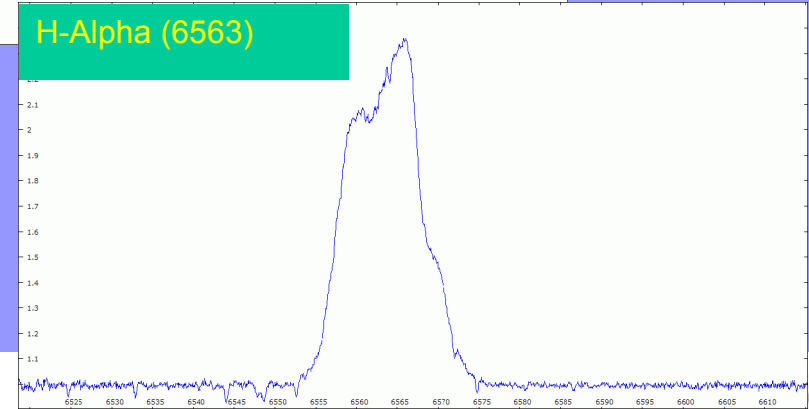
β Lyrae – Model (5/5)



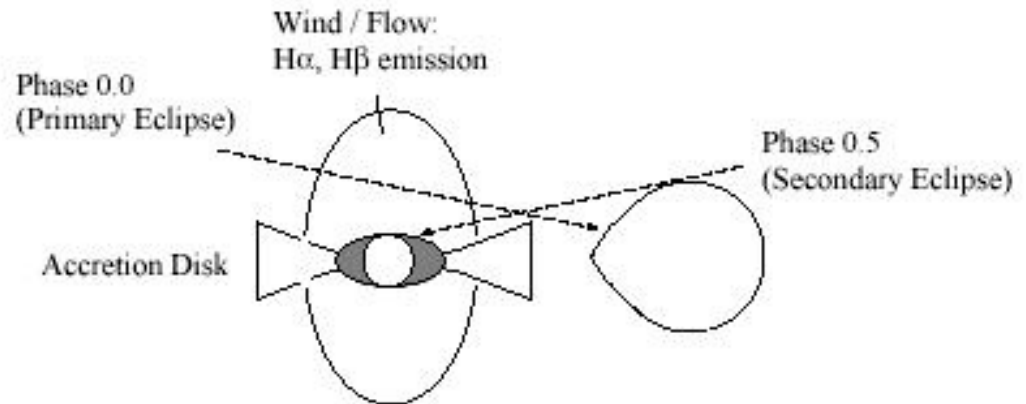
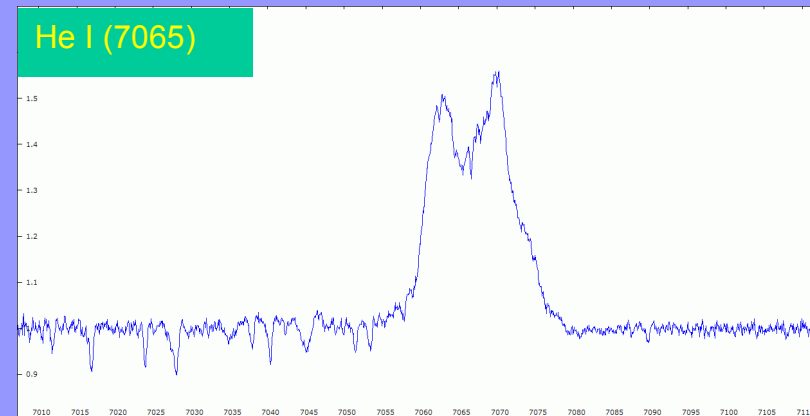
He I (6678)



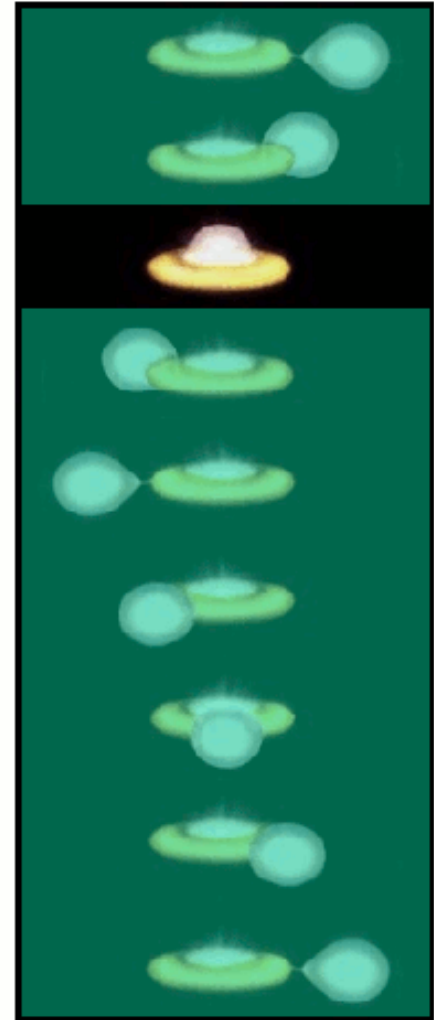
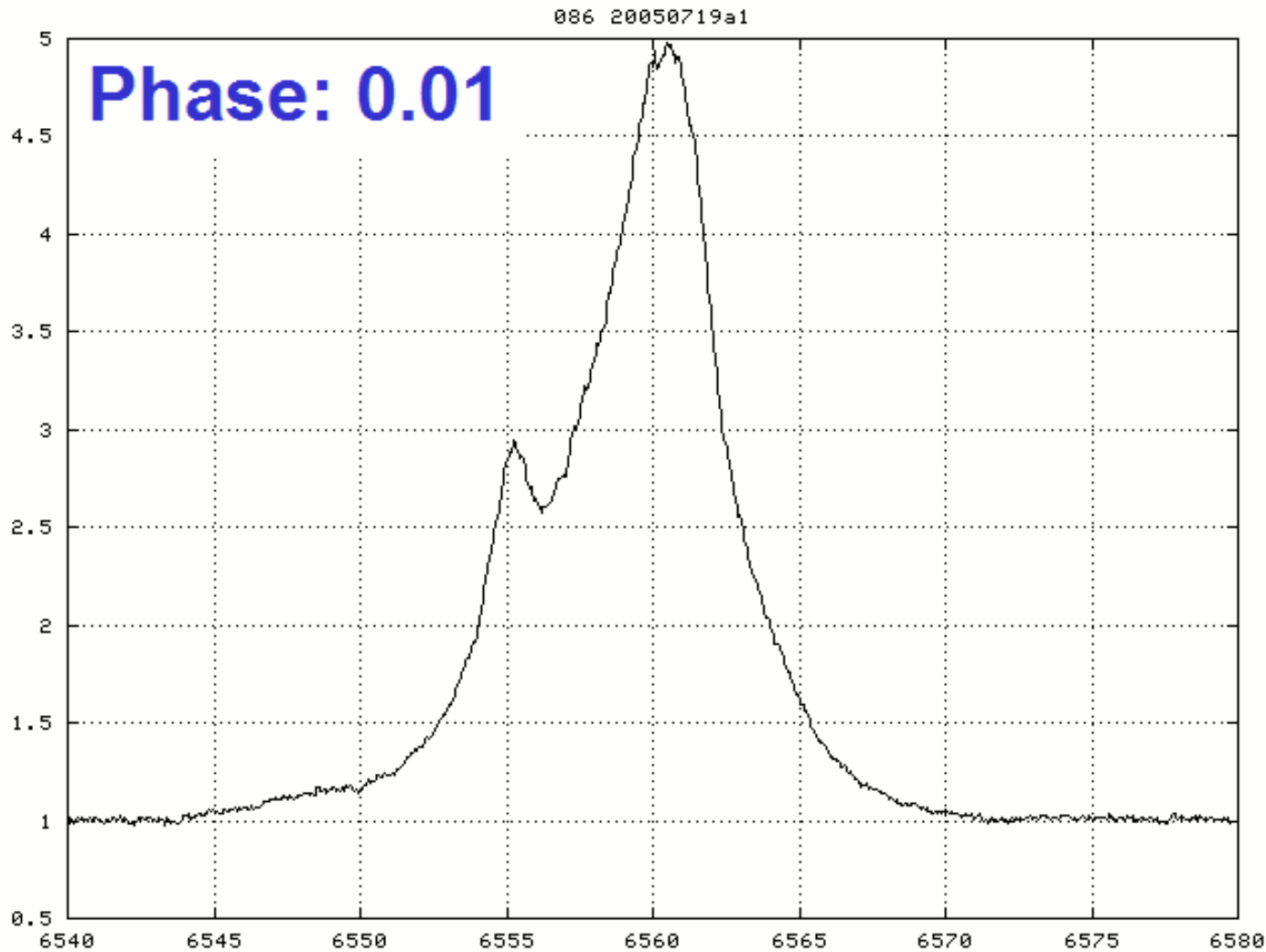
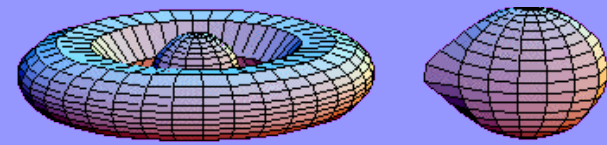
H-Alpha (6563)



