Symbiotic binaries

ARAS Monitoring and PRO-AM collaborations

François Teyssier
ARAS group

Telc
2019, September
Binaries in Universe, Universe of Binaries

- **Introduction to symbiotic stars**
- **ARAS monitoring and collaborations**
- **A look at the activity of a few symbiotic stars**
  - EG And: orbital variations
  - AX Per: orbital behaviour and 2019 outburt
  - Z And: 2018 outburst
  - AG Dra: monitoring of outbursts
  - CH Cyg:
  - T CrB: monitoring of a recurrent nova before expected outburst
  - V3890 Sgr: recurrent nova

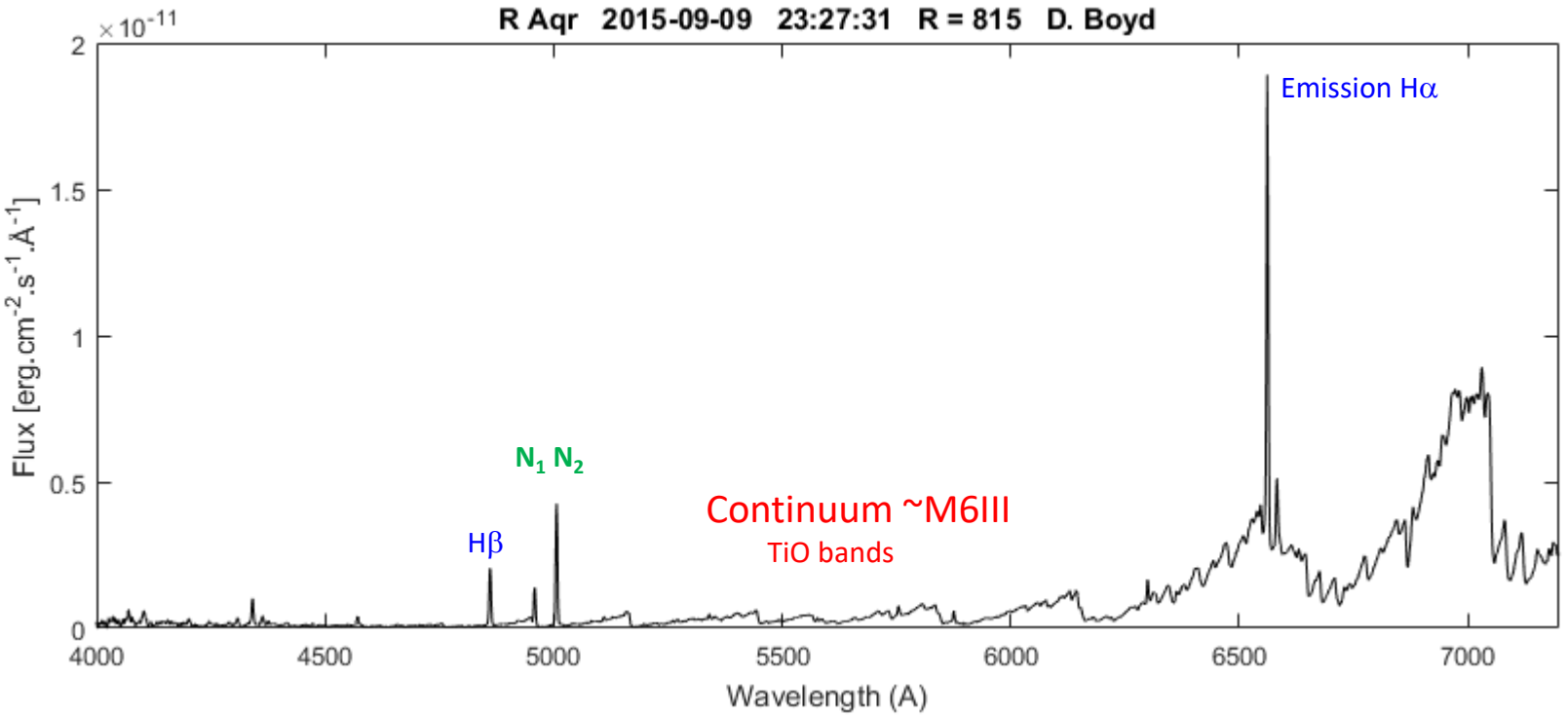
R Aqr, the « platypatus » :
« A peculiar spectrum »

Merrill, 1919

A Variable Star with a Peculiar Spectrum

The long-period variable star R *Aquarii 233815* has been found recently to possess a very peculiar spectrum. The data concerning

On the first three plates the chief nebular lines N1 and N2, and λ4363 are very conspicuous. On the later plates they are relatively

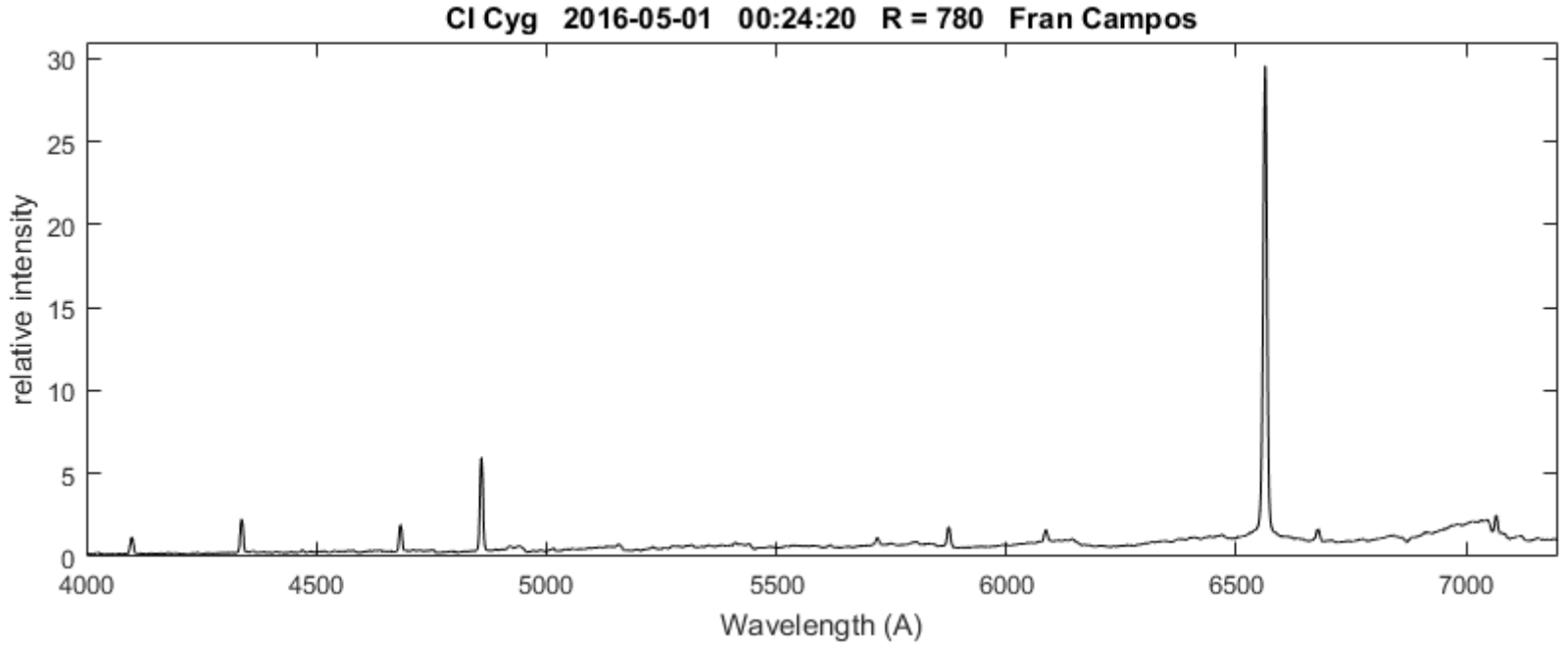


Merrill, 1932

A Bright Line of Ionized Helium, λ4686, in Three Stellar Spectra with Titanium Bands

1. Anon	$1^h\,31^m.8$	$+53°\,52'$	**AX Per**
2. RW *Hydrae*	13 30.2	−25 1	**RW Hya**
3. Anon	19 47.3	+35 29	**CI Cyg**

In the spectra of these stars bright hydrogen lines and a narrow bright line of wave-length 4686A are superposed on a continuous background showing dark titanium bands whose intensities are about equal to those regularly found in class M4. The



jects for traces of titanium bands.

Z And
Prototype in the GCVS

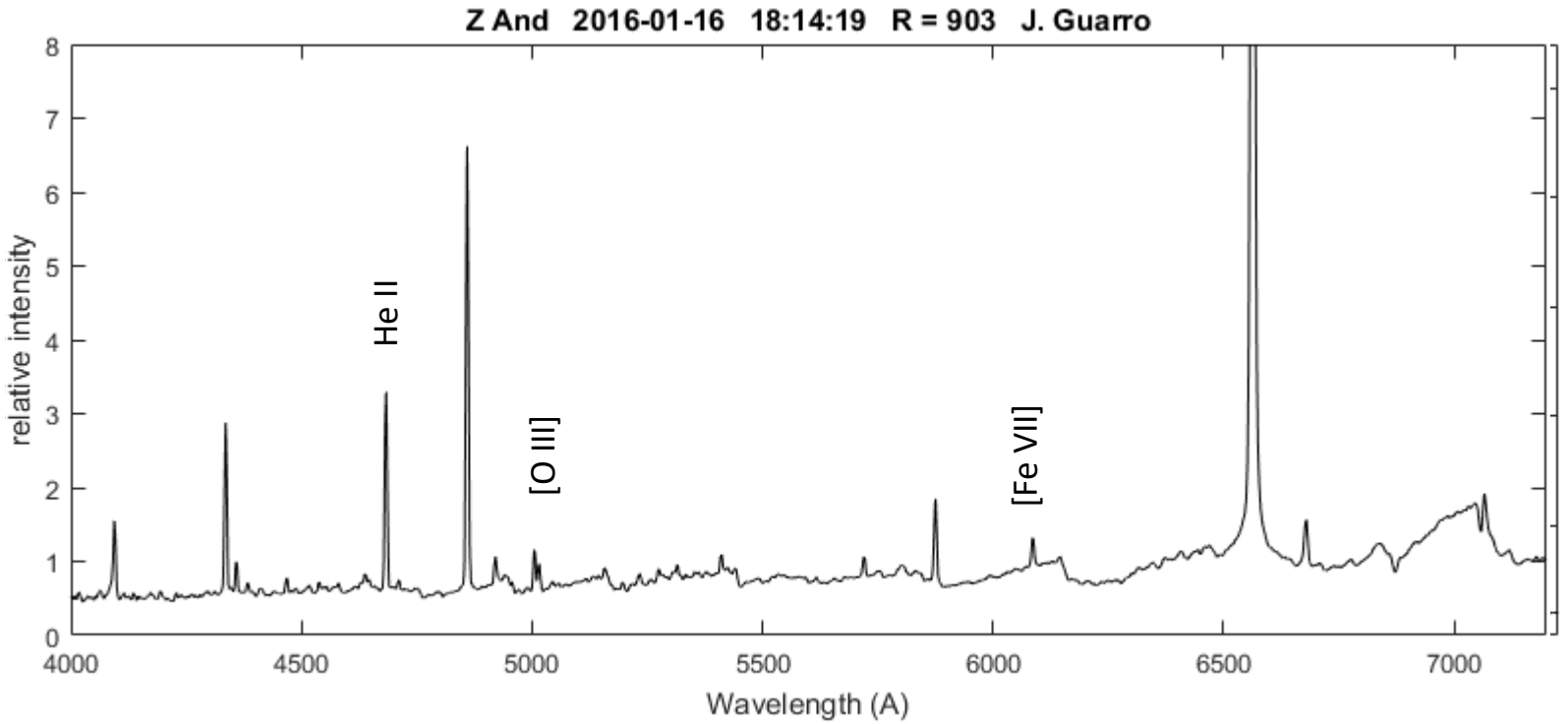
Symbiotic concept

Low-temperature absorption spectrum
High-excitation emission lines

Merrill, 1958

51 — SYMBIOSIS IN ASTRONOMY: INTRODUCTORY REPORT

spectrograms. Thus Z Andromedae has become the prototype for those anomalous «symbiotic» stars in which high-excitation emission lines are superposed on a low-temperature absorption spectrum, usually of type M.



A spectroscopic definition (Belczinski & al., 2000)

1. The presence of the absorption features of a **late-type giant**; in practice, these include (amongst others) TiO,H2O, CO, CN and VO bands, as well as Ca I, Ca II, Fe I and Na I absorption lines.
2. The presence of **strong emission lines of HI and He II**
and either
– **emission lines of ions with an ionization potential of at least 35 eV** (e.g. [OIII]), or
– an A- or F-type continuum with additional shell absorption lines from HI, He II, and singly-ionized metals.
The latter corresponds to the appearance of a symbiotic star in outburst.
3. The presence of the 6825 emission feature, even if no features of the cool star (e.g. TiO bands) are found.

"every known symbiotic star has, at one
time or another, violated all the classification criteria invented"
(Kenyon, 1986)

"a binary in which a red giant
transfers enough material to a WD
for the interaction to produce
an observable signal at some waveband."
(Sokolovski, 2017)

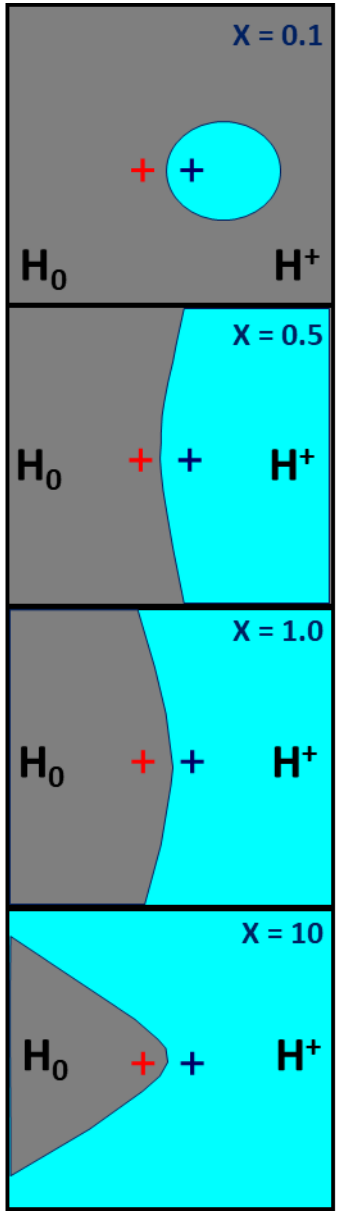
Catalogs

Authors	Date	Nb Syst	Suspected
Allen	1984	129	15
Kenyon	1986	135	20
Belczinski & al.	2000	188	28

On line catalog:
Jaroslav Merc, Rudolf Gális, and Marek Wolf (2019)
http://astronomy.science.upjs.sk/symbiotics/galactic-symbiotic-stars/

Wide interacting binaries (orbital periods 1 to 3 years)

- Red giant (RG) as the donor star
- Accreting white dwarf (WD) : $T_h = 10^5$ K L_h 10^1-10^4 $L_\odot$
- Nebula partially ionized by the hot component



Radio survey of symbiotic stars
Seaquist, Taylor, Button 1984

$$X = \frac{4\pi a L}{\alpha}\left(\frac{m_H v}{M'}\right)^2$$

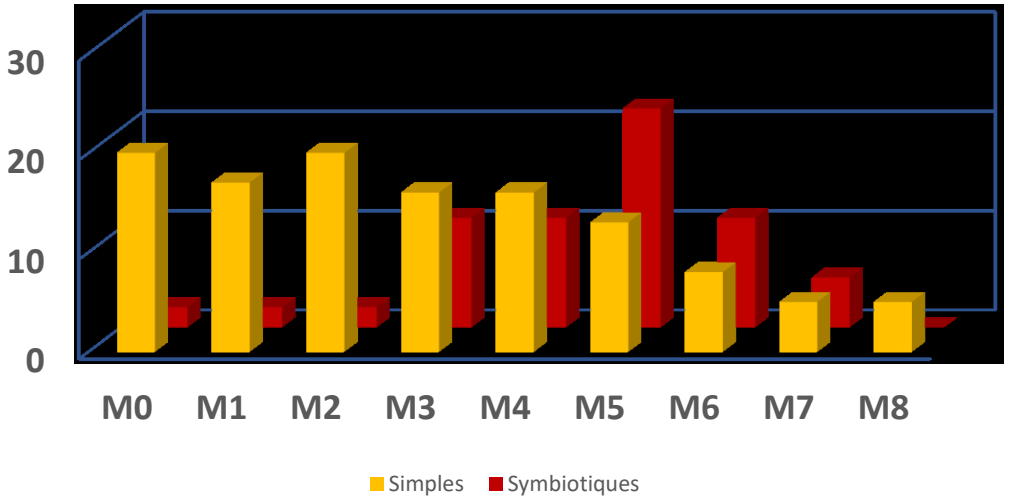
a = séparation
L = luminosity of the ionizing photons
v = speed of the stellar wind
M' = RG loss rate

Spectral type of the Red Giant Distribution

Later type than single RG

→ High mass loss

→ = condition of symbiotic pheomenon



[Mürset & Schmid, 1999]

RG Mass loss rate from Single RG

Reimers (1975)

$$M' = 4.10^{-13}\eta r\,((L_* R_*)/(M_*))$$

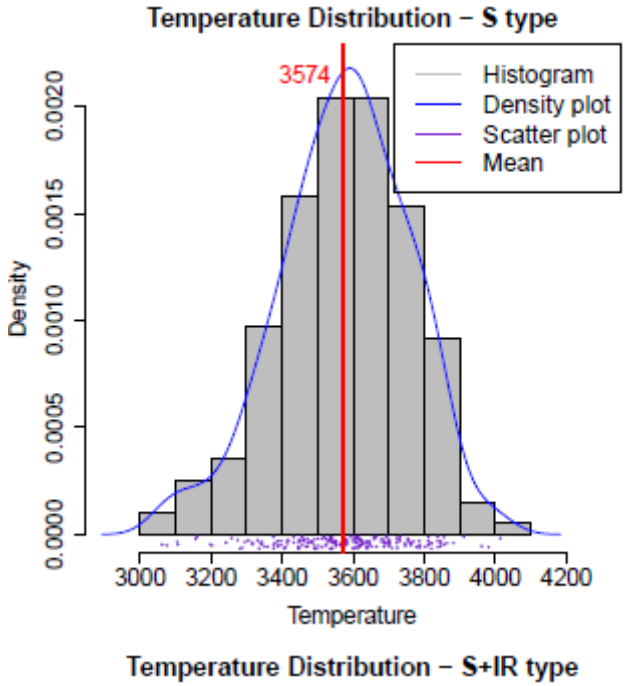
ηr : 1/3 à 3

L_* R_* M_* in $M_\odot$

M' en $M_\odot$ / year

L_* R_* / M_* ~ 100 000

M' ~ 10^{-8} $M_\odot$ / an



[Akras, 2019]

Symbiotics : $\dot{M}$ ~ 10^{-7} $M_\odot$ / an

Radio emission

[Seaquiest, 2019]

Nebular emission

[Skopal, 2005]

