Eruptive stars spectroscopy
Cataclysmics, Symbiotics, Novae

ARAS Eruptive Stars
Information Letter n° 32 #2017-02 05-03-2017

Observations of February 2017

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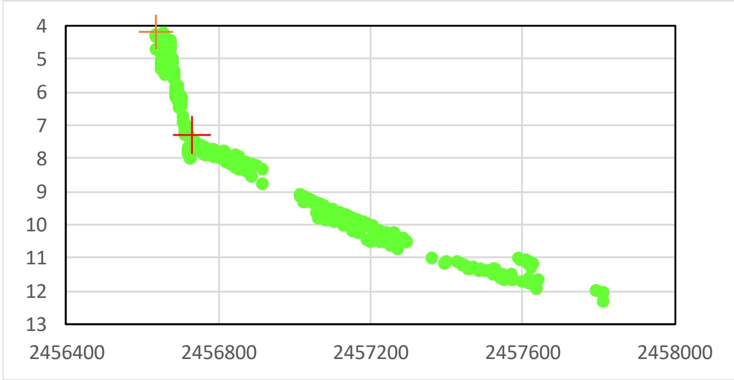
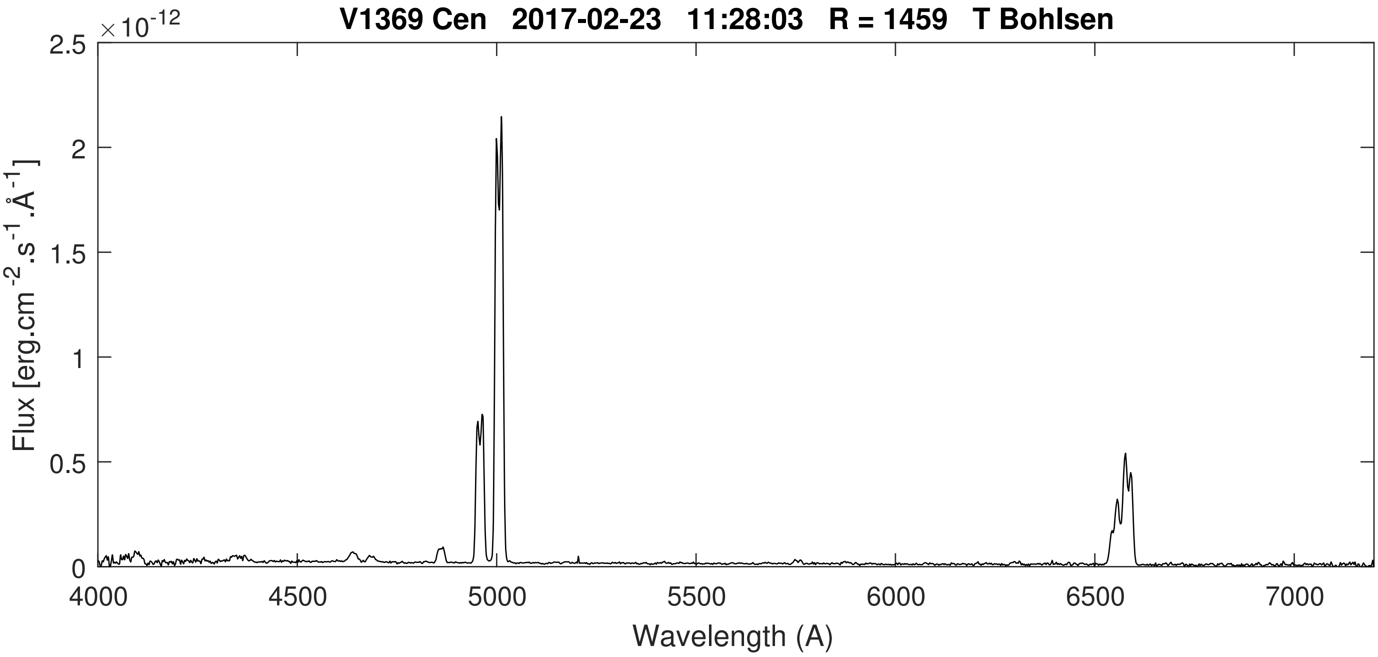
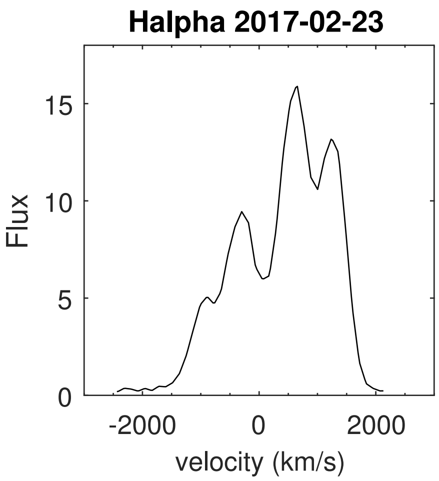
Authors : F. Teyssier, S. Shore, P. Somogyi, D. Boyd, P. Berardi, F. Boubault, D. Verhillac, F. Campos, J. Guarro, L. Franco, J. Edlin, Y. Buchet, G. Martineau, K. Graham

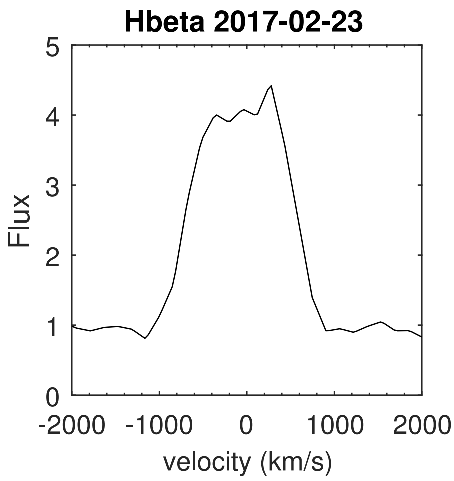
"We acknowledge with thanks the variable star observations from the AAVSO International Database contributed by observers worldwide and used in this letter."
Kafka, S., 2015, Observations from the AAVSO International Database, http://www.aavso.org

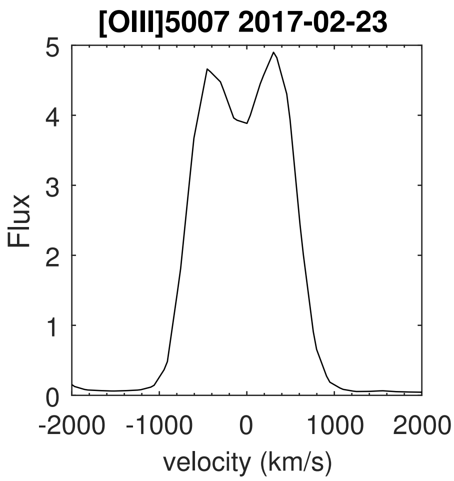
Nova Cen 2013 = V1369 Cen











H alpha blended with [NII]

The FWHM of H beta and [OIII] are respectively 1250 and 1300 km.s^{-1}

S Y M B I O T I C S

CH Cygni : ongoing campaign upon the request of Augustin Skopal and Margarita Karovska
AX Per : eclipse

Observing : main targets

Name	AD (2000)	DE (2000)
AG Dra	16 1 40.5	+66 48 9.5
AG Peg	21 51 1.9	+12 37 29.4
AX Per	01 36 22.7	+54 15 2.5
BF Cyg	19 23 53.4	+29 40 25.1
BX Mon	07 25 24	-03 36 00
CH Cyg	19 24 33	+50 14 29.1
CI Cyg	19 50 11.8	+35 41 03.2
EG And	00 44 37.1	+40 40 45.7
R Aqr	23 43 49.4	-15 17 04.2
RS Oph	17 50 13.2	-06 42 28.4
SU Lyn	06 42 55.1	+55 28 27.2
T CrB	15 59 30.1	+25 55 12.6
V443 Her	18 22 8.4	+23 27 20
V694 Mon	07 25 51.2	-07 44 08
Z And	23 33 39.5	+48 49 5.4

S Y M B I O T I C S

Symbiotics in ARAS Data Base Update : 04-03-2017

#	Name	AD (2000)	DE (2000)	Nb. Of spectra	First spectrum
1	**EG And**	0 44 37.1	40 40 45.7	70	12/08/2010
2	**AX Per**	1 36 22.7	54 15 2.5	153	04/10/2011
3	**V471 Per**	1 58 49.7	52 53 48.4	7	06/08/2013
4	**Omi Cet**	2 19 20.7	-2 58 39.5	12	28/11/2015
5	**BD Cam**	3 42 9.3	63 13 0.5	27	08/11/2011
6	**UV Aur**	5 21 48.8	32 30 43.1	55	24/02/2011
7	**V1261 Ori**	5 22 18.6	-8 39 58	10	22/10/2011
8	**StHA 55**	5 46 42	6 43 48	2	17/01/2016
9	**SU Lyn**	06 42 55.1	+55 28 27.2	10	02/05/2016
10	**ZZ CMi**	7 24 13.9	8 53 51.7	39	29/09/2011
11	**BX Mon**	7 25 24	-3 36 0	41	04/04/2011
12	**V694 Mon**	7 25 51.2	-7 44 8	188	03/03/2011
13	**NQ Gem**	7 31 54.5	24 30 12.5	50	01/04/2013
14	**GH Gem**	7 4 4.9	12 2 12	5	10/03/2016
15	**CQ Dra**	12 30 06	69 12 04	8	11/06/2015
16	**TX CVn**	12 44 42	36 45 50.6	34	10/04/2011
17	**IV Vir**	14 16 34.3	-21 45 50	3	28/02/2015
18	**T CrB**	15 59 30.1	25 55 12.6	158	01/04/2012
19	**AG Dra**	16 1 40.5	66 48 9.5	169	03/04/2013
20	**V503 Her**	17 36 46	23 18 18	2	05/06/2013
21	**RS Oph**	17 50 13.2	-6 42 28.4	33	23/03/2011
22	**V934 Her**	17 6 34.5	23 58 18.5	19	09/08/2013
23	**AS 270**	18 05 33.7	-20 20 38	2	01/08/2013
24	**YY Her**	18 14 34.3	20 59 20	19	25/05/2011
25	**FG Ser**	18 15 6.2	0 18 57.6	3	26/06/2012
26	**StHa 149**	18 18 55.9	27 26 12	3	05/08/2013
27	**V443 Her**	18 22 8.4	23 27 20	33	18/05/2011
28	**FN Sgr**	18 53 52.9	-18 59 42	4	10/08/2013
29	**BF Cyg**	19 23 53.4	29 40 25.1	102	01/05/2011
30	**CH Cyg**	19 24 33	50 14 29.1	429	21/04/2011
31	**V919 Sgr**	19 3 46	-16 59 53.9	2	10/08/2013
32	**V1413 Aql**	19 3 51.6	16 28 31.7	6	10/08/2013
33	**V335 Vul**	19 23 14	+24 27 39.7	7	14/08/2016
34	**HM Sge**	19 41 57.1	16 44 39.9	9	20/07/2013
35	**QW Sge**	19 45 49.6	18 36 50	7	14/08/2016
36	**CI Cyg**	19 50 11.8	35 41 3.2	133	25/08/2010
37	**StHa 169**	19 51 28.9	46 23 6	2	12/05/2016
38	**V1016 Cyg**	19 57 4.9	39 49 33.9	12	15/04/2015
39	**PU Vul**	20 21 12	21 34 41.9	12	20/07/2013
40	**LT Del**	20 35 57.3	20 11 34	1	28/11/2015
41	**ER Del**	20 42 46.4	8 40 56.4	5	02/09/2011
42	**V1329 Cyg**	20 51 1.1	35 34 51.2	8	08/08/2015
43	**V407 Cyg**	21 2 13	45 46 30	*12*	*14/03/2010*
44	**StHa 190**	21 41 44.8	2 43 54.4	17	31/08/2011
45	**AG Peg**	21 51 1.9	12 37 29.4	201	06/12/2009

ARAS Data Base Symbiotics : http://www.astrosurf.com/aras/Aras_DataBase/Symbiotics.htm

S Y M B I O T I C S

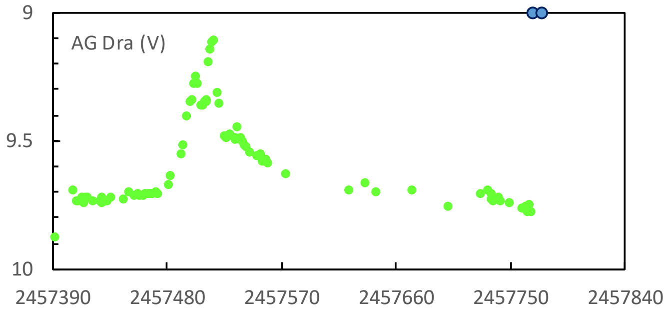
Symbiotics observed in February, 2017

Name	Observer	Date	l min	l max	Resolution
AG Dra	P. Somogyi	26/02/2017	6492	6602	17079
AXPer	P. Somogyi	12/02/2017	3626	7881	522
AXPer	D. Boyd	13/02/2017	3900	7376	710
AXPer	J. Guarro	14/02/2017	3739	7448	1038
AXPer	F. Campos	17/02/2017	3822	7331	835
AXPer	F. Boubault	18/02/2017	4001	7501	1000
AXPer	K. Graham	20/02/2017	3930	7379	600
AXPer	F. Campos	25/02/2017	3787	7309	890
BD Cam	J. Guarro	09/02/2017	3725	7448	1090
BD Cam	J. Guarro	09/02/2017	3980	7498	600
bfcyg	P. Somogyi	26/02/2017	6523	6632	17183
BX Mon	F. Campos	17/02/2017	3802	7328	812
CH Cyg	P. Somogyi	26/02/2017	6523	6632	17036
CI Cam	F. Campos	20/02/2017	3801	7336	821
EG And	F. Teyssier	13/02/2017	4141	7162	11000
EG And	J. Guarro	14/02/2017	3758	7444	1019
GH Gem	F. Campos	20/02/2017	3800	7333	841
NQ Gem	J. Guarro	09/02/2017	3752	7448	1090
NQ Gem	J. Guarro	14/02/2017	3809	7444	990
NQ Gem	K. Graham	20/02/2017	3786	7392	600
omi Cet	F. Campos	03/01/2017	3832	7370	834
omi Cet	J. Guarro	09/02/2017	3722	7445	1088
SU lyn	F. Teyssier	16/02/2017	4141	7162	11000
SU lyn	F. Boubault	18/02/2017	4002	7503	1000
SU lyn	Martineau Bu	18/02/2017	3602	7598	928
SU lyn	P. Berardi	26/02/2017	6330	6798	5907
T CrB	L. Franco	16/02/2017	4000	7201	545
T CrB	L. Franco	16/02/2017	3846	7235	545
T CrB	P. Somogyi	26/02/2017	6492	6602	16984
TX CVn	D. Boyd	18/02/2017	3901	7380	762
UV Aur	J. Guarro	09/02/2017	3782	7444	1087
UV Aur	P. Somogyi	12/02/2017	3616	7881	505
UV Aur	J. Guarro	14/02/2017	3828	7444	990
UV Aur	L. Franco	16/02/2017	3831	7235	543
UV Aur	K. Graham	19/02/2017	3815	7388	600
V1261 Ori	J. Guarro	08/02/2017	3785	7448	997
V1261 Ori	J. Guarro	14/02/2017	3772	7448	990
V1261 Ori	F. Campos	17/02/2017	3808	7343	817
V471 Per	F. Campos	20/02/2017	3800	7340	808
V627 Cas	D. Boyd	18/02/2017	3901	7401	720
V694 Mon	D. Boyd	05/02/2017	3900	7381	723
V694 Mon	J. Edin	13/02/2017	4285	7151	11000
V694 Mon	D. Boyd	13/02/2017	3900	7401	717
V694 Mon	J. Edin	16/02/2017	4285	7151	11000
V694 Mon	L. Franco	16/02/2017	3832	7235	543
V694 Mon	F. Teyssier	17/02/2017	4270	7150	11000
V694 Mon	F. Campos	17/02/2017	3804	7328	814
V694 Mon	D. Boyd	18/02/2017	3901	7400	722
V694 Mon	F. Campos	25/02/2017	3781	7308	878

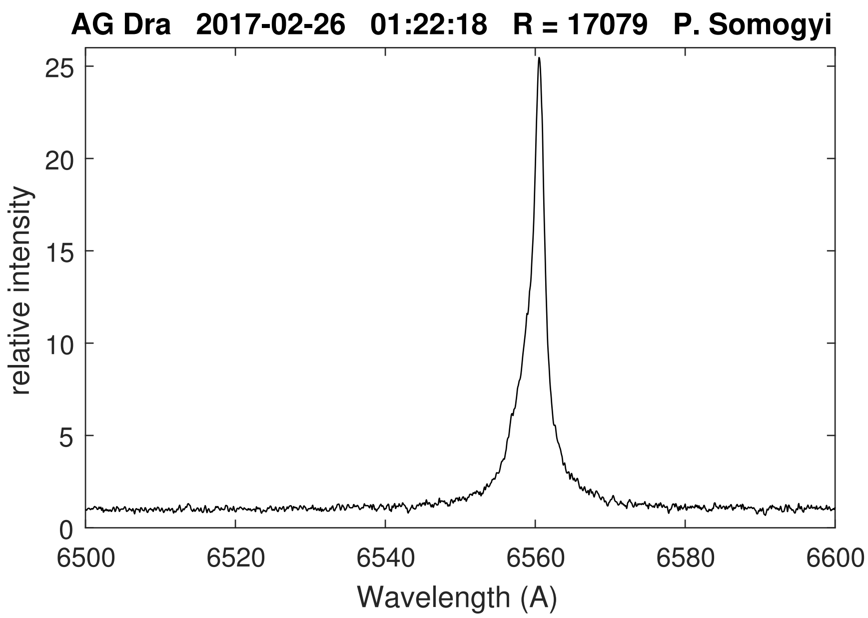
SYMBIOTICS

AG Dra

Coordinates (2000.0)	
R.A.	16 01 41.0
Dec	+66 48 10.1
Mag V	9.8



The yellow symbiotic star AG Dra in quiescence H alpha line obtained by Peter Somogyi (Lhires III 2400 l/mm R = 17000)

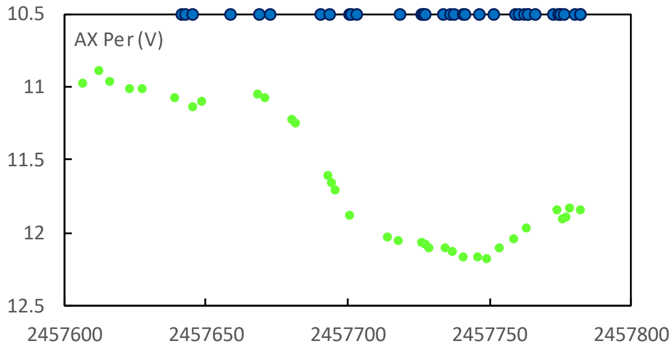


AX Per

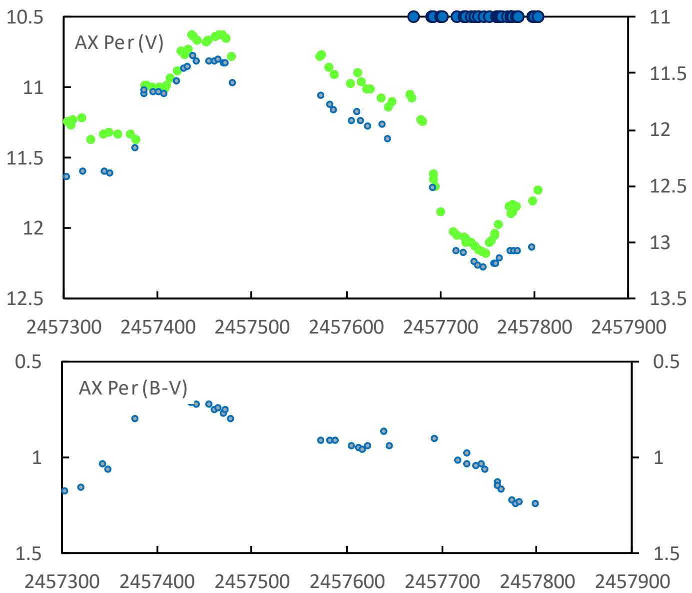
Coordinates (2000.0)	
R.A.	01 36 22.7
Dec	+54 15 02.4

The classical symbiotic AX Per is re-brightening during its current eclipse.

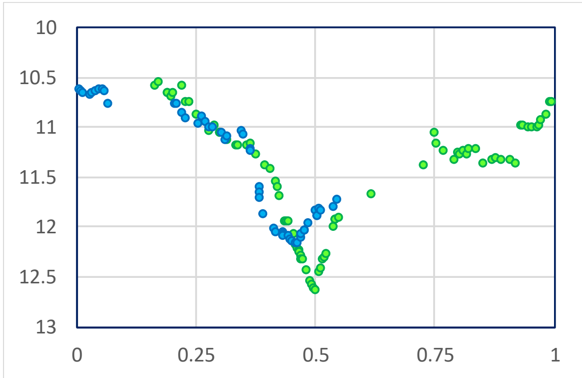
Observations of AX Per until the end of the eclipse is strongly recommanded



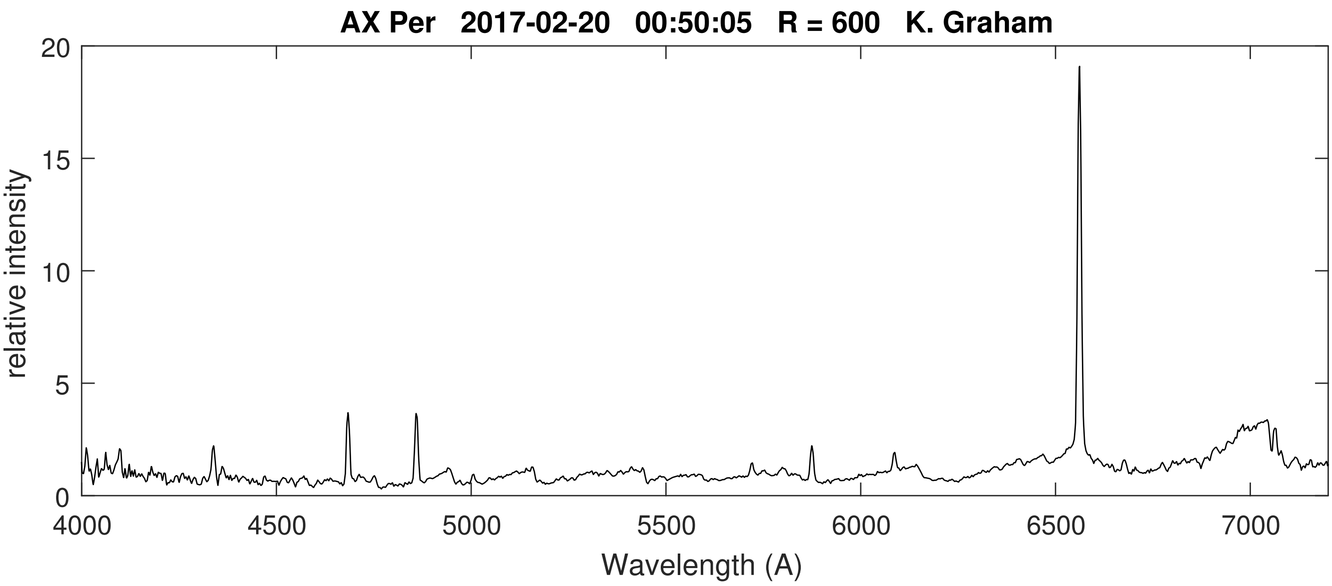
Top: AAVSO Blue and Green Lightcurve
ARAS Spectra duing the current eclipse: blue dots



The current eclipse from AAVSO database
Top : V and B band (resp. left and right scale)
Bottom : B-V



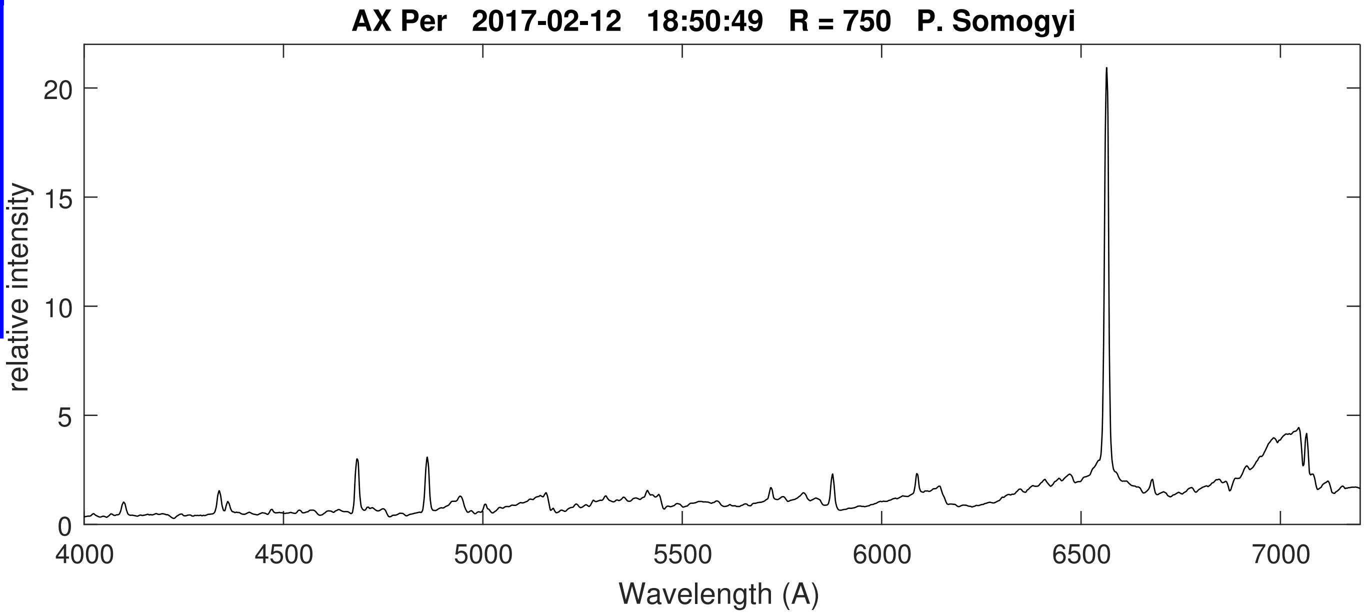
Comparison of V magnitude during the current eclipse (blue dots) and the former one (green dots)
Strong difference of the shape and deepest eclipse for the former eclipse
Note also the minimum at phase ~0.47 for the current eclipse but maximum B-V value is measured at phase 0.5