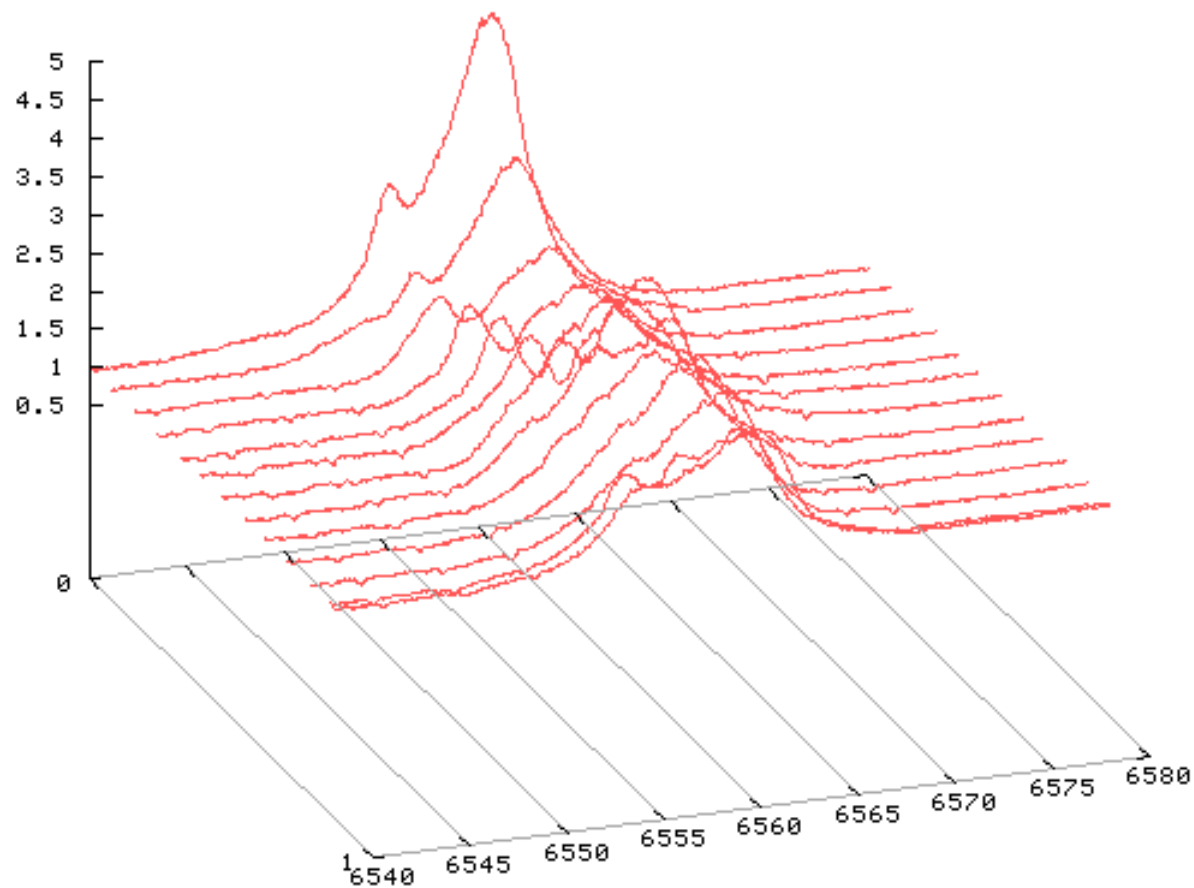
He I (7065)



H α - evolution

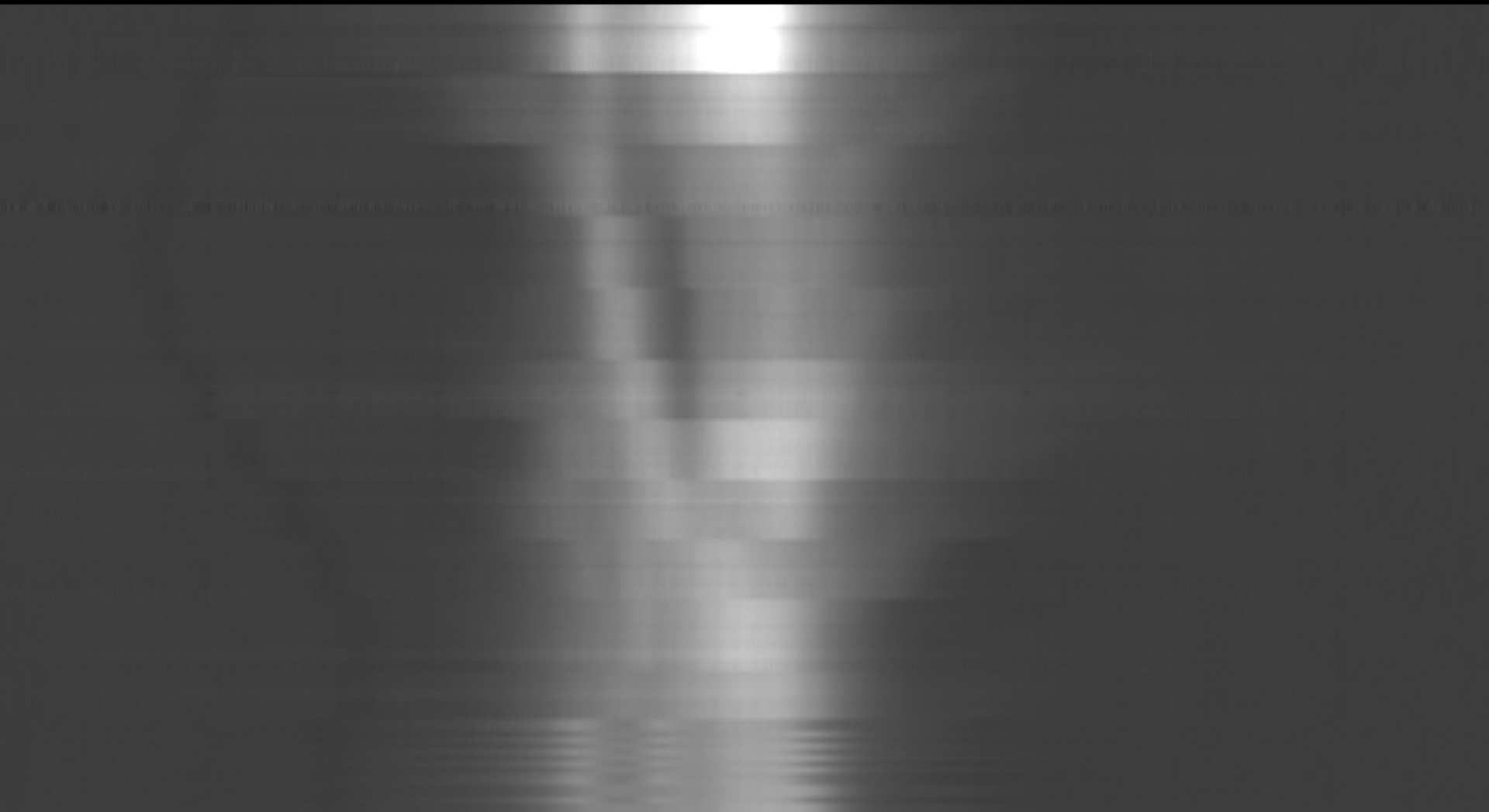
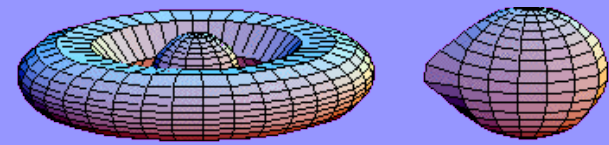