Cool component classification

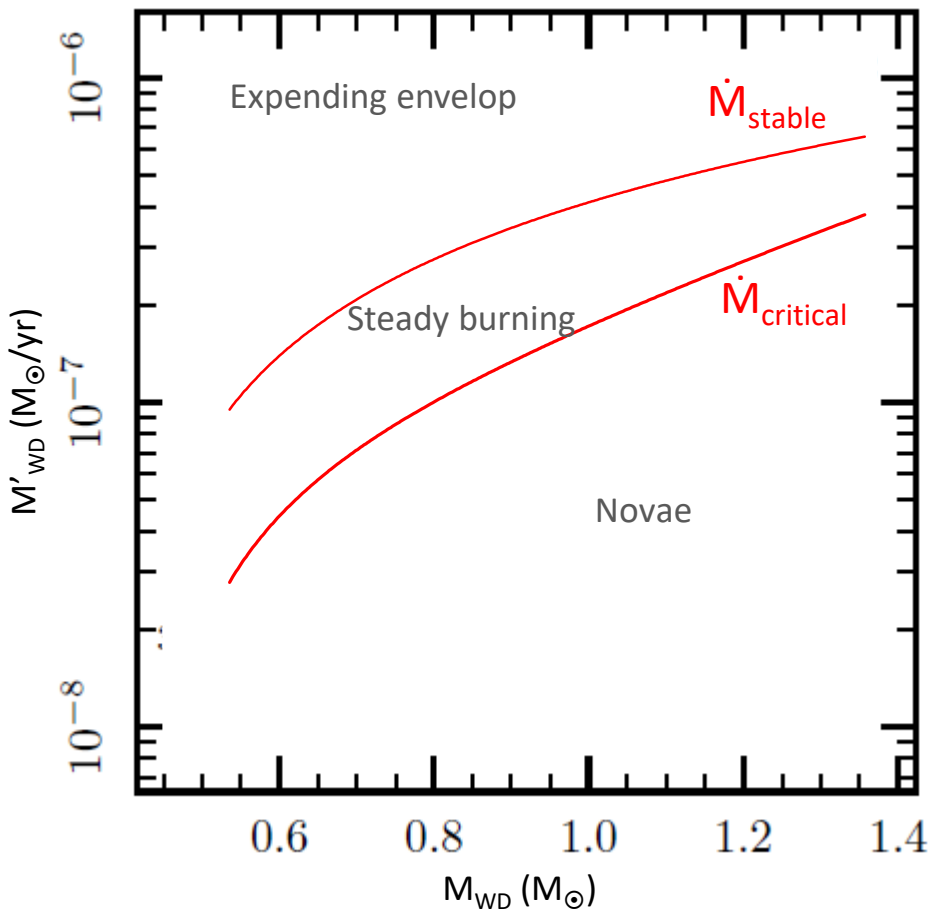
Keyes & al, 2004

Mürset & al., 1999

Kenyon & al., 1987

Hot Component

Accretion on WD: 3 regimes



Adapted from Wolf & al. (2013)

$\dot{M}_{acc} > \dot{M}_{stable}$

$\dot{M}_{stable} < \dot{M}_{acc} < \dot{M}_{crit}$

$\dot{M}_{acc} < \dot{M}_{stable}$

1. Nuclearly powered

1.2. Expending envelop - Mass loss

T ↘
L ~ L_{edd}

Classical SySt in outburst
Z And, CI Cyg

1.1. Steady H burning

T = > 10^5 K
L ~a few 10^3 $L_\odot$

Classical SySt at quiescence
Z And, AG Peg

2. Accretion powered

Degenerate envelop → nova

T = 5-8 10^4 K
L = 10 – 100 $L_\odot$

EG And CQ Dra
RSyN: T CrB RS Oph V3890 Sgr

Accretion

Most of RG in symbiotic systems do not fill their Roche Lobe
Bondi Hoyle accretion: too low accretion rate for steady burning regime

→ Wind Roche Lobe overflow (WRLOF)

→ Wind compression model (WCM): rotation of the RG

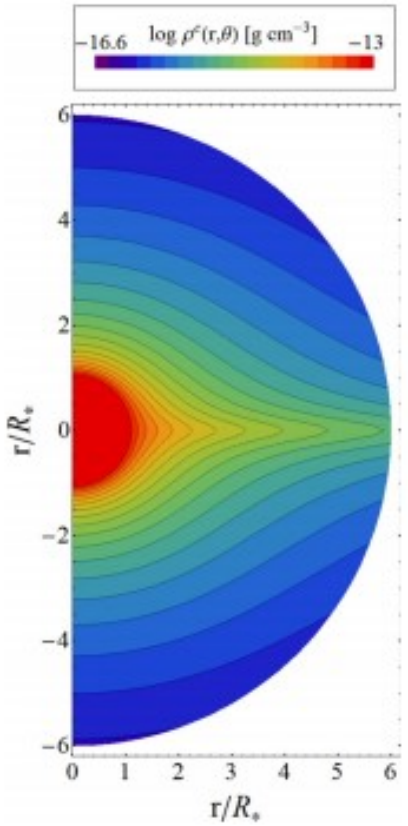
Subject to debates

Accretion disks

No evidence for permanent accretion disks [e.g. Mürset & al., 1991]

Formation of accretion disk during outbursts
e.g. Z And 2006, 2010

Accretion disk in accretion powered symbiotics
Source of X-rays (boundary layer)
e.g. T CrB, RT Cru (Luna & al., 2019)

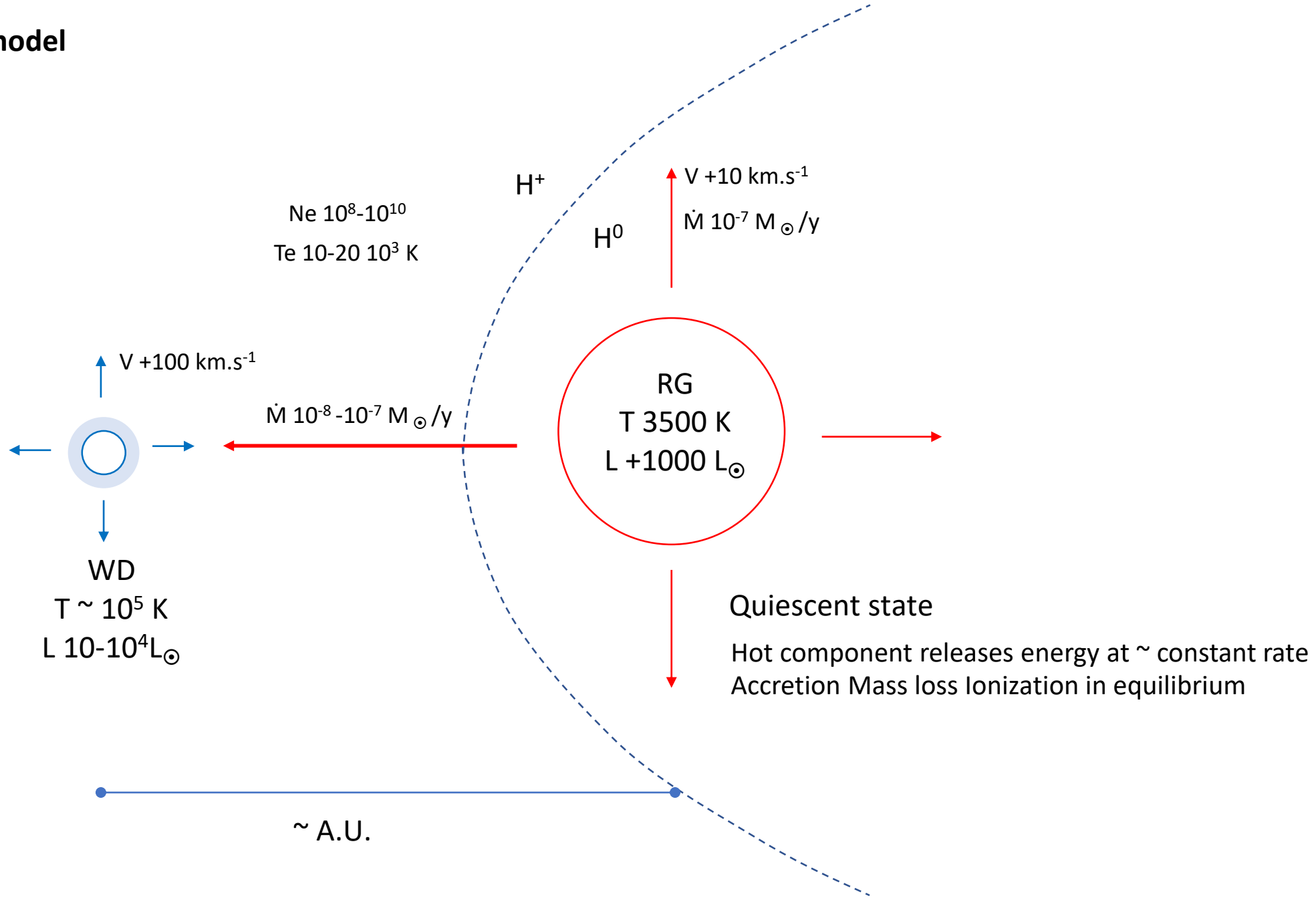


WCM

Skopal & Carikova, 2015

$\dot{M}_{hot}$ x factor 5-10

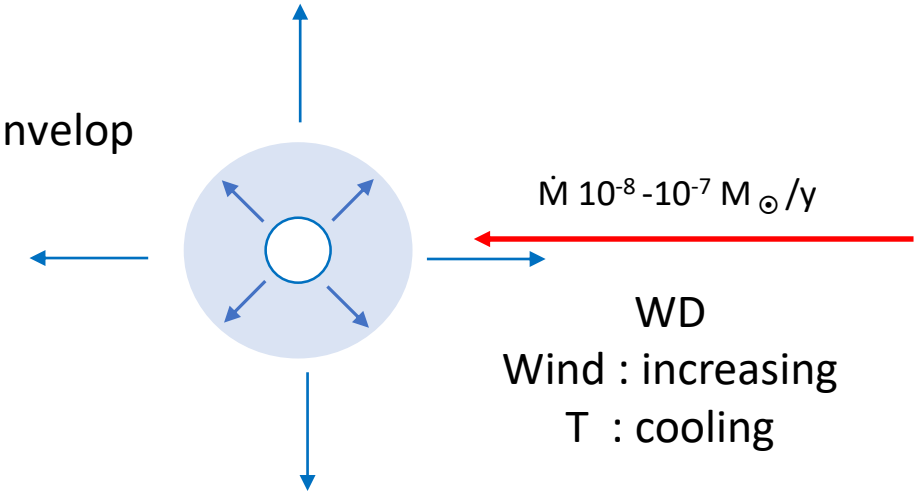
Classical Symbiotic model



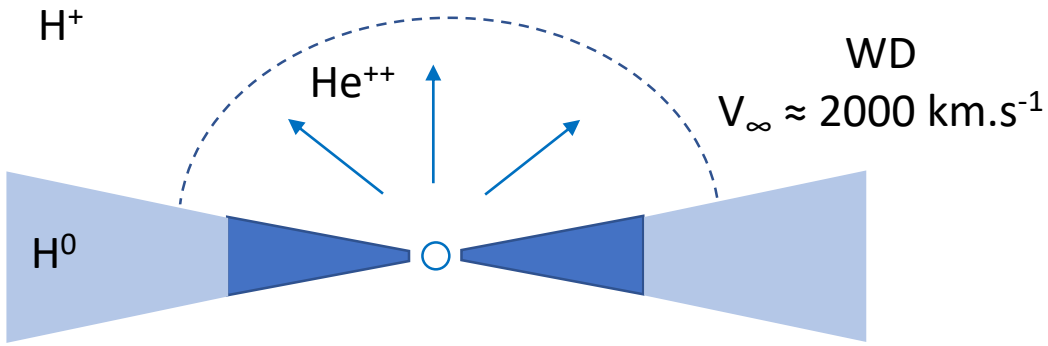
Scenarii for the outbursts

Increasing accretion rate
Enhanced mass outflow from the hot component

1 Expansion of the envelop



2 Formation of a neutral disk-like zone



Orbital inclination:

High

Low

Subject to debates

3 Disk instability

Lightcurves

❶ **Z And**

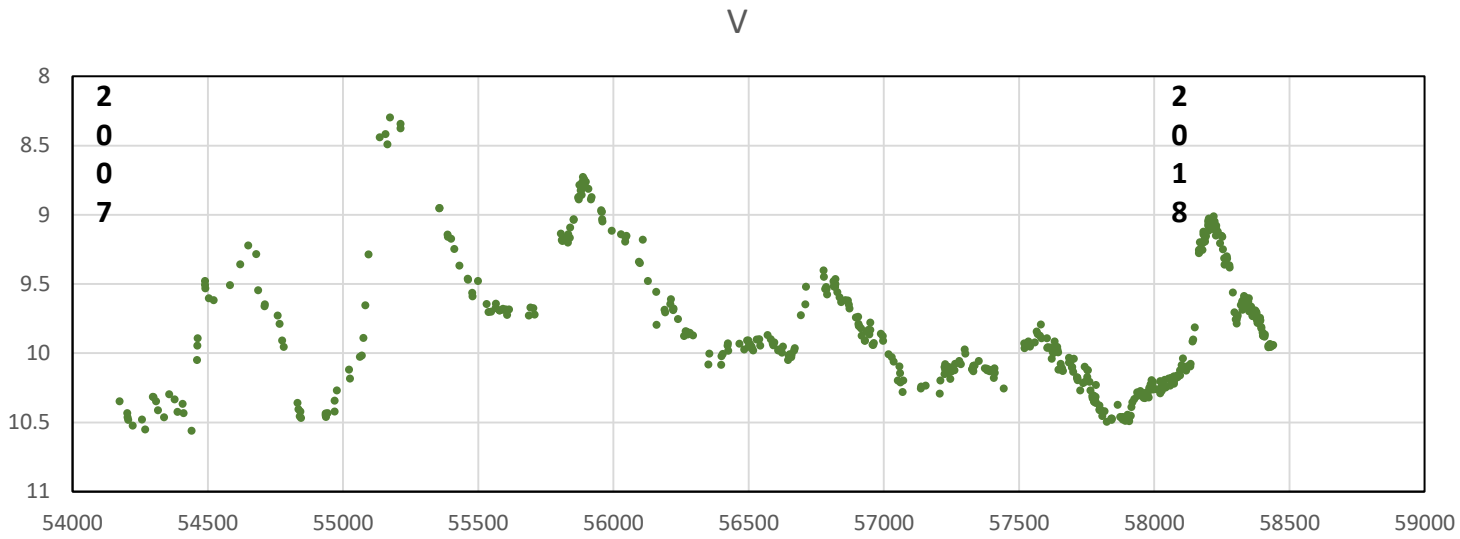
Prototype in GCVS

- Active states

'Z And' Outbursts Δmag ~ 0.5 – 3

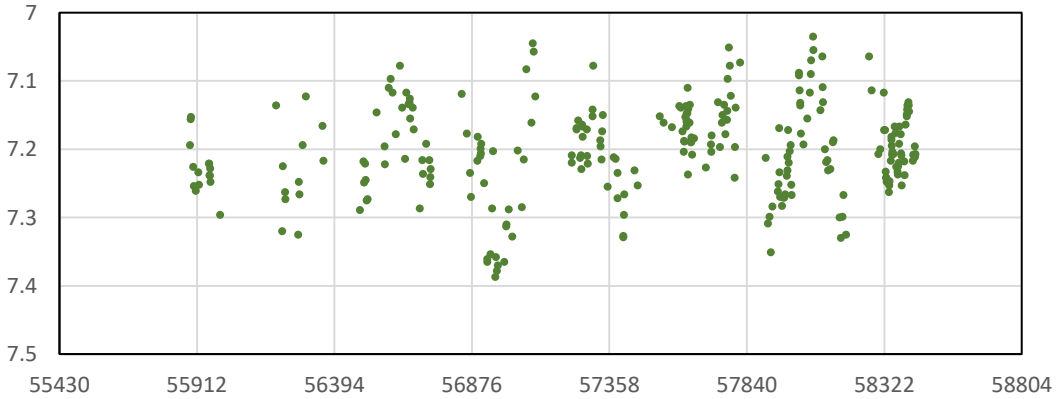
- Quiescent states

Orbital variations



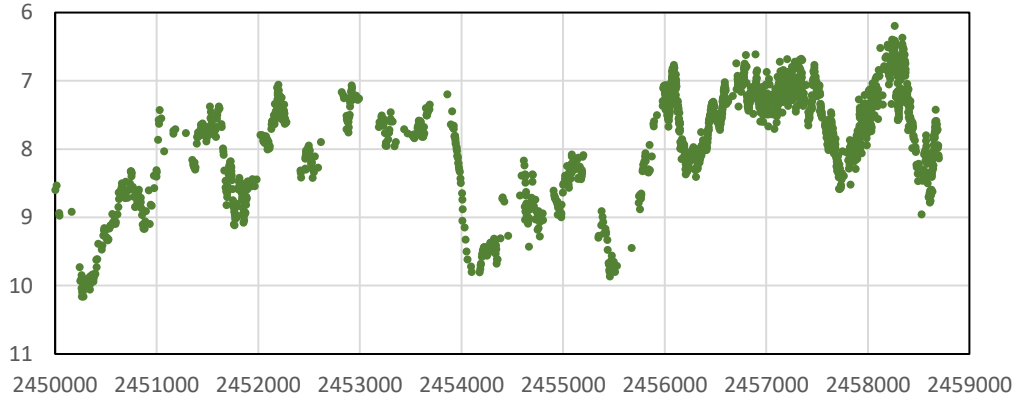
Z And V band lightcurve – Data: Sekeras &al., 2019

❷ Stable: wavelike variations ~ +++ 0.1 mag



EG And V band lightcurve – Data: Sekeras &al., 2019

❸ High states, low states

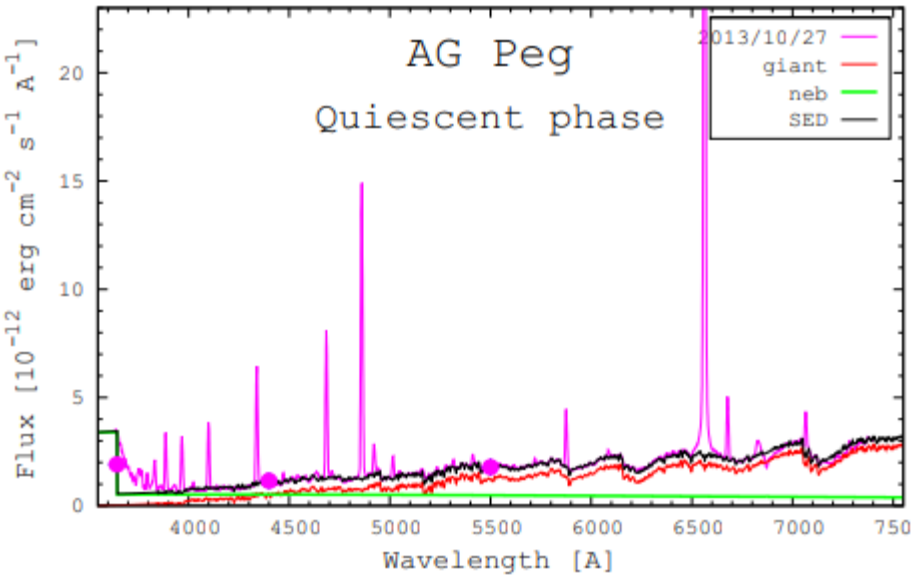


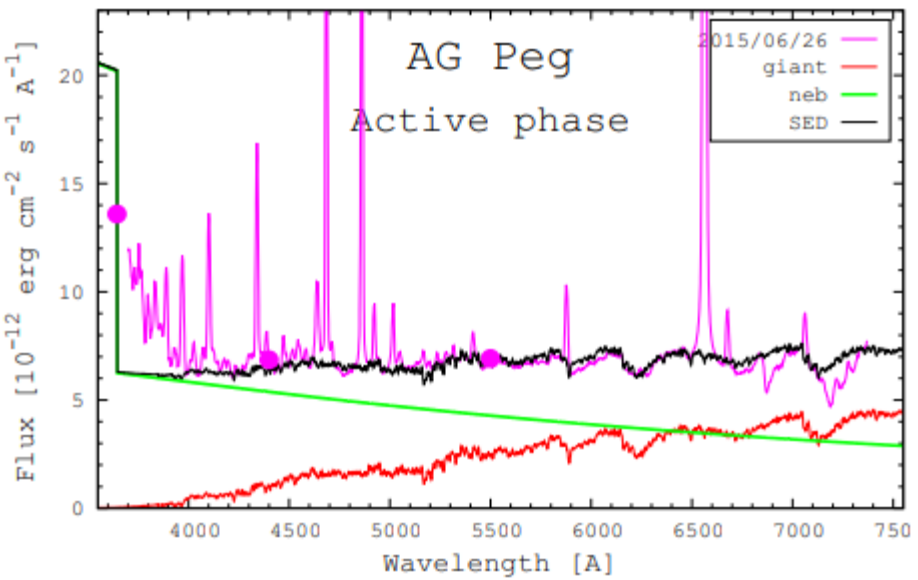
CH Cyg V band lightcurve – Data: AAVSO 1 day mag