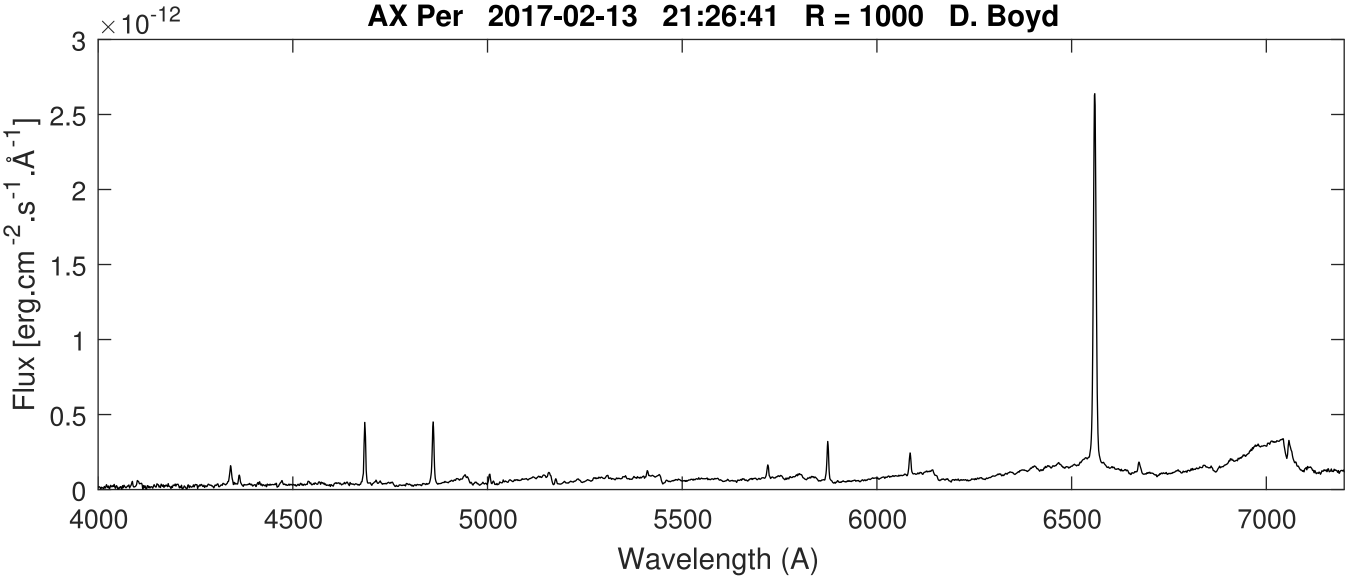


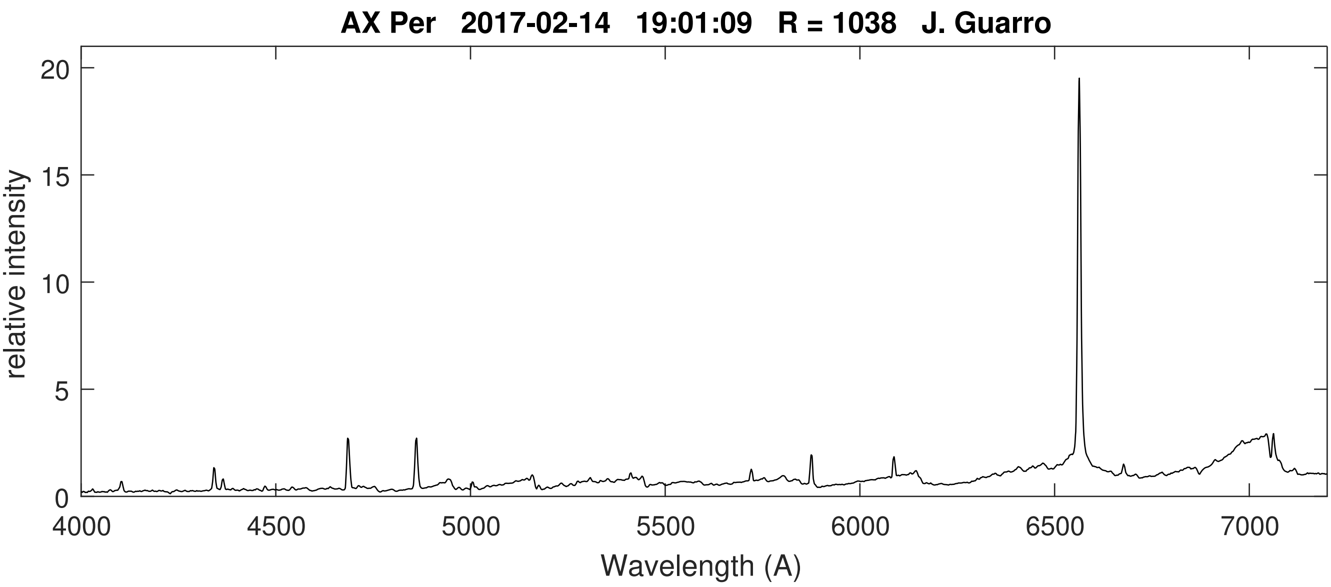
AX Per

AX Per in February at R 750-1000

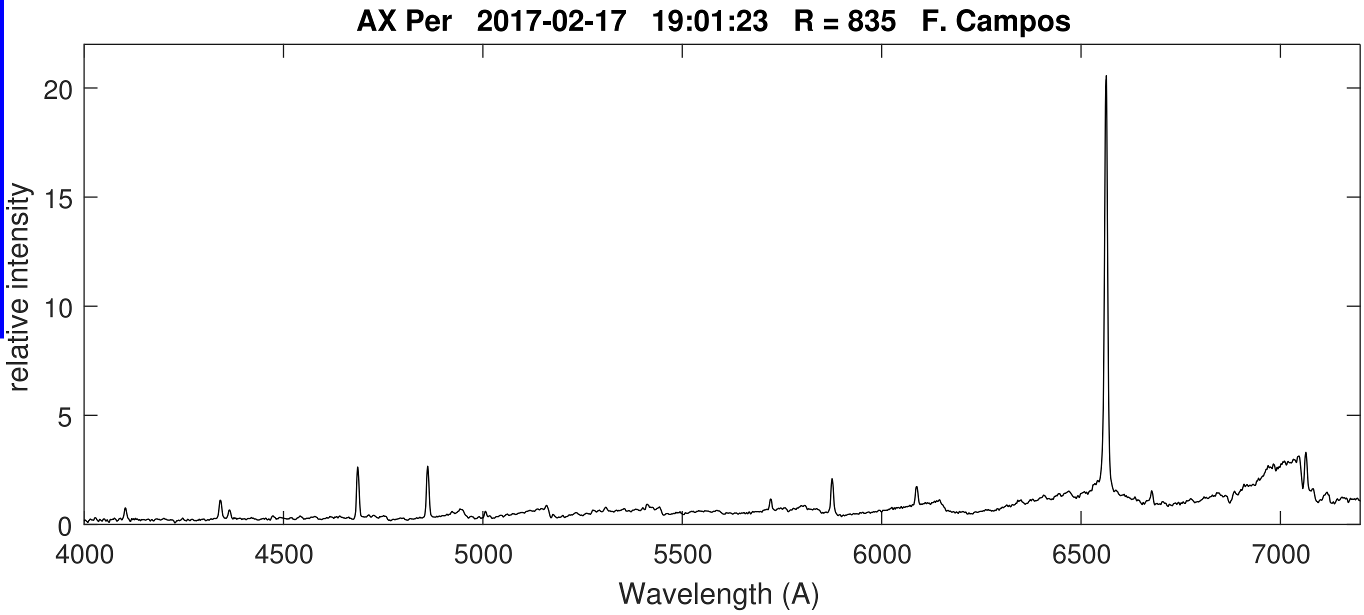
Peter Somogyi: Lhires III 150 l/mm
Joan Guarro: home made spectrograph
David Boyd: Lisa
Franck Boubault: Lisa
Francisco Campos: DADOS 200

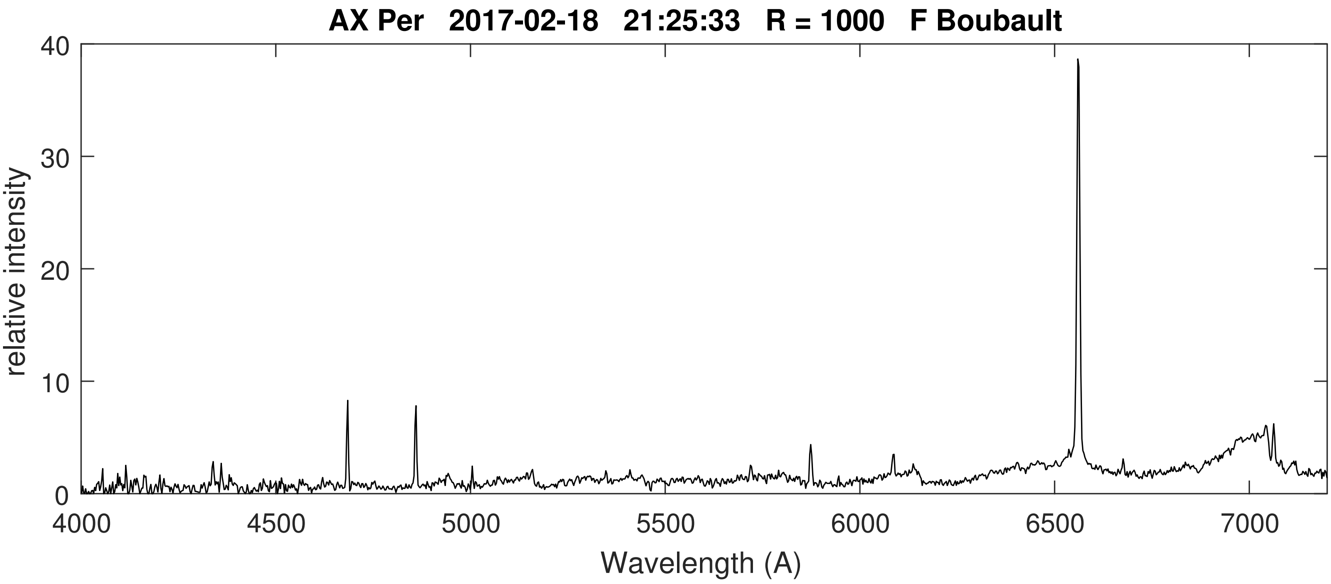


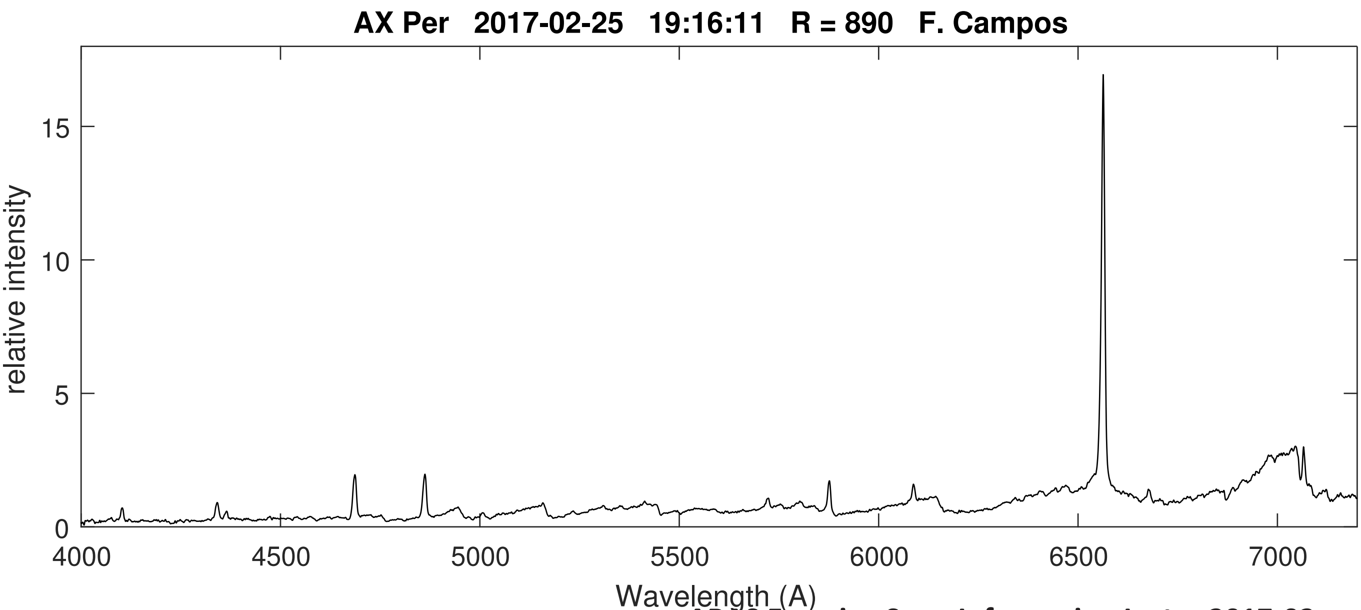




AX Per

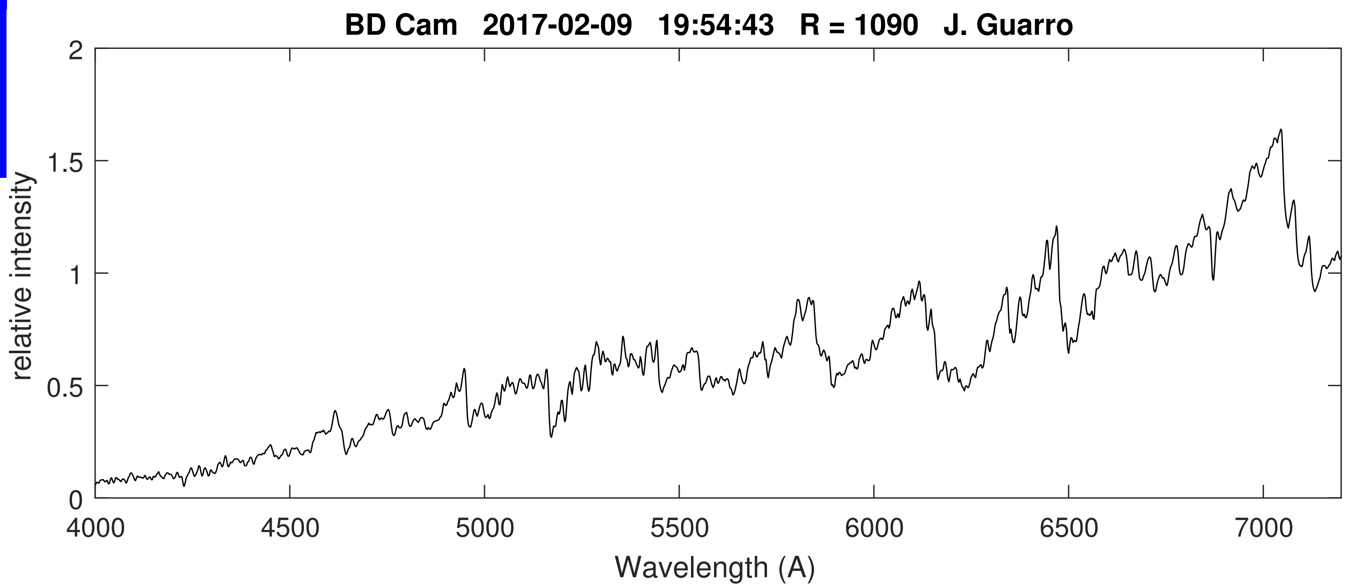

AX Per 2017-02-17 19:01:23 R = 835 F. Campos
relative intensity
0
5
10
15
20
4000
4500
5000
5500
6000
6500
7000
Wavelength (A)

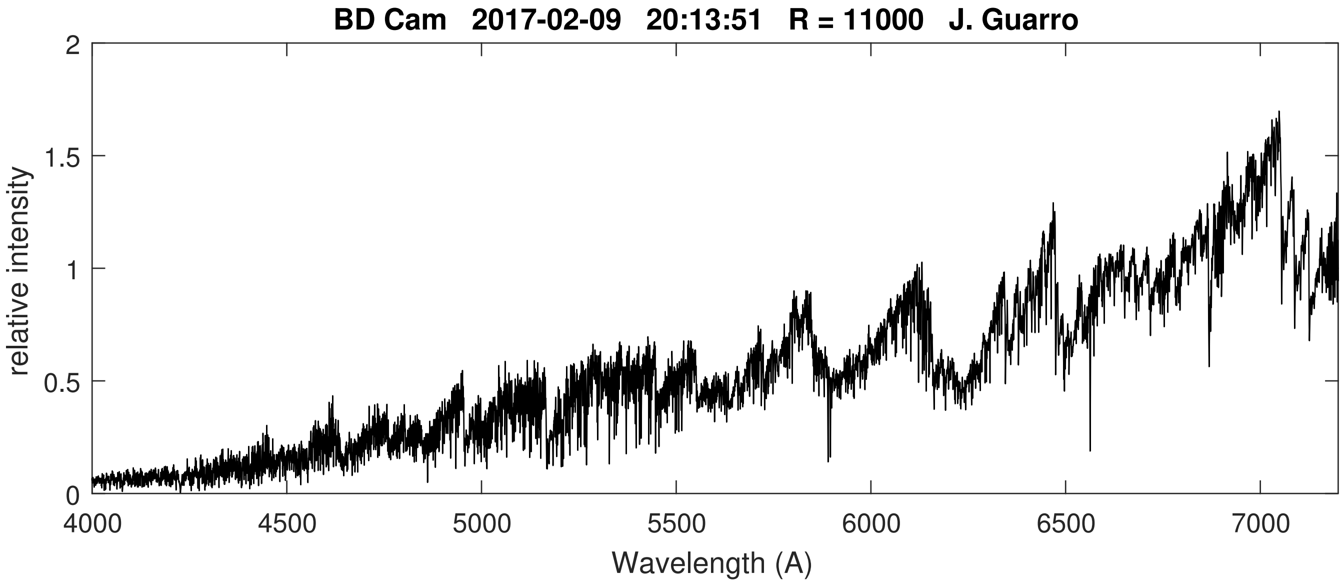

AX Per 2017-02-18 21:25:33 R = 1000 F Boubault
relative intensity
0
10
20
30
40
4000
4500
5000
5500
6000
6500
7000
Wavelength (A)


AX Per 2017-02-25 19:16:11 R = 890 F. Campos
relative intensity
0
5
10
15
4000
4500
5000
5500
6000
6500
7000
Wavelength (A)

BD Cam

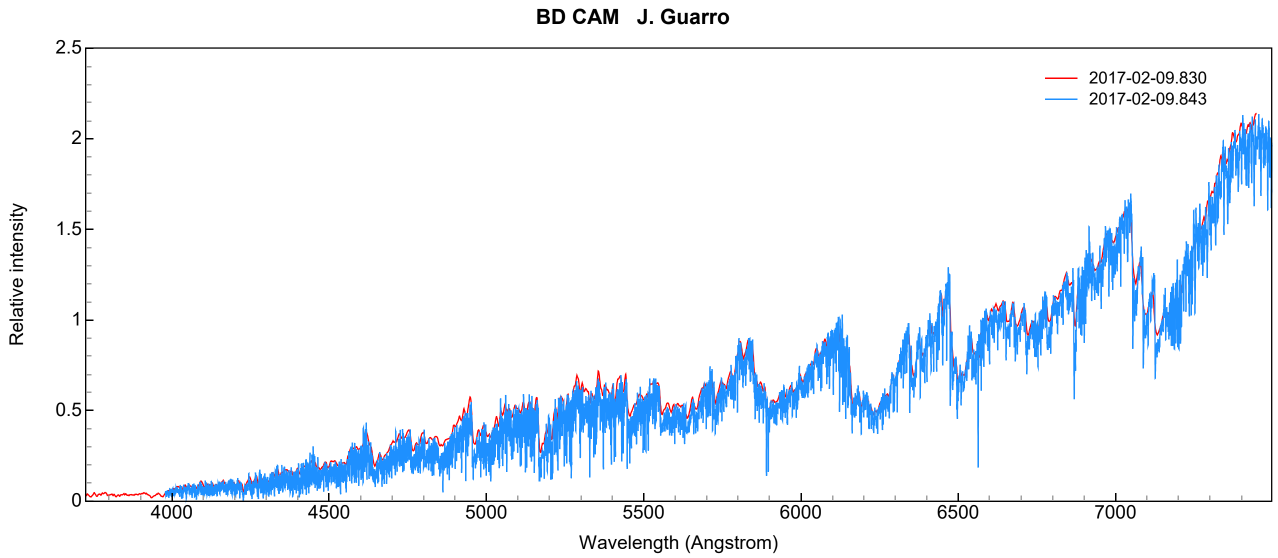
Coordinates (2000.0)	
R.A.	3 42 9.3
Dec	63 13 0.5
Mag	5.0

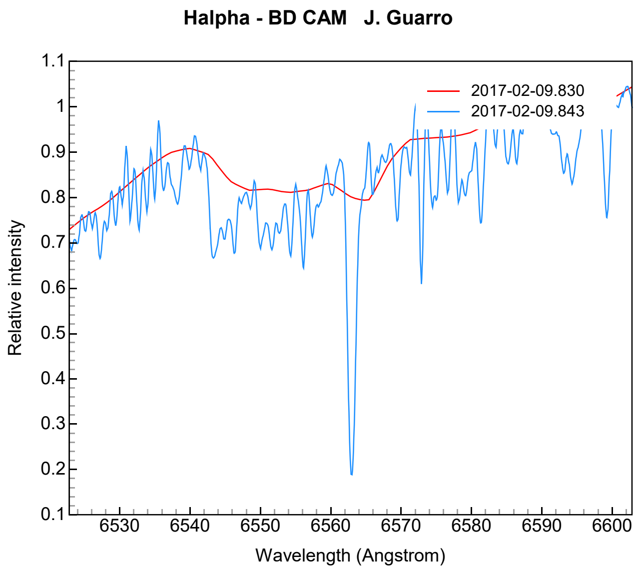




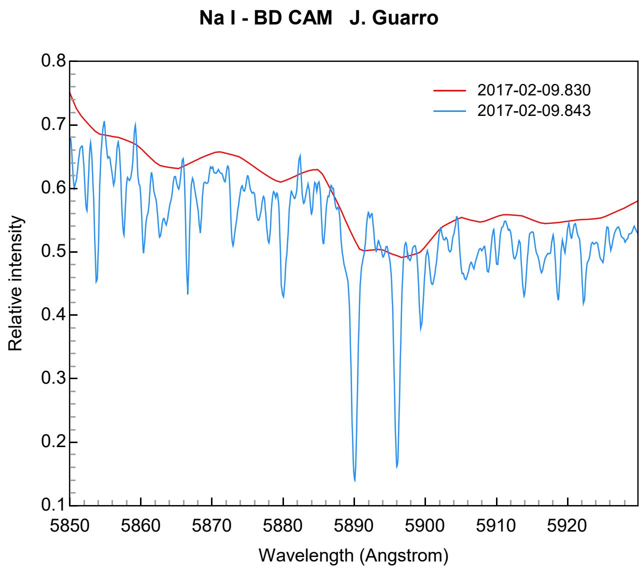
BD Cam

Comparison of the two spectra, using PlotSepctra (Tim Lester)





H alpha range



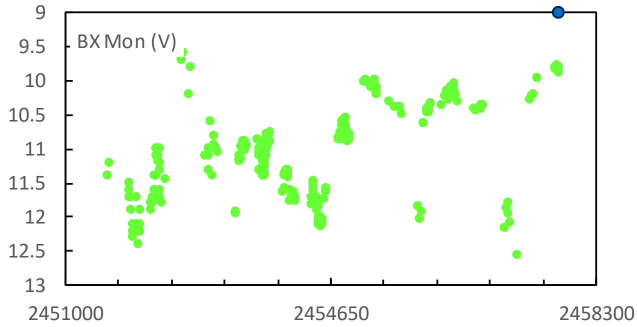
Na I D range

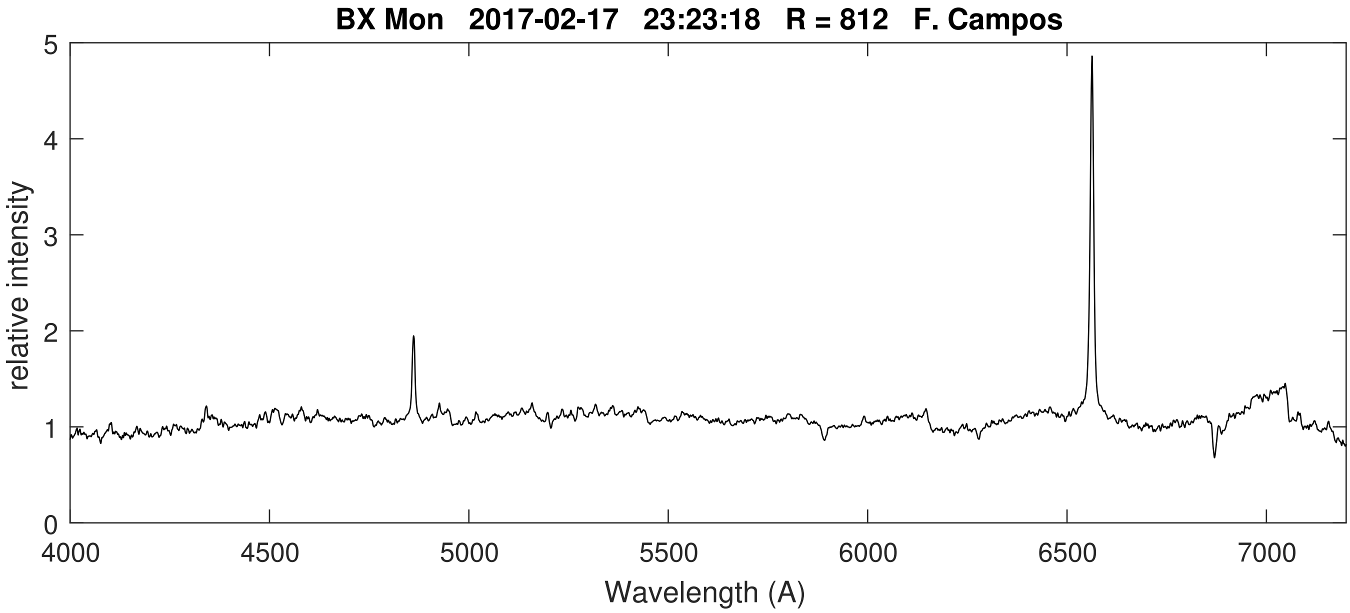
S Y M B I O T I C S

BX Mon

Coordinates (2000.0)	
R.A.	7 25 24
Dec	-3 36 0
Mag	9.8 (2016-12)

An interesting target for winter nights





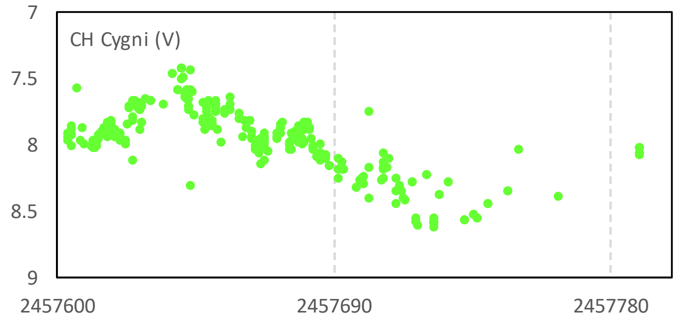
Spectrum obtained by Francisco Campos with a DADOS (200 l/mm)