Beta Lyrae: all spectra (2005)



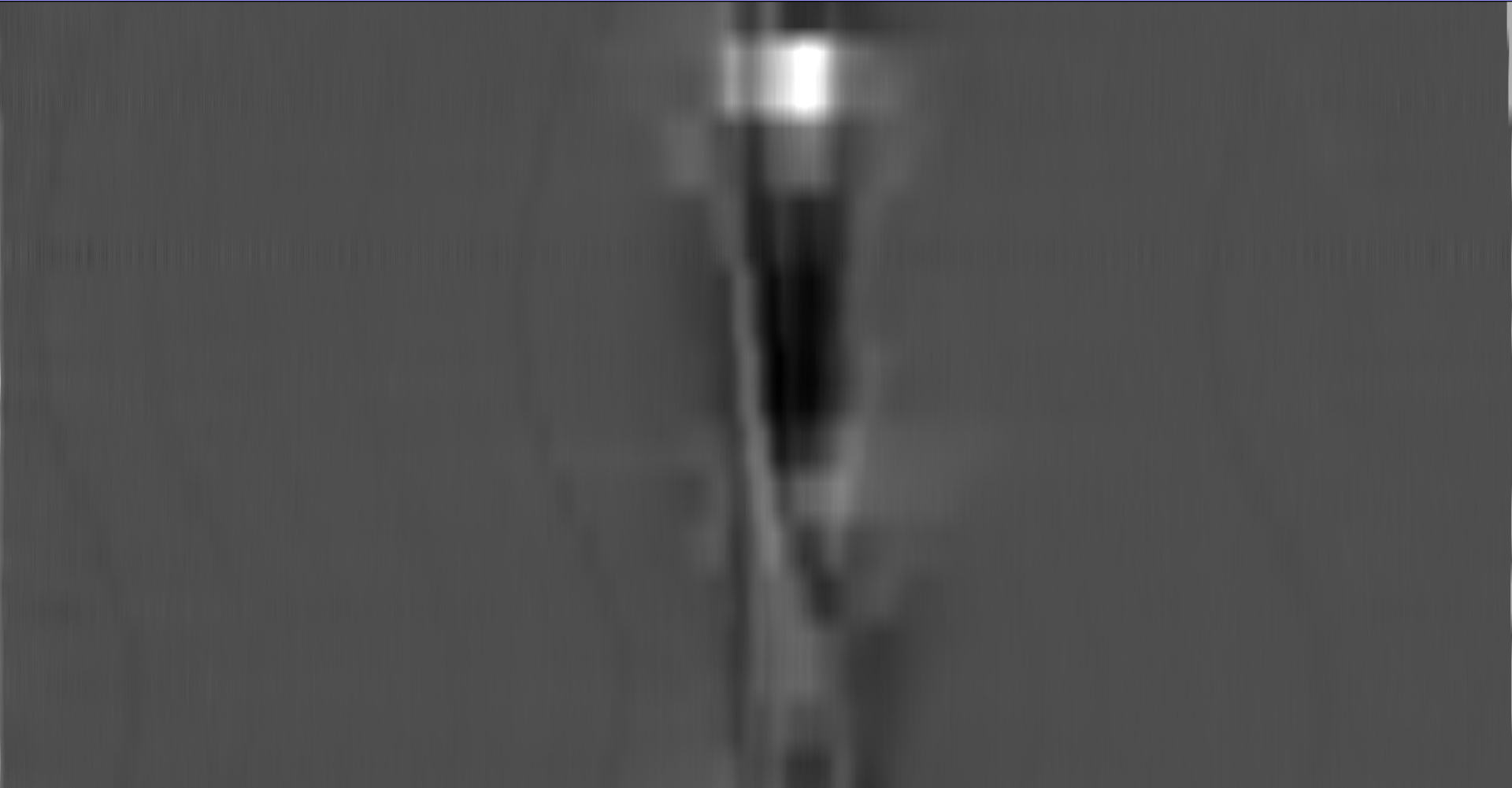
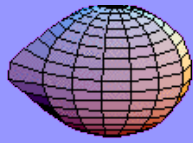
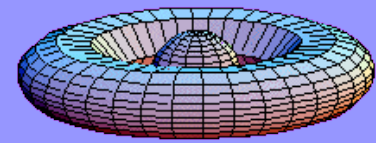
*Each spectrum is a combined 2h exposure (4*30min)*

H α - 2D plot



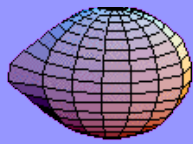
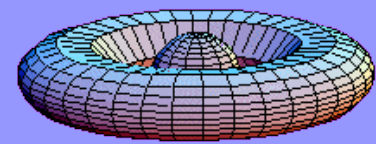
136 spectra

H α - 2D plot (difference)