Composite spectrum as a result of the 3 components of the system

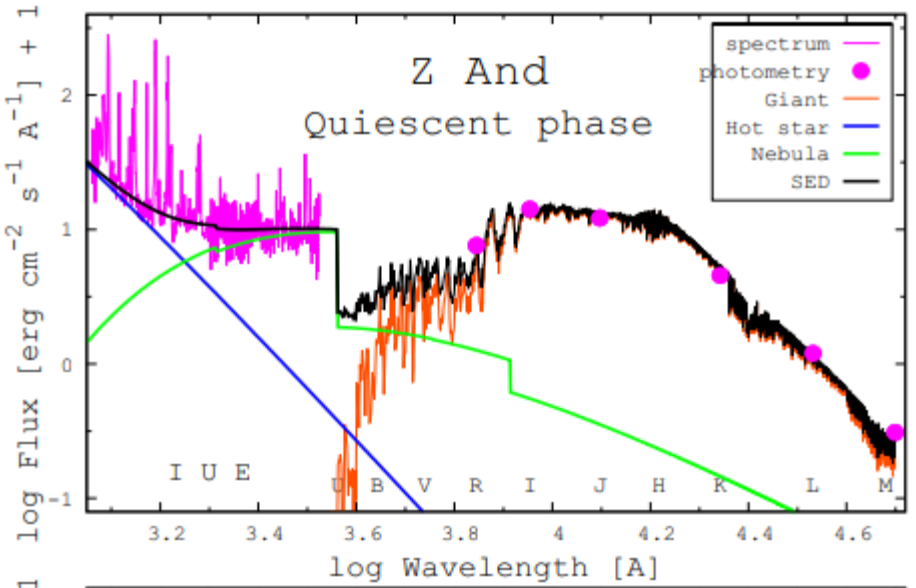
Augustin Skopal
In ESIL n°, 2016

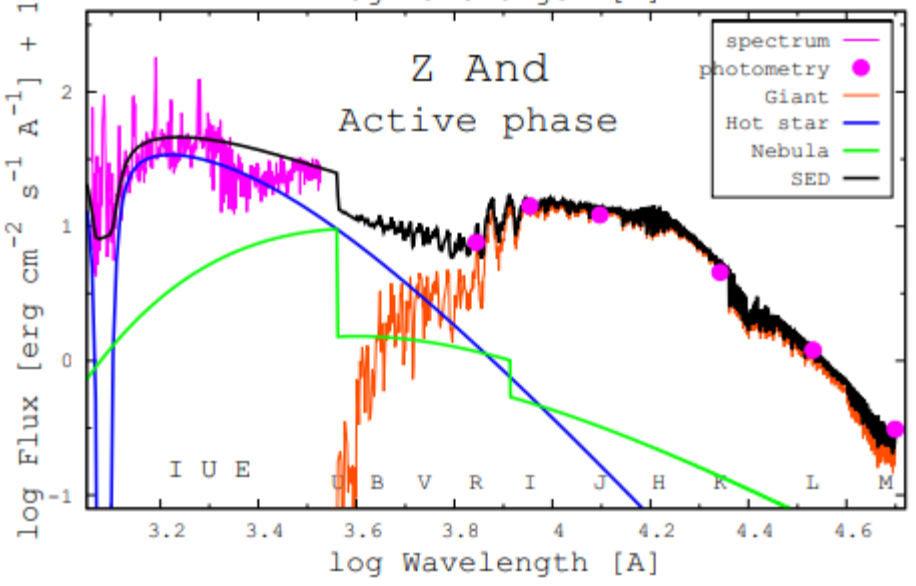
RG
Hot
Nebula





AG Peg spectra:
K. Graham
U. Sollecchia

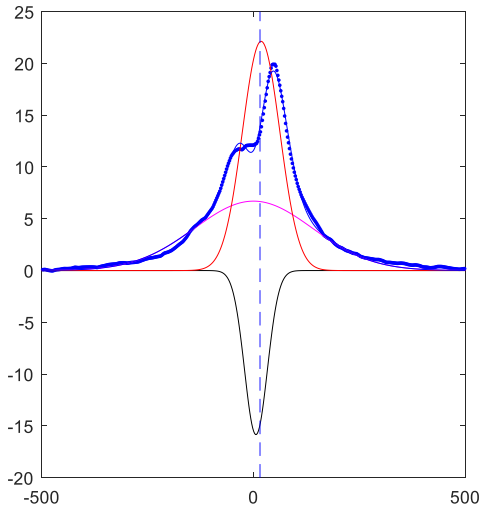


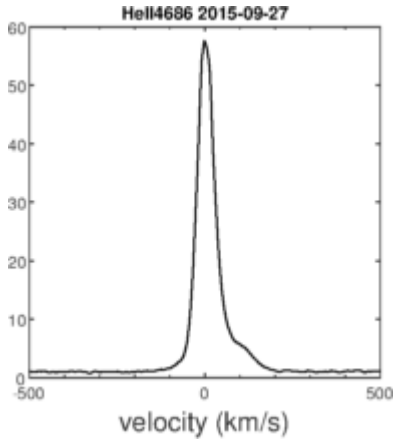


Emission lines in quiescence

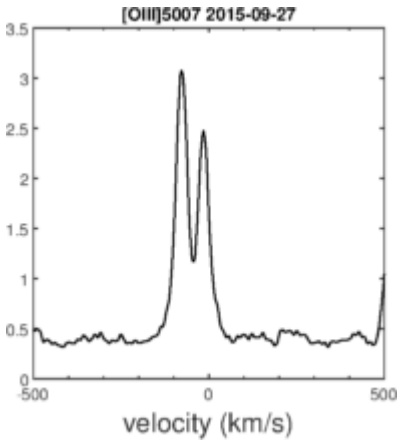
CI Cygni 2015-12-26
phase

Hα profile

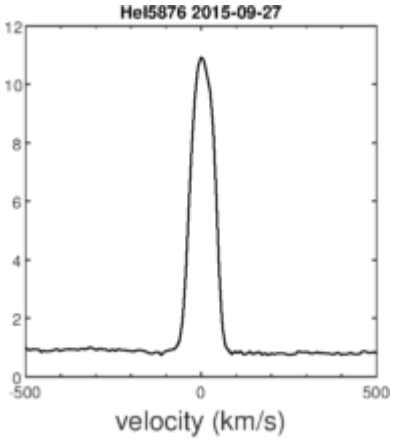




FWHM = 57 km.s^{-1}

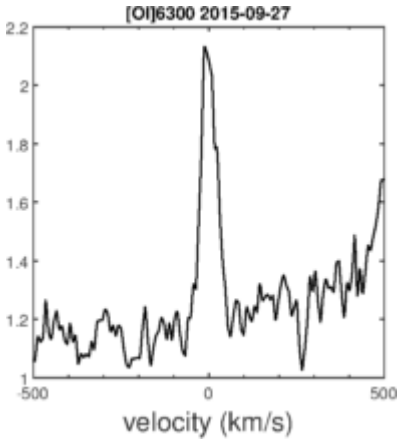


Δ peaks = 63 km.s^{-1}

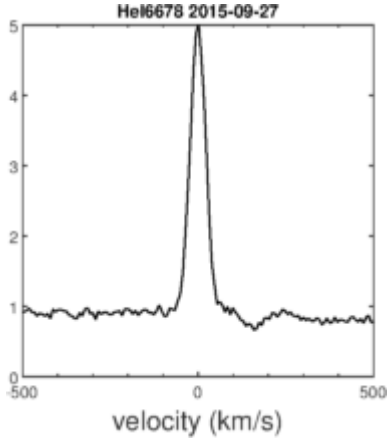


FWHM = 79 km.s^{-1}

Regions of formation



FWHM = 54 km.s^{-1}



FWHM = 52 km.s^{-1}

- Emission core FWHM = 104 km.s^{-1}
- Broad wings FWHM = 330 km.s^{-1}

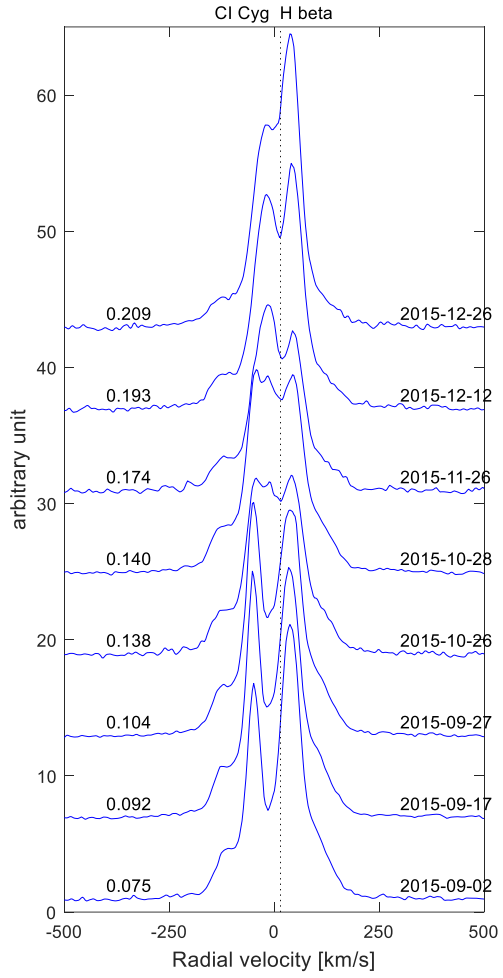
  Wind hot star / Scattering (?): *subject to debates*
- Blue-shifted Absorption FWHM = 63 km.s^{-1}

Dashed line : Systemic RV = +15 km.s^{-1}

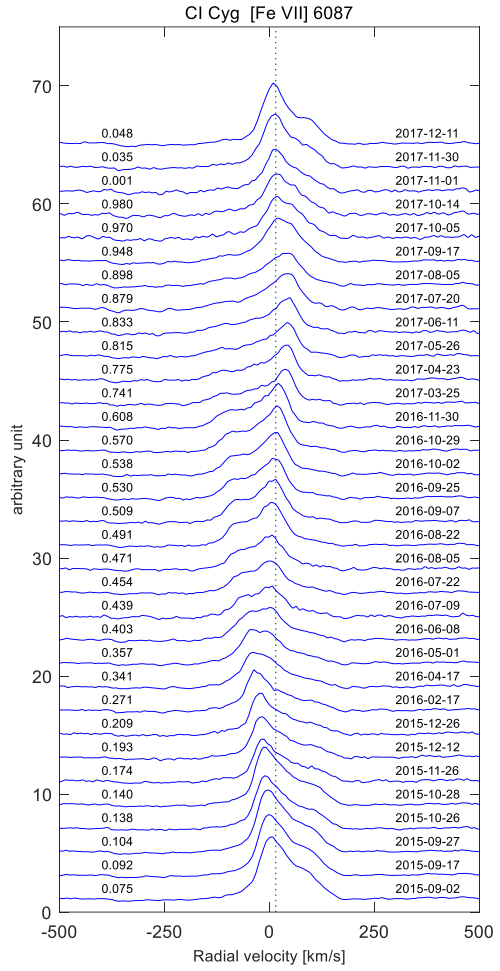
Emission lines: orbital variations

CI Cygni
P = 853.8 d

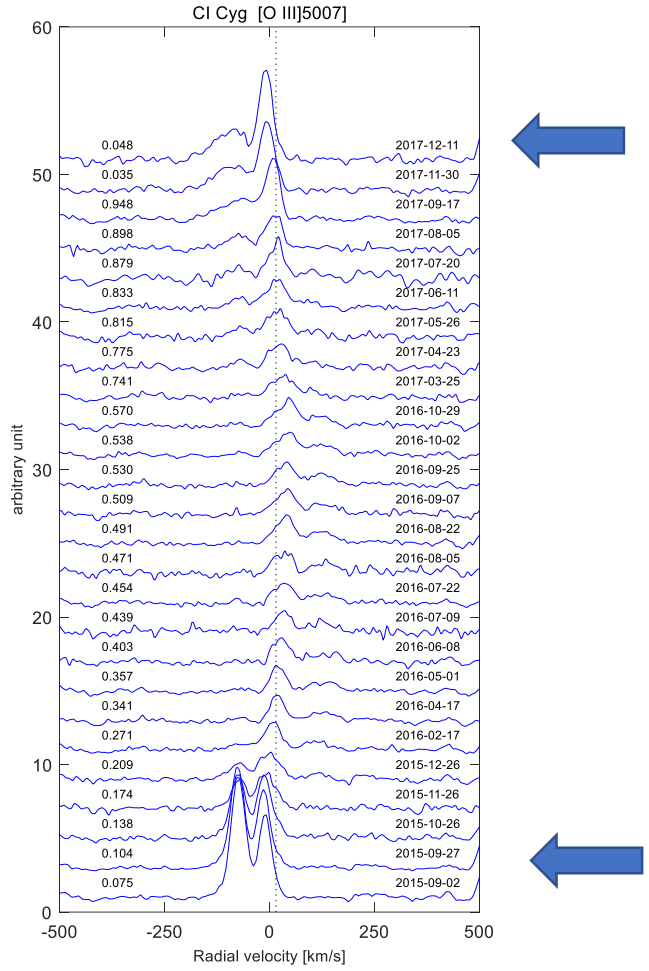
Ephemeris:
Siviero & al., 2009



Hβ: egress of the eclipse



[Fe VII] 6087: orbital motion

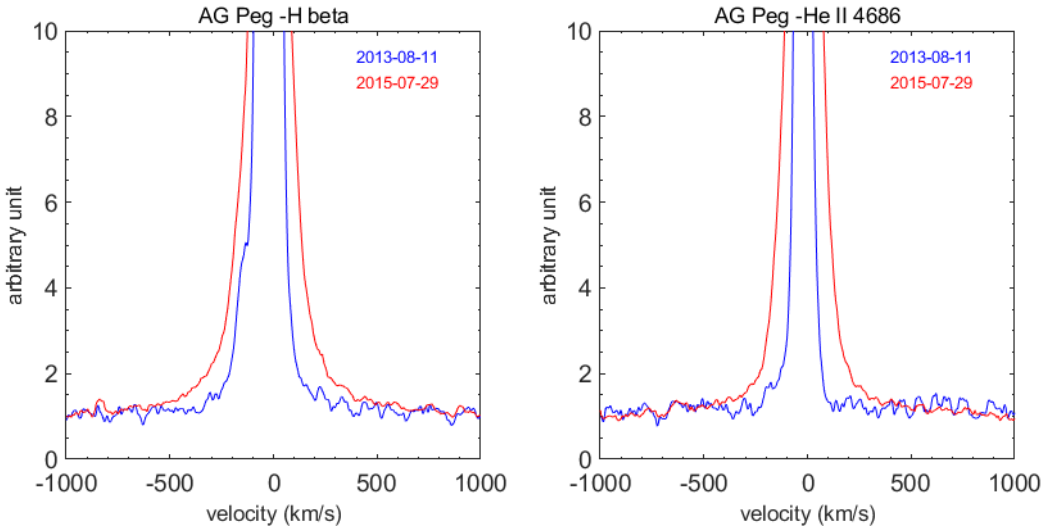


[O III] 5007

Emission lines in outbursts

Quiescence
Outburst

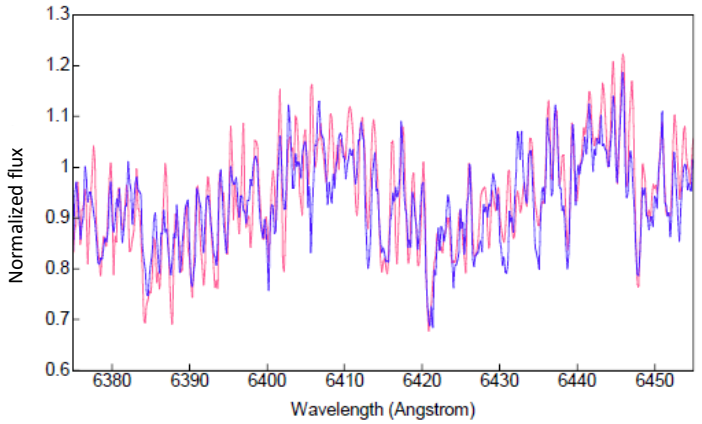
Increase of the velocities
→ 1000 – 2000 km.s^{-2}



Add FWHM and ½ FWZI

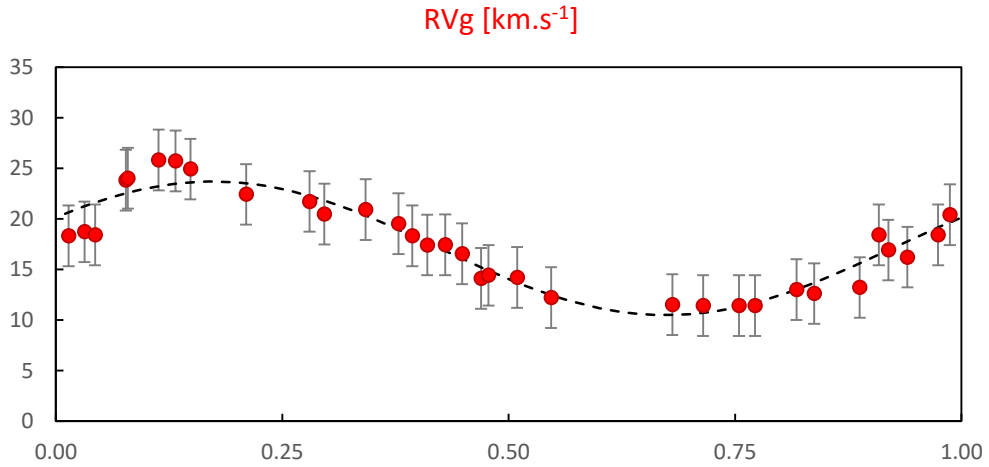
Orbital éléments: CI Cygni

Cross correlation (ISIS)

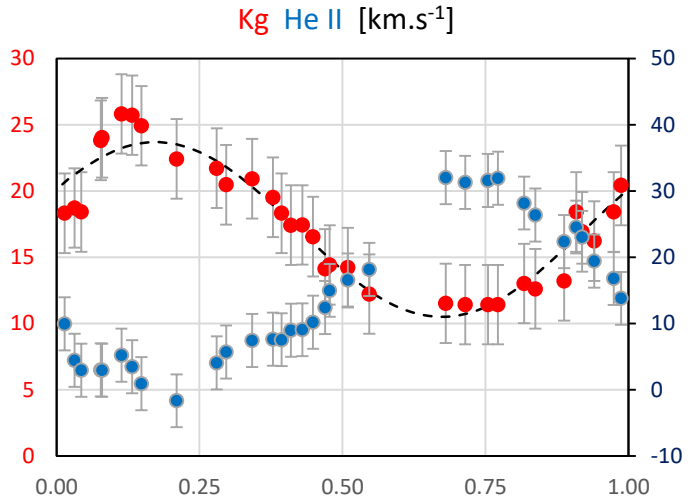


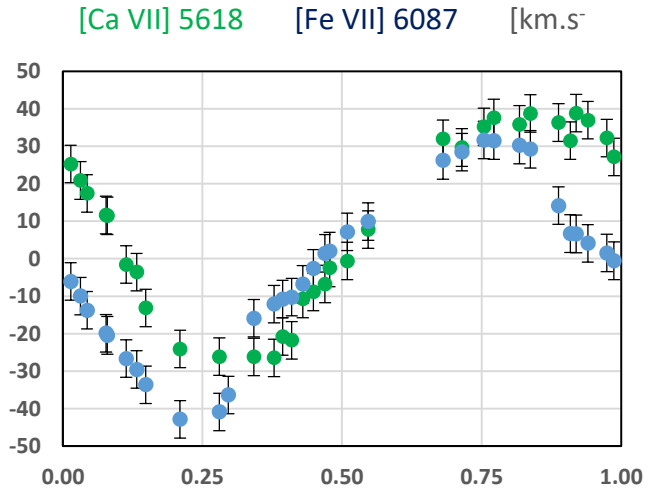
Range 6370-6460 Å
CI Cygni
13 Lyr M6 III Reference