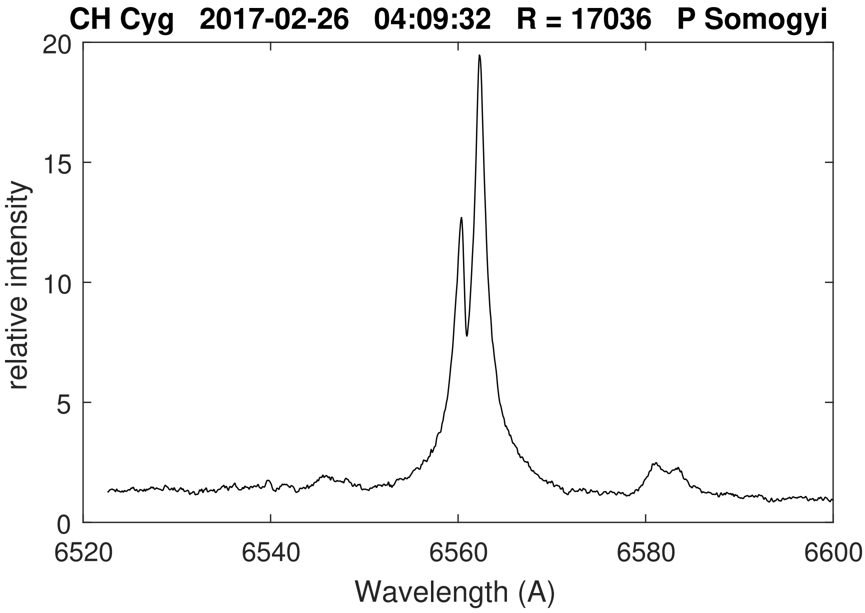
SYMBIOTICS

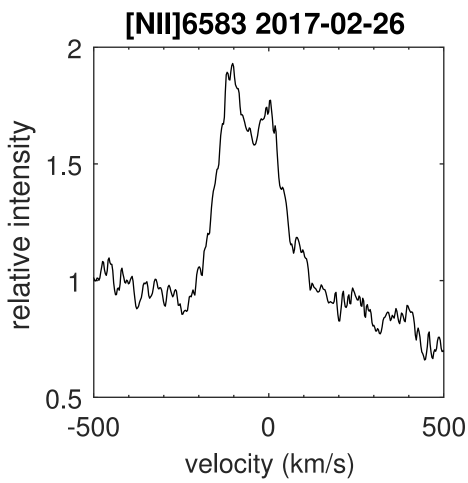
CH Cyg

Coordinates (2000.0)	
R.A.	19 24 33.1
Dec	+50 14 29.1
Mag	

Ongoing campaign upon the request of Augustin Skopal At least one spectrum a month (high resolution and low resolution, with a correct atmospheric response)

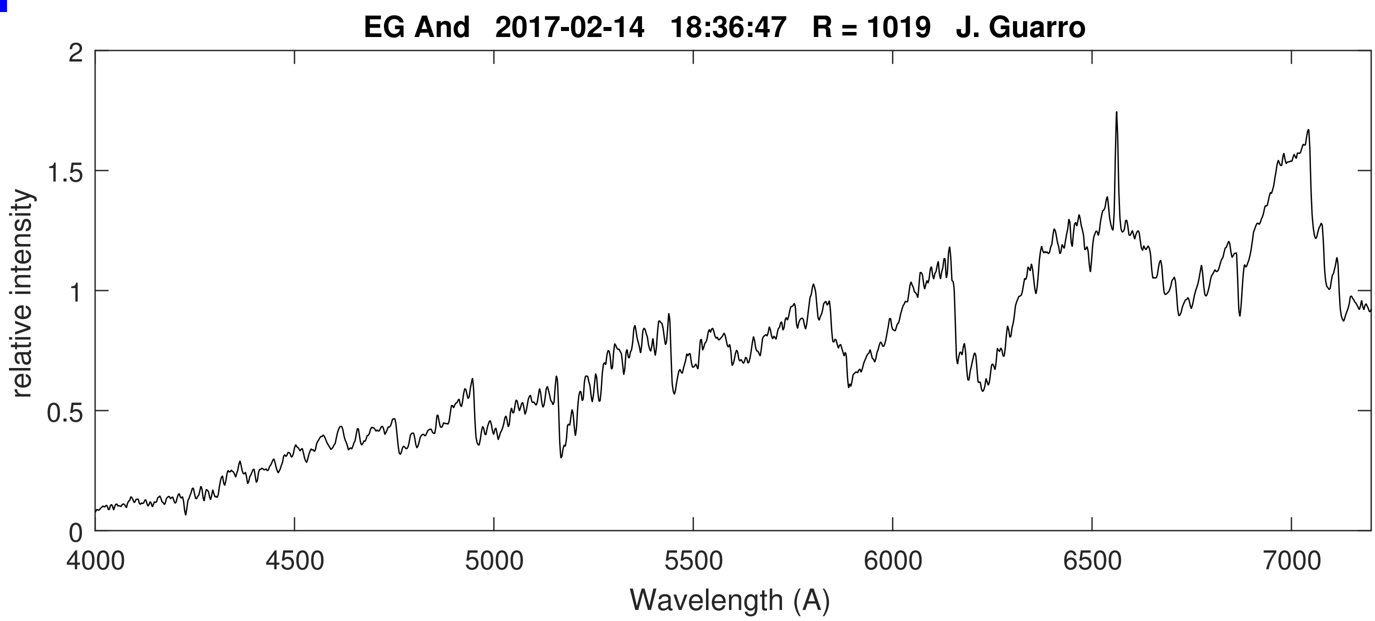






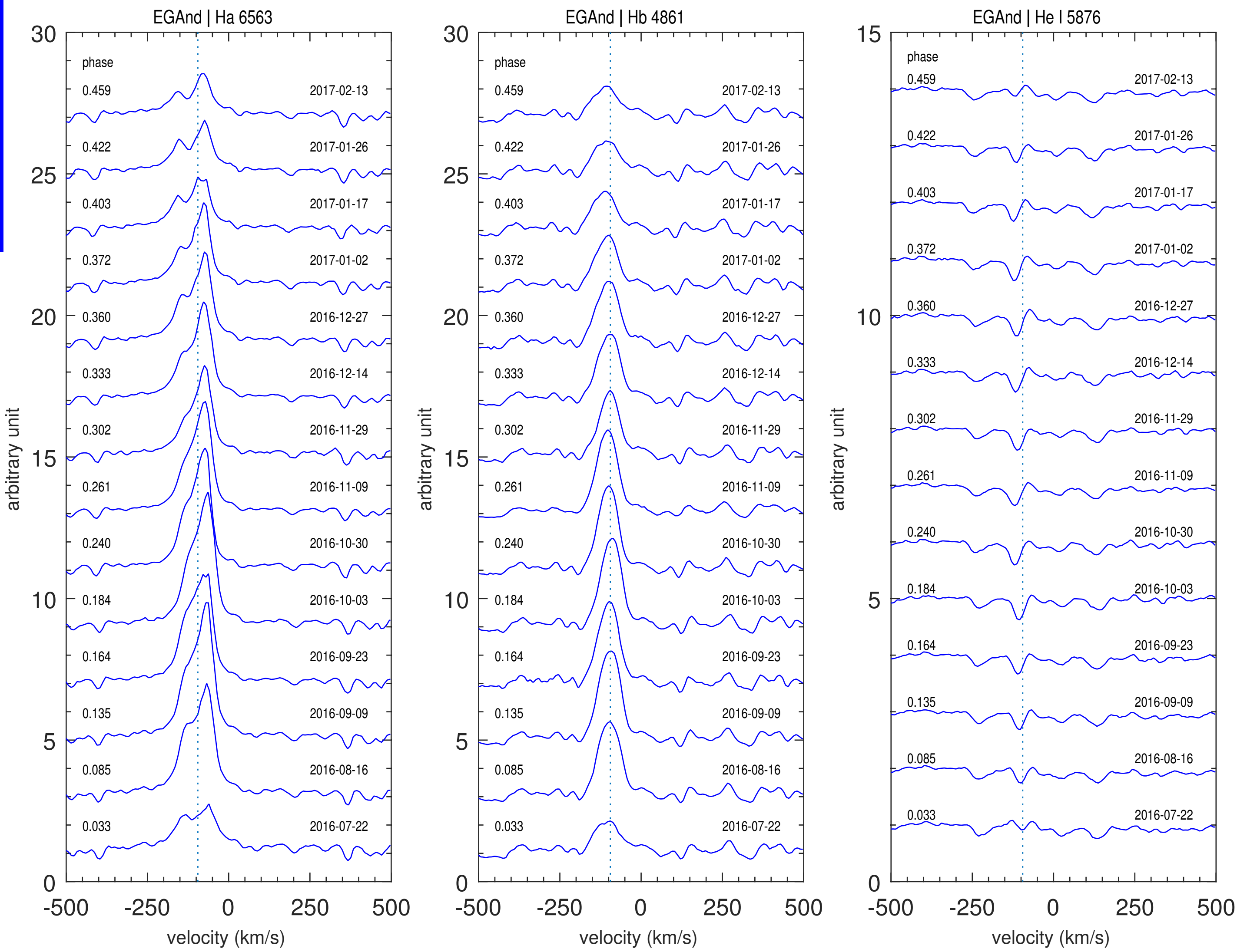
EG And

Coordinates (2000.0)	
R.A.	00 44 37.2
Dec	+40 40 45.7
Mag	7.2



EG And

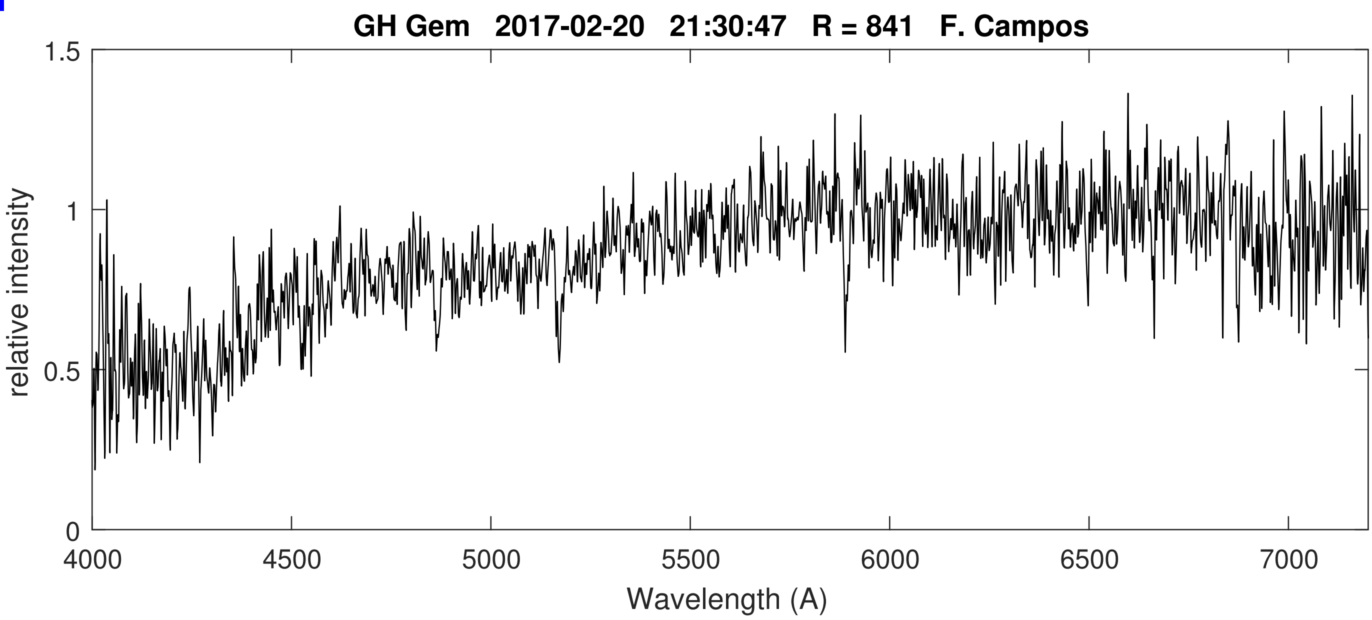
Lines evolution in 2016-2017 on half an orbital cycle
F. Teyssier - eShel R = 11000



SYMBIOTICS

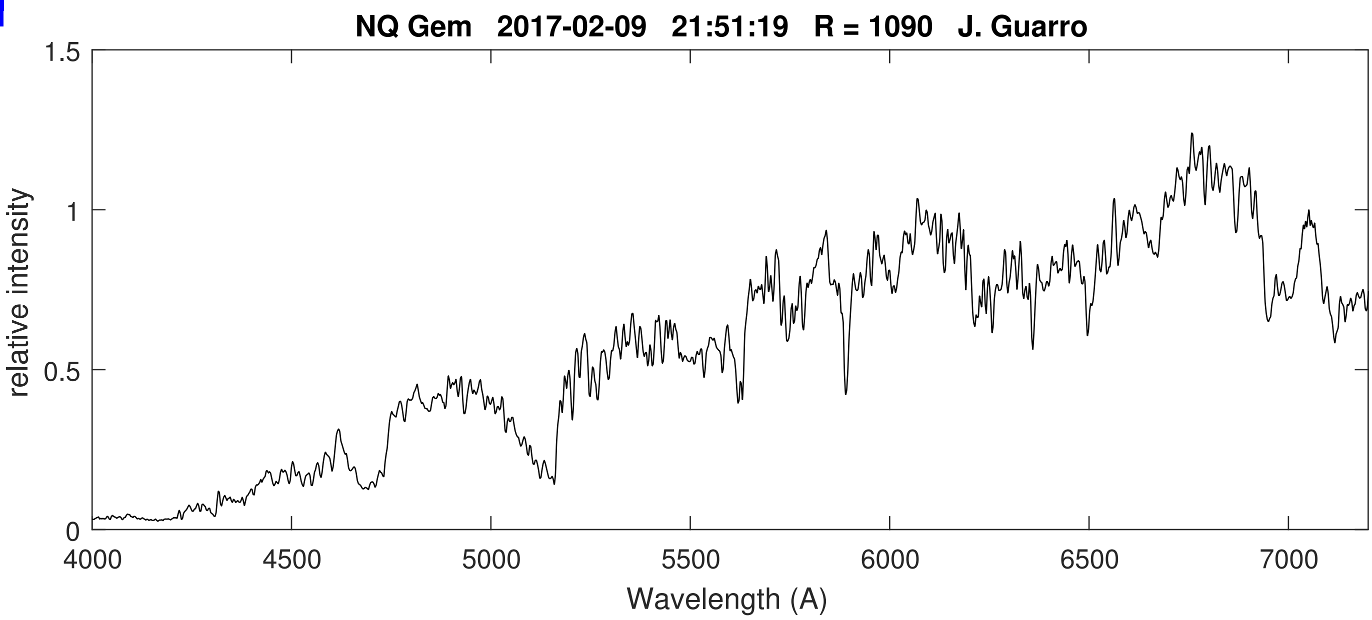
GH Gem

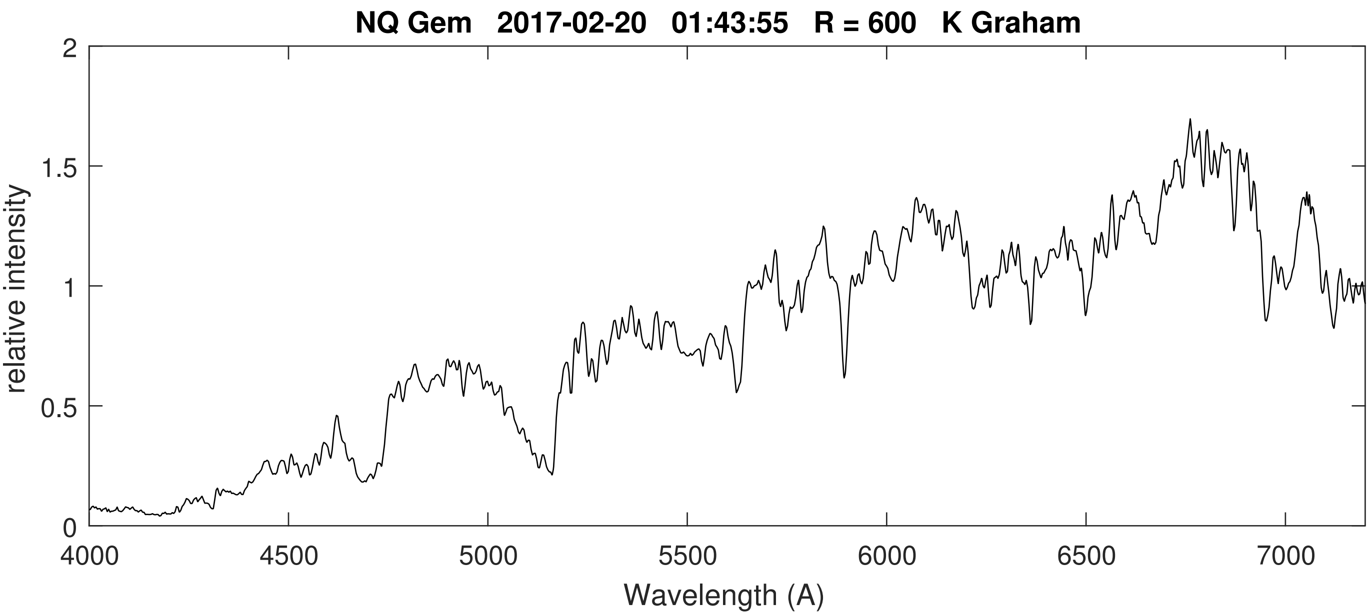
Coordinates (2000.0)	
R.A.	07 04 12.8
Dec	+12 03 34.3
Mag	12.7 (2017-02)



NQ Gem

Coordinates (2000.0)	
R.A.	07 31 54.5
Dec	+24 30 12.5
Mag	8.0 (01-2017)

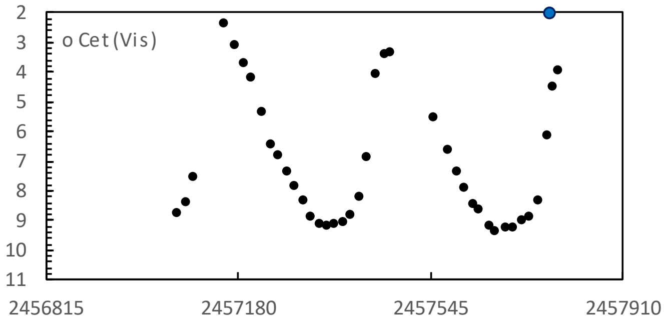




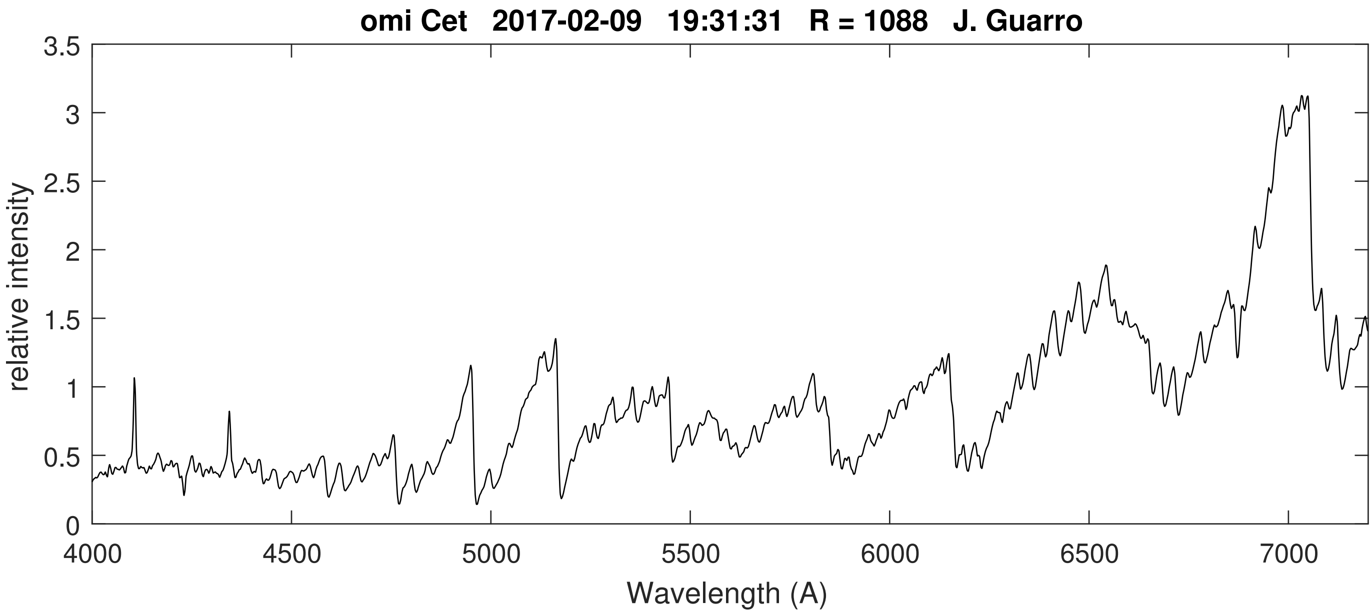
S Y M B I O T I C S

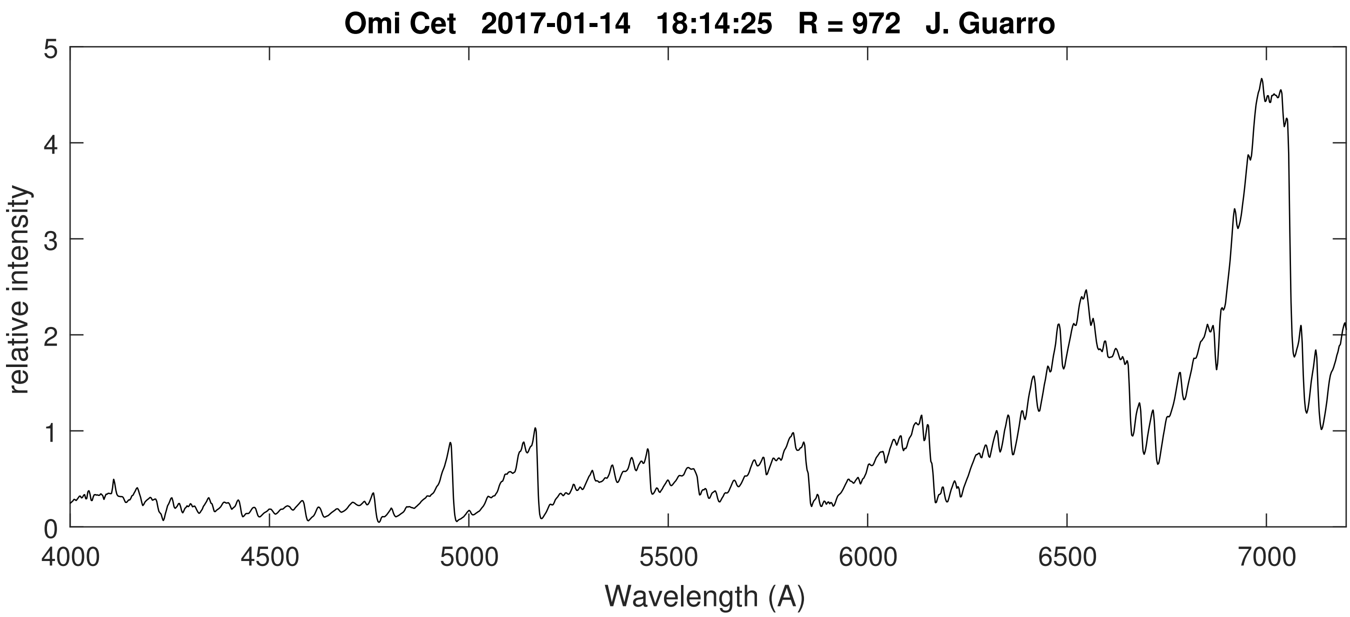
omi Cet

Coordinates (2000.0)	
R.A.	02 19 20.79
Dec	-02 58 39.5
Mag	(01-2017)



The symbiotic mira near its maximum
Strong Hγ and Hδ emission in Joan Guarro's spectrum, classical behavior for a Mira





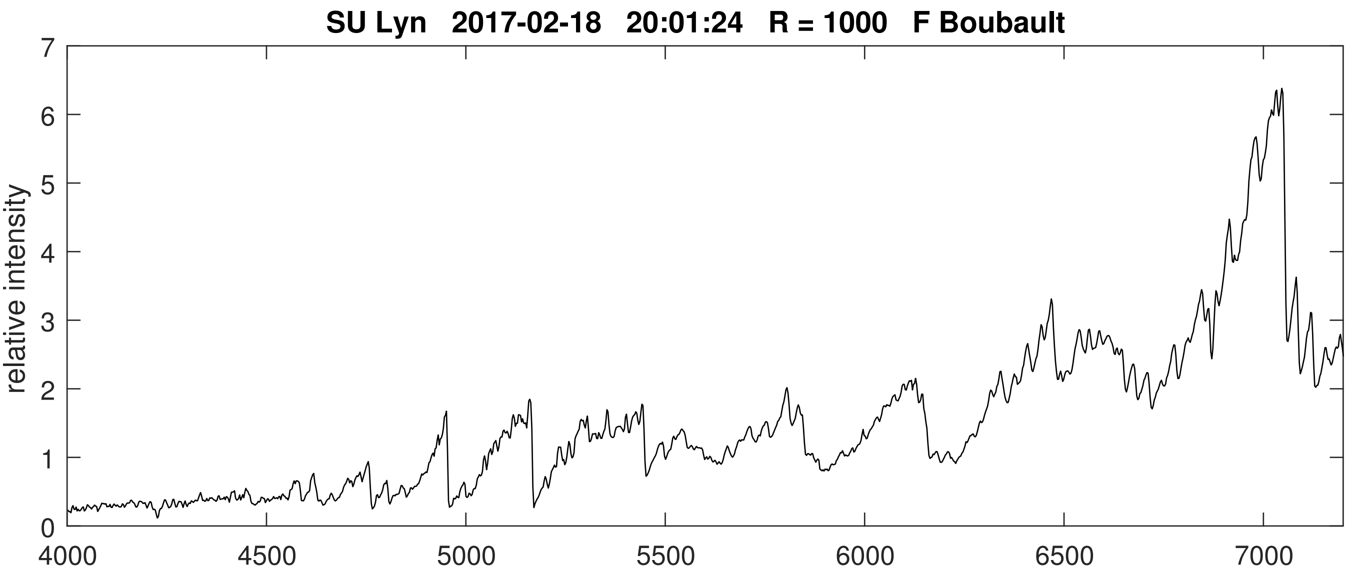
January spectrum for comparison (weak Hδ)

SU Lyn

Coordinates (2000.0)	
R.A.	06 42 55.1
Dec	+55 28 27.2
Mag	8.50 (2017-01)