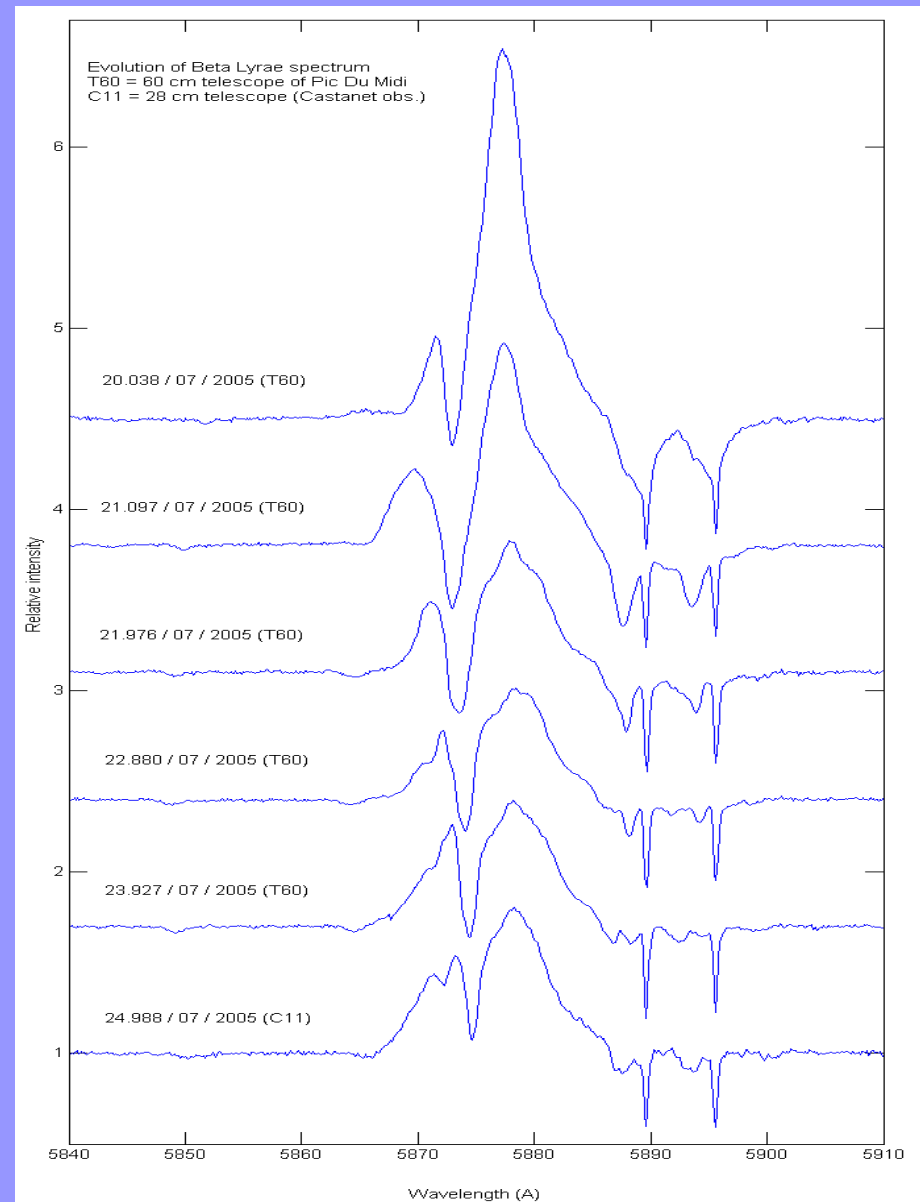
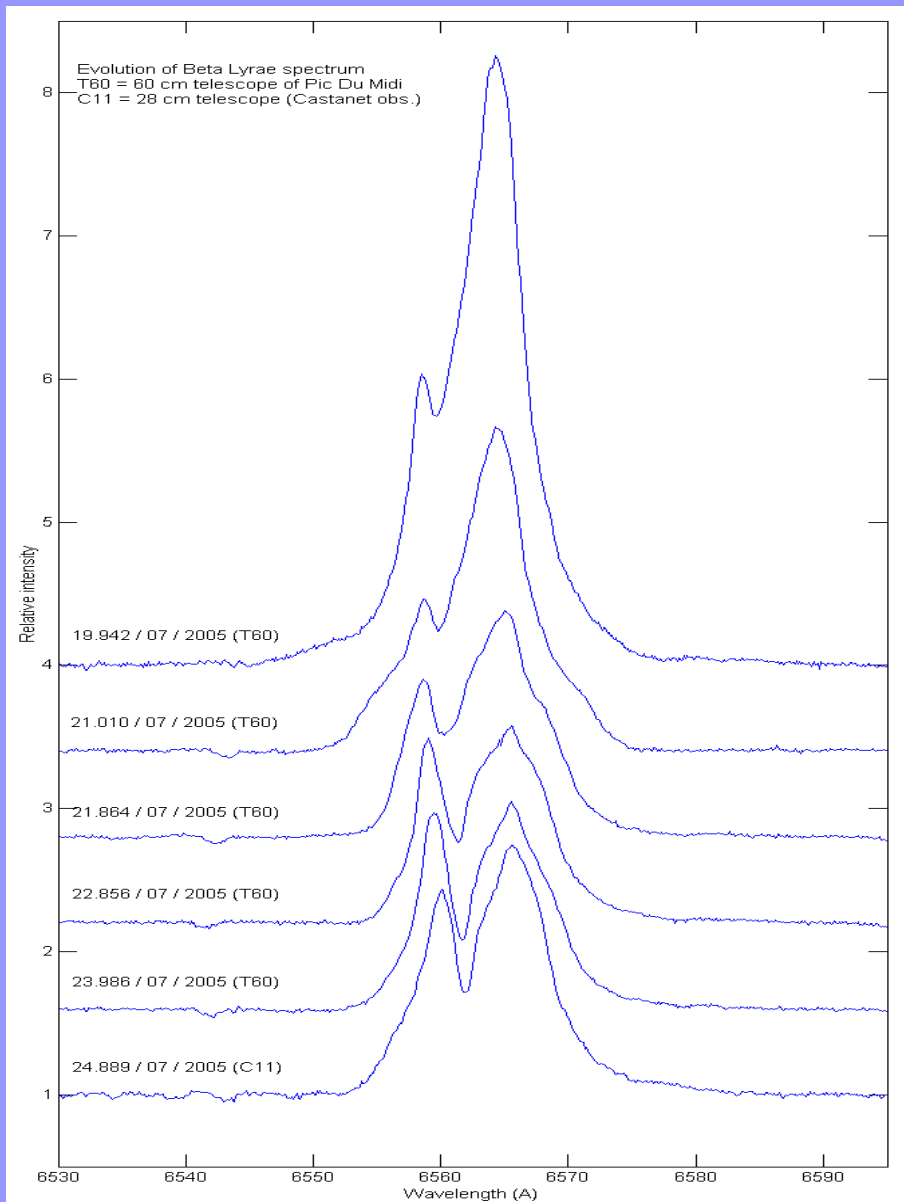
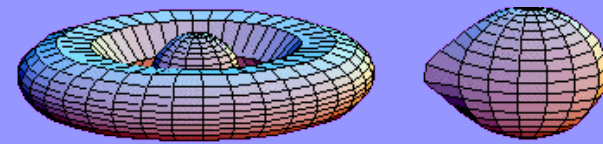


*32 spectra, each a combination of four 30min exposures ($\rightarrow 2h$)
Difference with the overall mean spectrum*

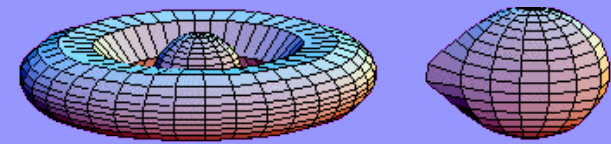
T60 mission



H α et HeI evolution



Other observations...



C11(SV): Lhires3 + C11 f/10; St Véran



C8(FC): Lhires3 + C8 f/10; François Cochard



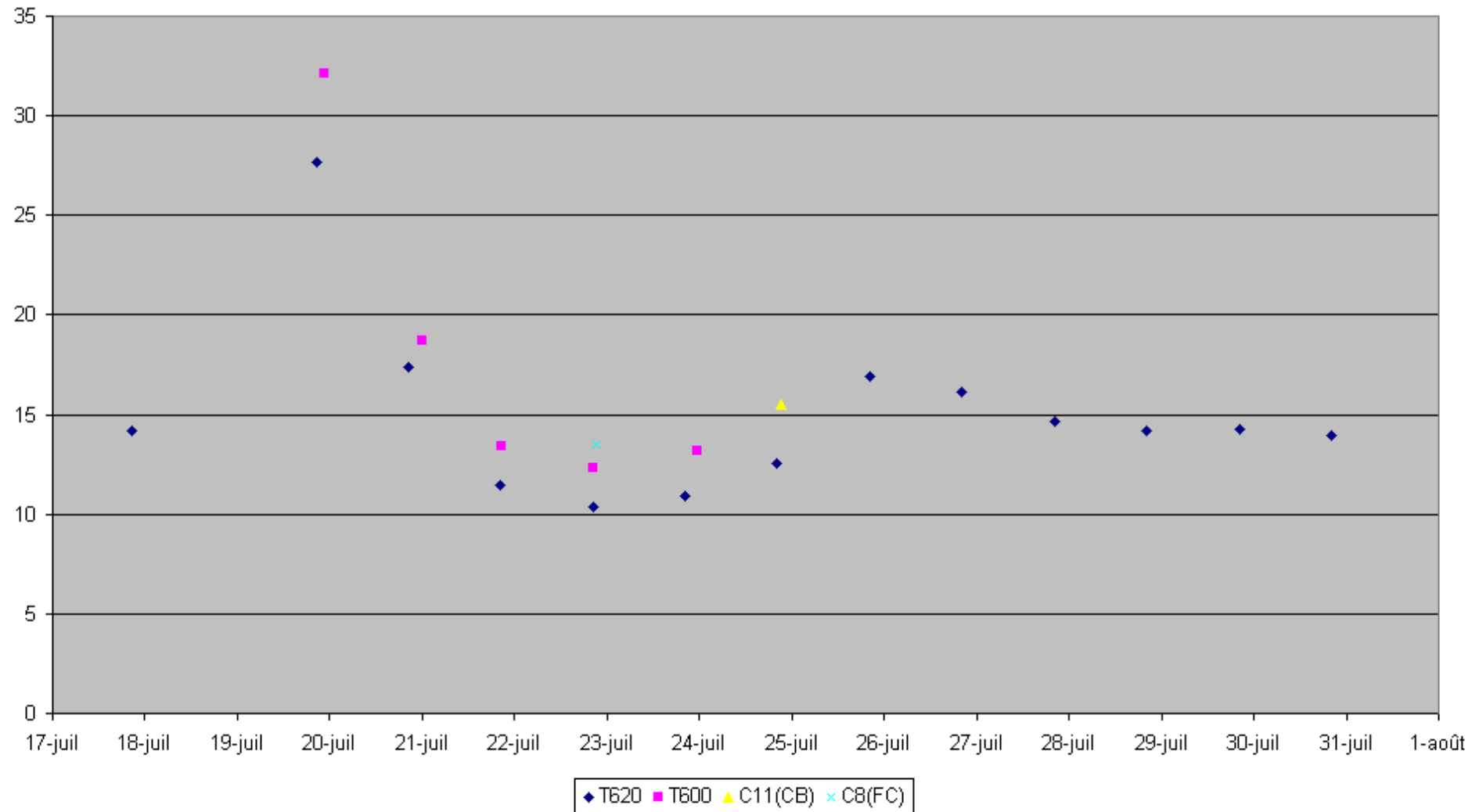
T60(IT): 600mm f/15 ; Paolo Valisa and Giorgio Cardarelli