Red giant orbit



Tracing the hot component





		Kenyon & al., 1991	Fekel & al., 2000	ARAS 2018
P	days	855.25	853.8 +/-2.9	853.8 [1]
T	HJD		2450426.4 +/-59.6	2456512.9+/-56.8
γ	km.s^{-1}	18.4 +/- 0.4	14.96 +/ -0.23	15.33+/-0.24
K1	**km.s^{-1}**	**7.0+/-0.5**	**6.70+/-0.23**	**6.63+/-0.37**
e		**0**	**0.109+/-0.048**	**0.126+/-0.058**
ω			297.7+/-24.7	341.2+/-21.8
a sin i	km	78.8 +/-9.4 10^6	78.2 +/-9.4 10^6	77.2+/-6.2 10^6
f (m)		0.027+/-0.010	0.0262+/-0.0035	0.0252 +/- 0.006

[1] adopted from Fekel & al. 2000

Echelle spectra (33)
R = 9000 to 13000
F. Teyssier (FR)
J. Guarro Flo (SP)
T. Lester (CA)

Orbital elements
Computed with SBS

Symbiotic stars monitoring by ARAS group
4600 spectra of 56 objects
Since 2009
At resolution 500 to 15000
Acquired by ~ 40 observers
Using
- Slit spectrographs (R = 500 to 15000)
- Echelle spectrographs (R = 9000 to 14 000)
Mounted on small telescopes (20 – 50 cm)

- Autonomous observing program
- Use of the data for publications

and

- Collaborations with professional teams

Mag V = 7 to 14

CH Cyg	**756**
AG Dra	**613**
T CrB	**304**
V694 Mon	**302**
AX Per	**288**
AG Peg	**257**
CI Cyg	**213**
R Aqr	**182**
SU Lyn	**164**
BF Cyg	**159**
Z And	**155**
EG And	**126**
UV Aur	81
NQ Gem	76
TX CVn	68
BX Mon	64
ZZ CMi	61
V443 Her	60
TCPJ195442	59
RS Oph	54
BD Cam	47
CQ Dra	38

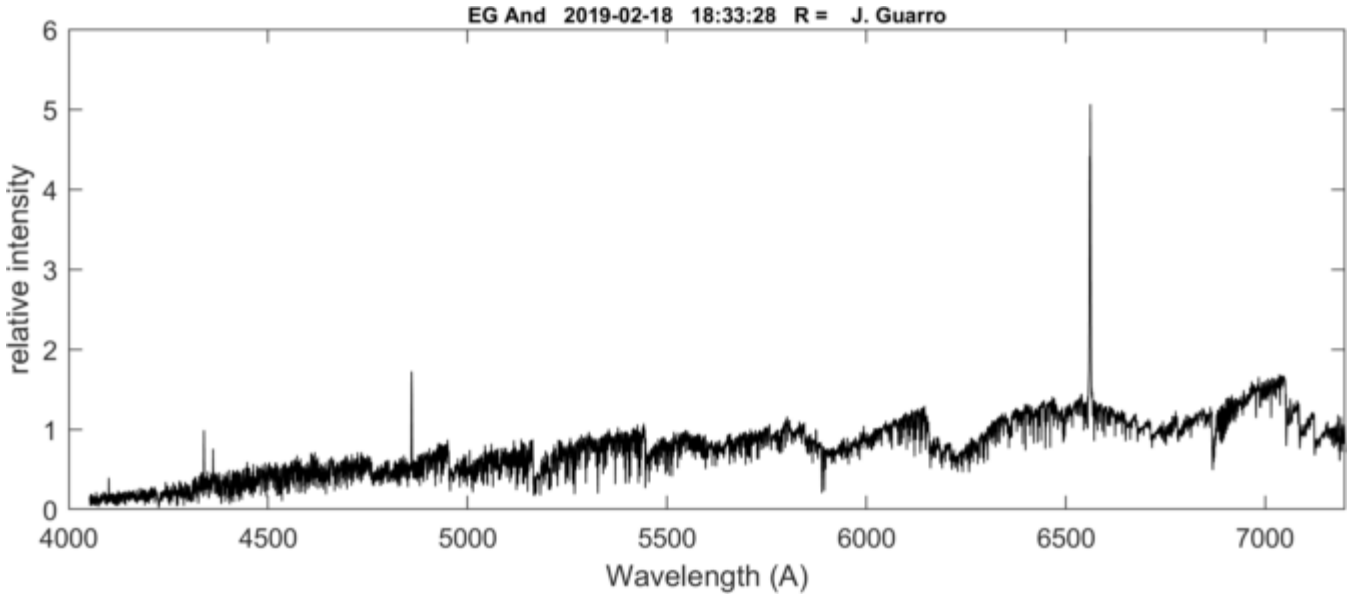
Omi Cet	33
V627 Cas	33
V934 Her	31
V471 Per	30
YY Her	30
PU Vul	24
V1016 Cyg	21
V1329 Cyg	21
StHa 190	21
RW Hya	19
LT Del	19
V1261 Ori	17
V1413 Aql	15
HM Sge	13
IV Vir	12
V335 Vul	12
QW Sge	12
V407 Cyg	12
ER Del	11
StHA 55	10
GH Gem	9
FG Ser	9

FN Sgr	9
V919 Sgr	9
V503 Her	8
SS Lep	8
AS 270	6
StHa 149	6
StHa 32	5
StHa 169	5
AS 210	4
RT Ser	3
AS 289	3
RR Tel	3
Hen 3-1341	2
Hen 3-1768	2
StHa 180	2
Hen 2-468	2
RT Cru	1
Hen 3-1342	1
AS 245	1
AS 323	1
EF Aql	1

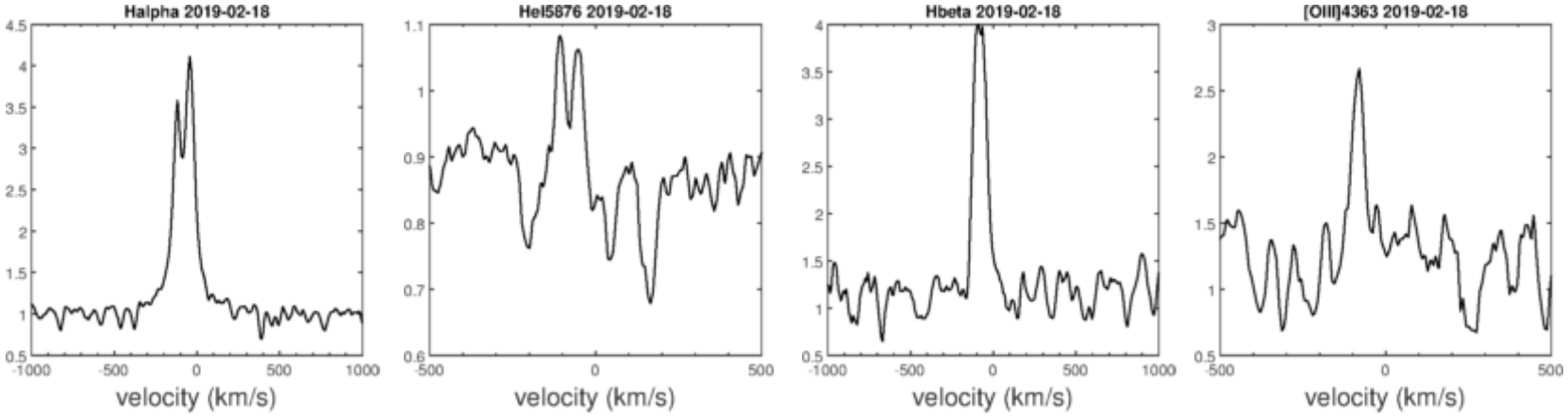
EG And

Low luminosity
Accretion powered

T_{WD}	75 000 K	
L_{WD}	16 $L_\odot$	
M_{WD}	0.4 (0.1) $M_\odot$	
$\dot{M}_{WD}$	$9.10^{-9} M_\odot/y$	
Sp. type	MIII 2.4	
L_{RG}	950 $L_\odot$	
M_{RG}	1.5 (0.6) $M_\odot$	
P_{orb}	482.6 d	Fekel &al. (2000)
e	~ 0	
d	673 pc	Gaia DR2

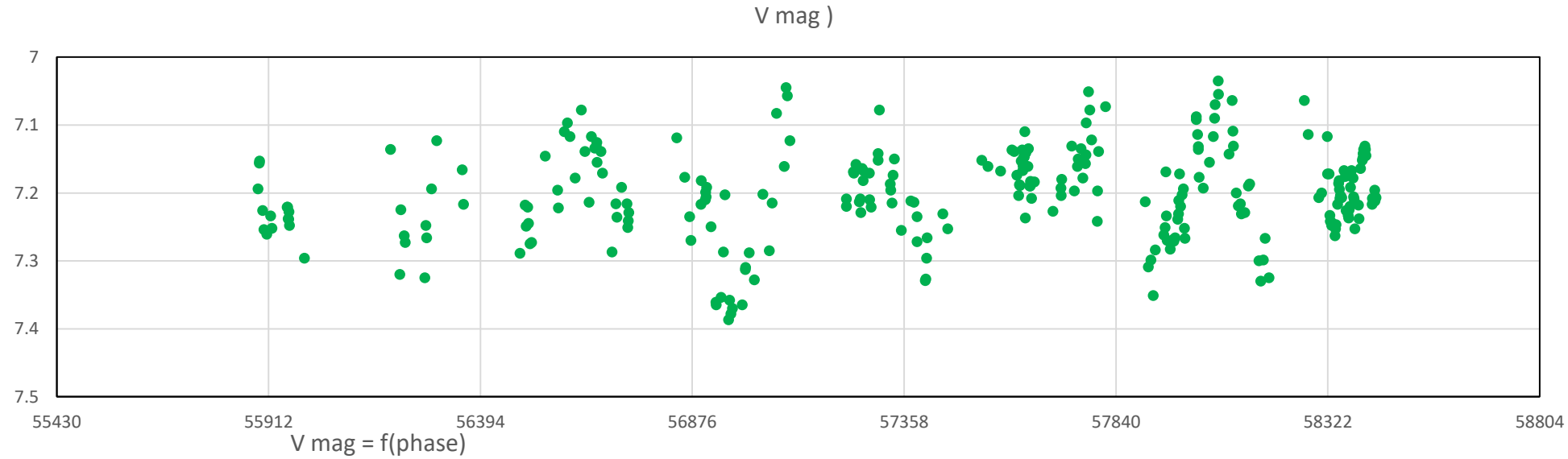


Echelle R = 9000
Joan Guarro



EG And

Data: Sekeras & al., 2019



- No outburst ($\dot{M} < \dot{M}_{stable}$) → nova outburst in the future?
- Double-wave light variation
  - Illumination of the RG (Kenyon 2016)
  - Ellipsoïdal effect (Skopal
  - Colliding winds (Tomov 1995 Calabro 2014)

- Scatter: short(s) period(s) 28 to 40 d pulse of the giant (e.g., Skopal, 2019)

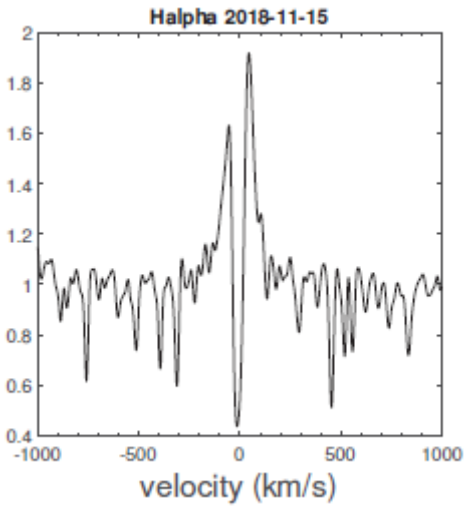
Ephemeris
E = 2450208.108
P = 482.5
Spectroscopic conjunction of the giant
Kenyon & Garcia, 2016

EG And

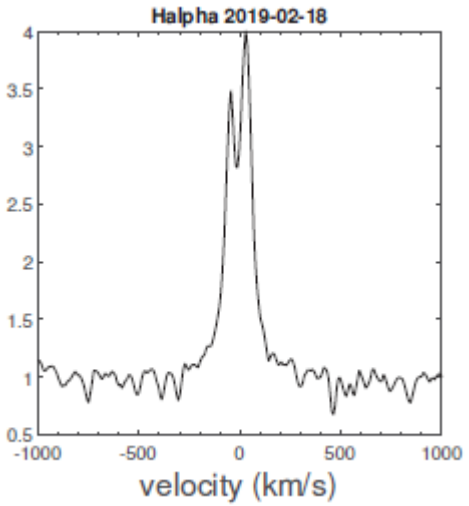
Collaboration: N. Shagatova, A. Skopal

Hα profile: Orbital variations

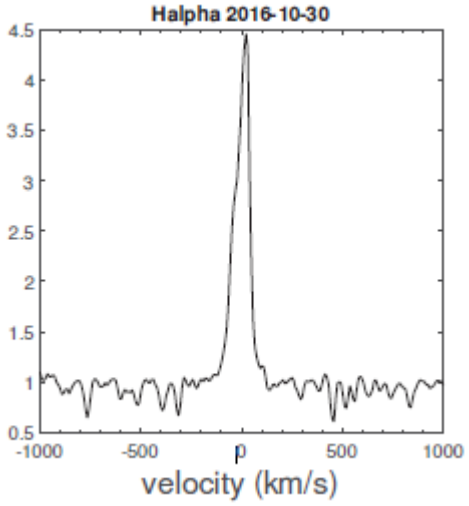
Echelle spectra R = 9000 to 13000
F Teyssier, J. Guarro, T. lester



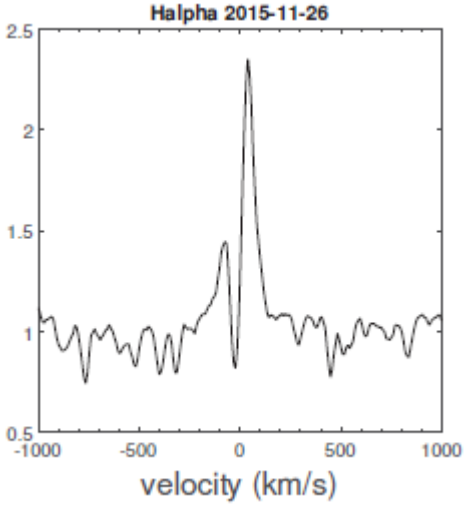
Phase 0.056



Phase 0.254



Phase 0.511



Phase 0.757

- High inclinaison ~ 80° (Vogel & al., 1992)
- Ionized and neutral region

→ orbitally related variation of the profile

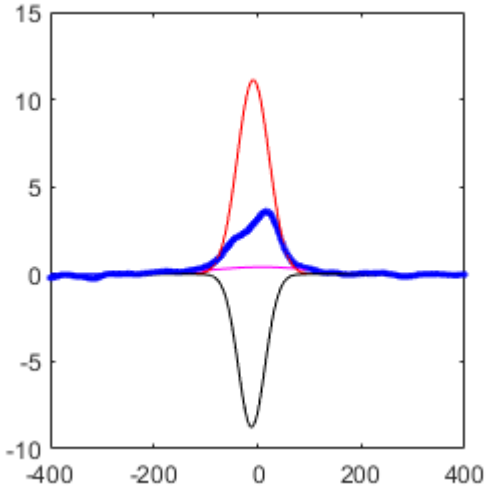
EG And

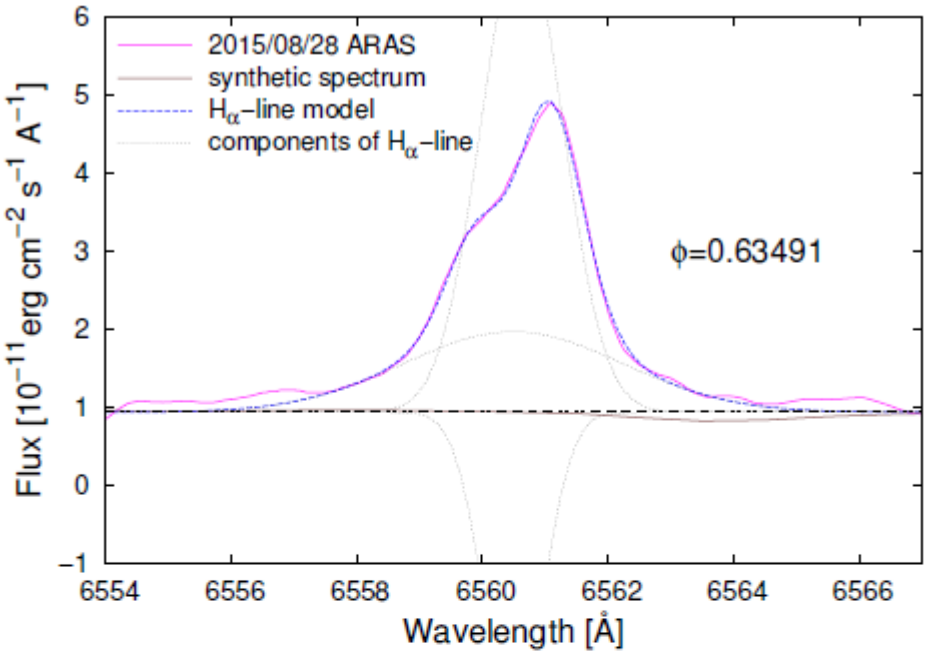
Collaboration: N. Shagatova, A. Skopal

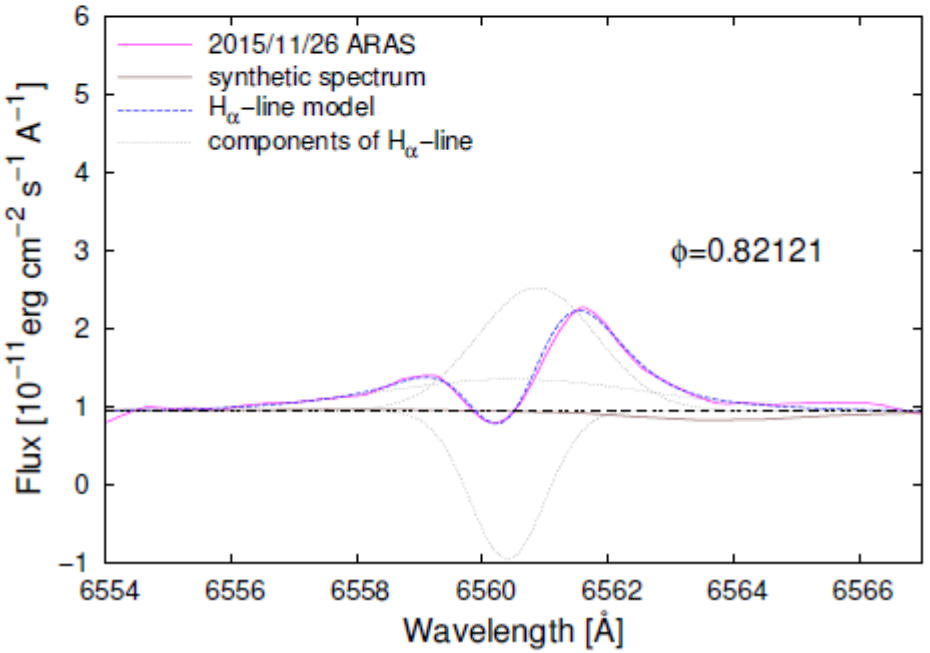
Hα profile: Orbital variations

Hα orbital variations of the symbiotic star EG And from optical spectroscopy
Shagatova, N. & al., 2019
Contributions of the Astronomical Observatory Skalnaté Pleso, vol. 49, no. 2, p. 406-410