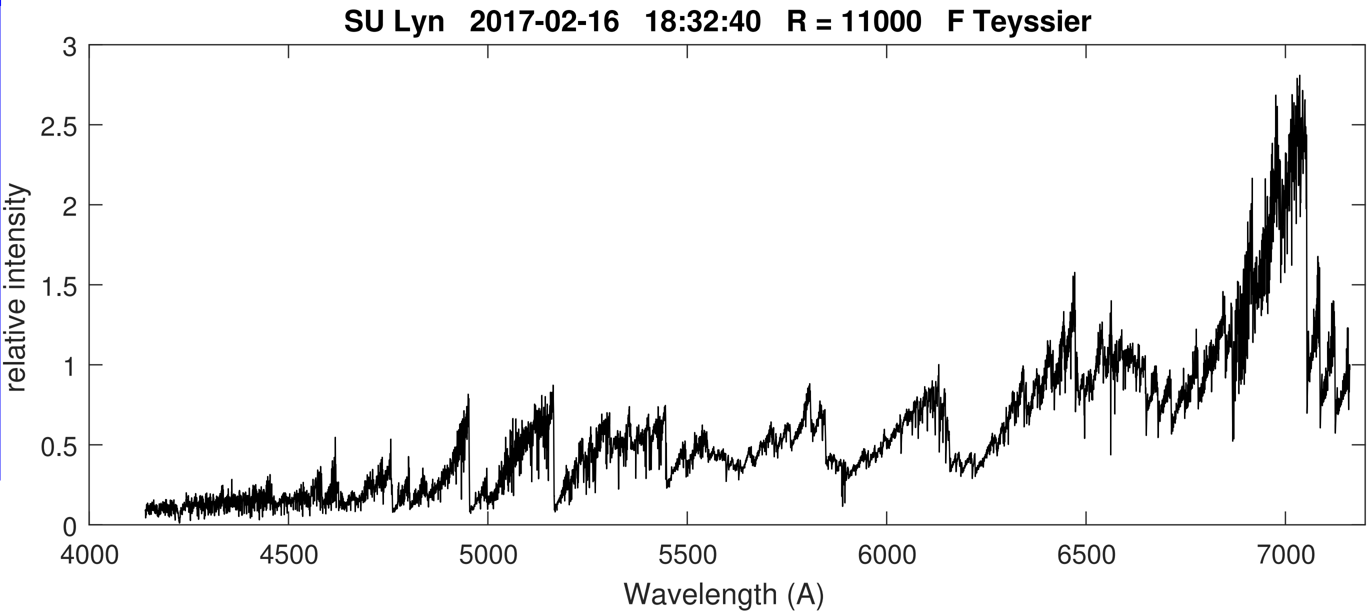
SU Lyn is newly discovered bright symbiotic (K. Mukai, 2016)

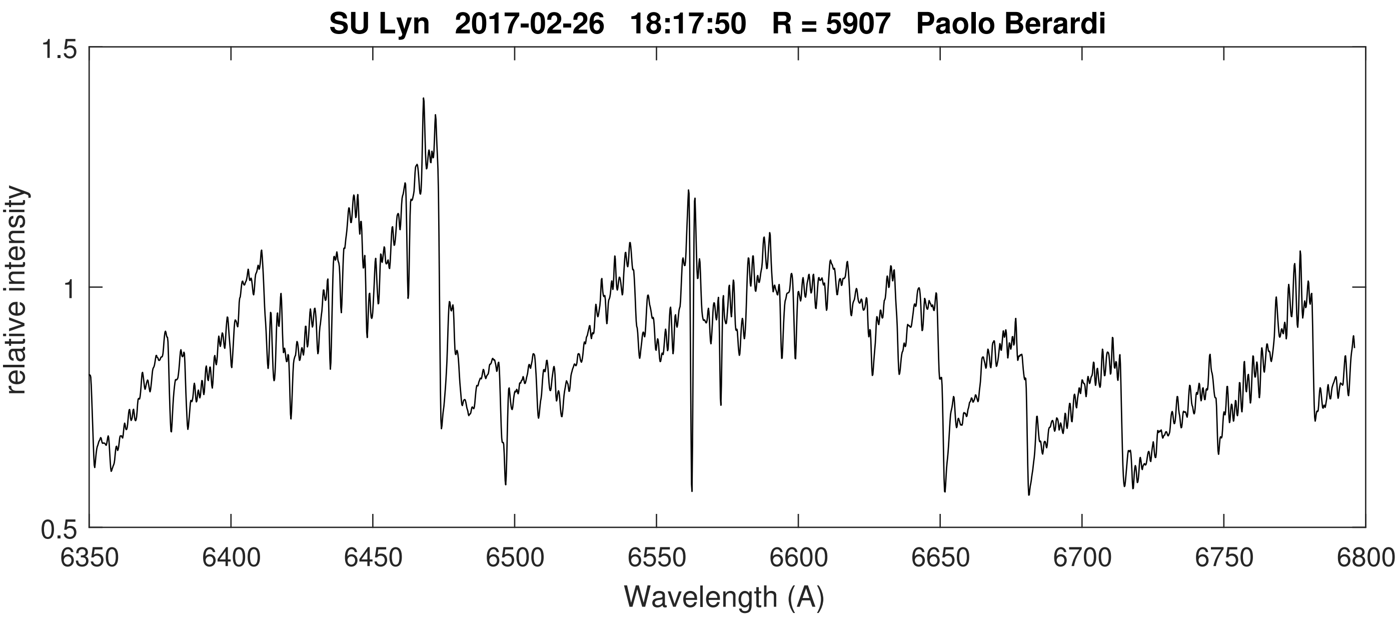
It shows strong orbital variation of H alpha line. Further observations are strongly encouraged



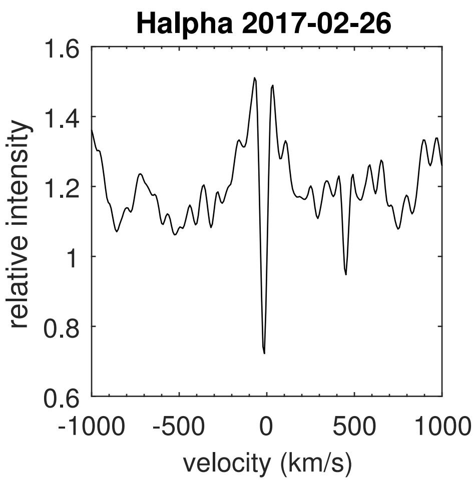
H alpha range

SU Lyn





H alpha range by Paolo Berardi with Lhires III 1200 l/mm and a crop on H alpha



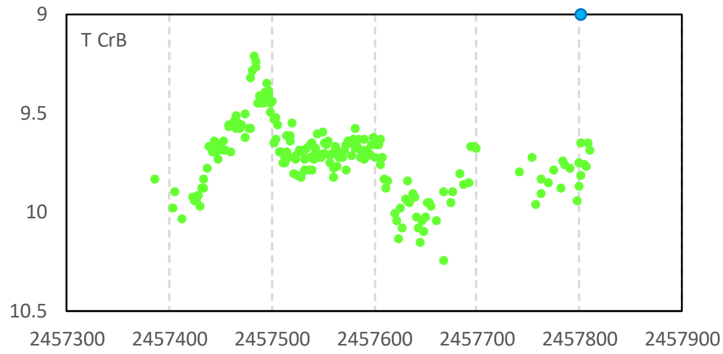
SYMBIOTICS

T CrB

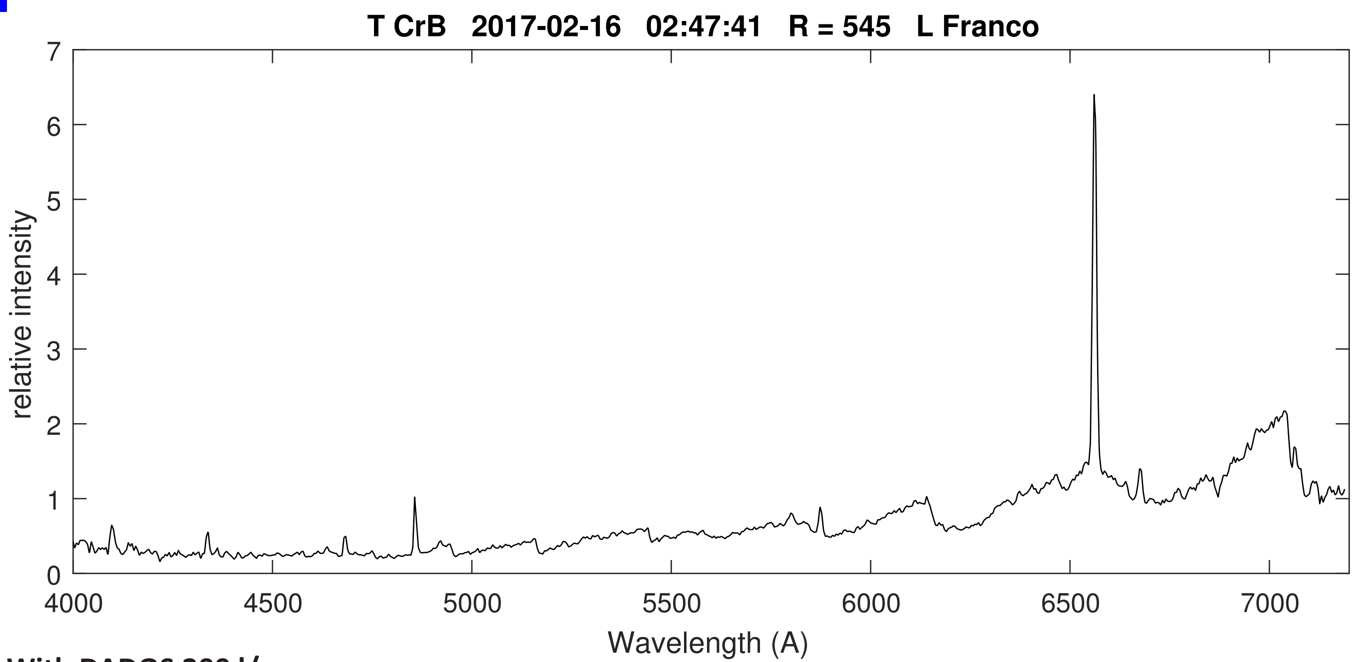
Coordinates (2000.0)	
R.A.	15 59 30.1
Dec	25 55 12.6
Mag	9.8 (2017-01)

T CrB in the morning sky

The symbiotic recurrent nova is a main target in our observing program for the next years until the next nova

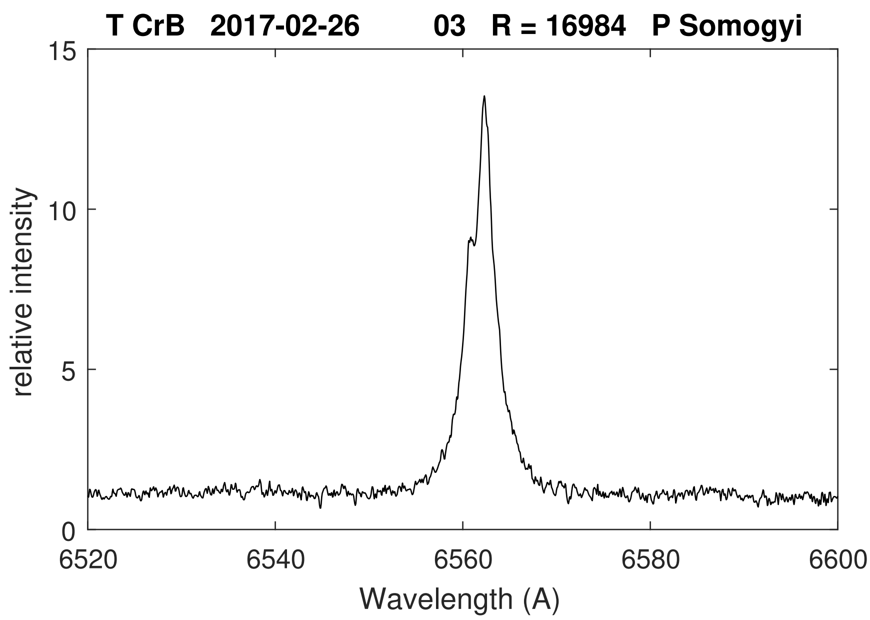


AAVSO V light curve 2016-2017



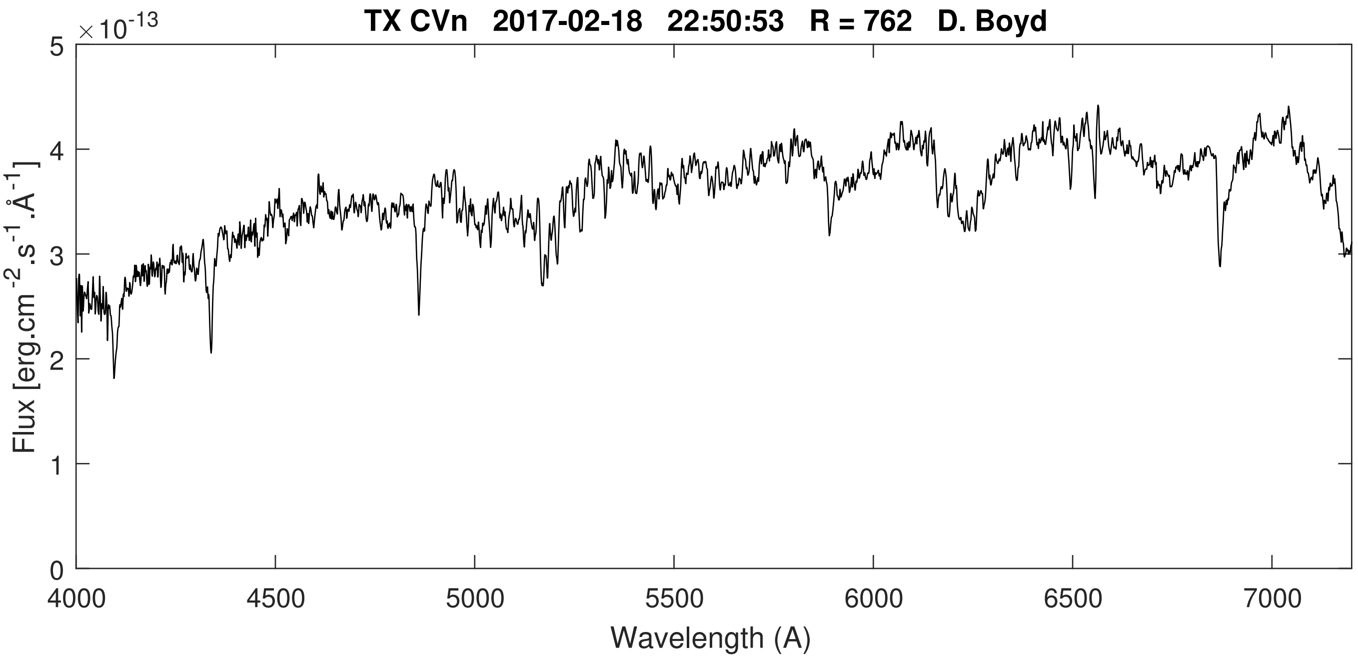
With DADOS 200 l/mm

Lhires III - 2400 l/mm - R = 170000



TX CVn

Coordinates (2000.0)	
R.A.	12 44 42.06
Dec	+36 45 50.7
Mag	10.3 (01-2017)

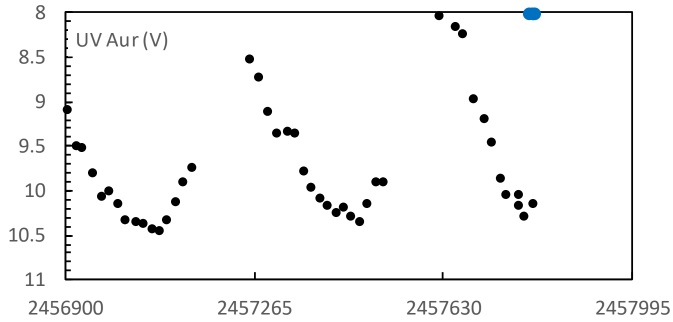


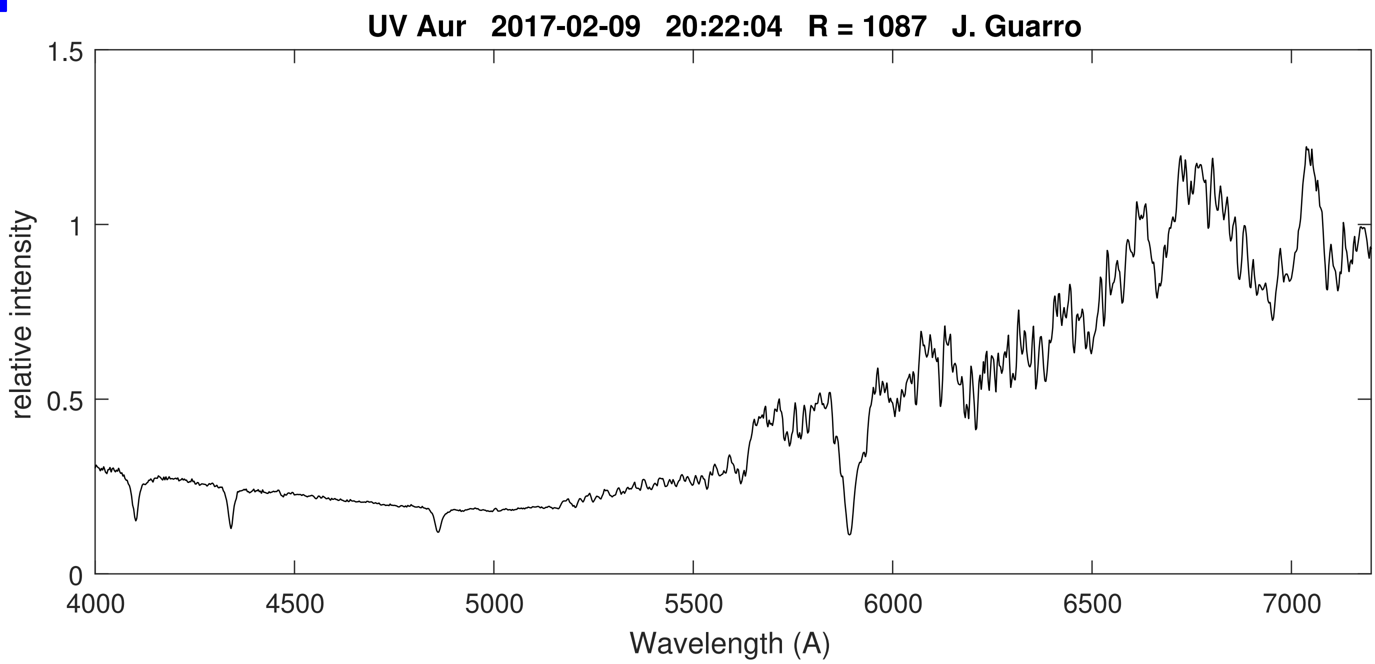
SYMBIOTICS

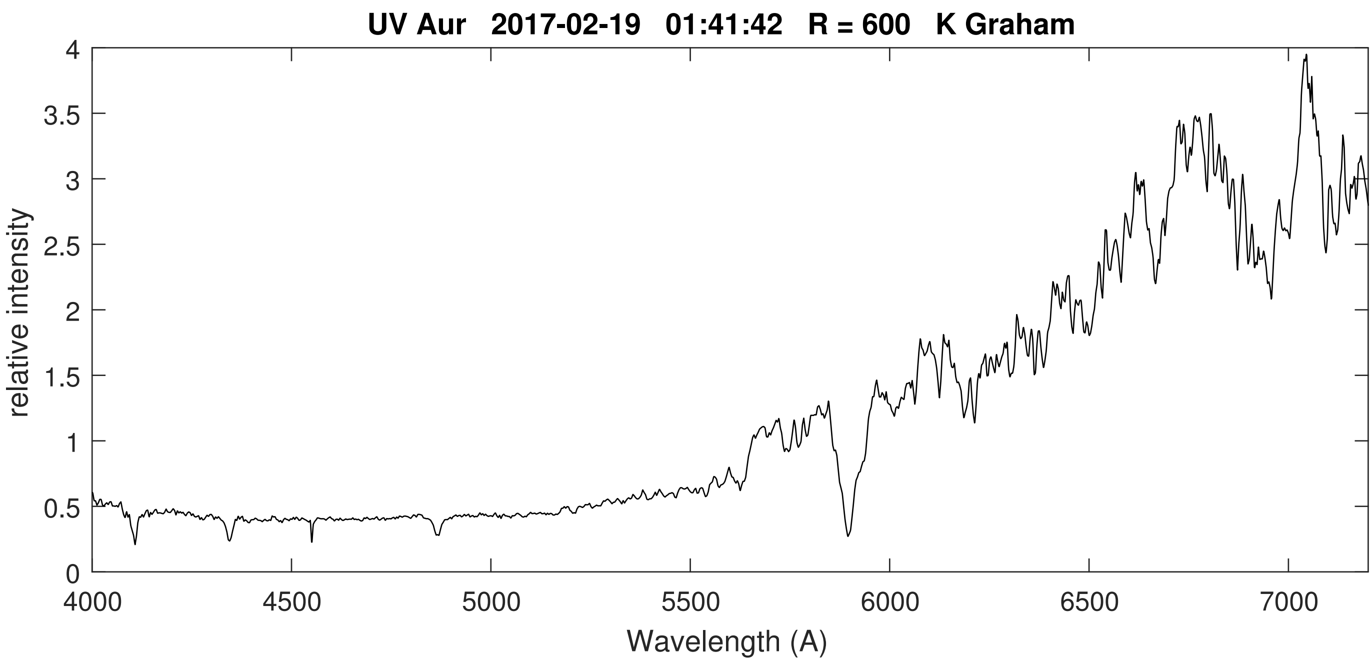
UV Aur

Coordinates (2000.0)	
R.A.	5 21 48.8
Dec	32 30 43.1
Mag	9.2 (2016-12)

Near the minimum of the pulsation cycle





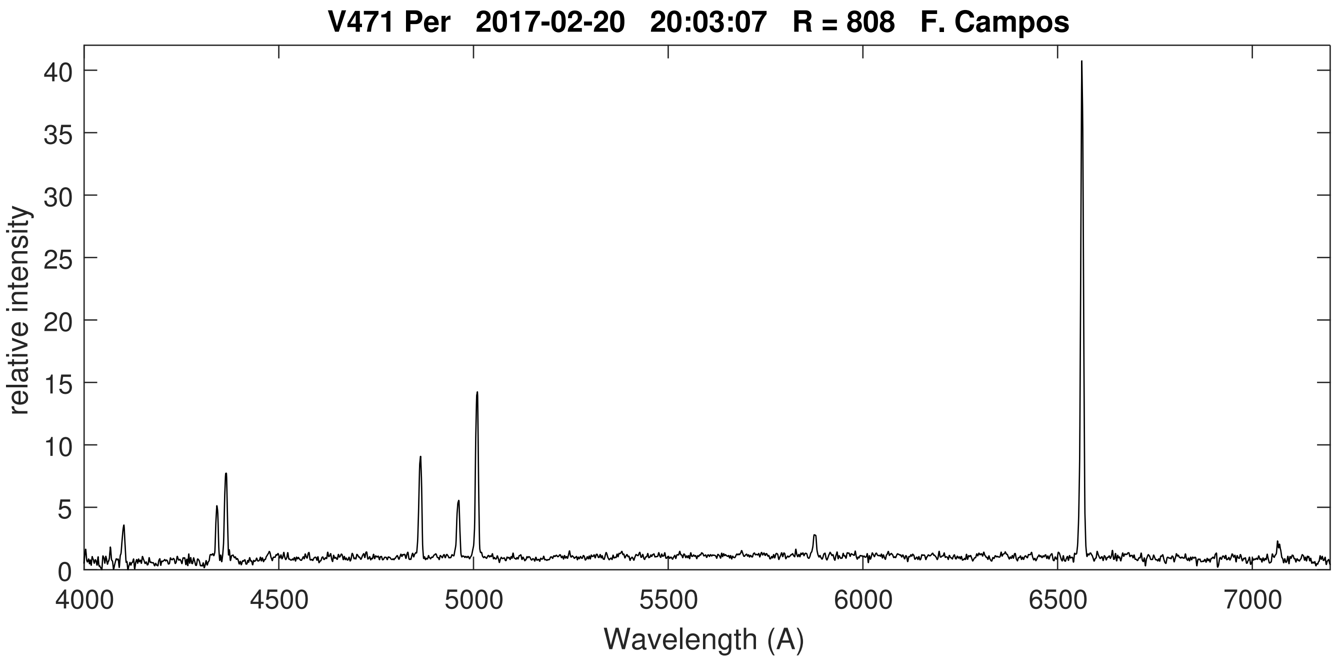


S Y M B I O T I C S

V471 Per

Coordinates (2000.0)	
R.A.	01 58 49.7
Dec	+52 53 48.4
Mag	~ 13 (V)

The faint yellow symbiotic V471 and its strong [OIII] lines obtained by Fran Campos DADOS 200 l/mm on a Newton 200 mm

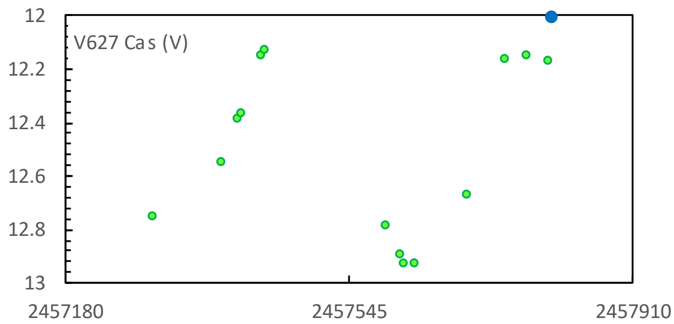


V627 Cas

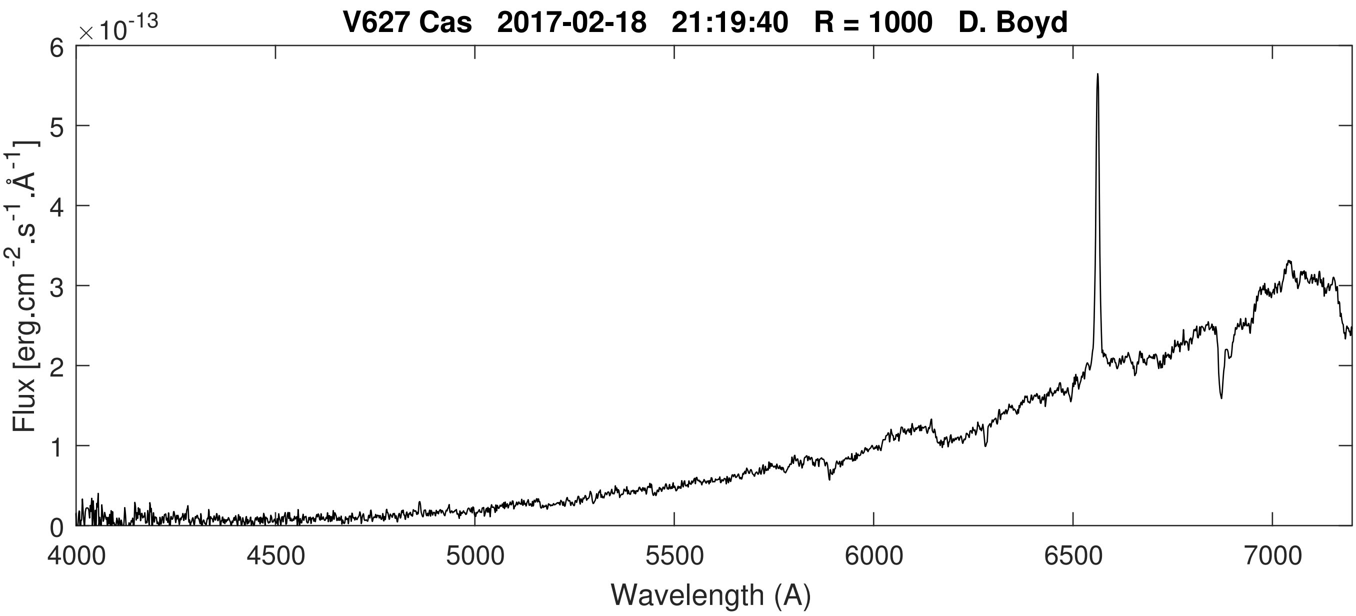
Coordinates (2000.0)	
R.A.	22 57 41.2
Dec	58 49 14.9
Mag	12.2 (2017-01)

V627 Cas is a poorly observed symbiotic star (suspected)

Description of the star by M. Gromadzki et al. (2006)
V627 Cas was initially classified as T Tau variable (Paupers et al. 1989), whereas Kolotilov (1998) proposed its symbiotic nature. It was included on the Belczynski et al. (2000) list of stars suspected to be symbiotic. The spectral type of the cool component is M2-4II (Kolotilov et al. 1991). Pulsations with a period of ≈ 466 days and brightness changes from night to night, indicating possible presence of flickering, were reported by Kolotilov et al. (1991, 1996). It has been suggested that the V627 Cas hot companion activity is of similar nature as that of CH Cyg. Kolotilov et al. (1991) also observed short-lived flares with amplitude of about 0.5 mag in B.