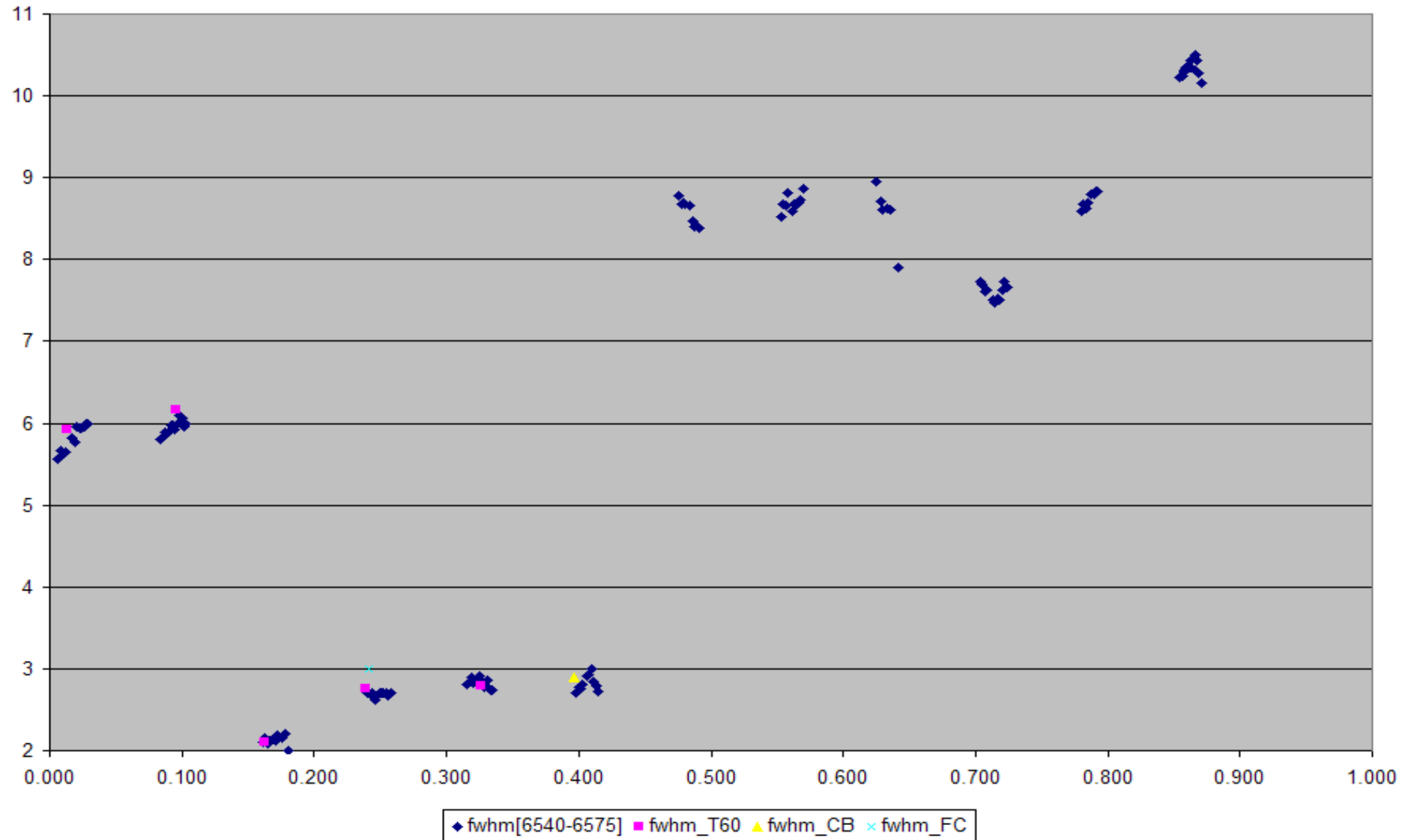
C11(CB): Lhires3 + C11 f/10; Christian Buil

Equivalent Width (EW)

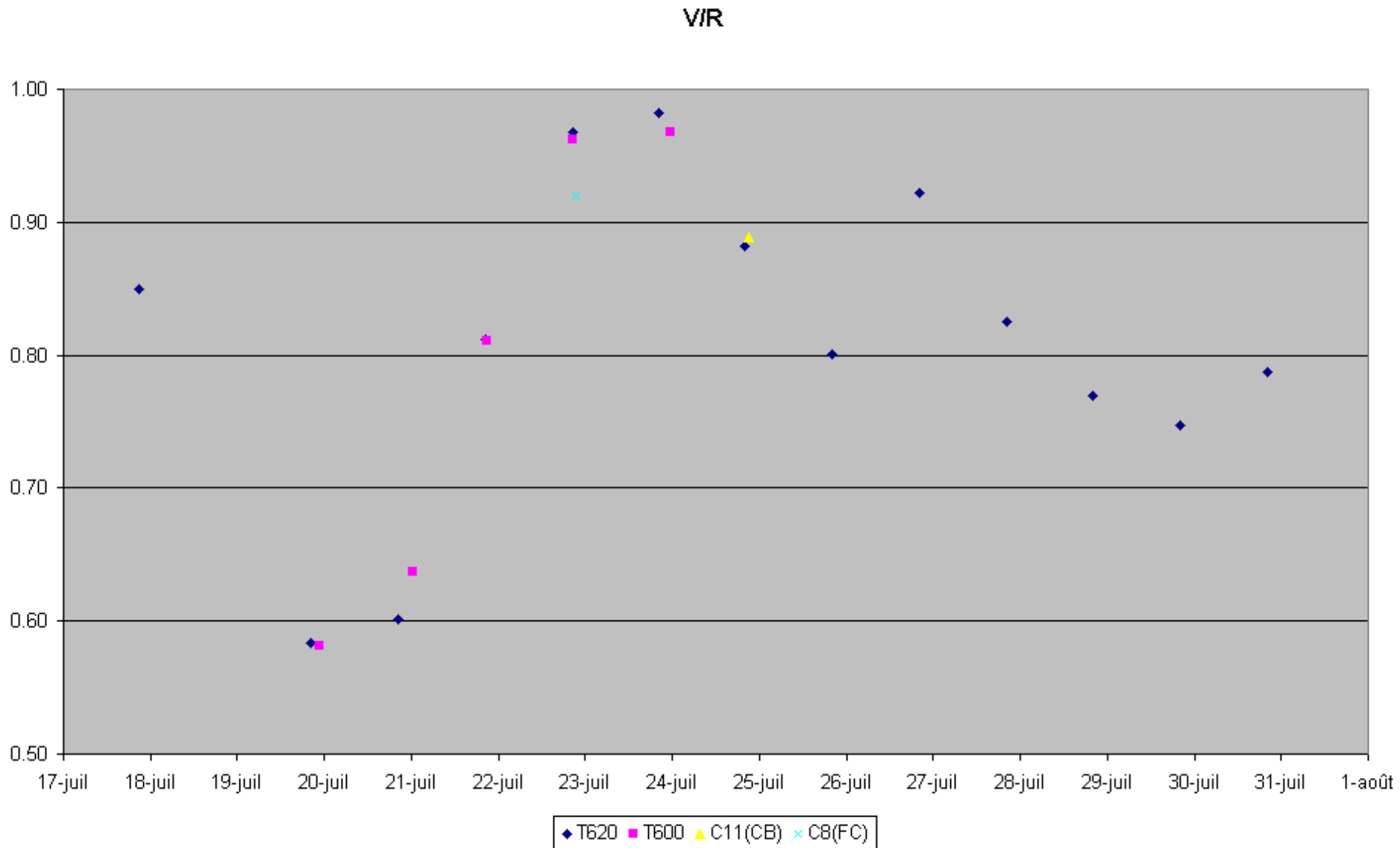
LEQ



Full Width Half Max (FWHM)



Violet/Red (V/R) ratio



Conclusions...