Fitting of ☐ Hα profile with 3 components
- ☐ Broad wings emission
- ☐ Core emission
- ☐ Absorption







EG And

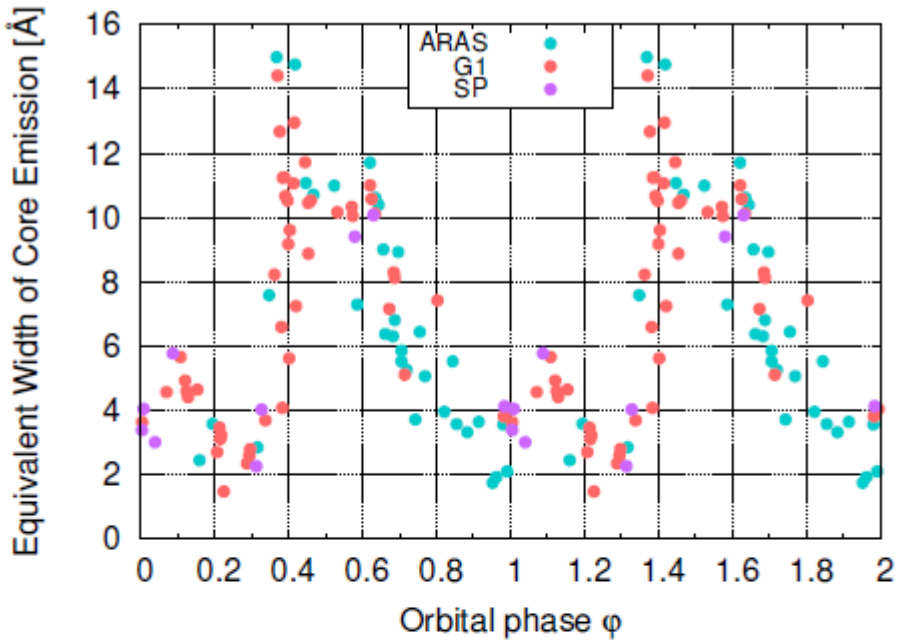
Shagatova, N. & al., 2019

Stará Lesná (G1)
Skalnaté Pleso (SP) observatories
ARAS
2015-2018

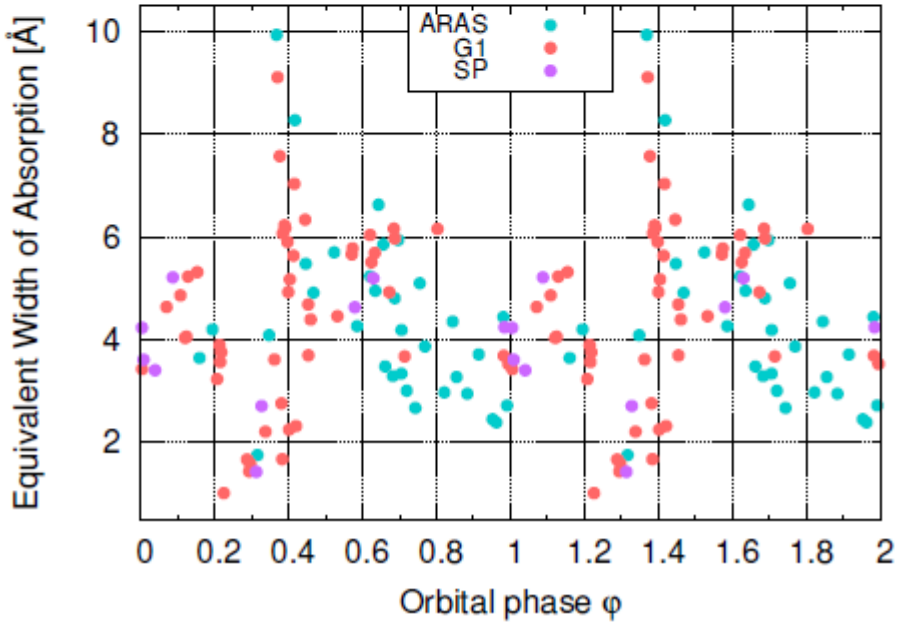
Ephemeris:

Equivalent widths of the core emission and absorption
strongest at ϕ = 0.4
weakest at ϕ = 0.2
→asymmetry of the circumstellar matter density distribution

Emission near the eclipse
→ Emission region larger than the size of the RG



EW Emission [Å]



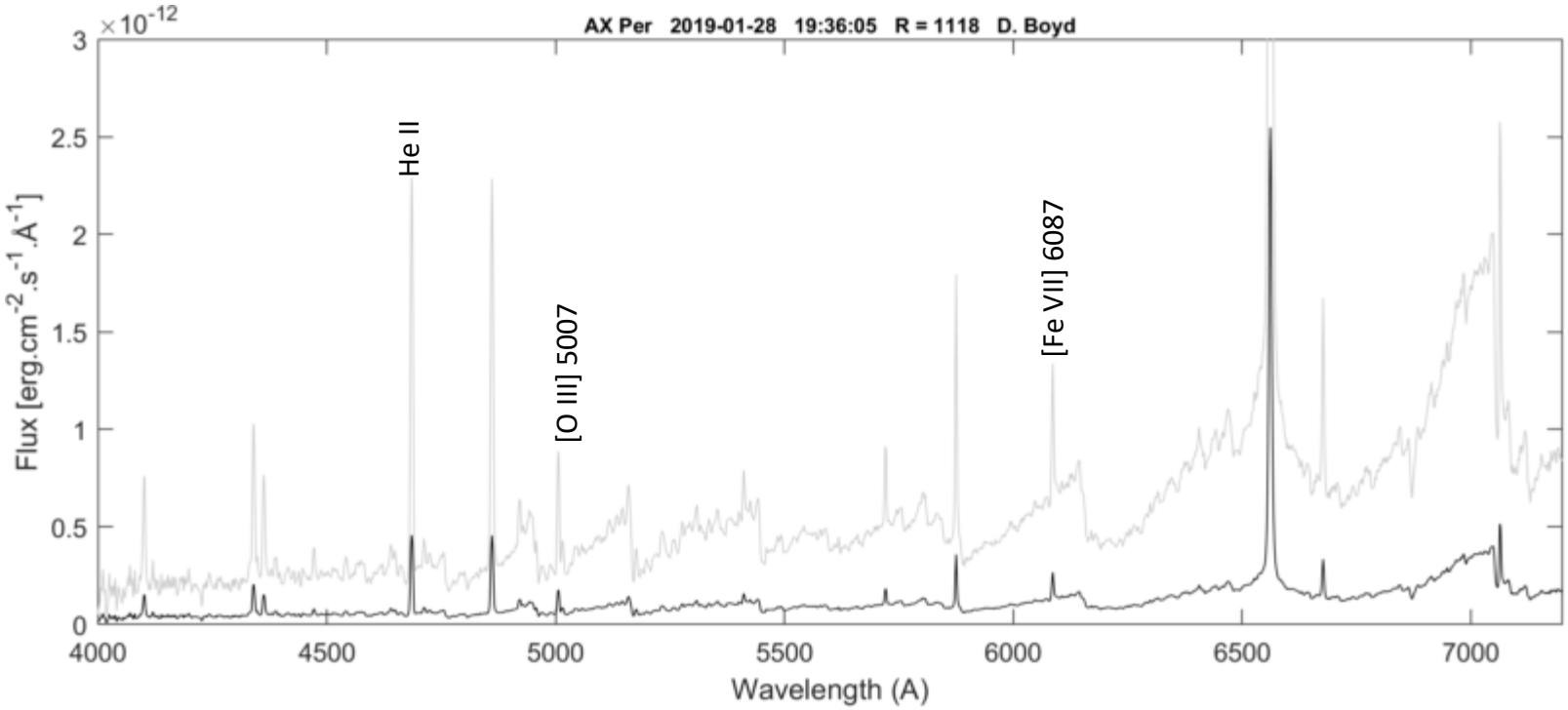
EW Absorption [Å]

AX Per

Classical symbiotic

Eclipsing

T_{WD}	105 000 K	
L_{WD}	710 $L_\odot$	
M_{WD}	0.4 $M_\odot$	
$\dot{M}_{WD}$	3.10^{-7} $M_\odot$/y	
Sp. type	M5 III	
M_{RG}	1.1 $M_\odot$	
P_{orb}	682.1 d	Fekel & al. (2000)
e	0	Fekel & al. (2000)
d	3357 pc	Gaia DR2



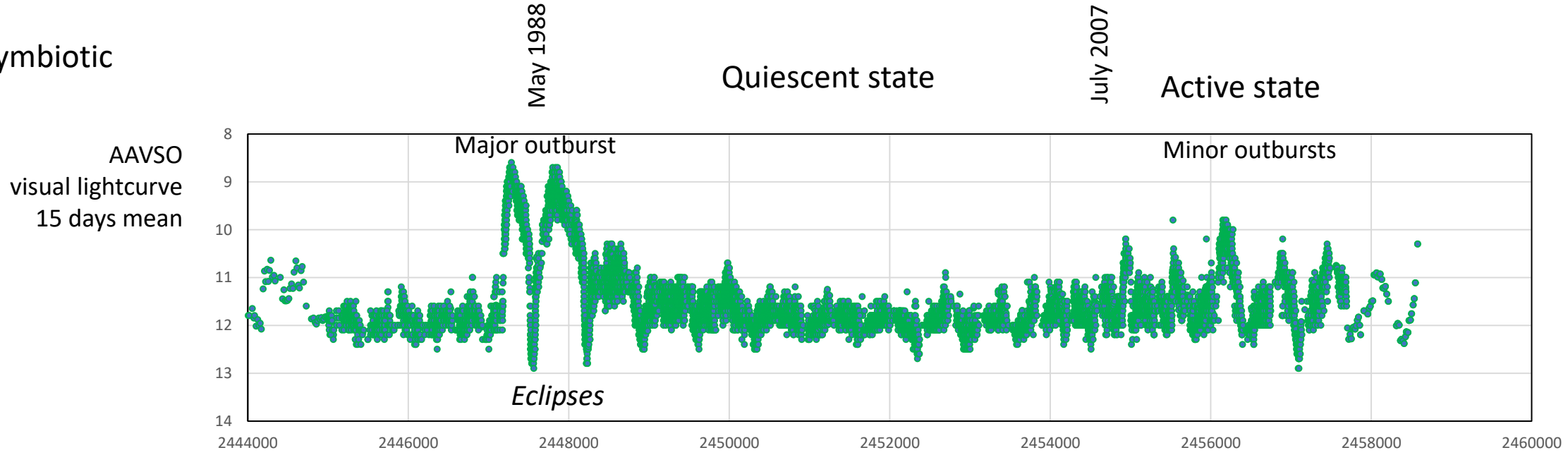
David Boyd – LISA – R = 1000 – Flux calibration with photometry in Johnson V

High ionization lines: He II [OIII] [Fe VII]

Symbiotic stars monitoring: AX Per

AX Per

Classical symbiotic



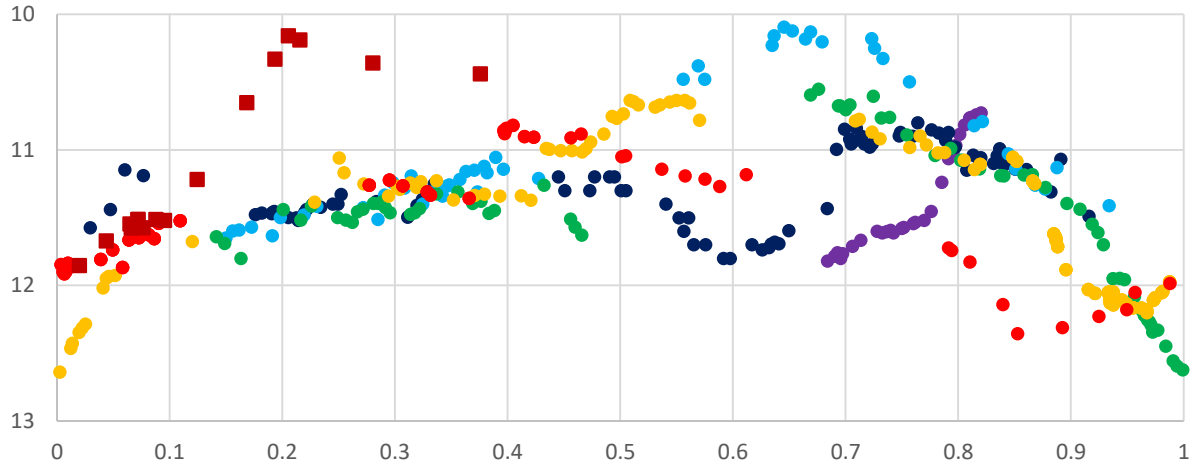
- Wave-like profile Δmag ~ 2
- LC and Eclipse profile change from cycle to cycle

complex and variable sources of radiation around the WD as well as within the circumbinary environment. (Sekeras & al., 2019)

Current outburst: brown squares

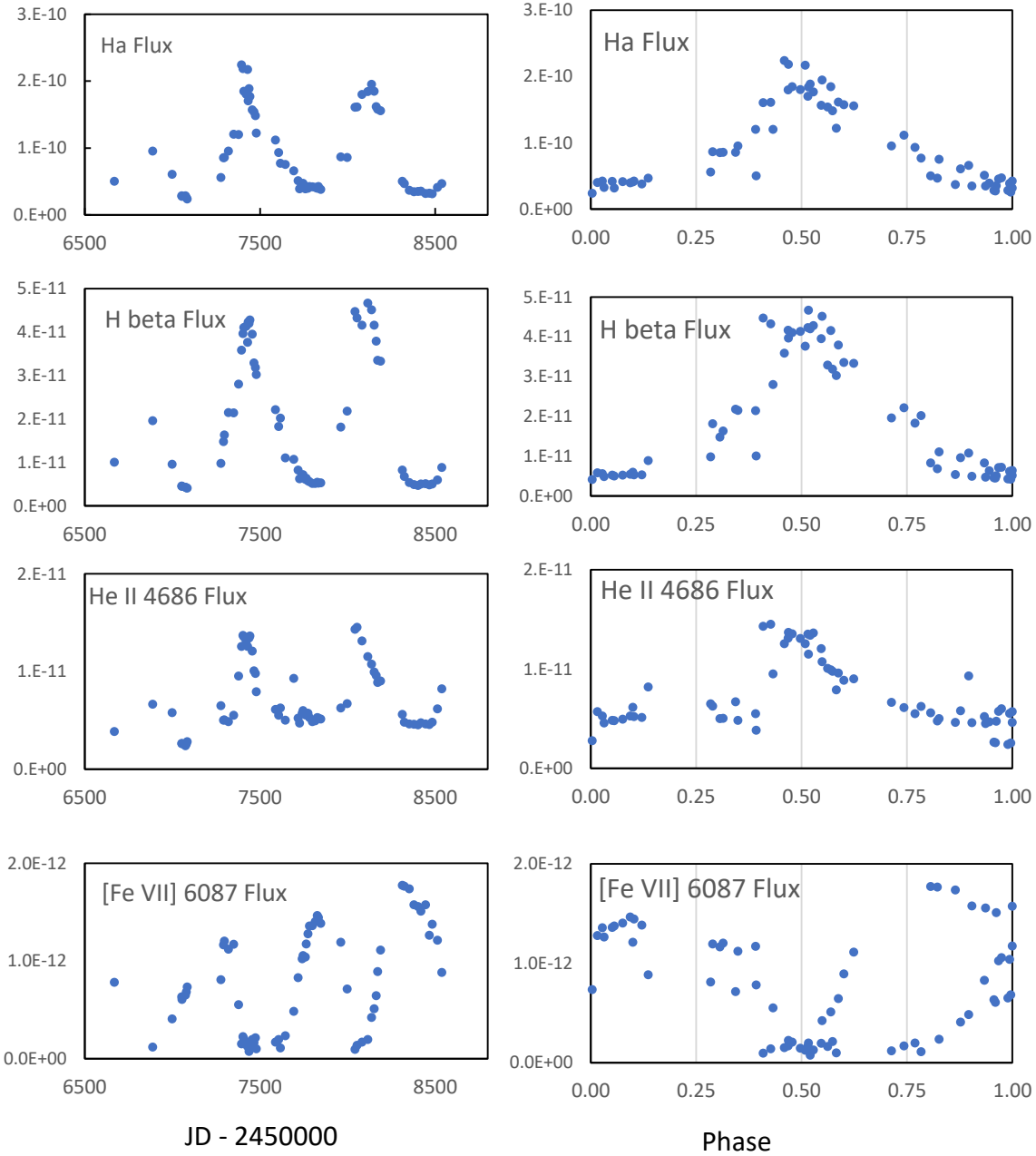
JD0	2436667
E	680.8

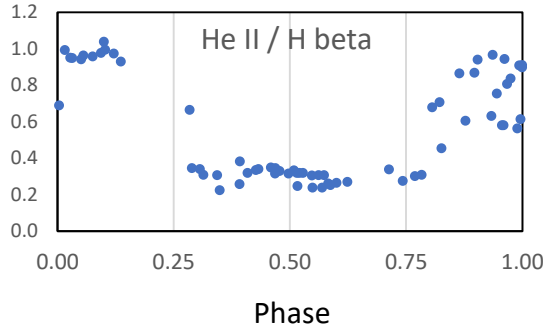
Cycle	Color
26	
27	
28	
29	
30	
31	
32	

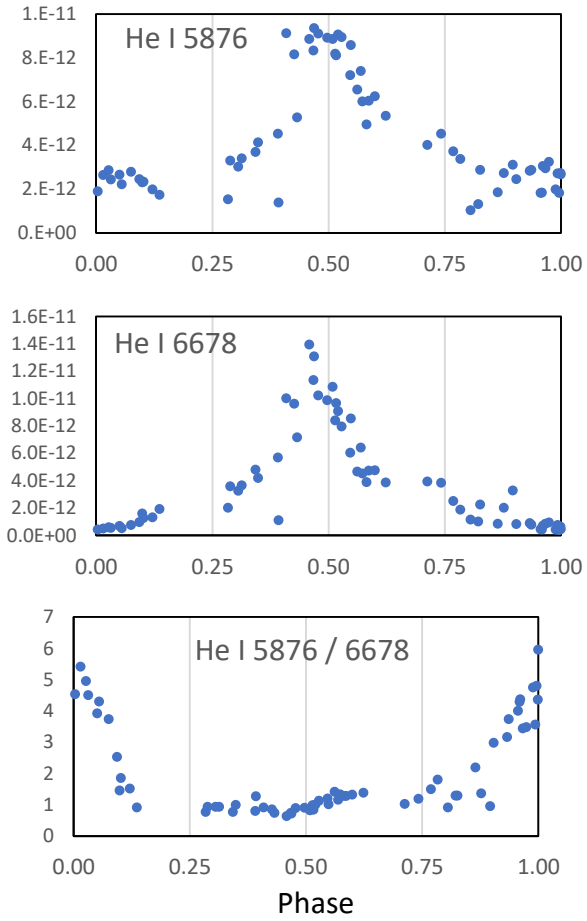


AAVSO V band 1 day mean According to phase

Symbiotic stars monitoring: AX Per



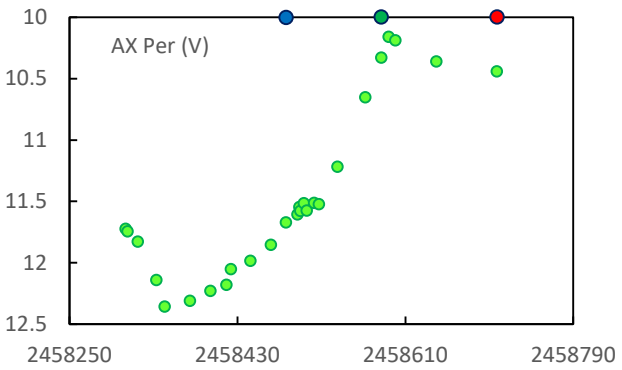




Long term monitoring
Low resolution spectra (LISA R = 1000) Flux calibrated obtained by David Boyd since 2015