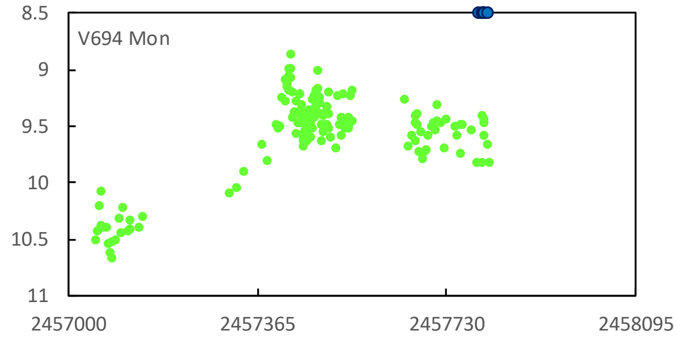
The AAVSO lightcurve (David Boyd's observations) showing the pulsation of the giant.



SYMBIOTICS

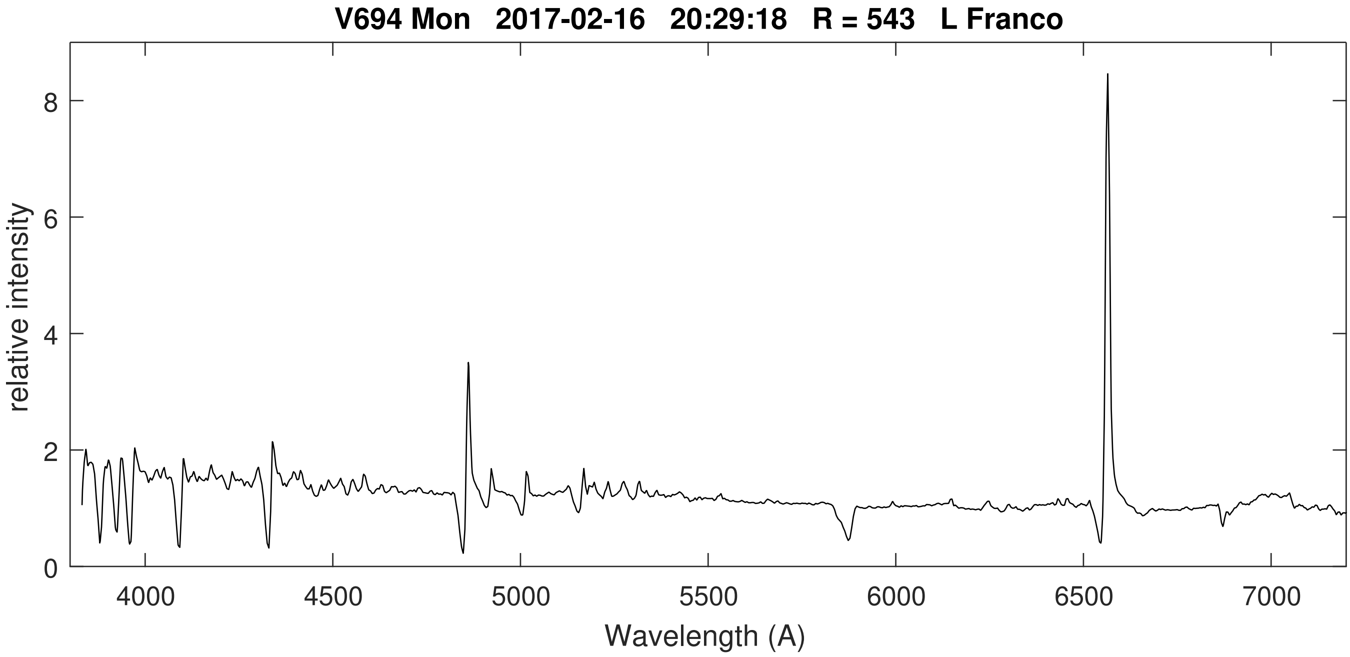
V694 Mon

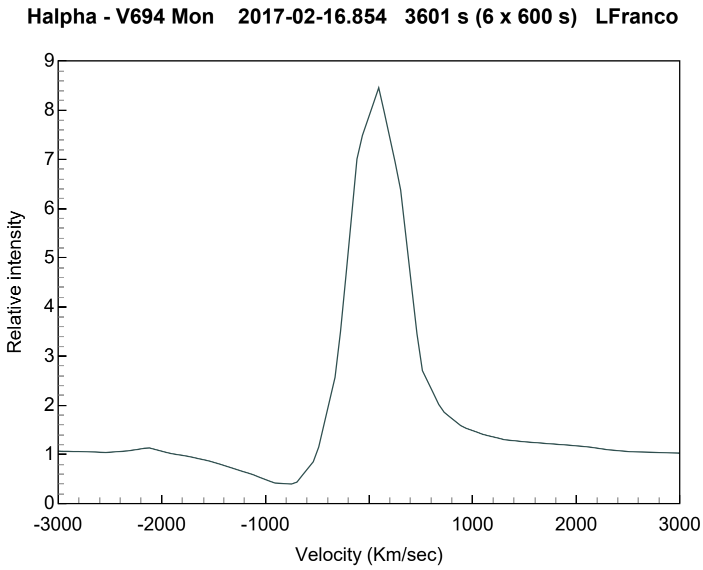
Coordinates (2000.0)	
R.A.	7 25 51.2
Dec	-7 44 8
Mag	



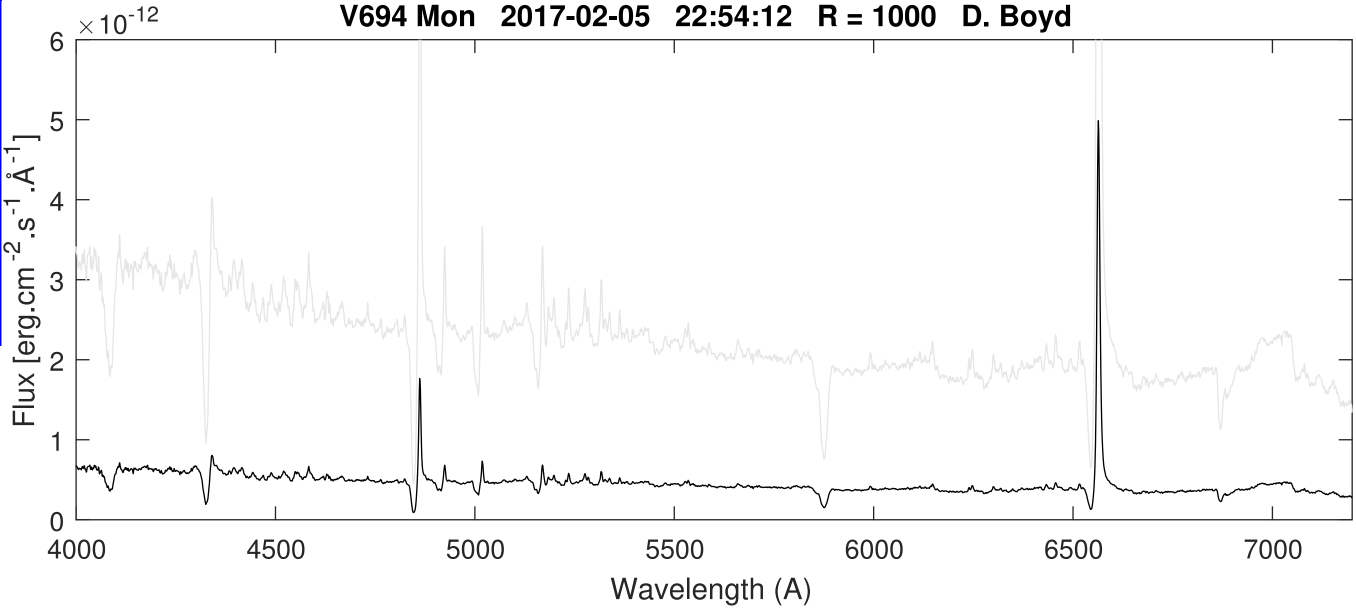
V694 Mon remains at high luminosity (Mean mag ~9.5)

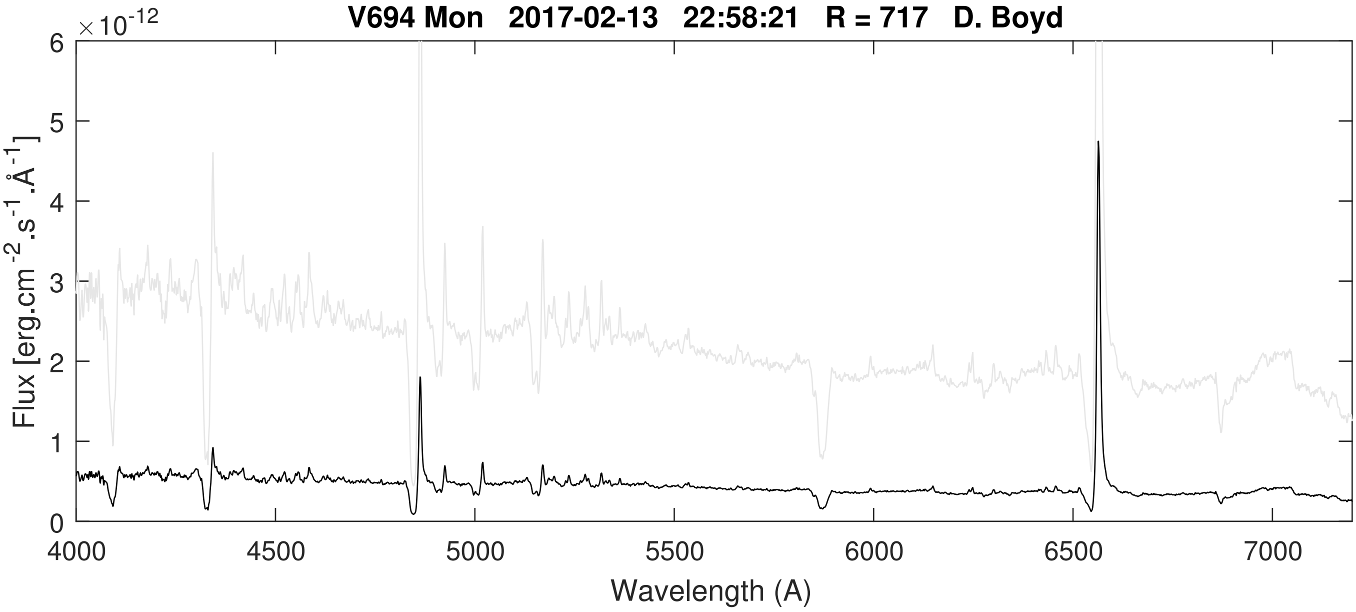
Observations during all the season are strongly encouraged.

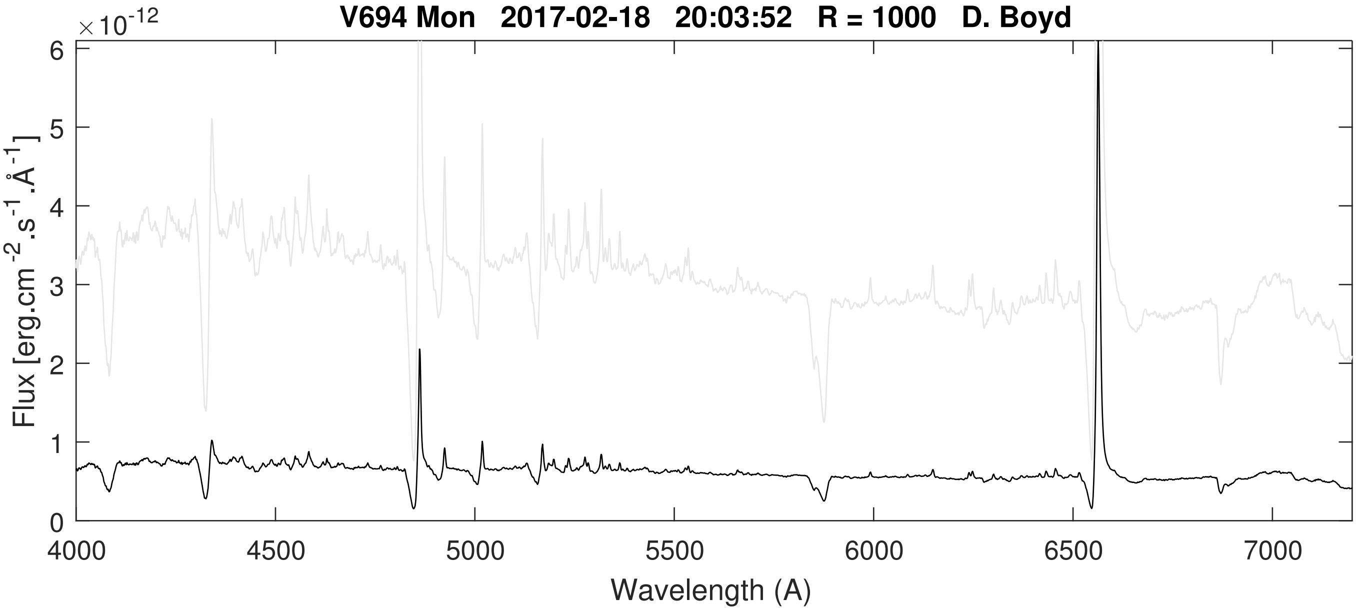




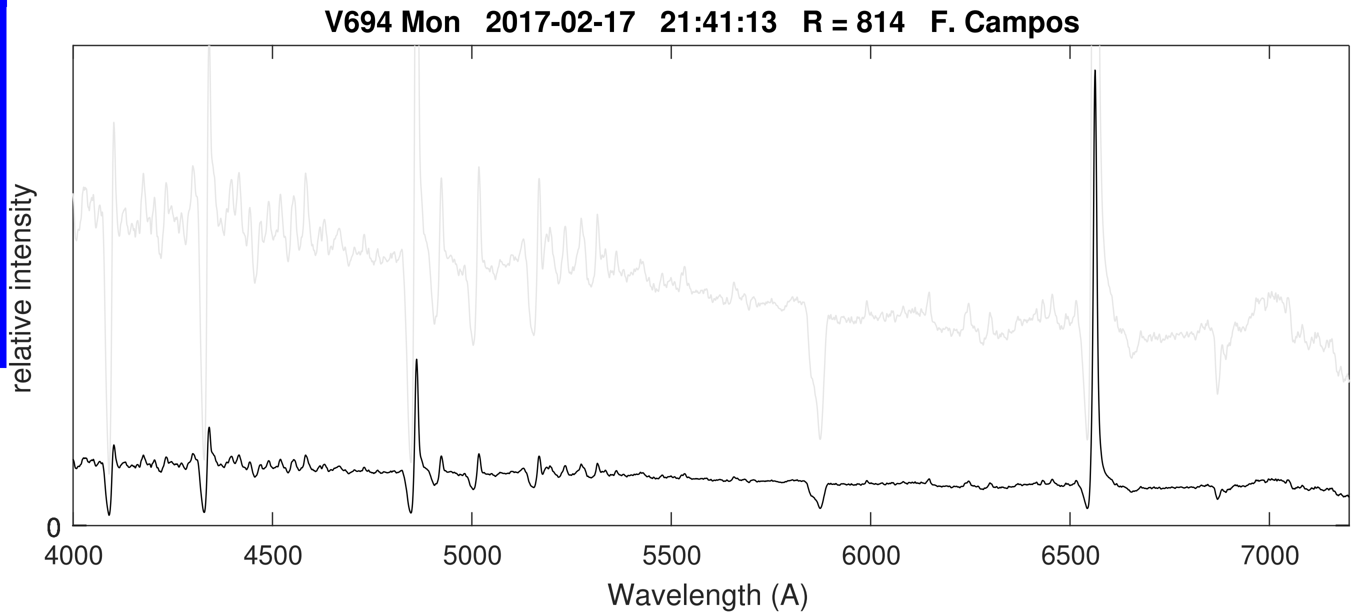
V694 Mon

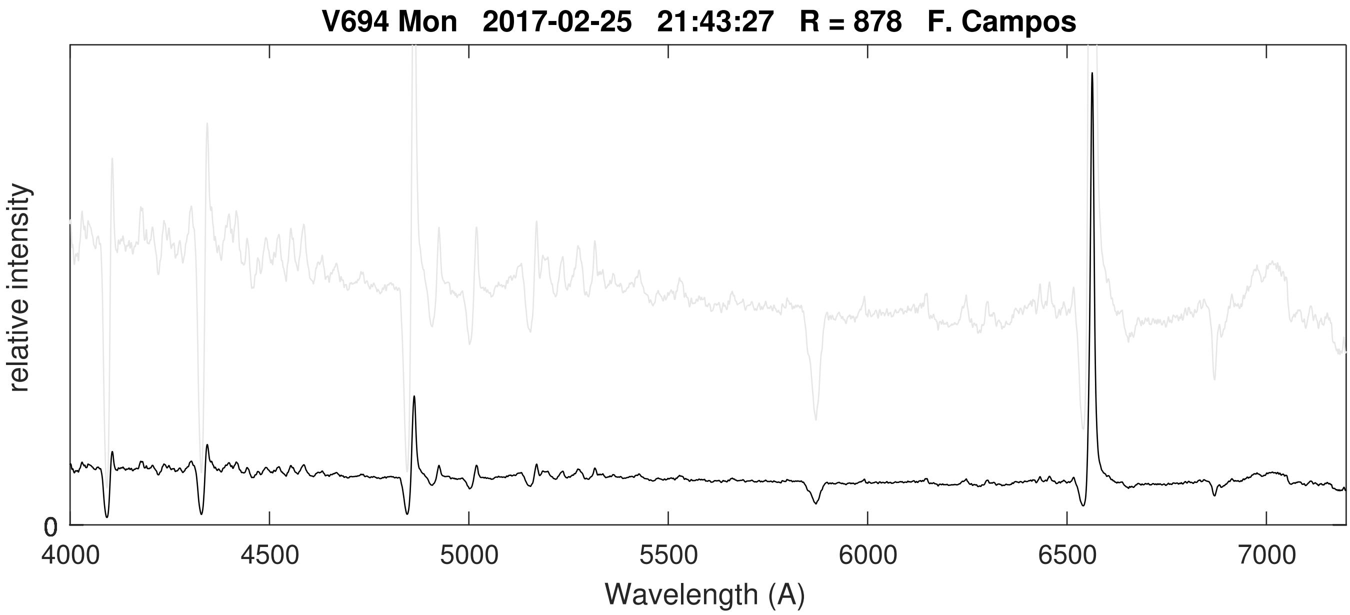

V694 Mon 2017-02-05 22:54:12 R = 1000 D. Boyd
×10^-12
Flux [erg.cm^-2.s^-1.Å^-1]
Wavelength (A)
0
1
2
3
4
5
6
4000
4500
5000
5500
6000
6500
7000


V694 Mon 2017-02-13 22:58:21 R = 717 D. Boyd
×10^-12
Flux [erg.cm^-2.s^-1.Å^-1]
Wavelength (A)
0
1
2
3
4
5
6
4000
4500
5000
5500
6000
6500
7000


V694 Mon 2017-02-18 20:03:52 R = 1000 D. Boyd
×10^-12
Flux [erg.cm^-2.s^-1.Å^-1]
Wavelength (A)
0
1
2
3
4
5
6
4000
4500
5000
5500
6000
6500
7000

V694 Mon

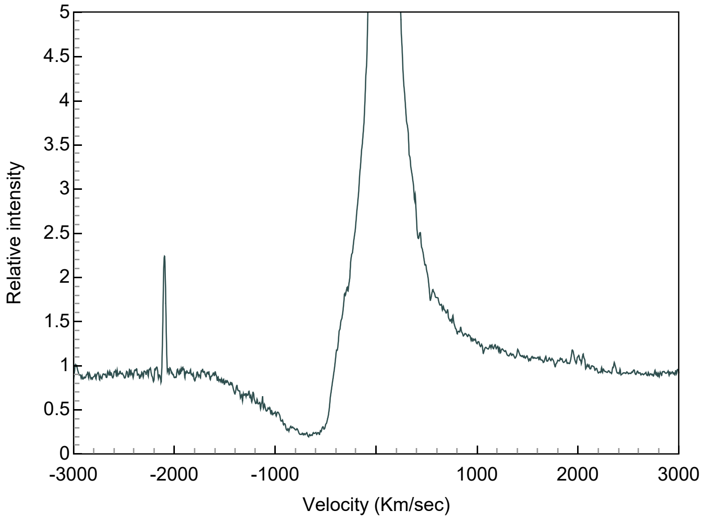

V694 Mon 2017-02-17 21:41:13 R = 814 F. Campos
relative intensity
0
4000
4500
5000
5500
6000
6500
7000
Wavelength (A)


V694 Mon 2017-02-25 21:43:27 R = 878 F. Campos
relative intensity
0
4000
4500
5000
5500
6000
6500
7000
Wavelength (A)

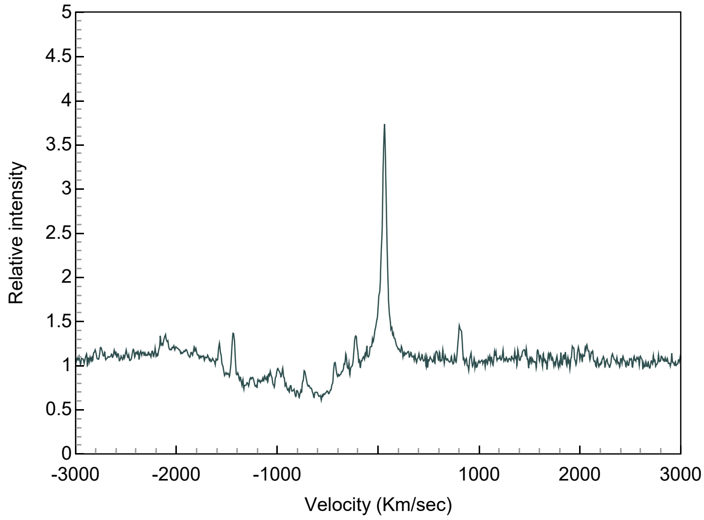
V694 Mon

Various profiles obtained by J. Edlin and F. Teyssier (eShel R = 11000)

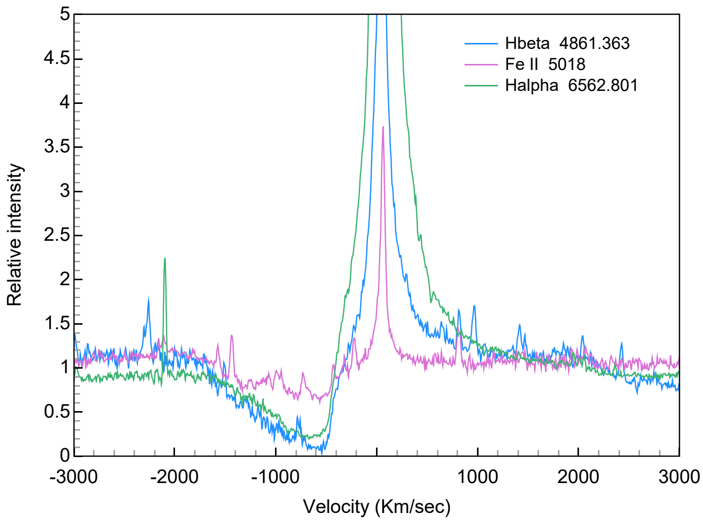
Halpha - V694 Mon 2017-02-17.860 4947 s (8 x 600 s) fteyssier



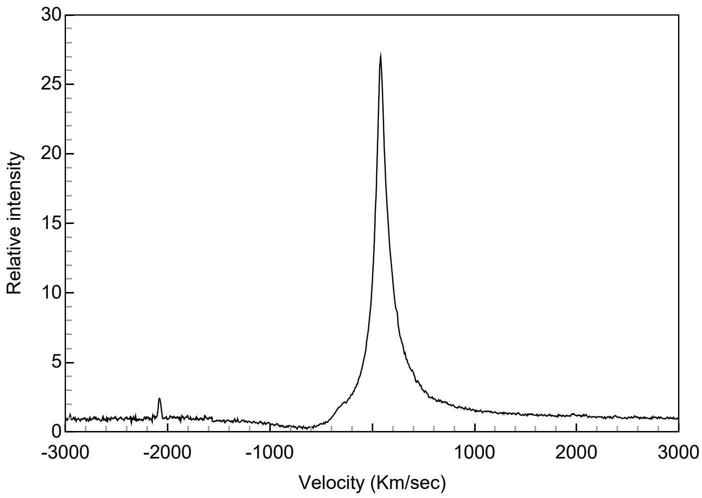
Fe II - V694 Mon 2017-02-17.860 4947 s (8 x 600 s) fteyssier



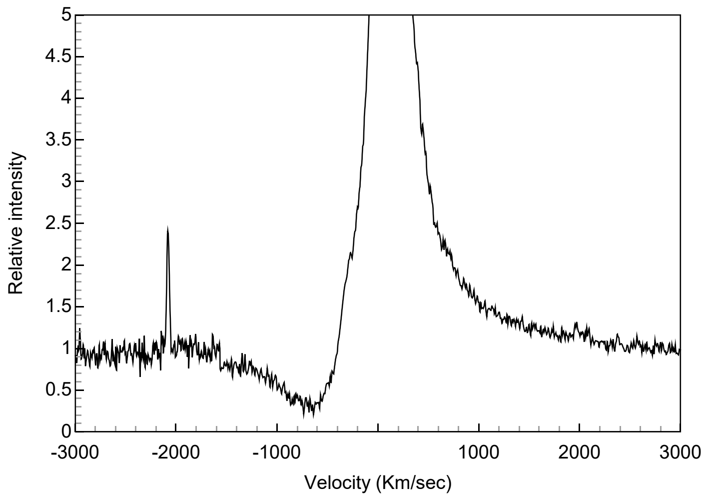
V694 Mon 2017-02-17.860 4947 s (8 x 600 s) fteyssier