- Data analysis can be very time consuming for an amateur
- Interpretation is uncertain, specially for such complex system as β Lyrae
- This type of monitoring and spectra acquisition is now possible from your backyard
- Engage with professional astronomers to select proper targets



Pro/Am collaboration



ARAS group

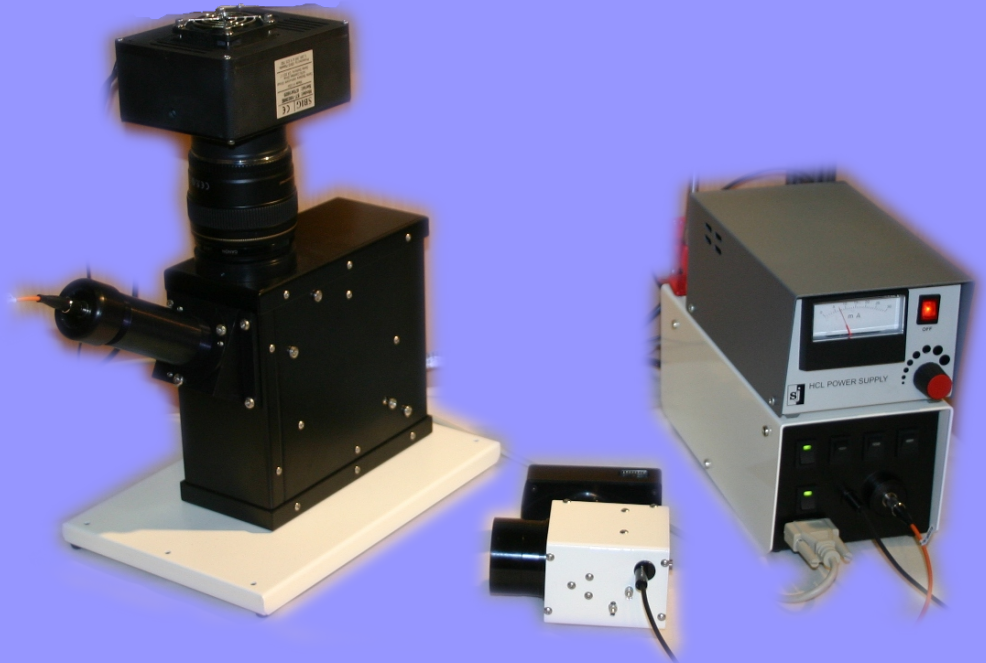
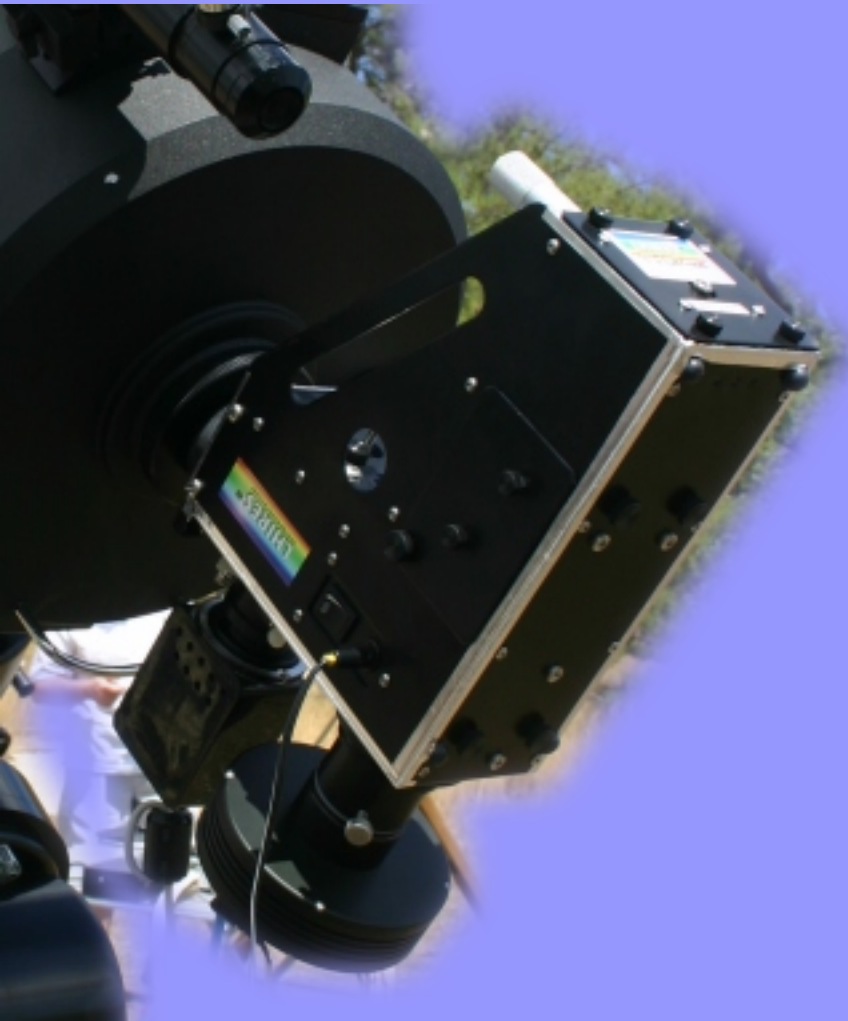
- 2003: Oléron pro/am school (CNRS)
 - need identified for an higher resolution spectrograph
 - need for a common portal (-->ARAS) and discussion group (-->Spectro-L)
- 2004 & 2005: Practical spectro camps at OHP observatory
- 2006
 - Standard high resolution spectrograph Lhires III available
 - la Rochelle, second pro/am school
- 2007 & 2008
 - Setup of BeSS database
 - Setup of ArasBeAm front-end
 - Practical spectro camps at OHP observatory

OHP spectro camps



Development of spectrographs

Lhires III



eShel

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



Be Star Spectra Database

UK FR DE

Menu

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

Logout

Visits

13752 visitors since February 26, 2007

Database of Be stars

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

Be stars query

There is currently 2025 Be stars in the BeSS catalogue

Be star		this star only around this star
RA (α)	h m s	
DEC (δ)	d ' "	
V magnitude between and		
Spectral type between and		
Vsin <i>i</i> between and km/s		

<

Rechercher : ☐ Respecter la casse

Terminé

BeSS database

BeSS Database - Mozilla Firefox

Echier Édition Affichage Historique Marque-pages Outils ?

http://basebe.obspm.fr/basebe/Accueil.php?flag_lang=en

AGENDA nos LIENS Revel Caisse d'Épargne Crédit Agricole Yahoo! Groups : My ... Revelois & Acteurs Le blog de la famille - ... AstroSurf - Forum d'A... Association des Maire... Revel-Infos : Revel (...)