AX Per

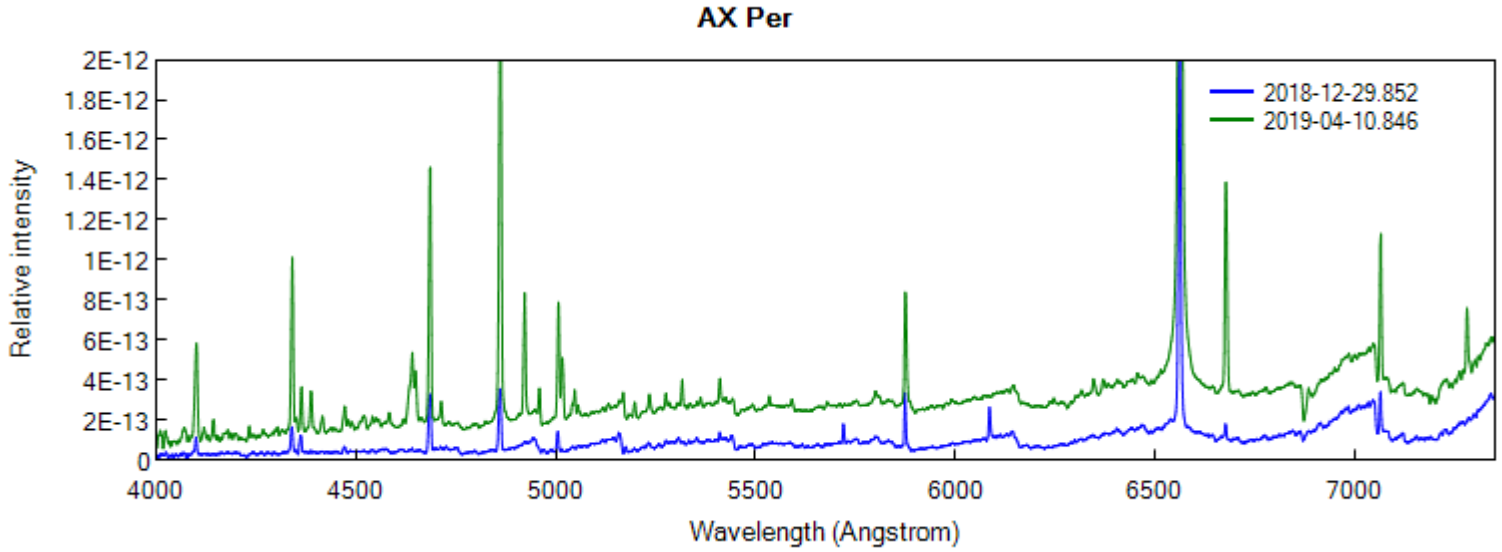
Outburst 2019

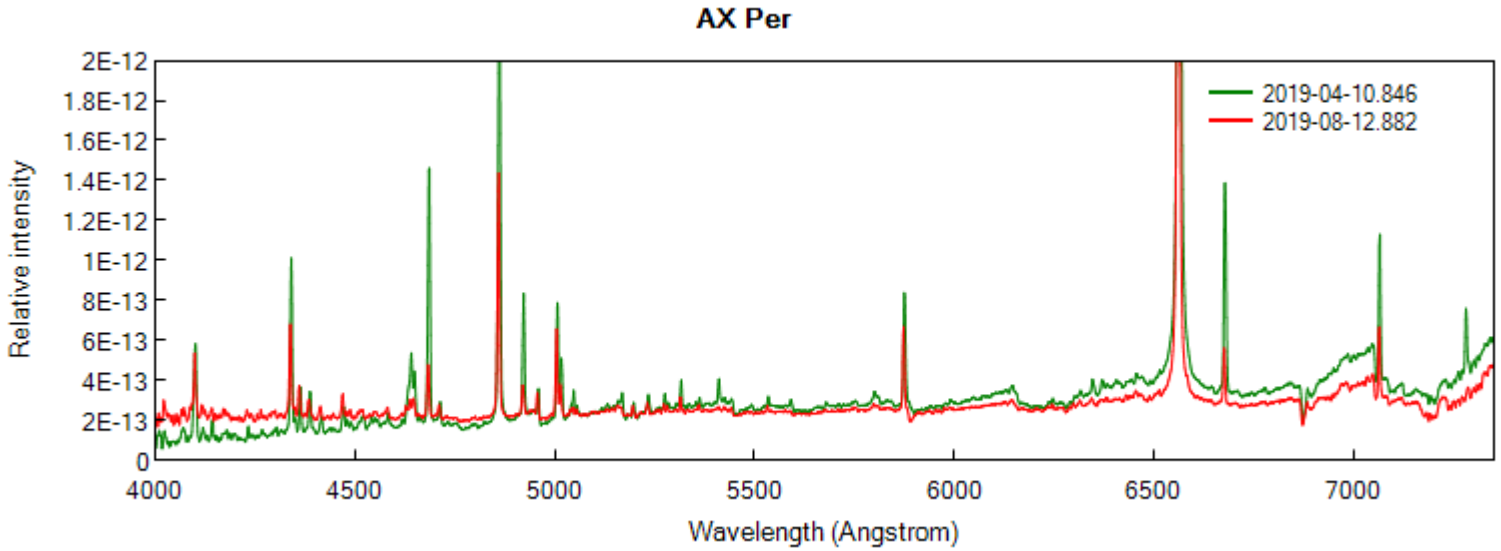


Eclipse egress | Outburst

The symbiotic star AX Per is going into strong outburst

ATel #12660; *J. Merc (UPJS in Kosice, Charles University), R. Galis (UPJS in Kosice), F. Teyssier, D. Boyd, W. Sims, C. Boussin, F. Campos (ARAS)*
on 13 Apr 2019; 11:21 UT

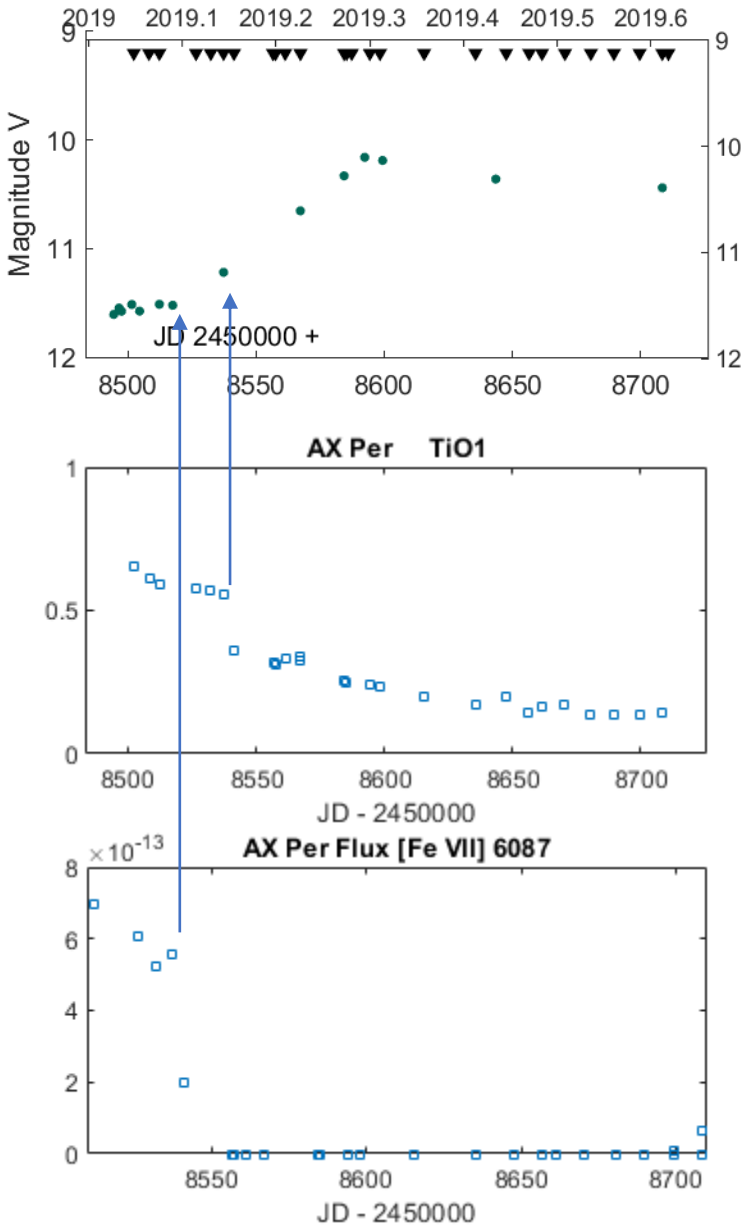




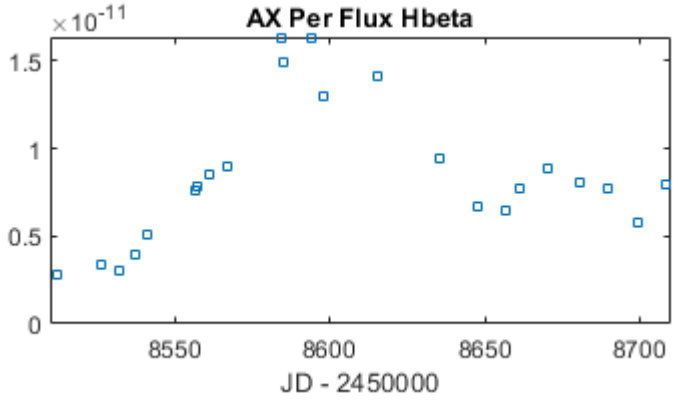
Flux calibrated spectra – D. Boyd – LISA R = 1000

Symbiotic stars monitoring: AX Per 2019 outburst

AX Per



Flux in erg.cm$_{-2}$.s^{-1}



Rise to maximum:

Low ionization lines HI, HeI and continuum increase

He II increases more slightly

[Fe VII] vanishes very early

TiO bands weakens

Maximum:

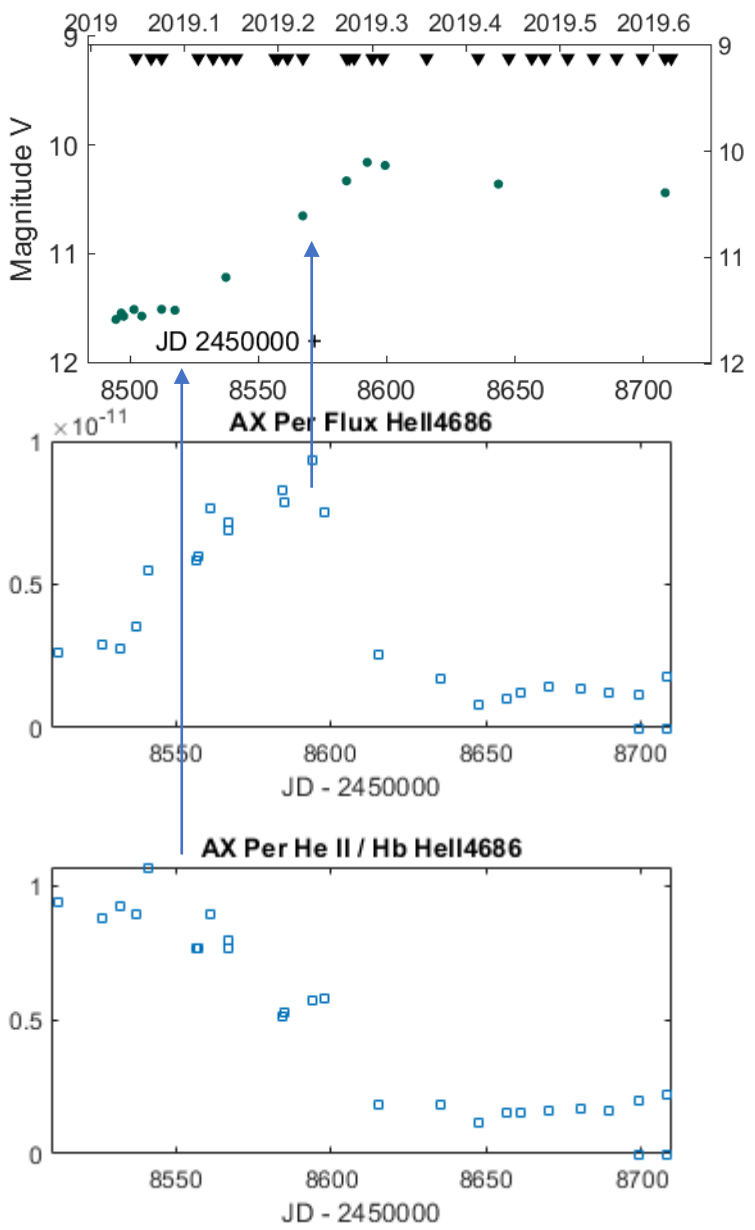
He II fades quickly

Low res spectra

D. Boyd (LISA R =1000)

C. Boussin (Alpy R = 600)

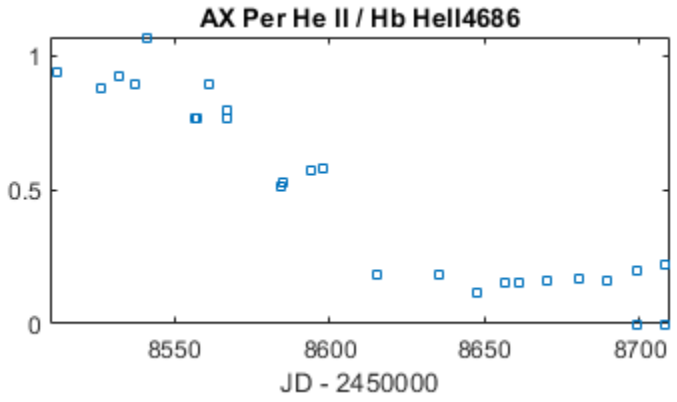
W. Sims (LISA R =1000)

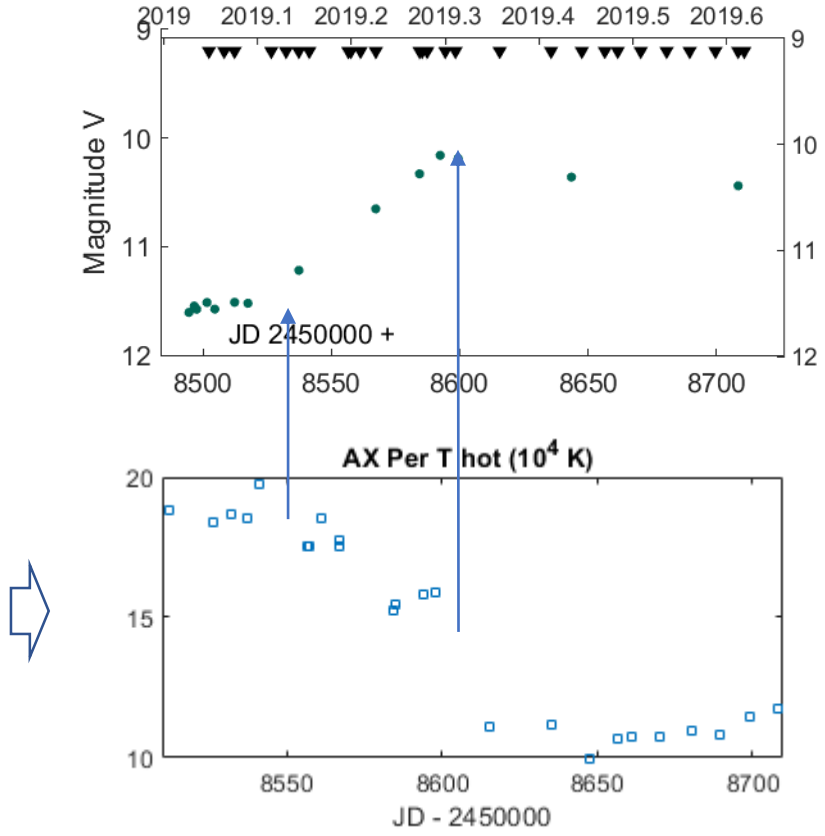


AX Per: T_{hot} during the outburst

T_{hot} derived from Iijima's (1980)

$$T_{hot}(10^4\,K) \sim 14.16\sqrt{\frac{F(4686)}{F(4861)}} + 5.13$$



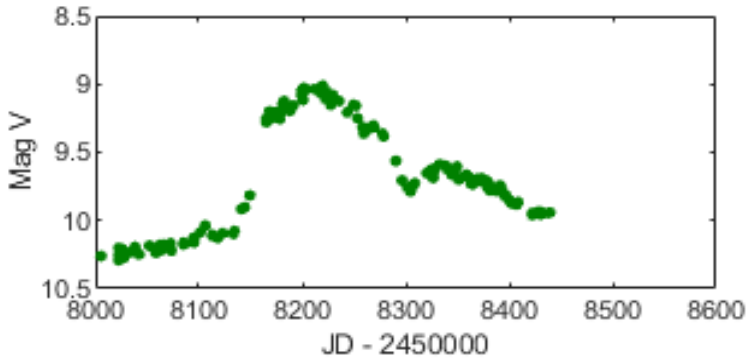


Z And

The activity of the symbiotic binary Z Andromedae and its latest outburst

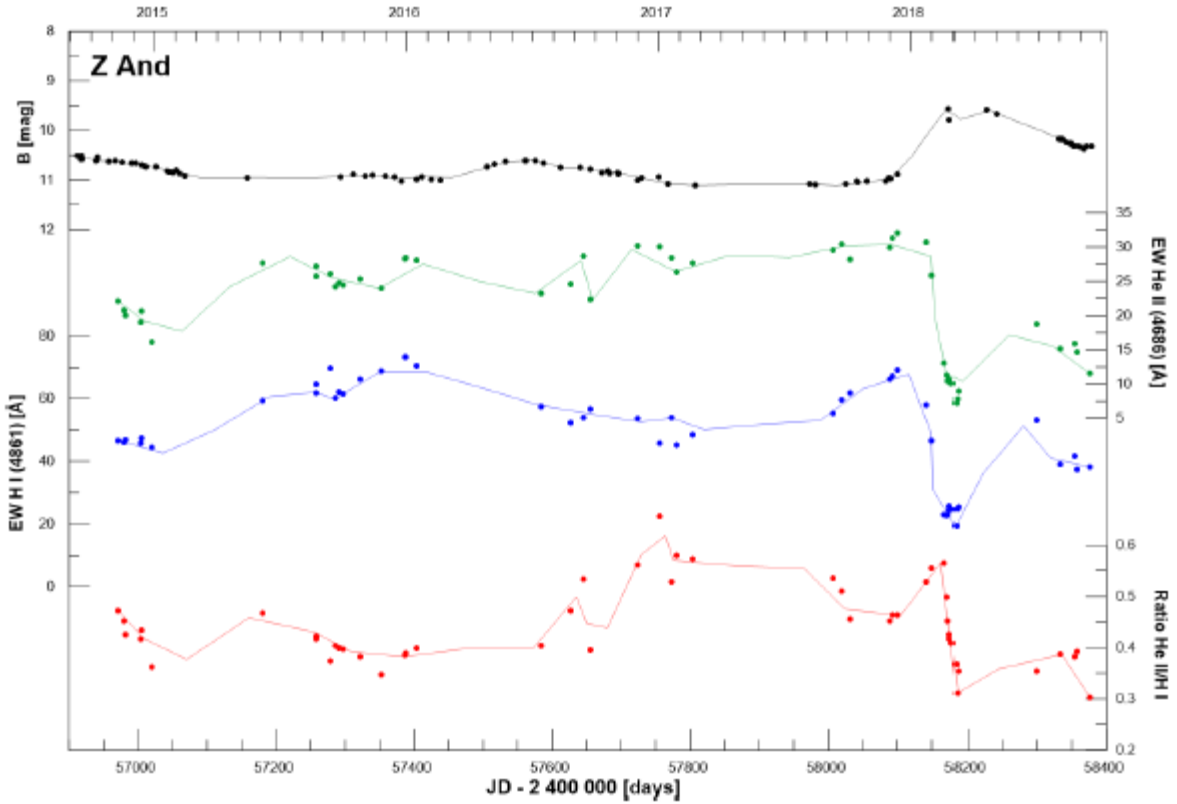
Merc & al., 2019

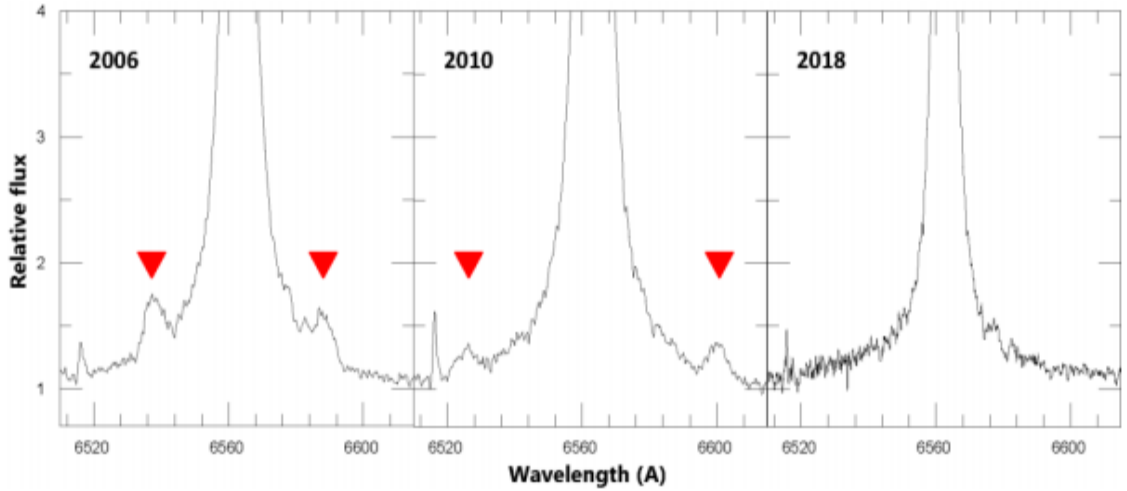
Proceedings of the 50th Conference on Variable Stars Research, vol. 197, 2019