Halpha - V694 Mon 2017-02-13.160 3665 s (12 x 300 s) Jim Edlin

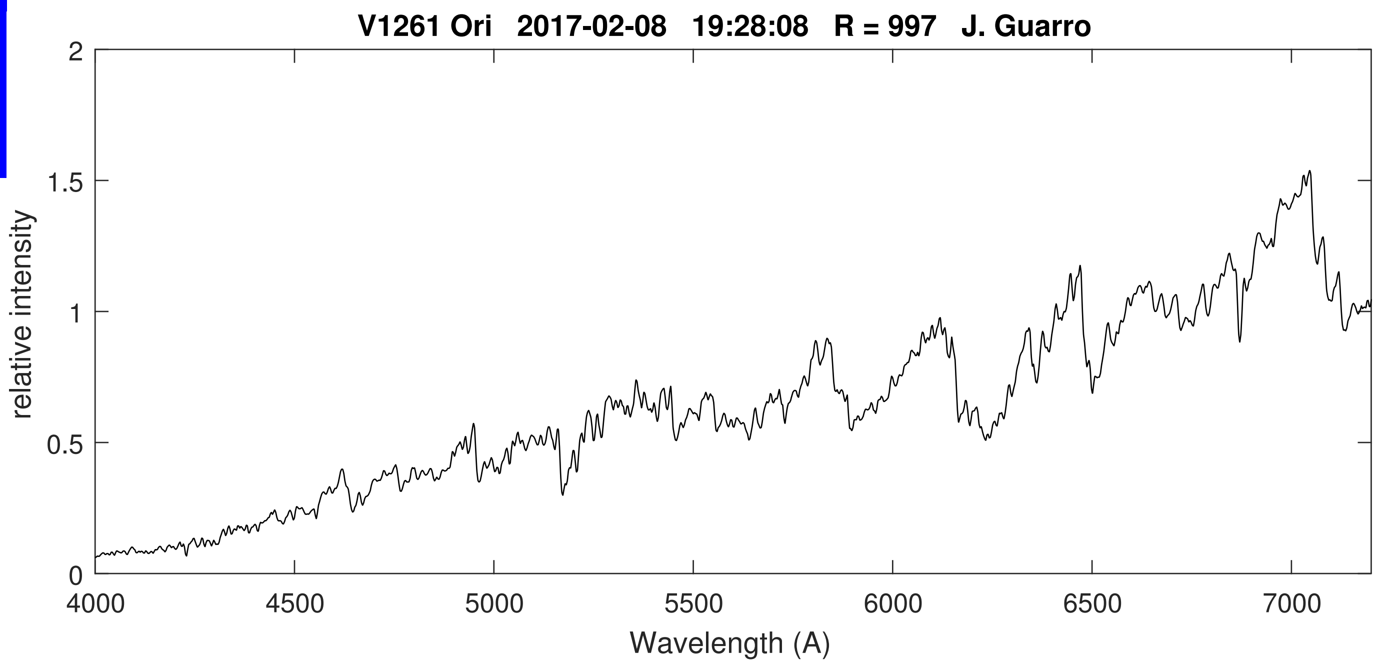


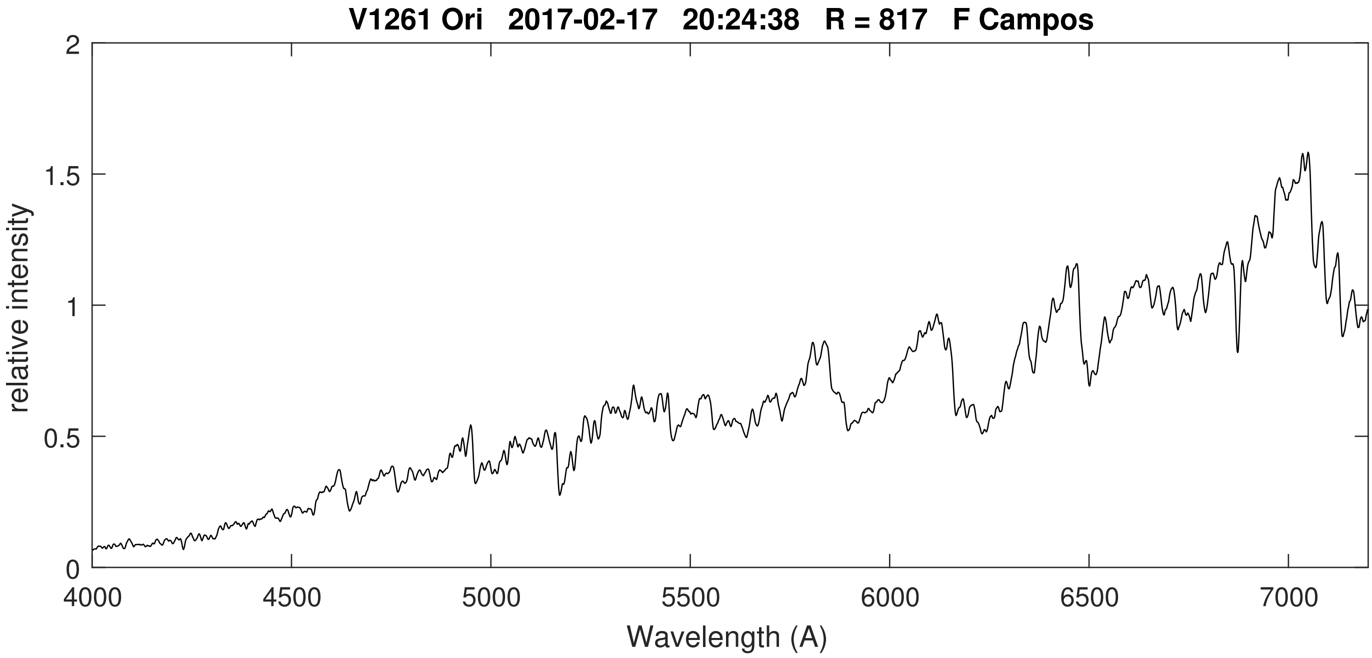
Halpha - V694 Mon 2017-02-13.160 3665 s (12 x 300 s) Jim Edlin



V1261 Mon

Coordinates (2000.0)	
R.A.	05 22 18.6
Dec	-08 39 58.0
Mag V	6.9 (2017-02)

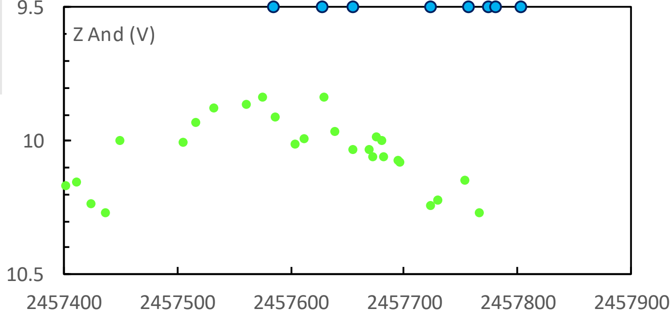




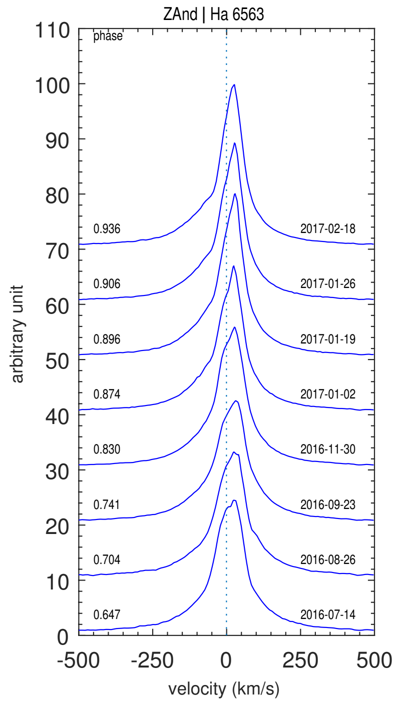
SYMBIOTICS

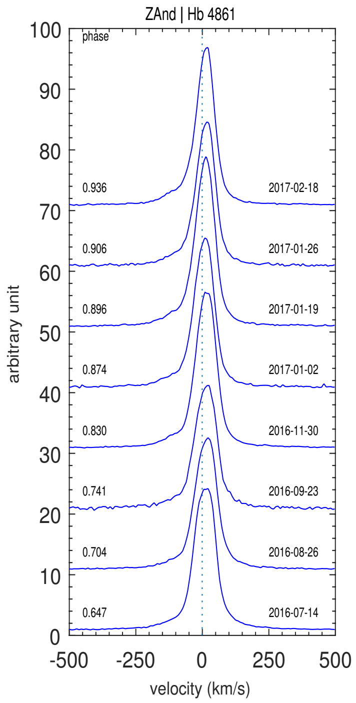
Z And

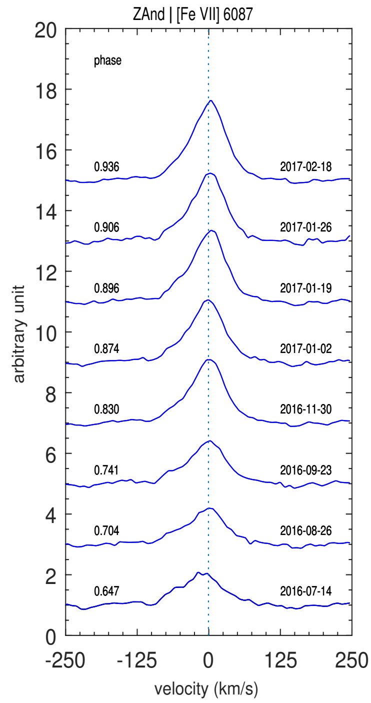
Coordinates (2000.0)	
R.A.	23 33 39.9
Dec	+48 49 06.0
Mag	10.3 (2017-02)

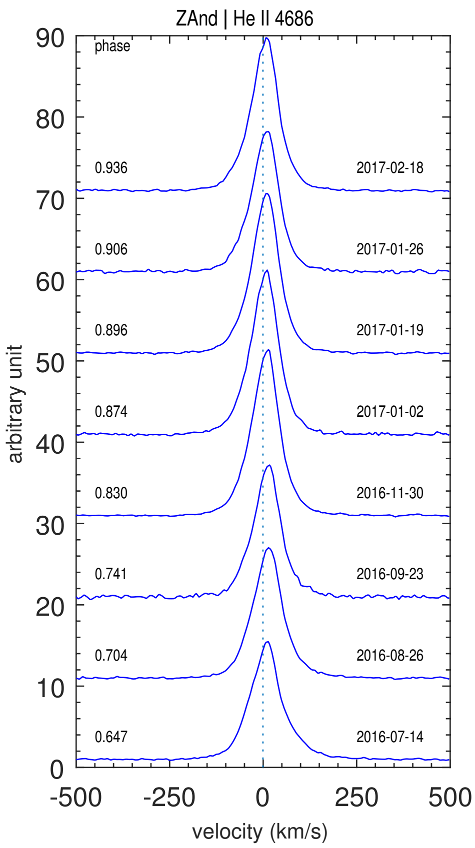


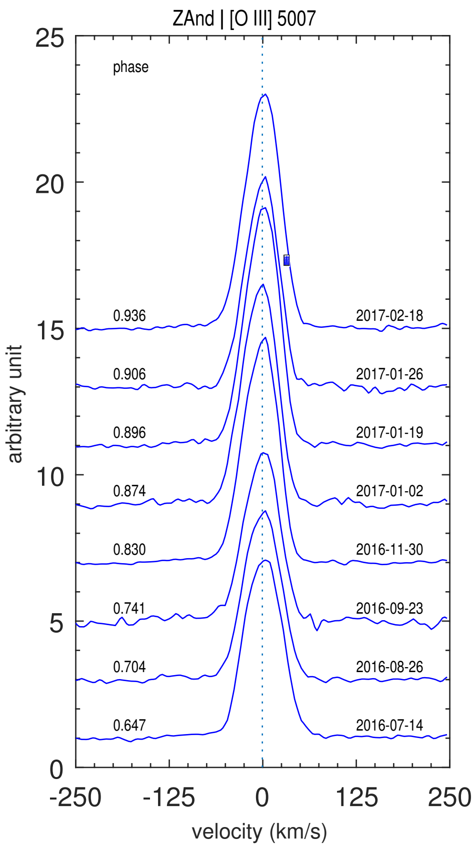
F. Teyssier R =11000







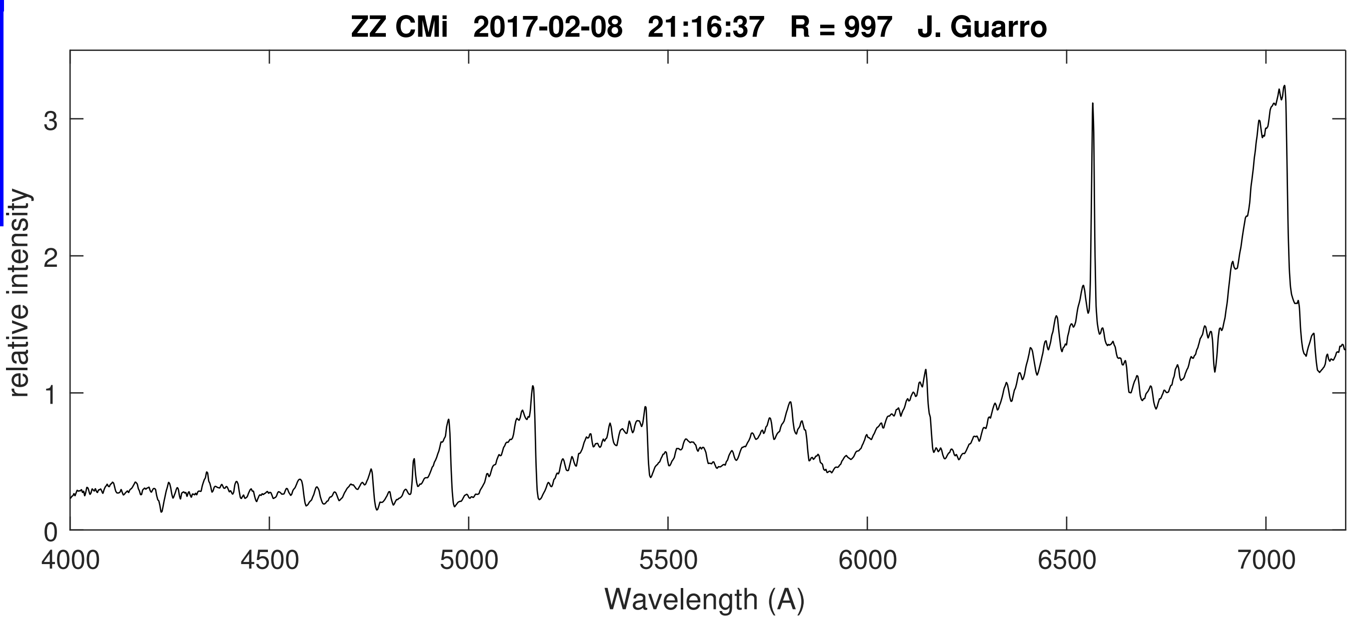


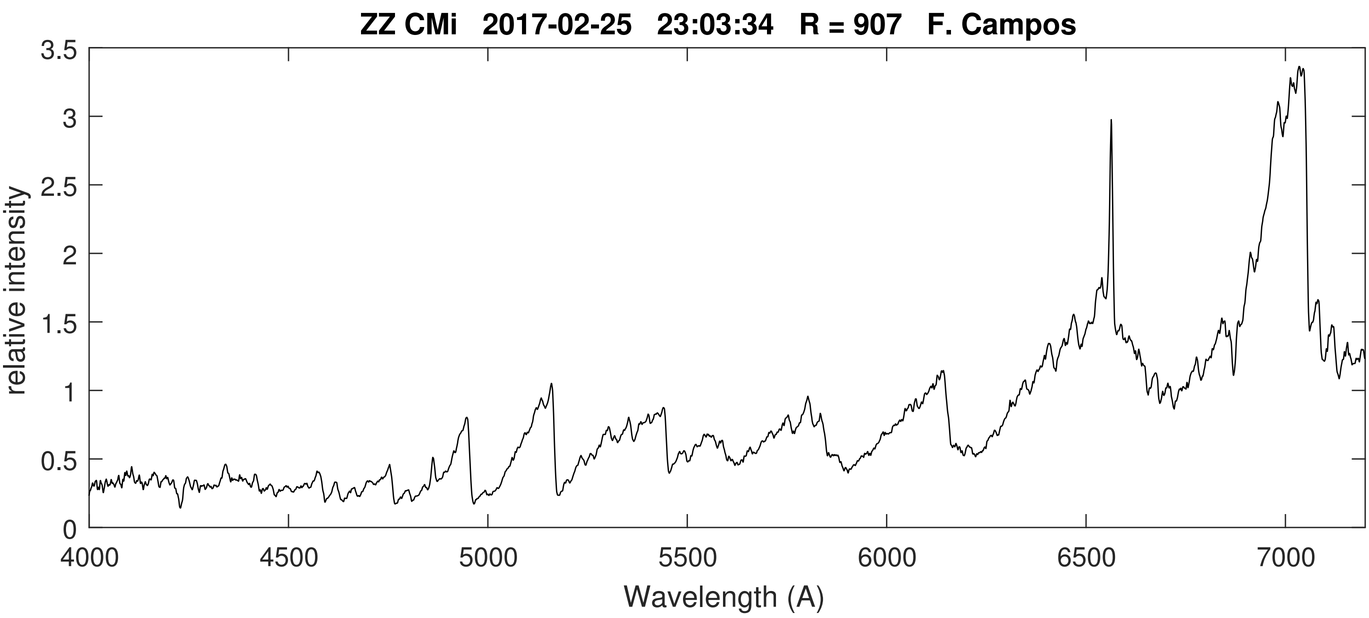


S Y M B I O T I C S

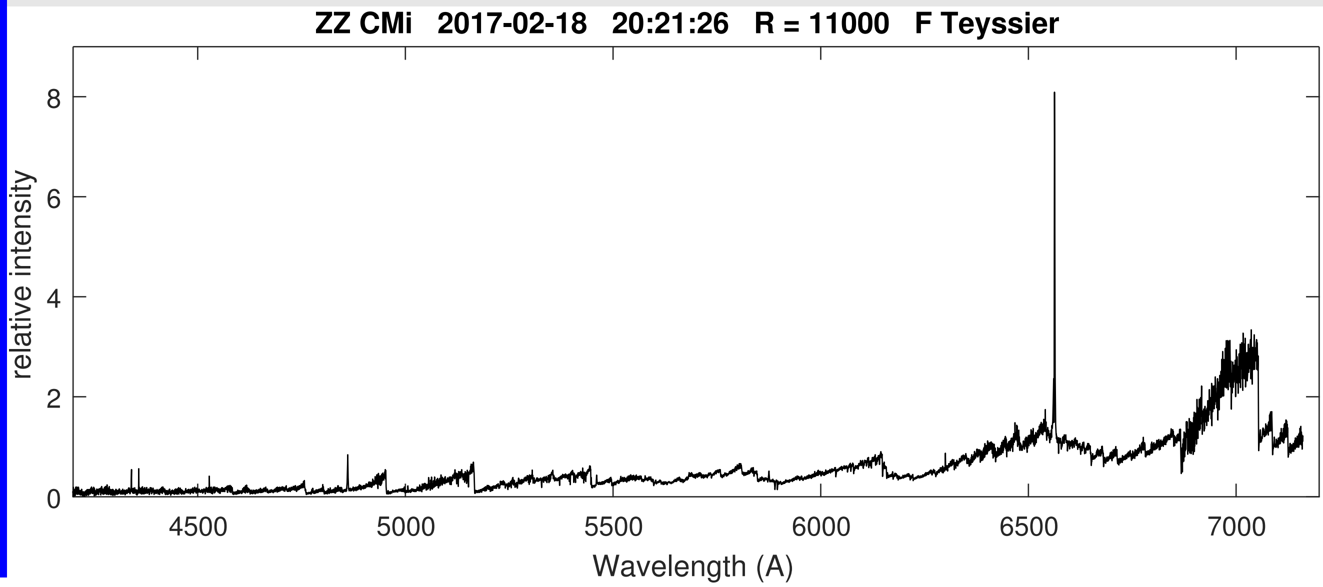
ZZ CMi

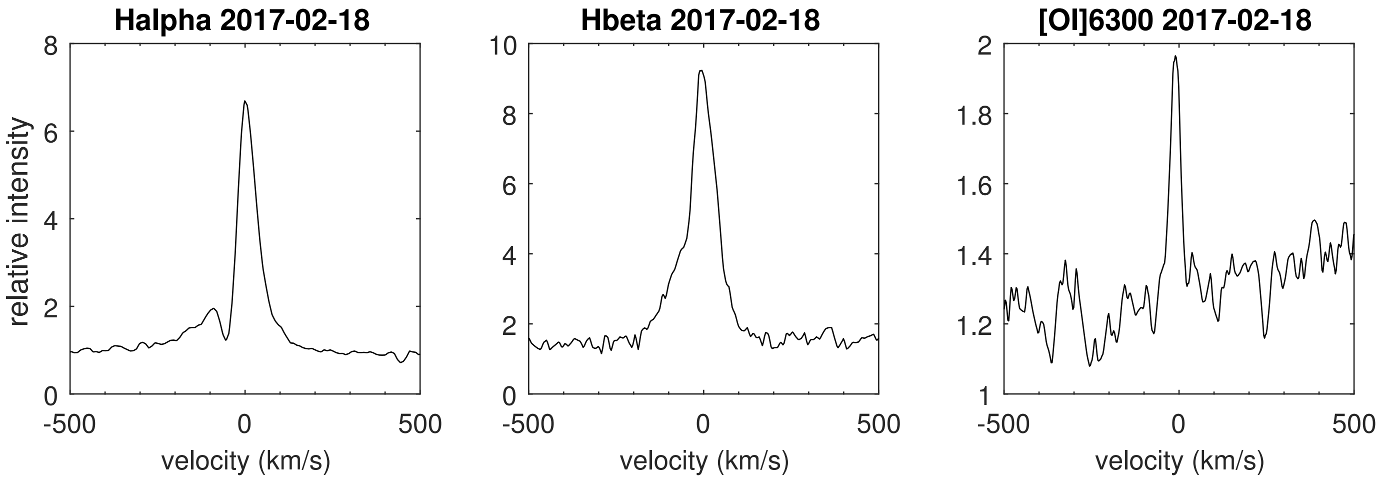
Coordinates (2000.0)	
R.A.	07 24 14.0
Dec	+08 53 51.8
Mag	10.1 (2017-02)

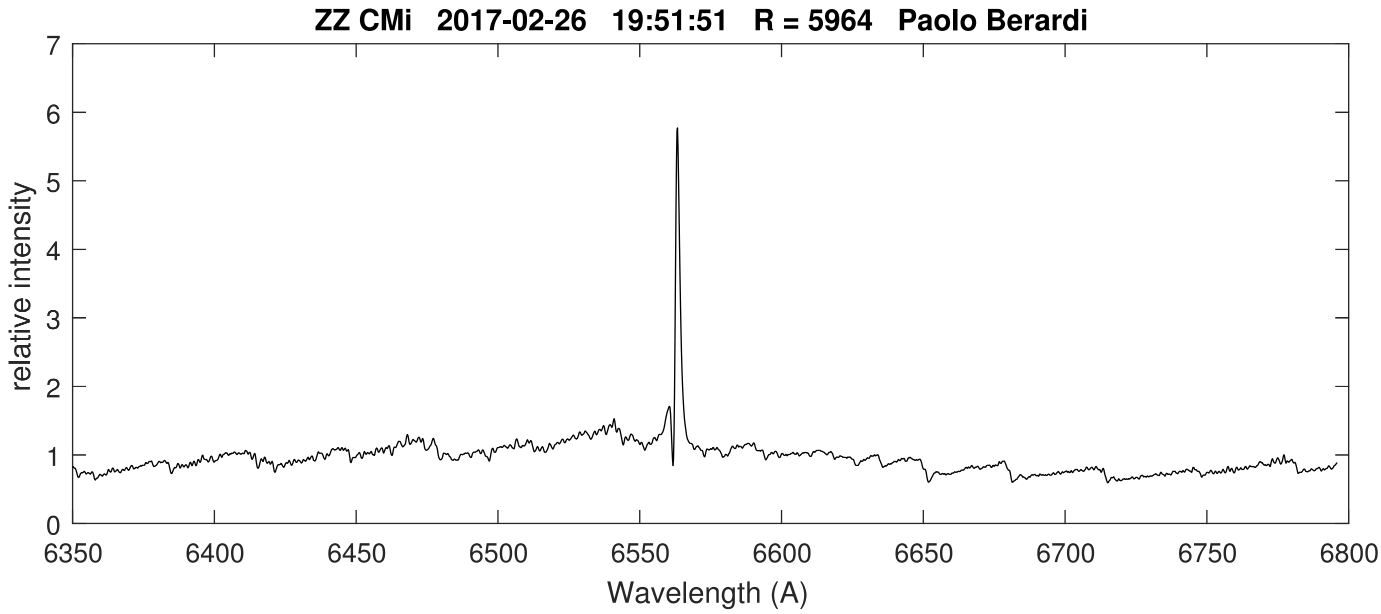




ZZ CMi


ZZ CMi 2017-02-18 20:21:26 R = 11000 F Teyssier
relative intensity
Wavelength (A)


Halpha 2017-02-18
Hbeta 2017-02-18
[OI]6300 2017-02-18
relative intensity
velocity (km/s)


ZZ CMi 2017-02-26 19:51:51 R = 5964 Paolo Berardi
relative intensity
Wavelength (A)