 Be Star Spectra Database

 l'Observatoire de Paris

GEPI

Spectra query

There is currently 34377 Be stars spectra in BeSS

Be star

RA (α) h m s

DEC (δ) d ' "

V magnitude between and

Spectral type between and

Vsini between and km/s

Observations date between and (AAAA-MM-JJ)

Source

Observer

Instrument

Wavelength domain between $\lambda_1 =$ and $\lambda_2 =$

Menu

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

Member Zone

Observer

Password

Terminé

démarrer Article Presentation Be stars high-resolu... bess - OpenOffice.o... content.txt - Bloc-n... BeSS Database - Mo... FR 21:03

BeSS database

- Currently 42998 Be stars spectra in BeSS
- 538 Be stars covered among 2026 total catalog size
- ~5000 amateur spectra from over 25 different users



All insomniacs top ten		Amateur insomniacs top ten		Pro insomniacs top ten	
Spectra	Observer	Spectra	Observer	Spectra	Observer
37180	Coralie Neiner	3299	Olivier Thizy	37180	Coralie Neiner
34940	Bertrand de Batz	1600	Christian Buil	34940	Bertrand de Batz
31153	archive ELODIE	504	Valerie Desnoux	31153	archive ELODIE
5292	Claude Catala	458	Joan Guarro Fló	5292	Claude Catala
3299	Olivier Thizy	370	Michel Pujol	3015	Huib Henrichs
3015	Huib Henrichs	198	Ernst Pollmann	2650	Anne-Marie Hubert
2650	Anne-Marie Hubert	141	José Ribeiro	2601	database INES
2601	database INES	100	Jean-Noël TERRY	1876	Philippe Mathias
1876	Philippe Mathias	75	Benjamin MAUCLAIRE	1186	database GAUDI
1600	Christian Buil	20	Eric Sarrazin	871	Pascale Ehrenfreud

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 is new but provides larger spectral coverage

ARAS BeAm front-end

Resultats - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Outils ?

http://arasbeam.free.fr/spip.php?page=listebe&lang=en

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QR Vul
Updated expected period for several stars
2 BeSS Data
Be list
Last spectra in BeSS
Spectrum of a Be star
3 Links

List of Be stars with Magn lower than 6
Limit Declination : -25

105 objects

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

Terminé

ArasBeAm: new spectra

Spectras - Mozilla Firefox

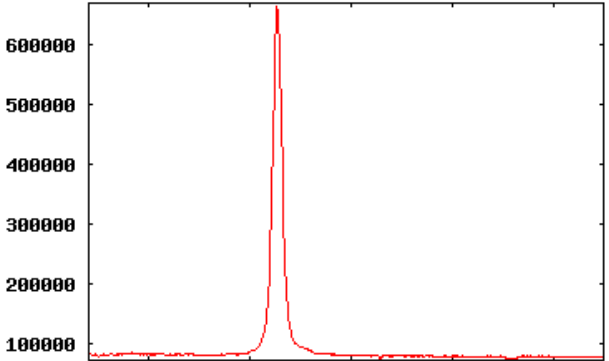
Fichier Édition Affichage Historique Marque-pages Outils ?

http://arasbeam.free.fr/spip.php?page=lastspectres&lang=en

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Observe the current Corot Be targets HD51193 & HD51452
QR Vul
Updated expected period for several stars
2 BeSS Data
Be list
Last spectra in BeSS
Spectrum of a Be star
3 Links

105tau20090104.fits



Star : **105 Tau**

Obs. date **2009-01-04 21:00:28**

Instrument : NOU 16

Observation duration : 1531 s.

Resolution : 6000

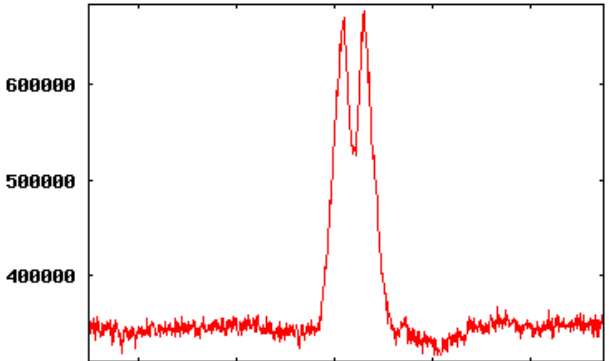
Observation site : PIERA

Observer : Joan Guarro Fló

Wavelength range : 6470.89 - 6724.54 ang.

45873

oneori_20090110.fits



Star : **ome Ori**

Obs. date **2008-01-10 20:54:44**

Instrument : STC 254 LHIRE#129 Sbig ST8

Observation duration : 2878 s.

Resolution : 0

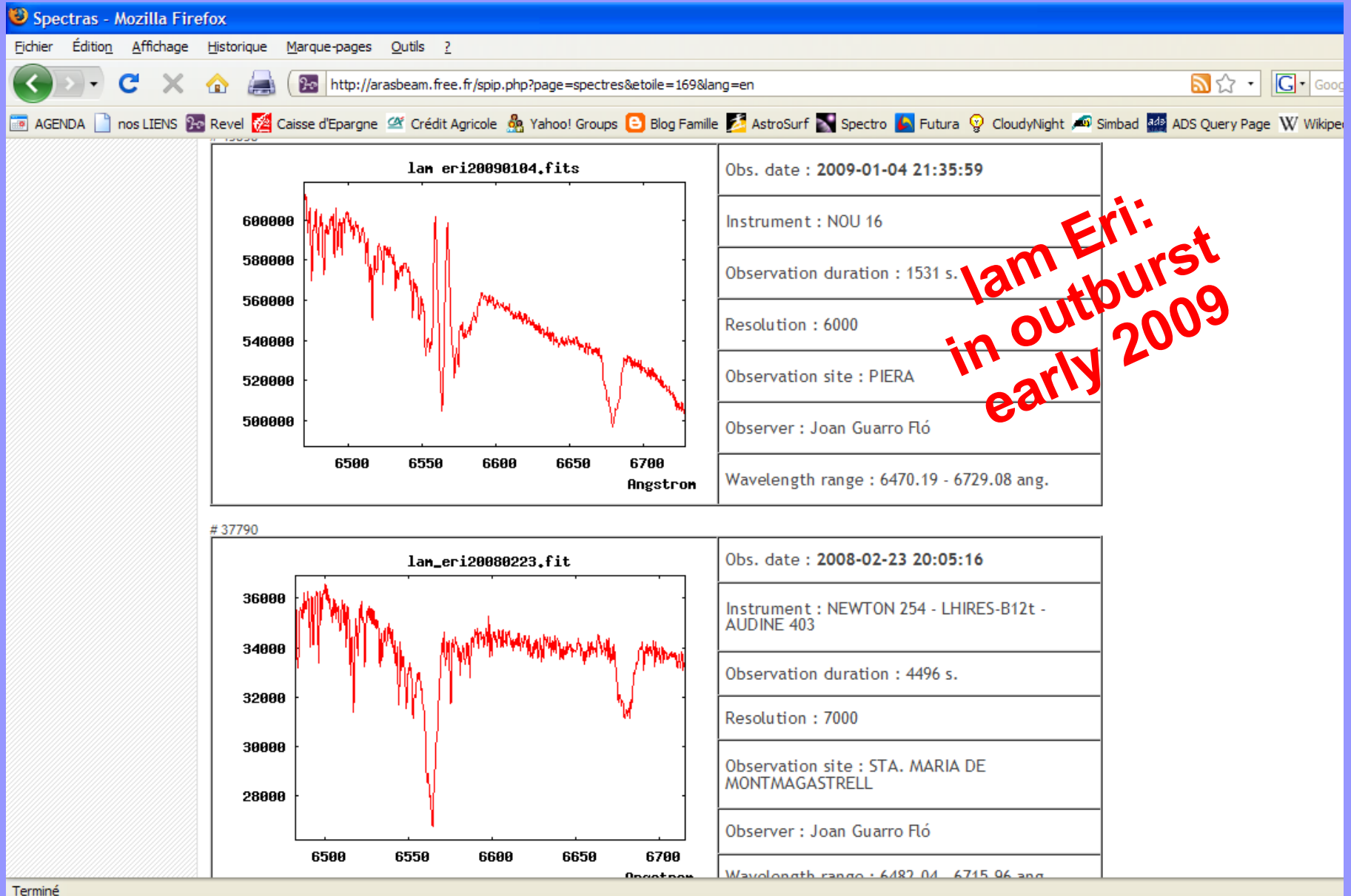
Observation site : Observatoire du Pilat