V Mag in 2018
Sekeras & al. (2019)

Significant decline of EW
Drop of the temperature (145 to 129 10^3 K)

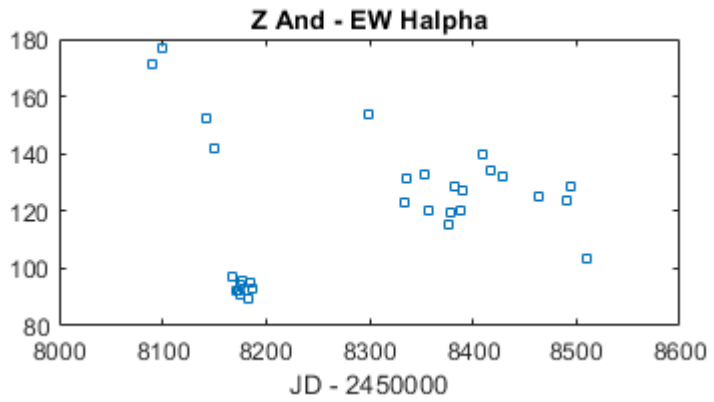


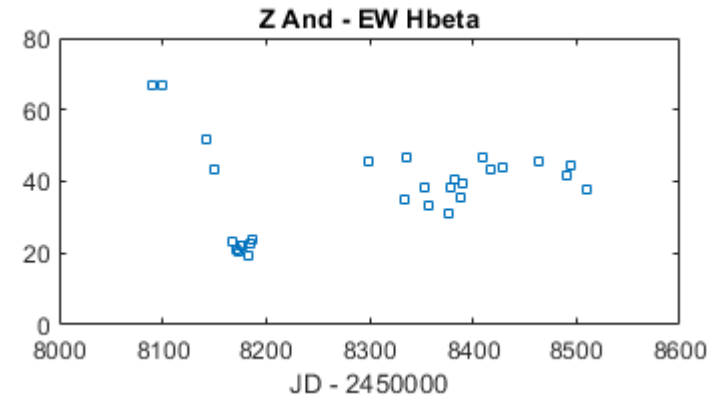


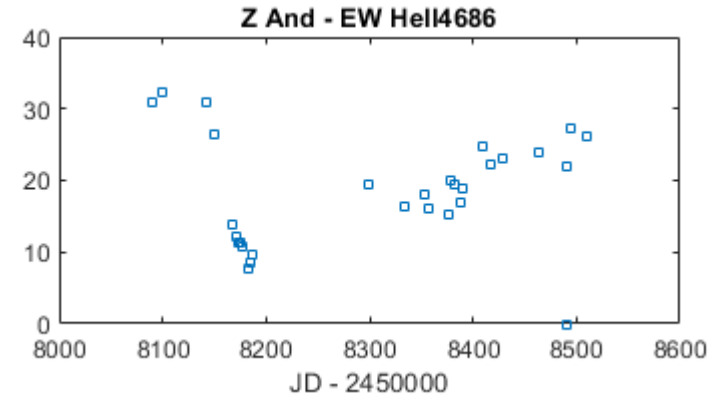
Satellite components during 2006 & 2010 outbursts (bipolar jets)
No detection in 2018

Each outburst is different
and must be studied to constraint the models

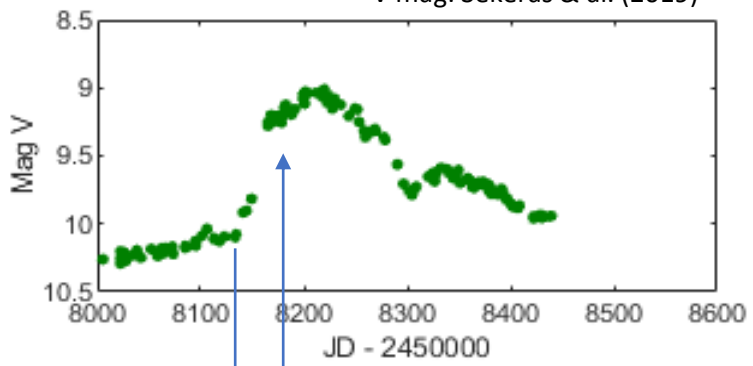
Symbiotic stars monitoring: Z And 2018 outburst

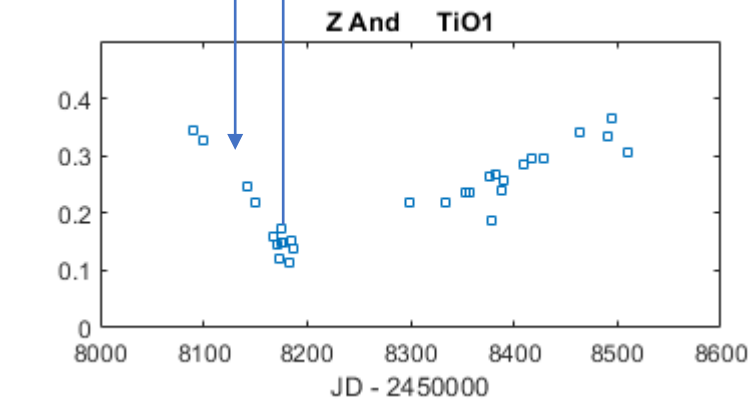






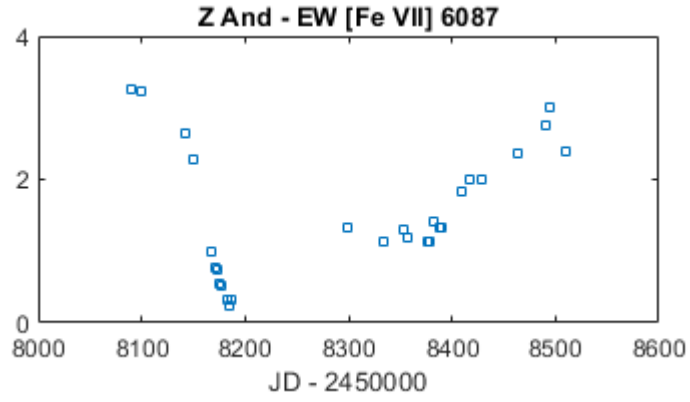
V mag: Sekeras & al. (2019)

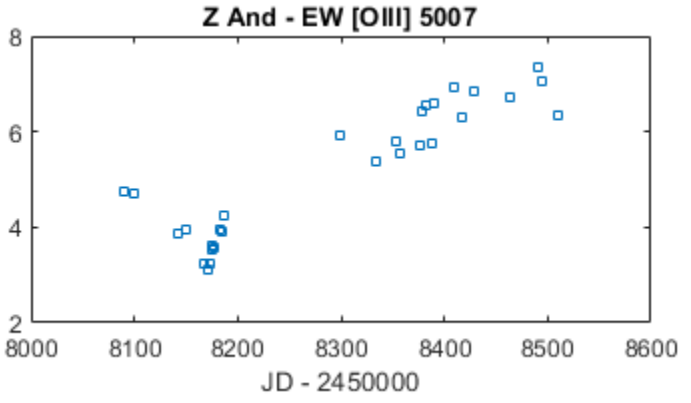


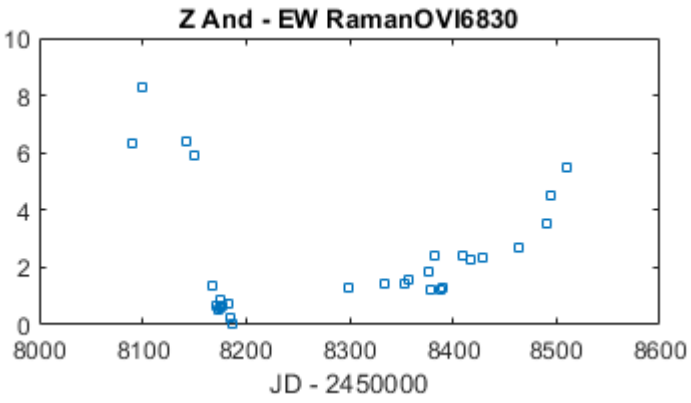


TiO1 gradually fades
HeII decreases strongly
High ionization lines disappear

Echelle spectra
J. Guarro (R = 9000)
T. Lester (R = 13000)
F. Teyssier (R =11000)





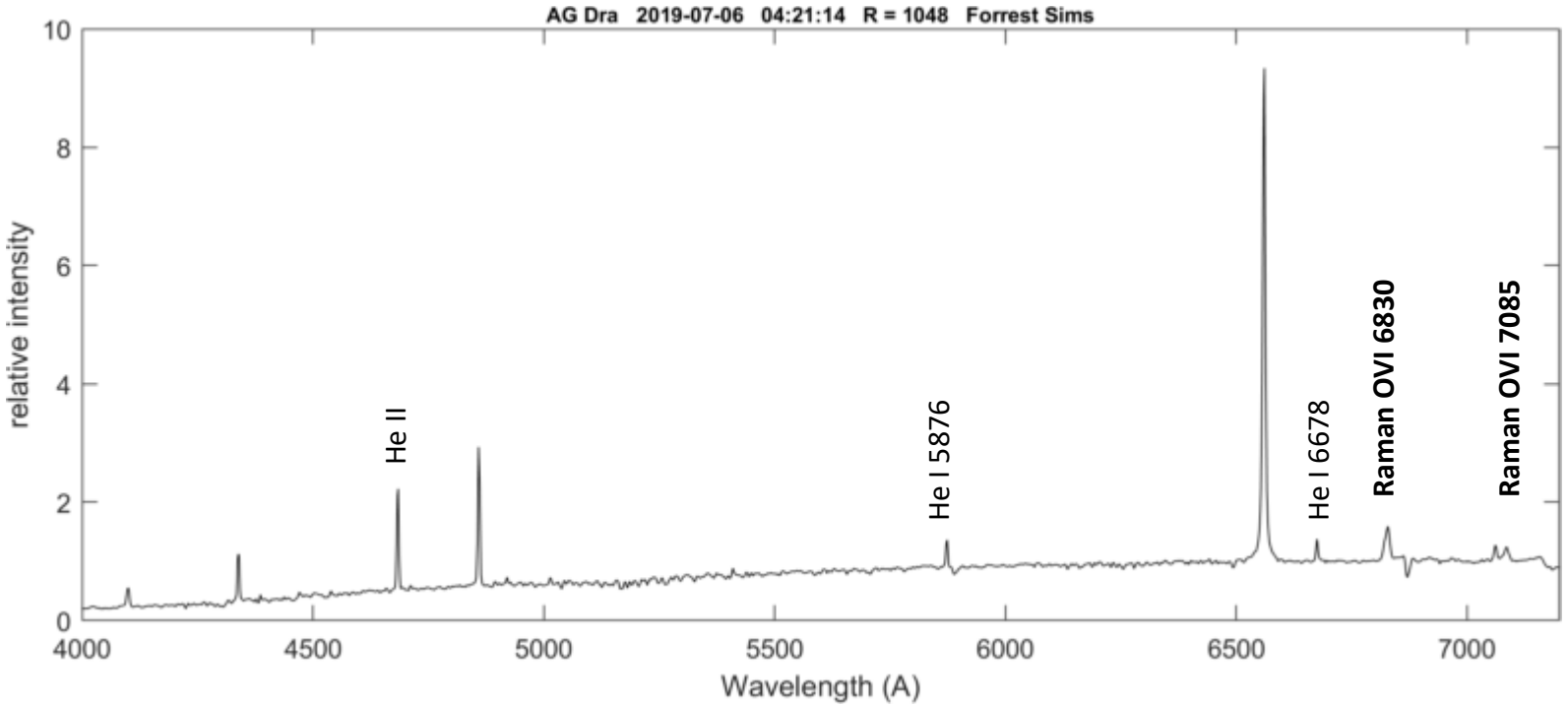


AG Dra

Yellow symbiotic

Low metallicity, pulsating K3III

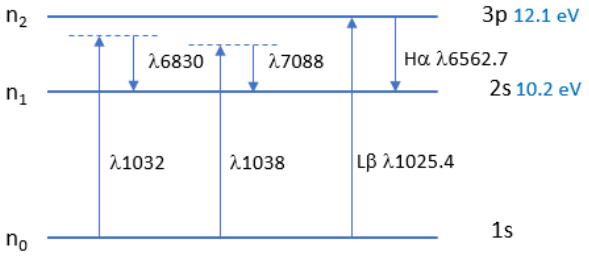
T_{WD}	100 - 150 10^3 K	
L_{WD}	$L_\odot$	
M_{WD}	0.5 $M_\odot$	
$\dot{M}_{WD}$	< 2.10^{-8} $M_\odot$/y	Seaquist & al. (1993)
Sp. type	K0-3 III	
M_{RG}	1 $M_\odot$	
P_{pulse}	~ 355 d	
P_{orb}	548.6	Fekel & al. (2000)
e	0	Fekel & al. (2000)
i	40 – 70°	
d	pc	Gaia DR2



AG Dra

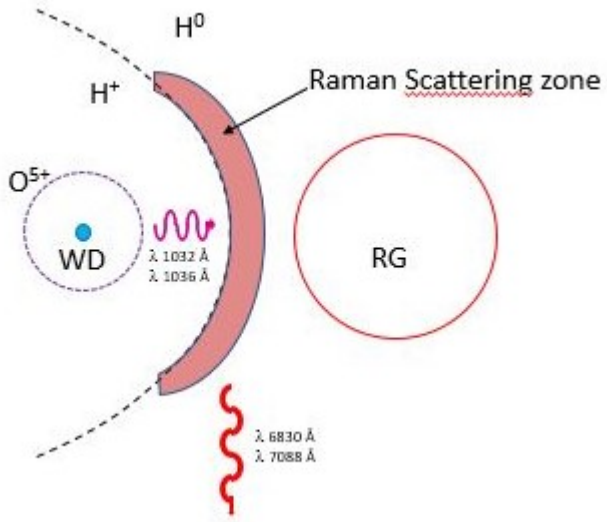
Raman OVI λλ 6830, 7085

Mysterious lines marked « ? » in number of publications before 1990
Identified as Raman scattering of OVI λλ 1032, 1036 by H^0
in 1990 by Schmid
Characteristic of Symbiotic Stars (Belckzinski & al., 2000)

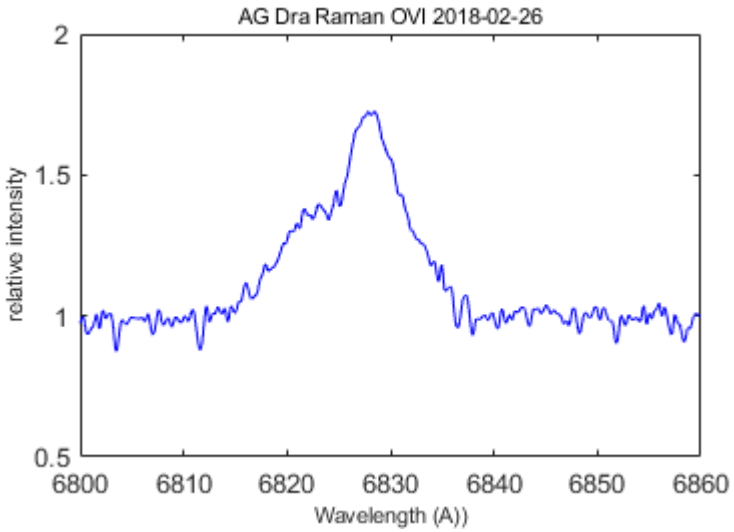


Specific physical conditions:

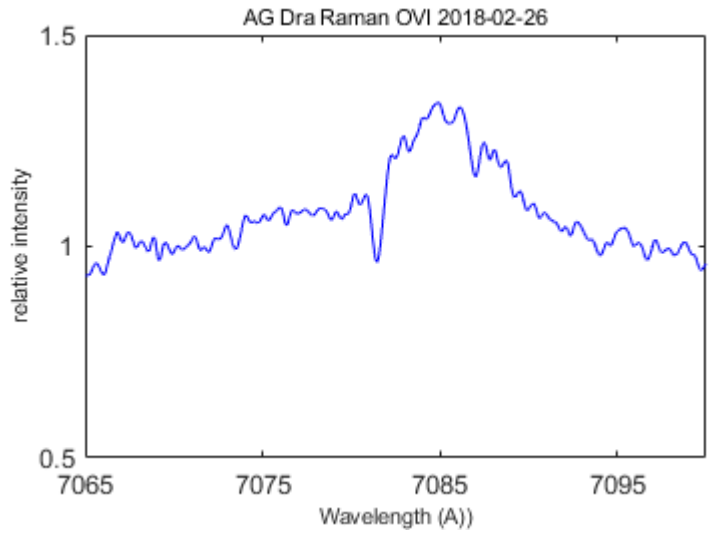
- presence of a hot radiation source (O^{5+})
- enough neutral hydrogen atoms