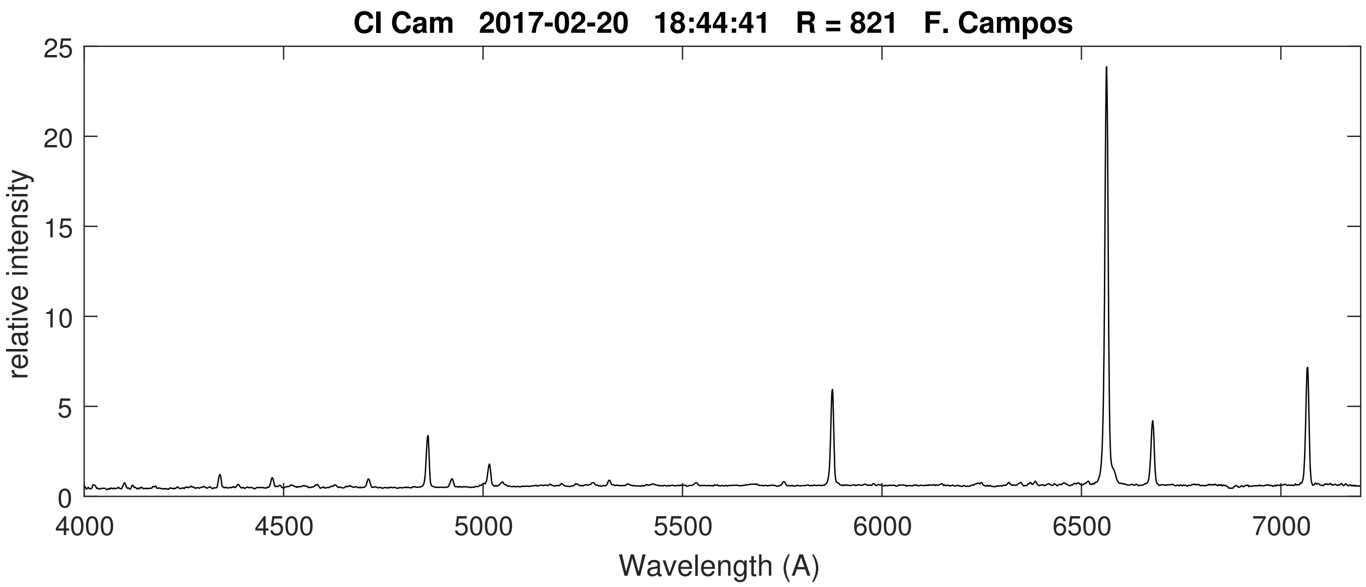
H
M
X
B

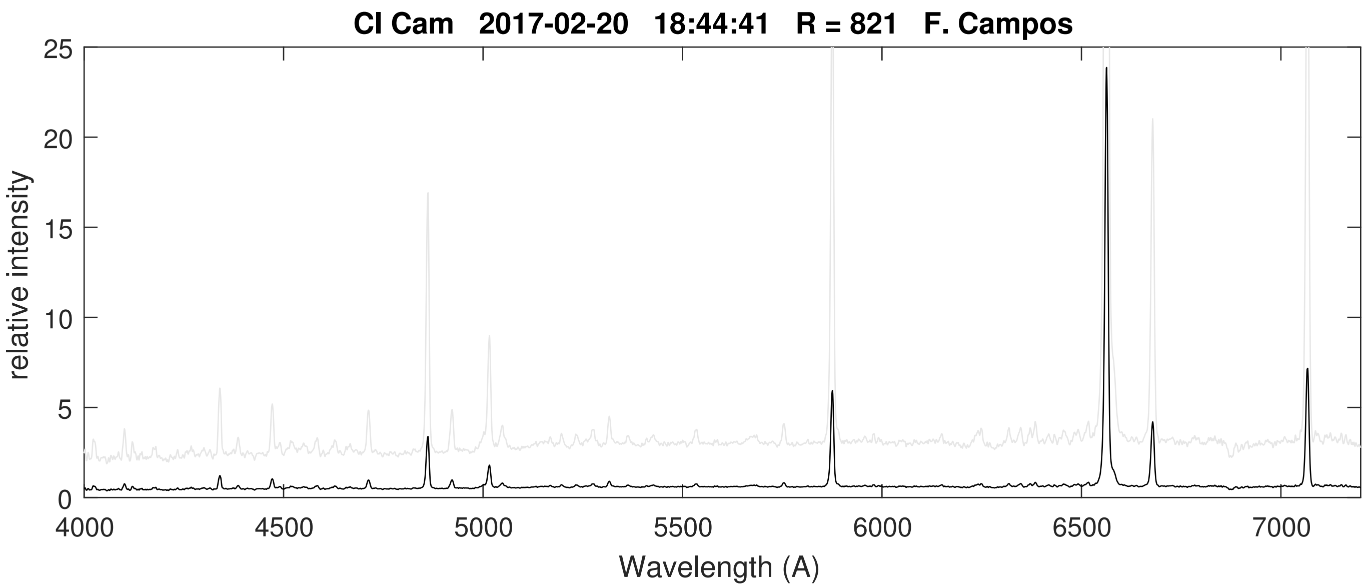
CI Cam

Coordinates (2000.0)	
R.A.	**04 19 42.1**
Dec	**+55 59 57.7**
Mag	11.4 (V)

Spectra in ARAS data base:
http://www.astrosurf.com/aras/Aras_DataBase/XB/CICam.htm

Ongoing observation of CI Cam by F. Campos

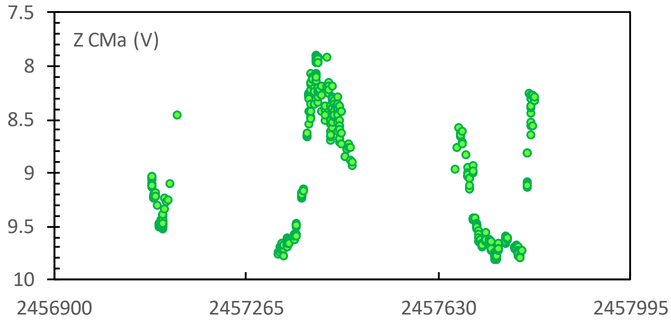




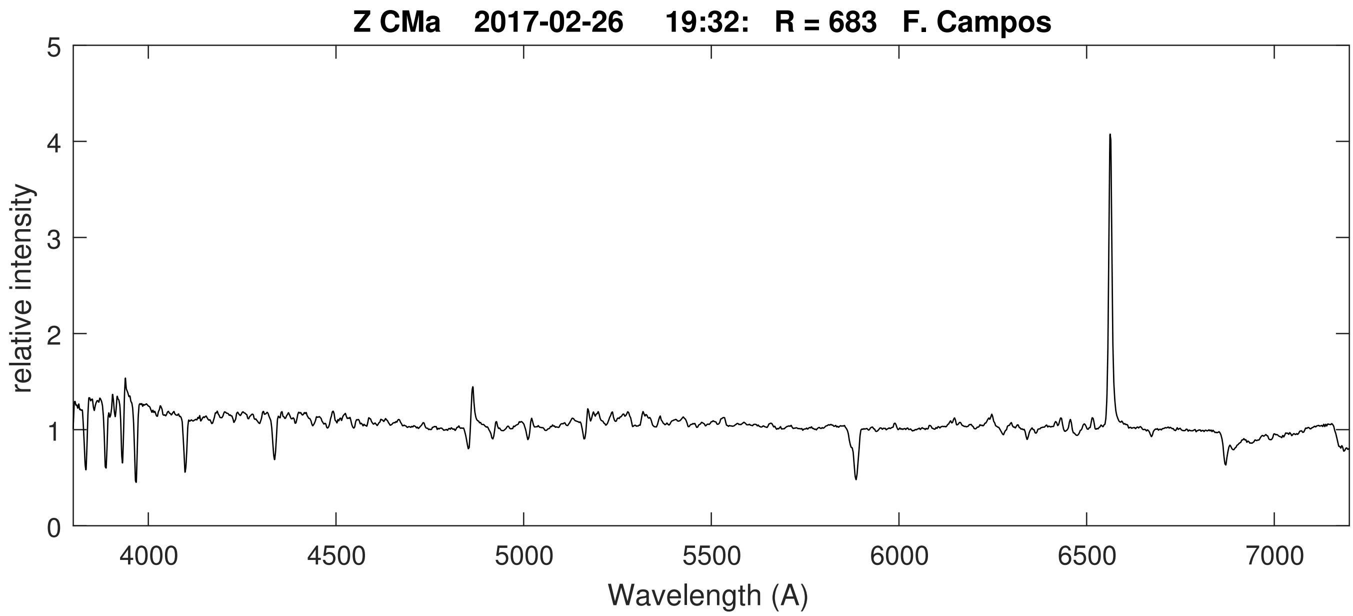
HERBIG Ae Be

Z CMa

Coordinates (2000.0)	
R.A.	**07 03 43.16**
Dec	**-11 33 06.2**
Mag	



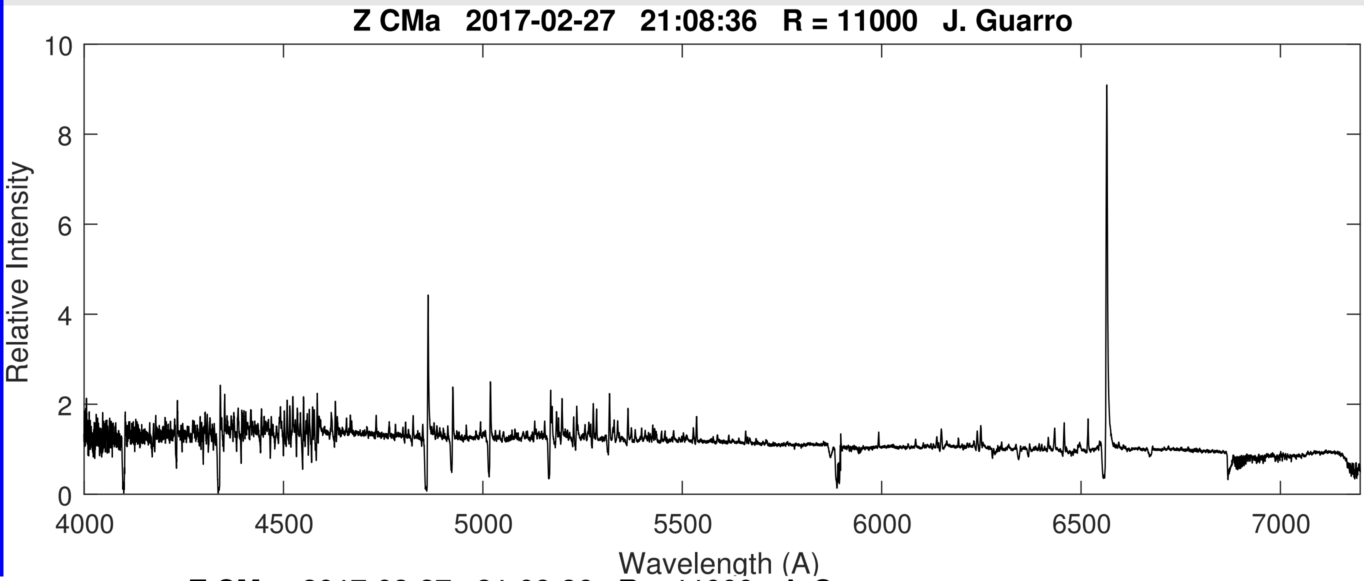
A new outburst of the Herbig Ae/Be star Z CMa, detected by AAVSO observers.
Francisco Campos obtained a low resolution spectrum, following the outburst

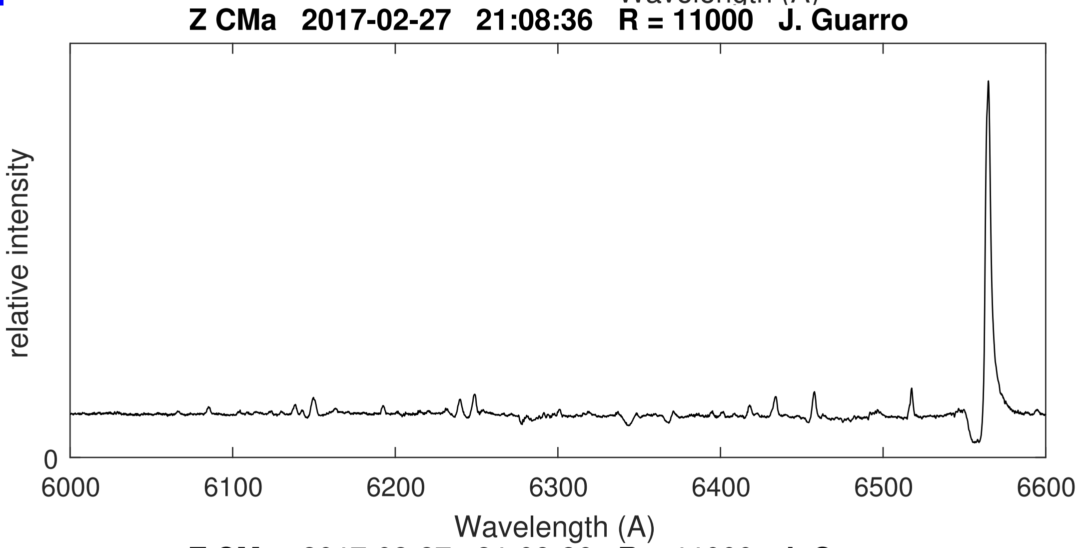


HERBIG

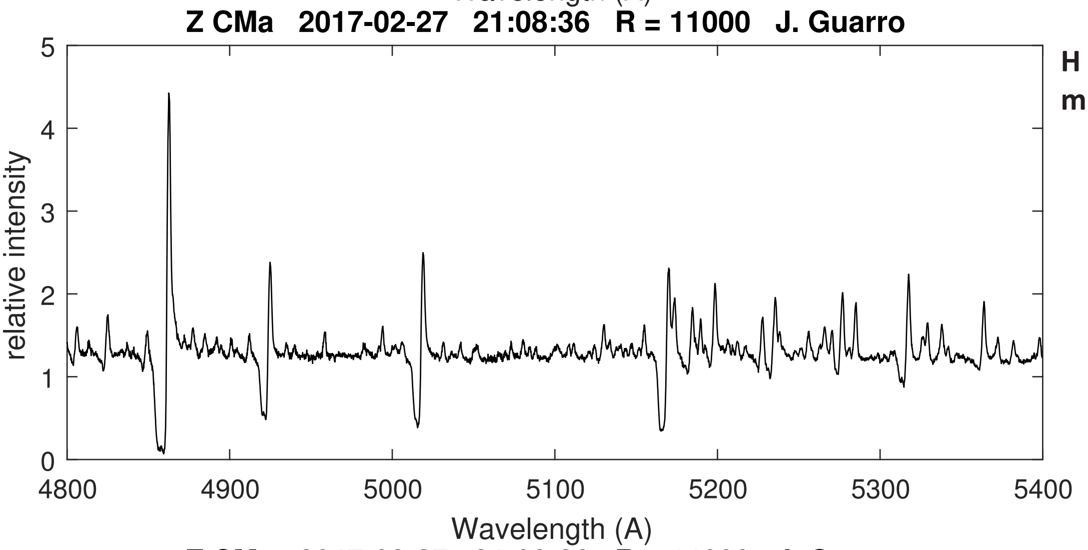
Ae Be

Z CMa

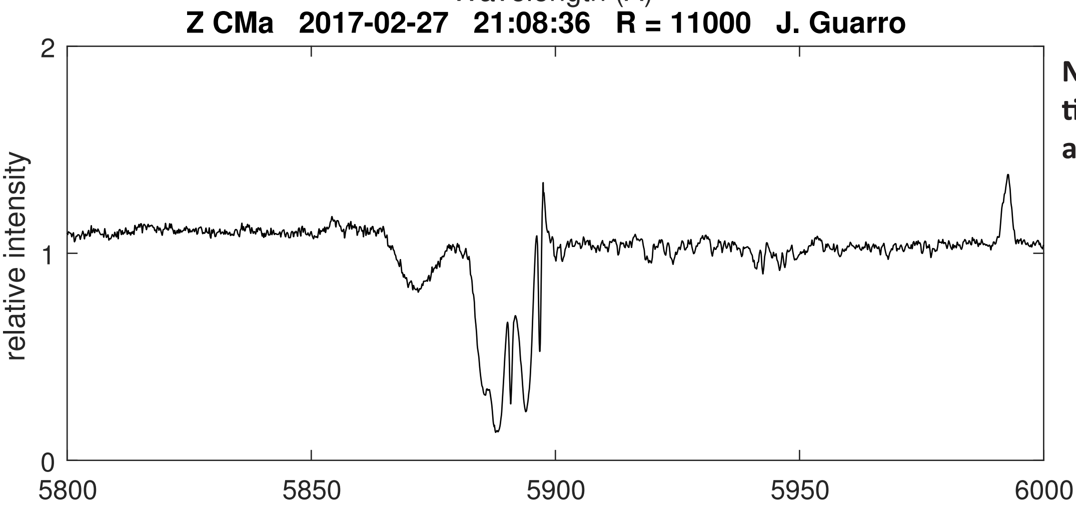




H alpha range Maximum velocity of the P cygni profile is ~ 570 km.s^{-1}



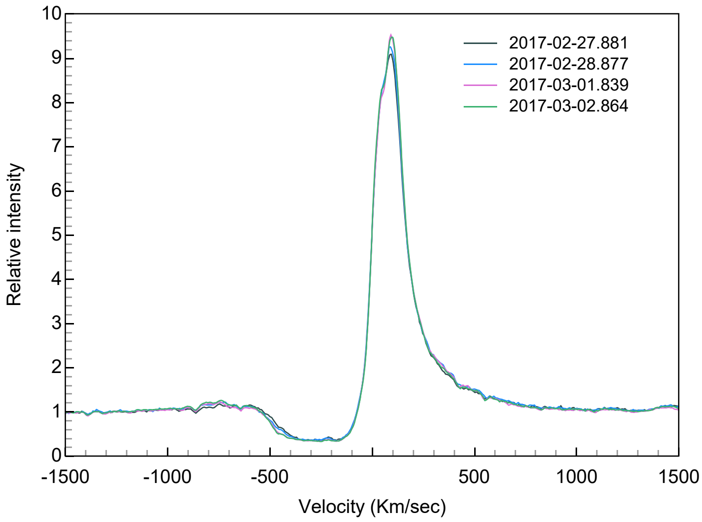
H beta and Fe II (42) multiplet



Na I D complex absorption and a faint emission and He I absorption

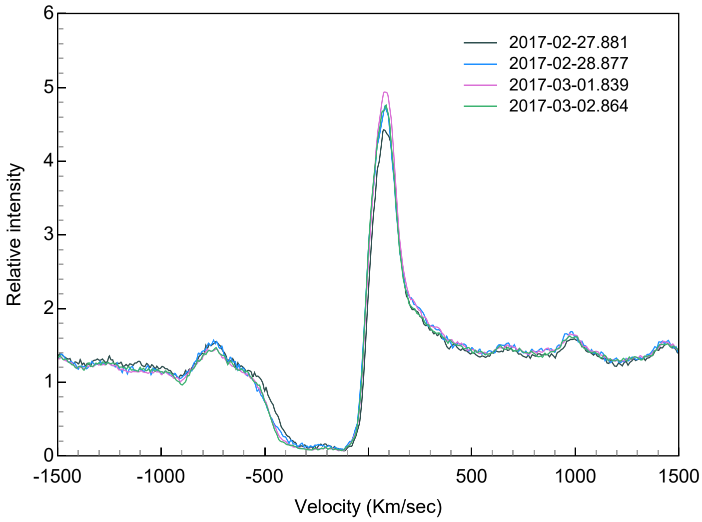
Z CMa

Halpha - Z CMA J. Guarro

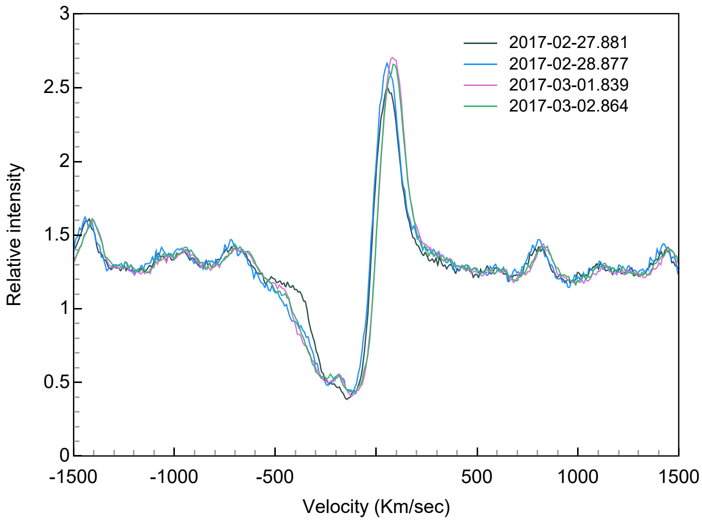


Day to day variations in the absorptions

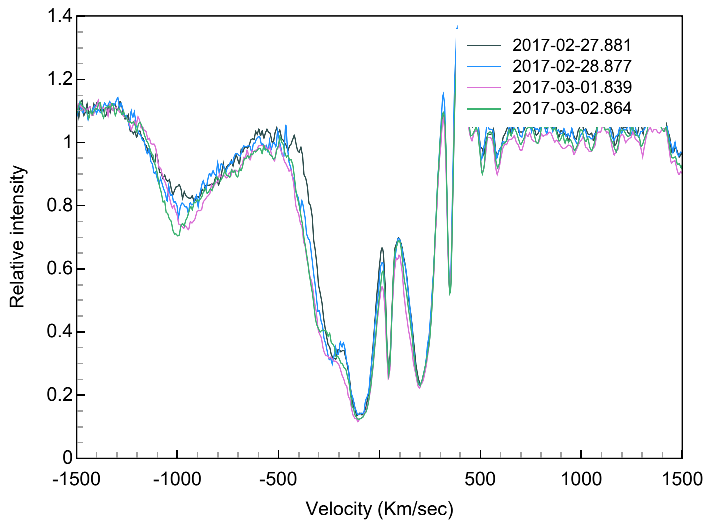
Hbeta - Z CMA J. Guarro



Fe II - Z CMA J. Guarro



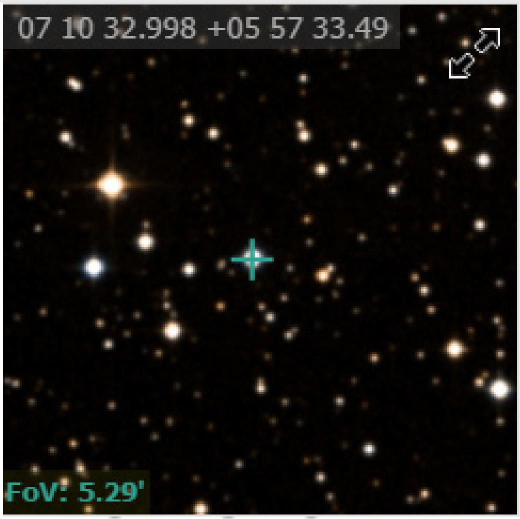
Na I - Z CMA J. Guarro



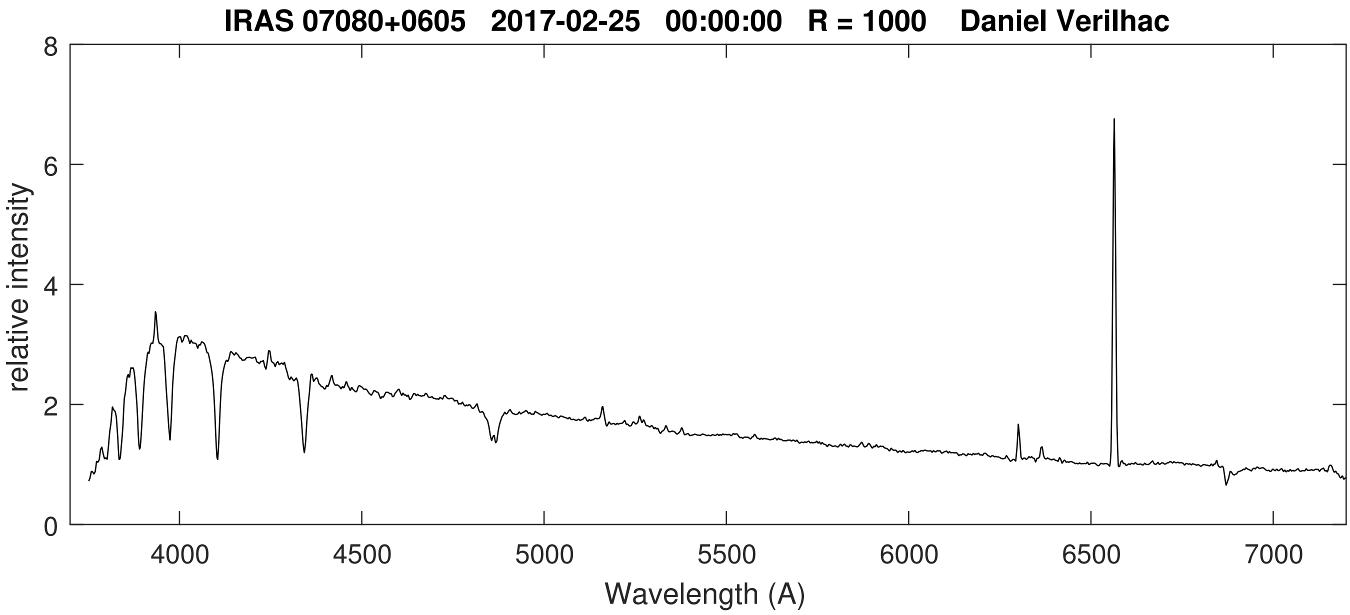
IRAS 07080+0605

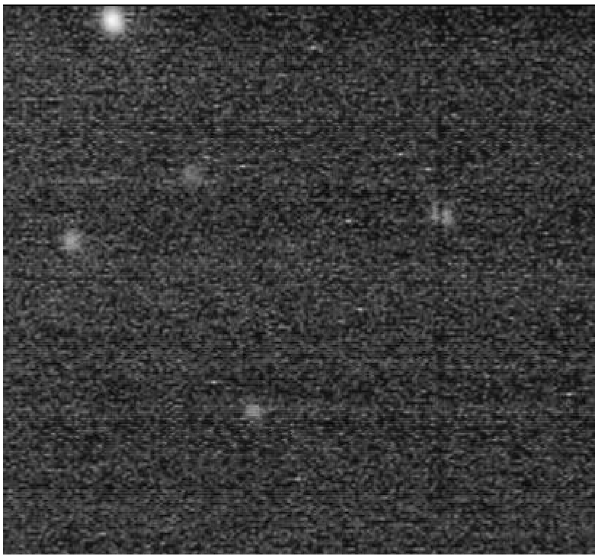
Coordinates (2000.0)	
R.A.	**07 10 43.8**
Dec	**+06 00 07.8**
Mag	~ 12.8 (V)

Spectrum of Daniel Verilhac obtained with the 600 mm scope of MARS observation) (France - 07) and a LISA



Aladin/SDSS





The target in the guiding field

When you look at the spectrum of a symbiotic star, especially one with weak emission, what strikes you immediately is the complexity of the spectrum.

First a comment on an aspect of atomic structure we haven't yet discussed, what happens in multi-electron atoms. You know that electrons distribute in shells depending on heir mutual interactions. These are the definitions used by chemists, for instance, for the ground states, such as the $1s^2$ K shell. In other words, for example, the lowest shell can be occupied by at most two electrons and these have oppositely directed spins. With one, it's H I. For two it's He I. But now think of what happens with Li I. The K shell is filled, and there's a single (valence) electron in the 2s state. Instead of being more tightly bound than He I, Li I has a very low ionization potential, 5.4 eV. The two inner electrons screen the nucleus and change the distribution of the states relative to those of hydrogen although there's only one electron beyond the closed shell. And so it goes. It's possible to excite one of the 1s electrons, however, and this changes the potential of the whole atom because you've changed the screening of the nucleus, although this state 1s2s(nl), where (nl) is the state of the "displaced" electron, not being the ground configuration) will have a short lifetime. But the central potential is still from the nucleus and we can treat that as a one dimensional system. The interactions of the individual electrons are in these shells.

Molecules are essentially different than atoms in one important property: they're not centrally symmetric. That is, you can't assume the states are formed in a potential centered on a single nucleus. The ground state of the hydrogen atom is spherically symmetric, that of the hydrogen *molecule* isn't. There's a xed axis in the *molecular frame* that connects the nuclei (I'll deal for now with diatoms to keep the discussion reasonable!). This implies that any electronic state requires treating the two nuclei together. You're familiar with a situation of this sort at the classical when dealing with tides. Although the Moon orbits the Earth, its orbit is wide enough relative to the Earth-Moon to Sun distance that there's a differential acceleration across the orbit (depending on the orbital phase) from the Sun and the orbit precesses (this even if the Earth and Moon were pointlike). The orbit is perturbed relative to the central potential field of the Earth. OK, this smells like an appeal to the Bohr atom, but I only mean it as a way of illustrating what a perturbation means. For a molecule, the orbitals for he electrons requires not a perturbation relative to the two centers but a complete solution to the energy taking both into account. Therefore the individual electron states you know from the atom are merged and here are many more possibilities. Each electron configuration changes the potential energy of the system.