Observer : Jean-Noël TERRY

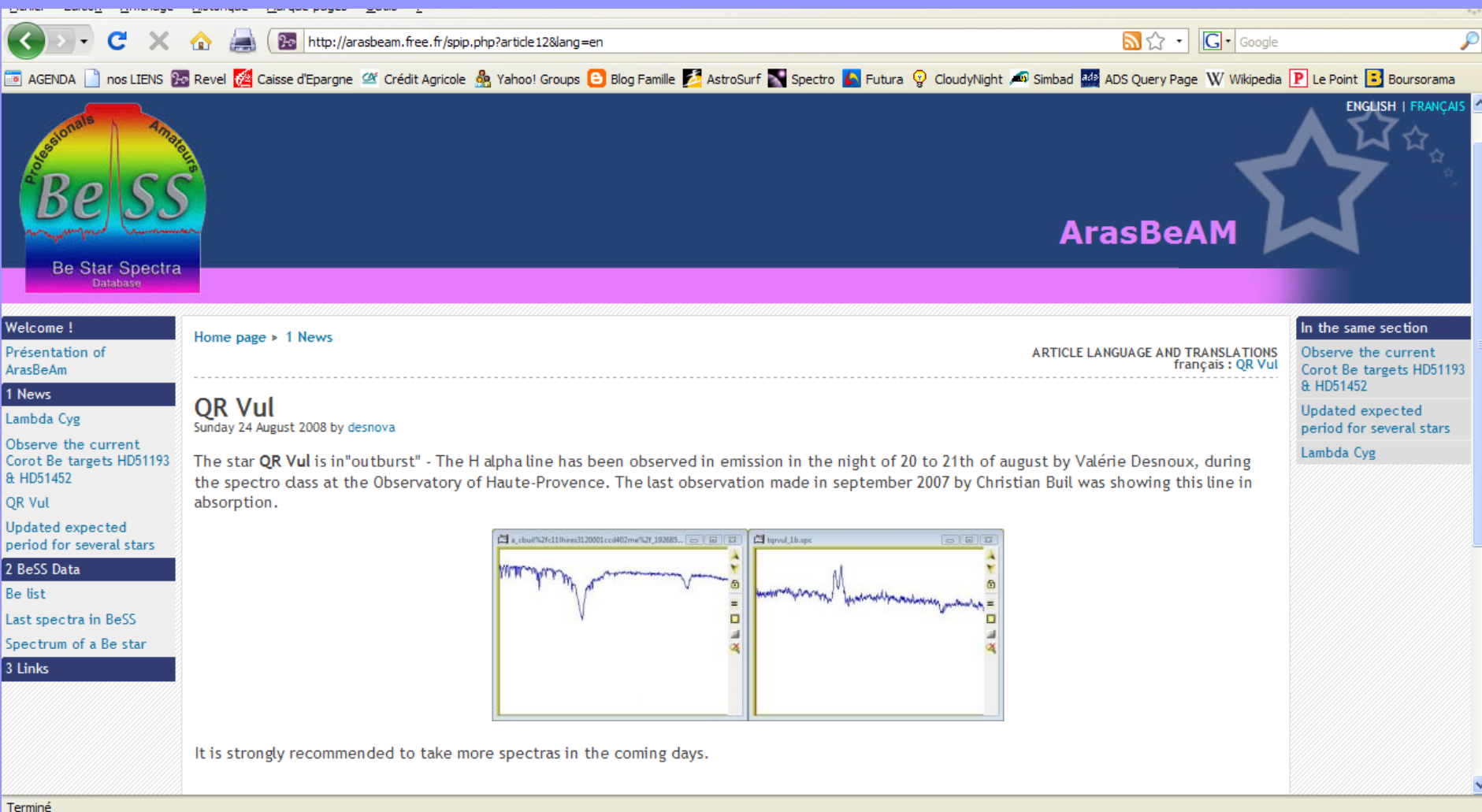
Rechercher : qr Suivant Précédent Surligner tout Respecter la casse Bas de la page atteint, poursuite au début

Terminé

ArasBeAm: detecting outburst



ArasBeAm: alerts



The screenshot shows a web browser window displaying the ArasBeAm website. The browser's address bar shows the URL <http://arasbeam.free.fr/spip.php?article12&lang=en>. The website has a blue header with the "BeSS" logo on the left, which includes the text "Professional's" and "Amateurs" and "Be Star Spectra Database". On the right of the header is the "ArasBeAM" logo with a large star and the text "ENGLISH | FRANÇAIS". Below the header is a pink navigation bar. The main content area has a dark blue sidebar on the left with links: "Welcome !", "Présentation of ArasBeAm", "1 News", "Lambda Cyg", "Observe the current Corot Be targets HD51193 & HD51452", "QR Vul", "Updated expected period for several stars", "2 BeSS Data", "Be list", "Last spectra in BeSS", "Spectrum of a Be star", and "3 Links". The main content area has a dark blue header with "Home page > 1 News" and "ARTICLE LANGUAGE AND TRANSLATIONS français : QR Vul". The article title is "QR Vul" by "desnova" on "Sunday 24 August 2008". The text says: "The star **QR Vul** is in 'outburst' - The H alpha line has been observed in emission in the night of 20 to 21th of august by Valérie Desnoux, during the spectro class at the Observatory of Haute-Provence. The last observation made in september 2007 by Christian Buil was showing this line in absorption." Below the text are two side-by-side spectral plots. The left plot shows a spectrum with a deep absorption line. The right plot shows a spectrum with a strong emission line. Below the plots, it says: "It is strongly recommended to take more spectras in the coming days." On the right side of the main content area is a dark blue sidebar with the heading "In the same section" and links: "Observe the current Corot Be targets HD51193 & HD51452", "Updated expected period for several stars", and "Lambda Cyg". At the bottom left of the browser window, the word "Terminé" is visible.

Welcome !

Présentation of ArasBeAm

1 News

Lambda Cyg

Observe the current Corot Be targets HD51193 & HD51452

QR Vul

Updated expected period for several stars

2 BeSS Data

Be list

Last spectra in BeSS

Spectrum of a Be star

3 Links

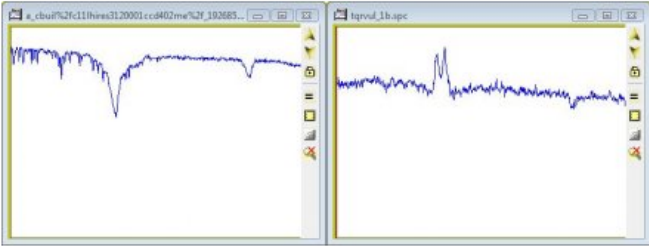
Home page > 1 News

ARTICLE LANGUAGE AND TRANSLATIONS
français : QR Vul

QR Vul

Sunday 24 August 2008 by [desnova](#)

The star **QR Vul** is in "outburst" - The H alpha line has been observed in emission in the night of 20 to 21th of august by Valérie Desnoux, during the spectro class at the Observatory of Haute-Provence. The last observation made in september 2007 by Christian Buil was showing this line in absorption.



It is strongly recommended to take more spectras in the coming days.

In the same section

[Observe the current Corot Be targets HD51193 & HD51452](#)

[Updated expected period for several stars](#)

[Lambda Cyg](#)

Terminé

- Discovered with a 12cm refractor during an OHP workshop !

Let's get started ...



Practice ...

- gamma Cassiopae
 - *bright, easy to find, circumpolar, strong emission*
 - *compare with BeSS latest spectra*
- beta Lyrae
 - Look for night after night changes
- zeta Tau
 - Look changes over ~5 months

...and contribute !

- ARAS BeAm
 - *Look for “red” status for your telescope range*
 - *Look for stars with short observation period requested (see next slide)*
- Spectro-L
 - Join the discussion group and follow campaign launched

Some Be stars of interest...

- Continuous monitoring of **delta Sco** is key, specially as it approached periastron (Feb-May 2011); seem its disk recently evolved toward a ring... 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**: EW changed, down from 48 to now around 36-38.
- **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 is now reaching 40Å (was 20 in the 1990's!).

▪ **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 continuously 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

Conclusions

- Be Stars = Fun and Exciting project
- Other pro/am collaboration are on their way:
 - epsilon Aurigae
 - WR 140 (finished)
 - P Cygni
 - VV Cep
- Some opportunities exist for:
 - Novae
 - RR Lyrae, BW Vul, other pulsating stars
 - Spectroscopic binaries
 - exoplanets...



JOIN US !!!

Some useful links

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

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

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

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

Shelyak http://www.shelyak.com/en/be_stars.html

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

Stars won't
look the same o

Thank You !!!



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

Back Up slides...