Now that also affects the structure of the molecule because the nuclei are bound because of the electrons. Left to themselves, bare nuclei repel (of course) but the screening and the combination of the electrons in the shells can lower that energy below zero, the states can be bound. The nuclei are separated in space and the diatom is a mechanical system with a finite size of two separate masses (the nuclei). Now it will be useful to create a sort of translation rule for how to think about the system so I'll put that in parentheses. Unlike an atom, this can execute harmonic motions (oscillations) around the center of mass and also rotate (undergo angle dependent oscillations). These are new degrees of freedom for the system and they are separate and quantized precisely like the orbitals of the electrons. The vibrations are motions of the nuclei along the internuclear axis, like a spring (really!) but with a frequency that depends on their separations and how the electrons screen the nucleus. Each electron configuration (the combined states of the electrons) changes that spring constant (changes the potential). The energy separations of the vibrational levels is generally lower than is much lower than that of the electrons because of the inertia of the nuclei. Assuming that the electrons don't fluctuate in energy when the nuclei execute a vibration (that the motions are separable), the energies are described by a single quantum number, ν and the separation is regular between two states ν and ν', $\Delta E_{\nu,\nu'}$ = constant($\nu'-\nu$) where the constant depends on the electron state. This looks like the Hooke law for a spring and that analogy actually works rather well. If the amplitude of the oscillation becomes large enough, however, the motion becomes an harmonic and the separation changes from linear in ν to a quadratic, or even cubic separation. But for a given electron configuration, there is a near overlap between, say, (0-1) and (1-2) and a larger separation for (0-2) or (0-3), etc. More energy is needed to excite the (1-2) than (2-1) transition because of the higher energy of the lower level but but otherwise the (1-2) and (1-2) have the same relative relation as (0-1) and (0-2).

If that is clear, then there's one more motion, rotation. Again, this isn't a continuous motion of a dumbell, as you'd expect for a macroscopic system. It's quantized and the rotational angular momentum J produces a state with energy $E_J \sim J(J + 1)/2I$, where I is the moment of inertia taken for the nuclei relative to the center of mass. The separation between two states is $\Delta E_{JJ'} \sim [J'(J' + 1) - J(J + 1)]/2I$ and is much smaller than the separation $\Delta E_{\nu,\nu'}$. Because the equilibrium state of the nuclei depends on the electron distribution, each electronic state has an associated I and this changes if the electron states change. Any configuration of the nuclei has associated rotational motion so you have all of these happening together: electron transitions changing the spring constant and the moment of inertia, rotational motion, and vibration.

I'm sorry if this seems terribly technical, it really isn't and a few analogies are physically appropriate. If you excite an electron transition, going (for H_2 for instance) from a $1s^2$ to a 1s2s or 1s2p (you would have that for the first excited state of He I), you would expect to have only a small number of possible lines. You know this from He I. But now, there are a vast number of vibrational and rotational transitions allowed that are excited by frequencies little different from that producing the electronic transition. So you have a set of bands. The vibrational bands each bound a set of rotational lines so you'll have a set of bands, each being the range of ΔJ possible for rotation and $\Delta\nu$ for vibration for any electronic transition. Optical photons have energies high enough to produce electronic changes so the labeling of the bands depends on that transition. In symbiotic spectra, the heavy metals are especially important because they have very large dipole moments (that determines the strength of the transition) and form at relatively high temperature, e.g., ZrO, VO, TiO. It's not that Ze, Ti, Mn, or other heavy metals are particularly abundant (they're orders of magnitude less abundant than CNO, for instance), but their oxides and hydrides are stable to very high temperatures. So you see these even in spectra of stars (not only in the colder environs of interstellar clouds or planets). Abundant species also form molecules in stellar atmospheres, the most important being C_2 (seen mainly in comets but also in carbon stars), CN, and CH. The designation gives the (ν,ν') vibrational transition for the electronic transition. The later is similar in form to what you know from atomic spectra, but instead of forming the orbital angular momentum for the electrons by simple combination, they are formed relative to the line joining the nuclei. So the ground state of H_2 is a 1Σ state where for He I it would be a $^1S_0$ The rest of the details are not important for understanding the spectra you'll observe. It suffices, I hope, that the transitions are all grouped depending on the combined electronic and "mechanical" transitions. So, to recap, each electronic transition has a set of vibrational bands that have rotational bands. Each level is excited precisely as you have in an atom, and the collisional excitation and de-excitation of each proceeds in the same way (just that you have a broader energy range for the colliding electrons). The rotational bands are designated (P,Q,R,S,etc) depending on the ΔJ in the transition. Those for the vibrational bands are, instead, labeled by (ν,ν') and the electronic transitions are labeled by the configuration. Note that like atoms, the states can have the same combination of quantum numbers (i.e. in He I there are many ^3P states from combinations of an s and p electron but these are designated by the n of the upper state, such as 2^3P; in a molecule, instead of using the principal (radial) quantum number you use a conventional designation in which X is the ground state, i.e. $X^1\Sigma$ for H_2). I'm sure this will be the most confusing part of this whole discussion because it makes looking up individual molecular transitions hellishly difficult. You have one great advantage here. No electronic transition produces a single line and there are no vibrational transitions without accompanying rotational bends. So you can use the same patterns as in the atomic case, you look for multiplets for atoms and bands for molecules. You're all very familiar with several molecular species that make life hard when observing in the red part of any stellar spectrum, the bands of water and molecular oxygen (see figure 1). But this also illustrates the complication arising from a polyatomic molecule, since now there are many more degrees of freedom and the spectra are correspondingly denser (look at the bands and see if you can distinguish the H_2O from O_2). Notice also that O_2 is a

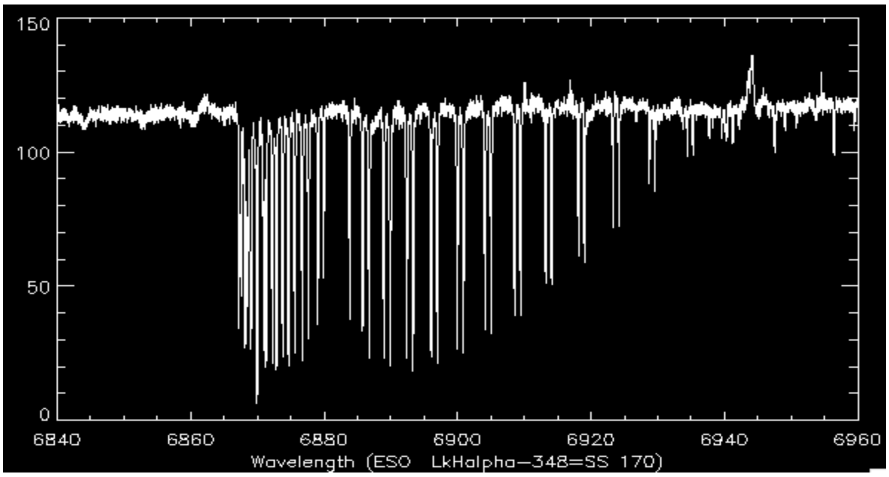
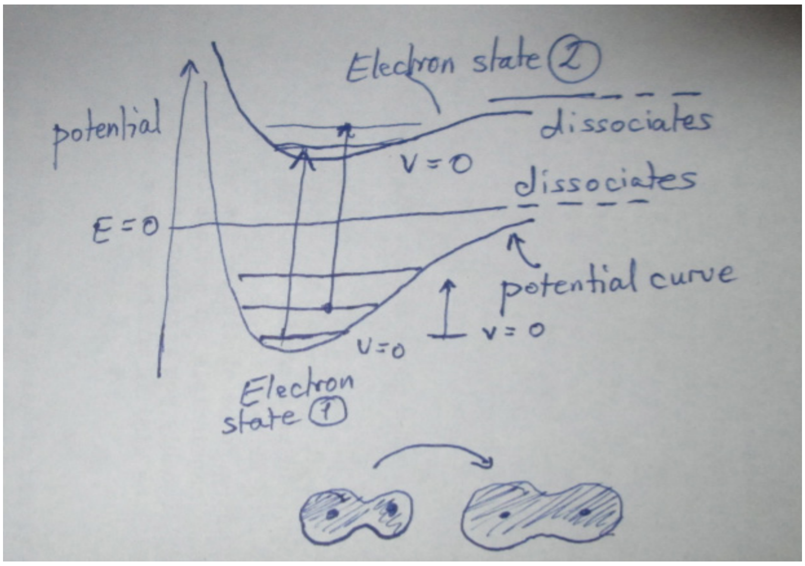
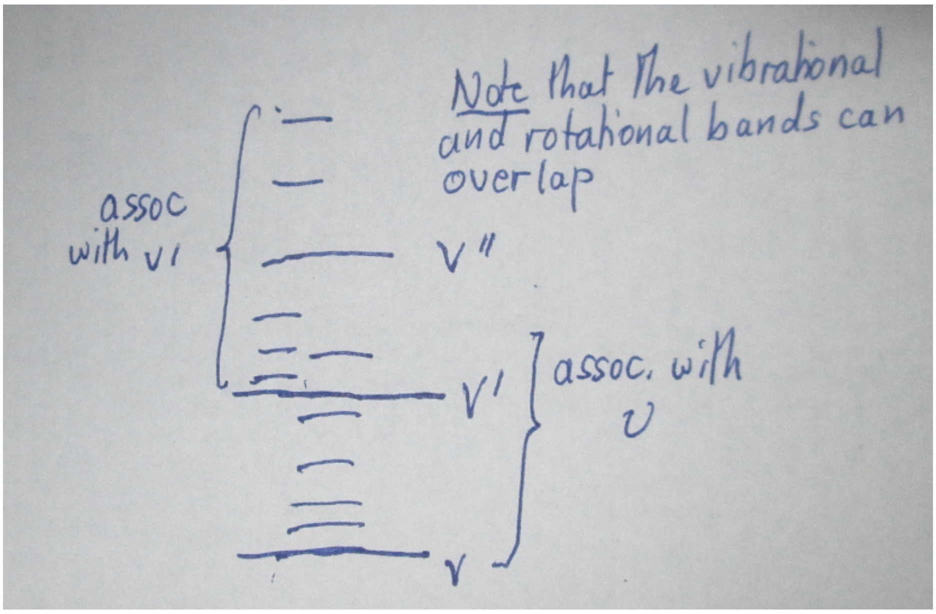


figure 1 - "see if you can distinguish the H_2O from O_2

homonuclear molecule so it has no dipole moment, yet in its excited electronic state it does form vibrational and rotational bends like any other nonsymmetric diatom. The symbiotics are the worst of both worlds in how the bands of the different molecules superimpose. They're also not formed at the same depths in the giant's atmosphere so their relative absorption strength requires treating them together. Fortunately, you won't have to consider this most of the time regardless of your resolution. Where it becomes a potential headache is if any of the lines go into emission (such as AlO in some phases of Mira variables, or H_2 in shocks), but for your considerations they form the opaque photosphere against which the emission lines are seen. The ionized region of the wind, and the region around the companion, are physically distinct from the photosphere but all are combined in a single spectrum. It is essential to check that a blip or feature in an emission line is not caused by the underlying photosphere of the red giant (not to mention a terrestrial line). While you can remove the atmosphere, you can't get rid of the photosphere as easily and even comparisons with standard stars doesn't make this certain. What is needed is to be sure you can identify the contributions so, stepping away from any emission feature, the comparison of the "uncontaminated" photosphere will allow this. Note that there is another problem with symbiotic stars: they orbit. The photospheric spectrum is moving relative to the emission line-forming region relative to your line of sight. To be sure this is properly checked, you again have to use that part of the spectrum that is away from any emission lines, as done for orbital determinations in these very long period, low amplitude systems (see our discussion a few months ago on correlation methods for radial velocity measurements, you look at the shifts in sets of absorption lines). A final problem arises for symbiotics with Mira variable companions. The spectrum of the red giant photosphere changes with pulsational phase since the radius and surface gravity are varying. The excitation varies and the relative fraction in molecules relative to atoms can also change. You won't have to deal with this often but keep it in mind. In one system I worked on, V407 Cyg, there were changes in the photospheric spectrum of two subtypes (M4 to M6) with phase between archival spectra from the mid-1990s and those we had for the nova outburst in 2010.





Thank you all for getting this far! If the discussion this month has been confusing, I apologize, but I don't think it's possible to appreciate the enormous wealth f symbiotic spectra without considering what molecules mean for your observations. There are several books on the subject that make it almost comprehensible, my particular favorite has the almost funny title (for anyone who can remember the '60s), Herzberg, G. 1971, *Spectra and Structure of Simple Free Radicals* (Cornell Univ. Press) that's recently been reprinted (2012) by Dover so is available in a cheap edition. Please buy this, it's one of those important books any spectroscopist should have at hand. There are some ne discussions of the appearances of various bands and their role in classication in Corbally and Gray 2009, *Stellar Spectral Classification* (Princeton), where you'll find a very good guide to the main bands needed for identification and pointers to the literature (almost al of which is accessible through the ADS). In the hope of seeing you next month, that I haven't frightened (or disgusted) you this time, my promise to deal in the next columns with specific objects and their peculiarities.

Steve Shore
6-03-2017

Some new targets: the B[e] stars, an introduction

Steve Shore

*S*ome of you also observe Be stars, so you're used to stars with disks, strong Balmer and He I emission lines, and evidence of mass outflows. In some cases, for instance γ Cas, interferometry has resolved the outer disks. These systems, some of which are binaries, are well known for their intrinsic variability and relatively narrow range of luminosity and T_{eff} . The problem is that there's another group of early type stars, in part overlapping these, that show more extreme optical spectra. These are notable for their strong infrared continuum emission (longward of 2 μm) that appears best described by a warm dust continuum, Fe group emission (and P Cyg) lines with relatively low velocity widths and absorption shifted to less than about 100 $km.s^{-1}$, absorption line prole variability on timescales of hours to years, and forbidden lines of neutral species, e.g. [O I] 6300,6363 A along *with virtually no trace of a photospheric spectrum*. Called the B[e] stars, or rather phenomenon (since other types of stars show this extreme behavior) the group that seems to be nearest the Be stars and the main sequence have FS CMa as their prototype. For once, this is a good choice since the star shows many of the effects that seem to define the class

http://adsabs.harvard.edu/abs/2015EAS....71..181M
http://adsabs.harvard.edu/abs/2016A%26A...586A.116J
http://adsabs.harvard.edu/abs/2017ApJ...835...53K

It's important to note that even if these systems are surrounded by disks, the properties of the circumstellar matter are closer to those you know from early classical nova spectra than normal Be stars. The Fe-curtain stage of novae, the optically thick stage of the expansion, has a characteristic optical spectrum: neutral and singly ionized Fe group transitions, most f which are powered by absorption in the UV being illuminated by the central white dwarf. It's not a surprise that the ensemble of lines includes forbidden transitions since these are optically thin, including the [O I] 6300, 6364 Å doublet. What's unexpected is the presence of the same lines in non-eruptive early type star of such low luminosity (the Luminous Blue Variables, notably Car, AG Car, η Car, and HD 268858 in the LMC) are truly massive (likely > 40 $M_{\odot}$) and have strong winds that can become unstable and also channel to form disks. The FS CMa subgroup shows many of the same effects but in a range not expected for strong outflows. While they may be so rapidly rotating that they shed mass that is viscously expelled outward (something that the Be community has adopted as one scenario for the disks) there's little evidence of banisters and even less about the surface properties.

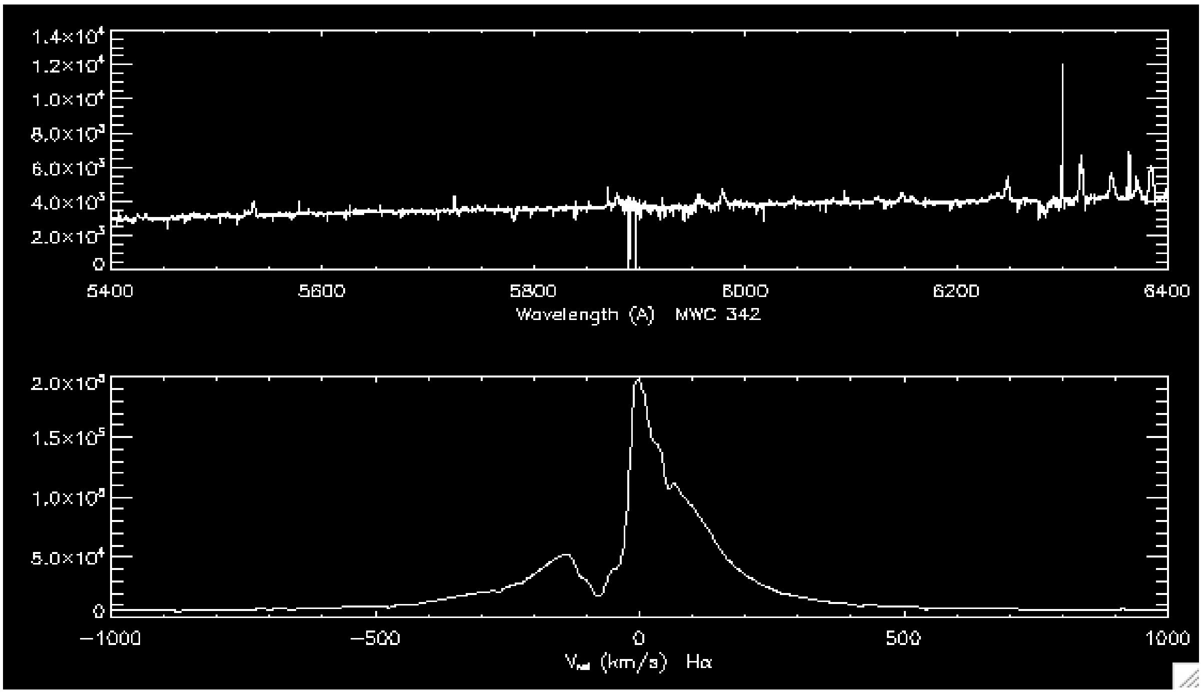
One other thing that's seriously lacking is monitoring (and calibrated spectra). Since these systems are more active, in general, than the Be stars and also more sporadic (they can show a timescale but rarely anything like a period) they seem ideal candidates for you. They're often faint (not the classical systems), IRAS 07080+0605 and IRAS 00740+6429 (among the strongest IR sources) are V > 10 but, with Alpy or LISA and calibration, there is an enormous contribution waiting to be made. Many of these stars have only photometry, if at all, and no spectrophotometry. Some have time series but these campaigns are very disconnected, a week here, a few days there, with no concentrated systematics. The problem is similar to the symbiotics, everyone knows they vary but few have the time or facilities to follow them densely with the result that the collections of spectra are heavily gaped.

For those who are willing to invest time observing the brighter stars, FS CMa, HD 50138 and MWC 728.

The one thing that makes me think there's gold to be had here is that a number of these stars, V669 Cep, FX Vel, AS174, IRAS 00470+6429, IRAS 07080+0605, IRAS 17449+2320, IRAS 07377+2523 , and AS38 show the Li I 6707 Å line. In one, IRAS IRAS 07080+0605, that line is variable! It may be ion the others but we just don't know. I only know one case of such behavior, V407 Cyg, where the change in this resonance line was because of the continuum contamination produced by the expanding ejecta (remember, it was a symbiotic-like recurrent). The Li line is a signature of one of two things: nuclear processing (by CNO hydrogen burning) in an advanced stage star (the asymptotic giant branch) at the bottom of the deep stellar envelope (as in the Carbon stars). The other is youth: T Tau and related stars (and the Herbig Ae/Be stars) show this because the lithium has not yet been destroyed by mixing (this is a tracer of young stars because lithium has a very low processing temperature and is destroyed during nuclear burning and mixing during star formation). If you see this line in the environment of a star that has a lot of dust but otherwise is not associated with any star formation, and the resonance line varies, that's weird. The best would be high resolution (LHIRES or higher) in the region around 6800 - 7000 Å (to avoid the Ha line and overexposures). Low resolution won't see the line but if calibrated would be invaluable. But any of these targets would be very helpful.

In general, the reason these stars are interesting for you who are more used, now, to symbiotics is that they show many of the same sorts of variability. The absorption features on the Balmer lines are like Be stars but, well, so are the V/R profiles on Hα in symbotics. They may show short timescale variability that indicates there are compact regions (relatively speaking), but not the sorts of very short time flickering seen in the symbiotics (there aren't white dwarf companions here). But if you want to extend your interests, at least to se what sorts of spectra resemble novae and symbiotics and are definitely not degenerate stars, these systems are a good way to get a feeling for what a symbiotic spectrum means.

I promise to discuss this class more, it's one of those little mysteries that may become important as new techniques come to bear (spectropolarimetry, for instance). Most important, these are disks without obvious mass transfer sources, no strong winds, and possible rapid rotation.



MWC 432 = V1972 Cyg - (V = 10,6 mag)

Recent publications

Novae

T Pyxidis: Death by a Thousand Novae
Joseph Patterson
http://adsabs.harvard.edu/abs/2017MNRAS.466..581P

Gamma-ray novae: rare or nearby?
Morris, Paul J.; Cotter, Garret; Brown, Anthony M.; Chadwick, Paula M.
Monthly Notices of the Royal Astronomical Society, vol. 465, issue 1, pp. 1218-1226
http://adsabs.harvard.edu/abs/2017MNRAS.465.1218M

Classical novae vs cataclysmic variables
Tappert, C.; Fuentes-Morales, I.; Puebla, E.; Ederoclite, A.; Schmidtobreick, L.; Vogt, N.
http://adsabs.harvard.edu/abs/2017arXiv170202415T

Optical and Near-infrared Study of Nova V2676 Oph 2012
Raj, A.; Das, R. K.; Walter, F. M.
The Astrophysical Journal, Volume 835, Issue 2, article id. 274, 7 pp. (2017)
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Rise and fall of the dust shell of the classical nova V339 Delphini
A. Evans & al.
https://arxiv.org/abs/1612.06241

A Comprehensive Observational Analysis of V1324 Sco, the Most Gamma-Ray Luminous Classical Nova to Date
Finzell, Thomas & al.
http://adsabs.harvard.edu/abs/2017arXiv170103094F

Symbiotics

Flows and Shocks: Some Recent Developments in Symbiotic Star and Nova Research
Sokoloski, J. L.; Lawrence, Stephen; Crotts, Arlin P. S.; Mukai, Koji
http://adsabs.harvard.edu/abs/2017arXiv170205898S

The Massive CO White Dwarf in the Symbiotic Recurrent Nova RS Ophiuchi
Mikolajewska, Joanna; Shara, Michael M.
http://adsabs.harvard.edu/abs/2017arXiv170208732M

New burst of the active symbiotic star BF Cyg at the beginning of 2017.

ATel #10086; A. Skopal, M. Sekeras, S. Shugarov, N. Shagatova (Astronomical Institute, Tatranska Lomnica)
on 17 Feb 2017; 08:33 UT

BF Cyg is an eclipsing symbiotic binary with the orbital period of 757 d. Historical light curve of BF Cyg shows a slow symbiotic-nova-like outburst (1895-1960) with superposed eruptions of the Z And type and bursts on the time scale of, or less than, one year (e.g. Leibowitz and Formiggini 2006, MNRAS, 366, 675). On August 2006, BF Cyg entered a large active phase (Munari et al. 2006, CBET No. 596) keeping a high level of its brightness to the present. Between Nov. 22, 2014 and Jan. 29, 2015, Munari et al. 2015 (ATel #7013) reported a large amplitude flare from BF Cyg. During the burst, the blueward deep and broad absorptions extended to ~ -550 km/s accompanied with redward emission bump extended to ~ +550 km/s developed in the H-alpha and H-beta line profiles (see ATel #7258).

Here we report on a new burst of the active symbiotic star BF Cyg. According to our recent (U)BVRcIc CCD photometry, the burst started between Nov. 23.688, 2016, when we measured BF Cyg at B=11.089, V=10.501, Rc=9.574, Ic=8.560 and Dec. 16.697, 2016, when its brightness increased to B=10.898, V=10.373, Rc=9.475, Ic=8.502. Our latest photometric observations made on Feb. 13.173, 2017 (U=9.702, B=10.052, V=9.608, Rc=9.121, Ic=8.493) and on Feb. 15.158, 2017 (B=10.042, V=9.595, Rc=9.065, Ic=8.459) suggests that BF Cyg is around its peak brightness of the current burst. Our UBVRcIc photometry was obtained with a 60 cm telescope using the FLI ML3041 CCD camera (Pavilion G2) and additional BVRcIc measurements were made with an 18 cm Maksutov telescope using the SBIG CCD camera mounted at a montage of another 60 cm telescope for spectroscopic observations (Pavilion G1).

Just prior to, and during the current burst, on Nov. 23.673, Dec. 16.688, Dec. 22.652, 2016, and Feb. 11.168, 14.143, 2017, we obtained Echelle medium-resolution spectra of BF Cyg (420 - 715 nm, R~11000) with our 0.6 m telescope in the G1 pavilion, simultaneously with the BVRcIc photometry. At the maximum, the UBV continuum increased by a factor of ~2.5 with respect to the pre-burst level. Prior to the burst, during the burst rise and around its maximum, the line spectrum was dominated by hydrogen lines with a sharp absorption at ~ -70 km/s and weak emissions of HeI, FeII, and [OI] 6300 lines. Before the burst maximum, to Dec. 22, 2016, the hydrogen Balmer lines were accompanied with satellite emissions at around -400 and +200 km/s. At the optical maximum, a complex absorption extended to around -400 km/s developed. This dramatic change is best recognizable in the H-beta profile (see http://www.ta3.sk/~astrskop/atel_feb2017/bf16022017.png). In addition, HeI lines nearly disappeared, whereas TiII lines and FeII, 42 (4924 A) developed a strong P-Cyg absorption component. All times here are in UT. This work was supported by the Slovak Research and Development Agency under the contract No. APVV-15-0458.

About ARAS initiative

Astronomical Ring for Access to Spectroscopy (ARAS) is an informal group of volunteers who aim to promote cooperation between professional and amateur astronomers in the field of spectroscopy.

To this end, ARAS has prepared the following roadmap:

- Identify centers of interest for spectroscopic observation which could lead to useful, effective and motivating cooperation between professional and amateur astronomers.
- Help develop the tools required to transform this cooperation into action (i.e. by publishing spectrograph building plans, organizing group purchasing to reduce costs, developing and validating observation protocols, managing a data base, identifying available resources in professional observatories (hardware, observation time), etc.
- Develop an awareness and education policy for amateur astronomers through training sessions, the organization of pro/am seminars, by publishing documents (web pages), managing a forum, etc.
- Encourage observers to use the spectrographs available in mission observatories and promote collaboration between experts, particularly variable star experts.
- Create a global observation network.

By decoding what light says to us, spectroscopy is the most productive field in astronomy. It is now entering the amateur world, enabling amateurs to open the doors of astrophysics. Why not join us and be one of the pioneers!

Submit your spectra to ARAS Eruptive Stars Data Base

Please :
- respect the procedure
- check your spectra BEFORE sending them

Resolution should be at least R = 500
For new transcients, supernovae and poorly observed objects,
SA spectra at R = 100 are welcome

1/ reduce your data into BeSS file format
2/ name your file with:
_ObjectName_yyyymmdd_hhh_Observer

Exemple: _chcyg_20130802_886_toto.fit

3/ send you spectra to
Novae, Symbiotics, Cataclysmics : François Teyssier

to be included in the ARAS database

Be Monthly report

Previous issues :
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