Double, triple peaked
→ Motion of the emission and/or Scaterring zone



Raman OVI λλ 6830



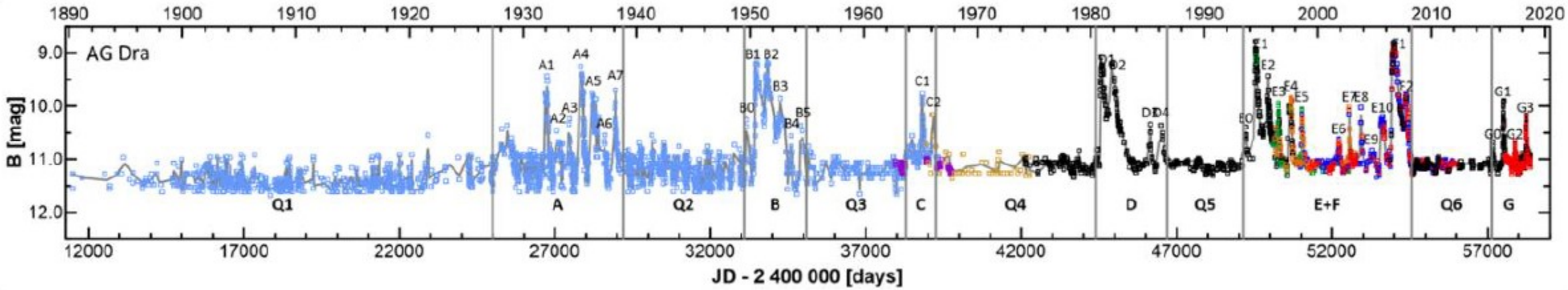
Raman OVI λλ 7085

Symbiotic stars monitoring: AG Dra Outbursts and Quiescent states

AG Dra

Collaboration: J. Merc, R. Gàlis, Leedjarv

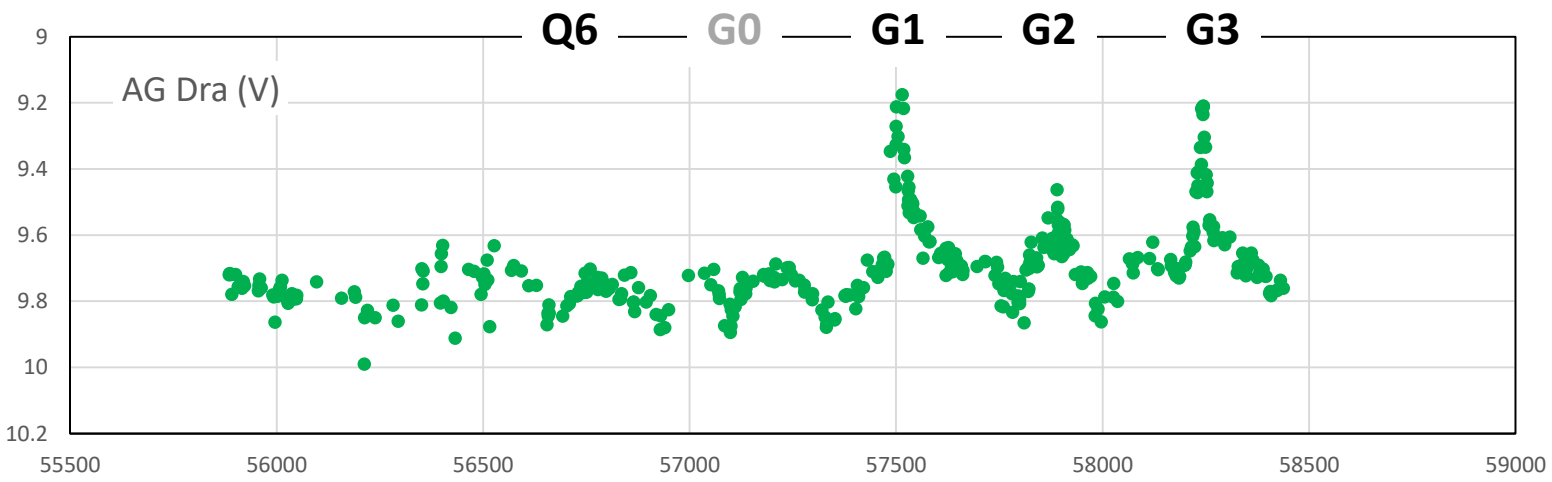
Outburst monitoring
Orbital variations



Historical light curve since 1890 (Gàlis & al., 2019)

Quescient phases (Q)
Active phases (A→ G)

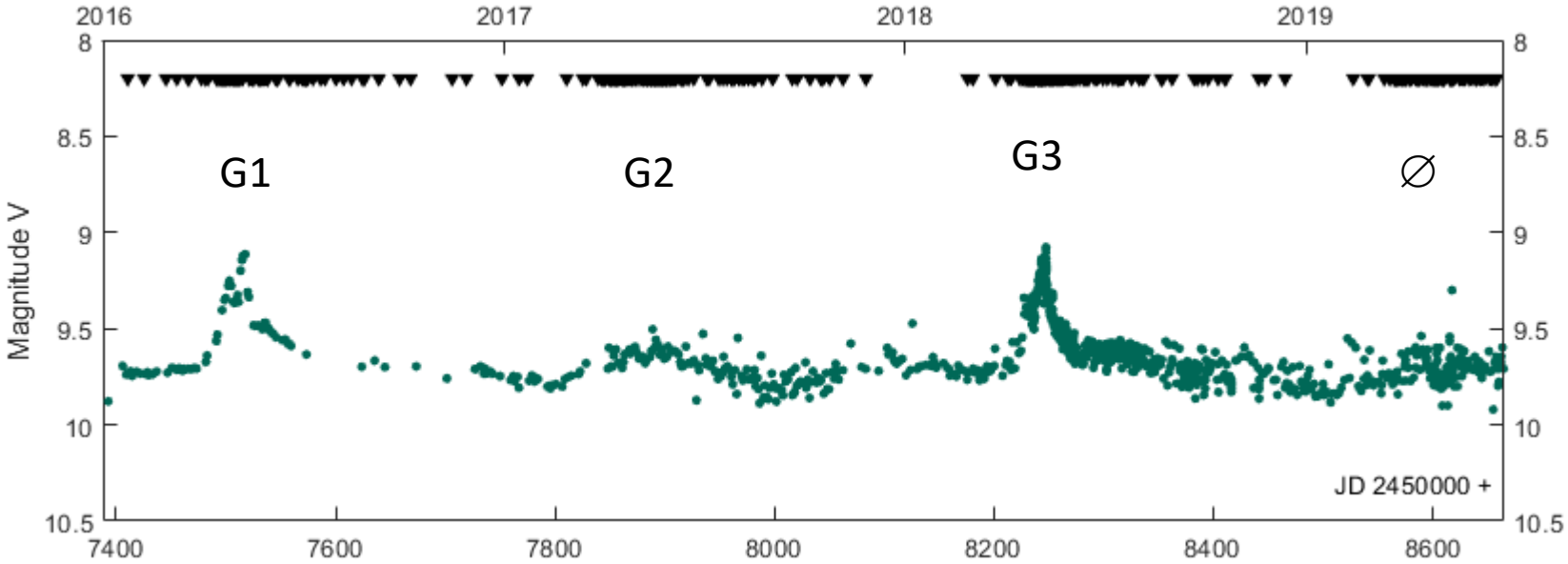
Two periods:
550 days: orbital motion
355 days: pulsation of the RG
(Hric & al., 2014 – Gàlis & al., 2019a)



Symbiotic stars monitoring: AG Dra Outbursts and Quiescent states

AG Dra

550 spectra obtained since 2015
Resolution 500 to 15000



Current series of 4 outbursts
Spaced by ~ 330-360 days
~ pulsation of the giant
Data : V in Sekeras & al., 2019
No outburst detected in 2019

Two types of outburst in AG Dra

Cool outburst Decrease of the temperature (10-25%)
= expension (R_{wd} x 2-6) /cooling of the WD
Longer and brighter

Hot outburst Increase of the temperature of the WD at ~ constant radius
Longer and brighter

« The variety of behaviours cannot be fully described
because of the **scarcity of the observations during the early stage** of the outburst »

Gonzales-Riestra & al. (1999):

	T_{hot}	R_{hot} [$R_\odot$]	L_{hot} [$L_\odot$]
Quiscence	110 000 K	0.08	930
Cool burst	86-96 000 K	0.25-0.45	5600-10200
Hot burst	115-131 000 K	0.11-0.14	3400

Symbiotic stars monitoring: AG Dra Outbursts and Quiescent states

AG Dra

Analysis of ARAS Spectra (Gàlis & al., 2019b)

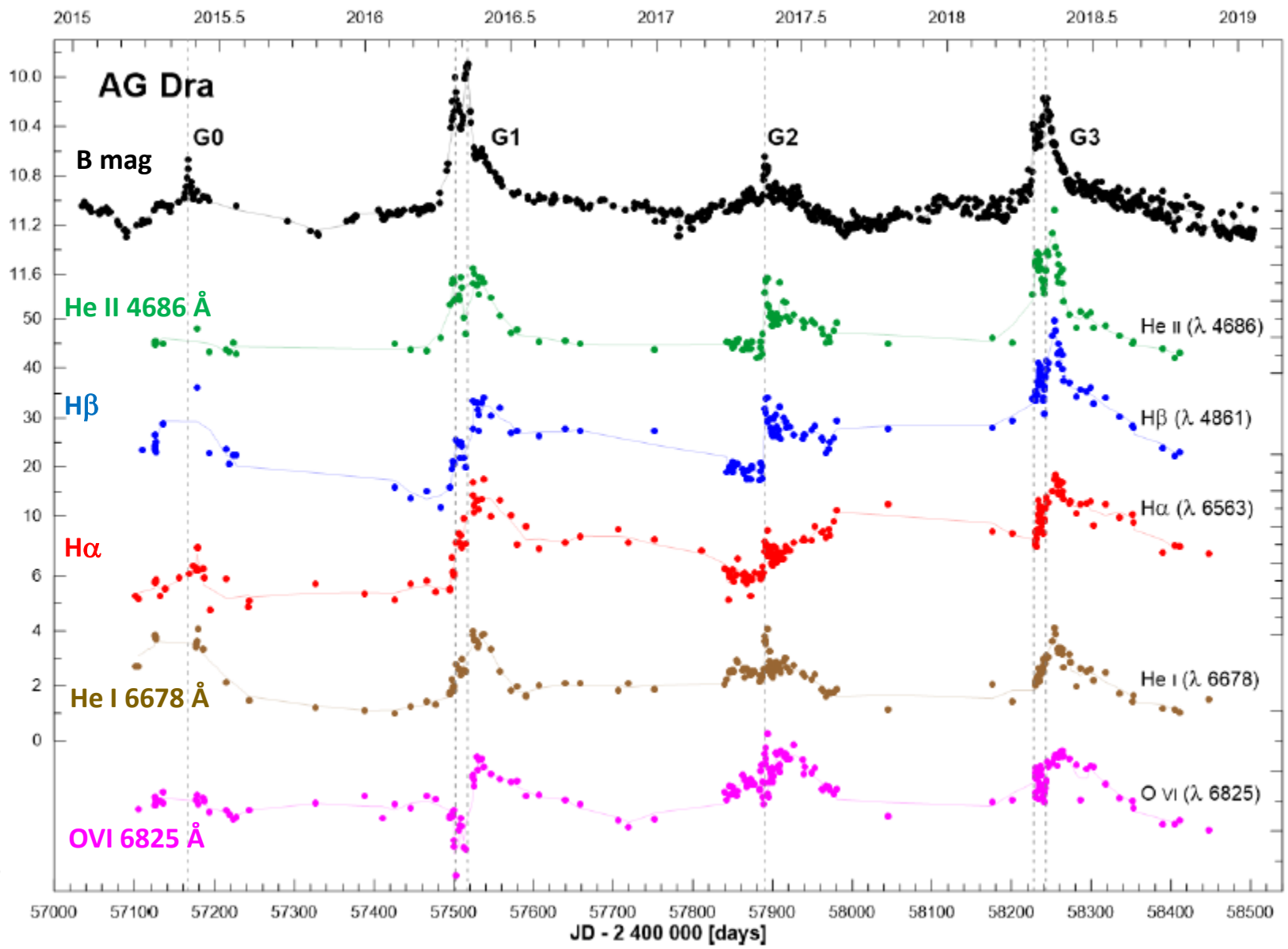
ARAS 278 spectra from April 17, 2014 to November 24, 2018
Tartu Observatory (4 spectra, 1.5-m telescope, R = 6000 and 7000)
Ondřejov (16 spectra, 2.0-m telescope, R = 13000).

The spectroscopic observations of AG Dra were acquired by ARAS Group observers mostly in the framework of two observing campaigns which we initiated and coordinated in 2017 and 2018.

Increase of the EW of the lines
(including Raman OVI)
Absorption component disappears in HI, HeI
→ **« Hot» outbursts**

But, especially G1:
Drop of Raman OVI

- new type of outburst
- some kind of transition between
- or combination of the *hot* and *cool* outbursts?



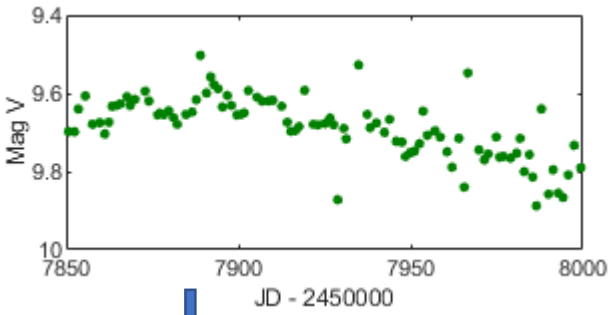
Symbiotic stars monitoring: AG Dra Outbursts and Quiescent states

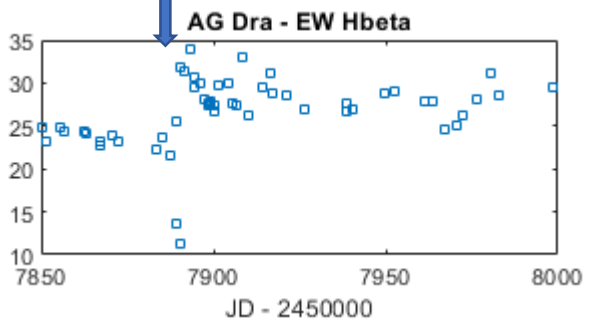
AG Dra

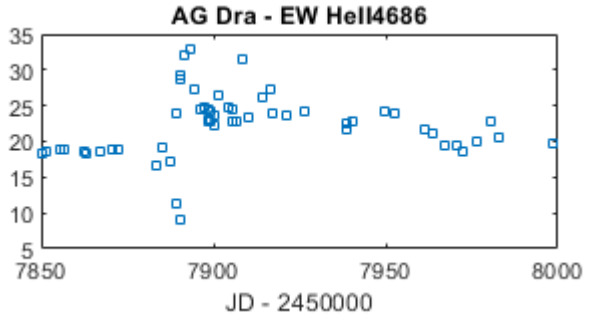
The fourth outburst during the present active stage of symbiotic binary AG Dra

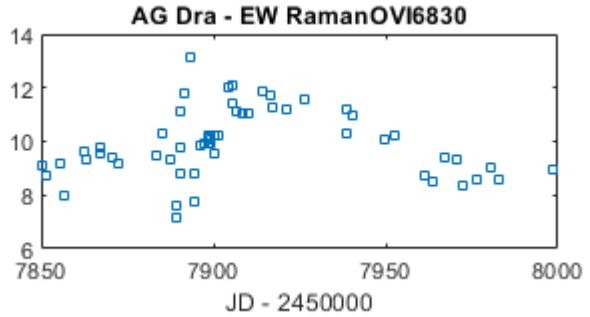
ATel #11559; *R. Galis, J. Merc (UPJS in Kosice), M. Vrastak (CAS), F. Teyssier, T. Lester, D. Boyd, W. Sims (ARAS Group), L. Leedjarv (Tartu Observatory)*
on 22 Apr 2018; 14:23 UT
Credential Certification: Rudolf Galis (rudolf.galis@upjs.sk)

G2 2017

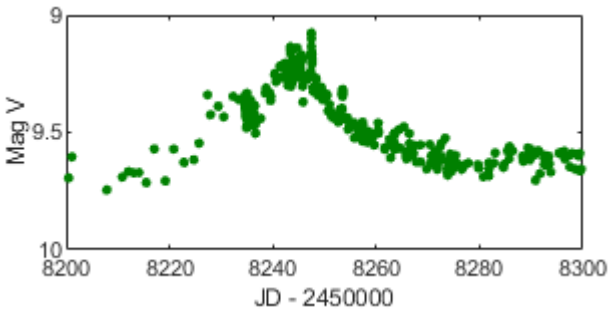


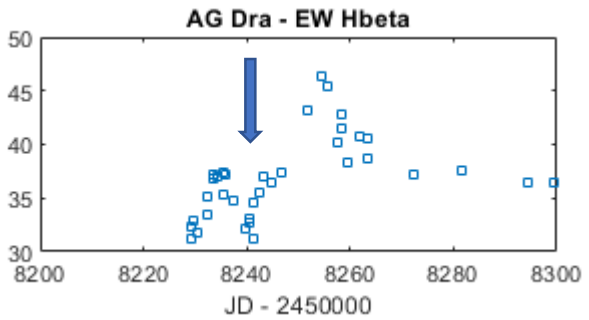


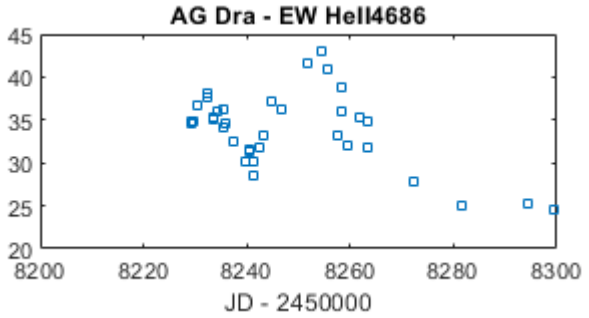


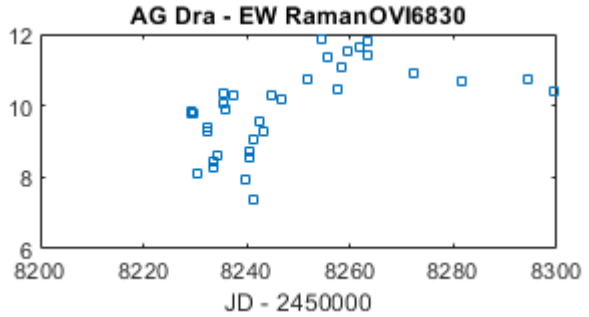


G3 2018





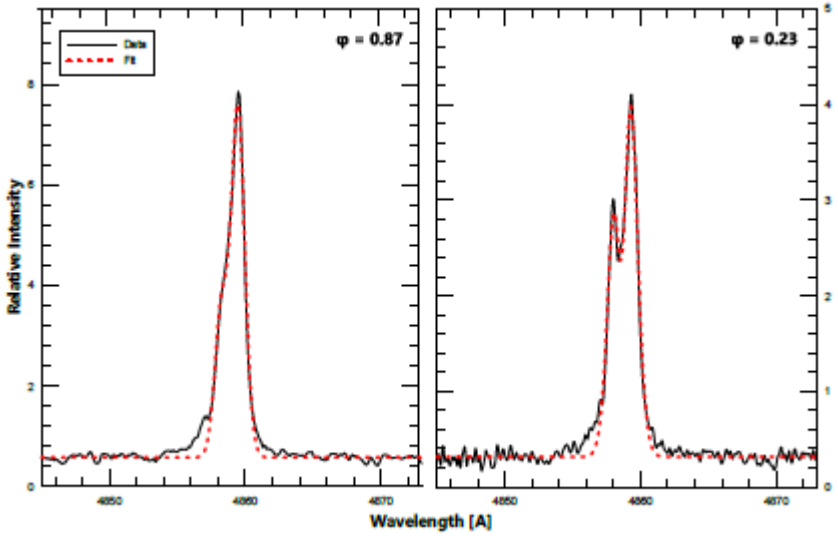


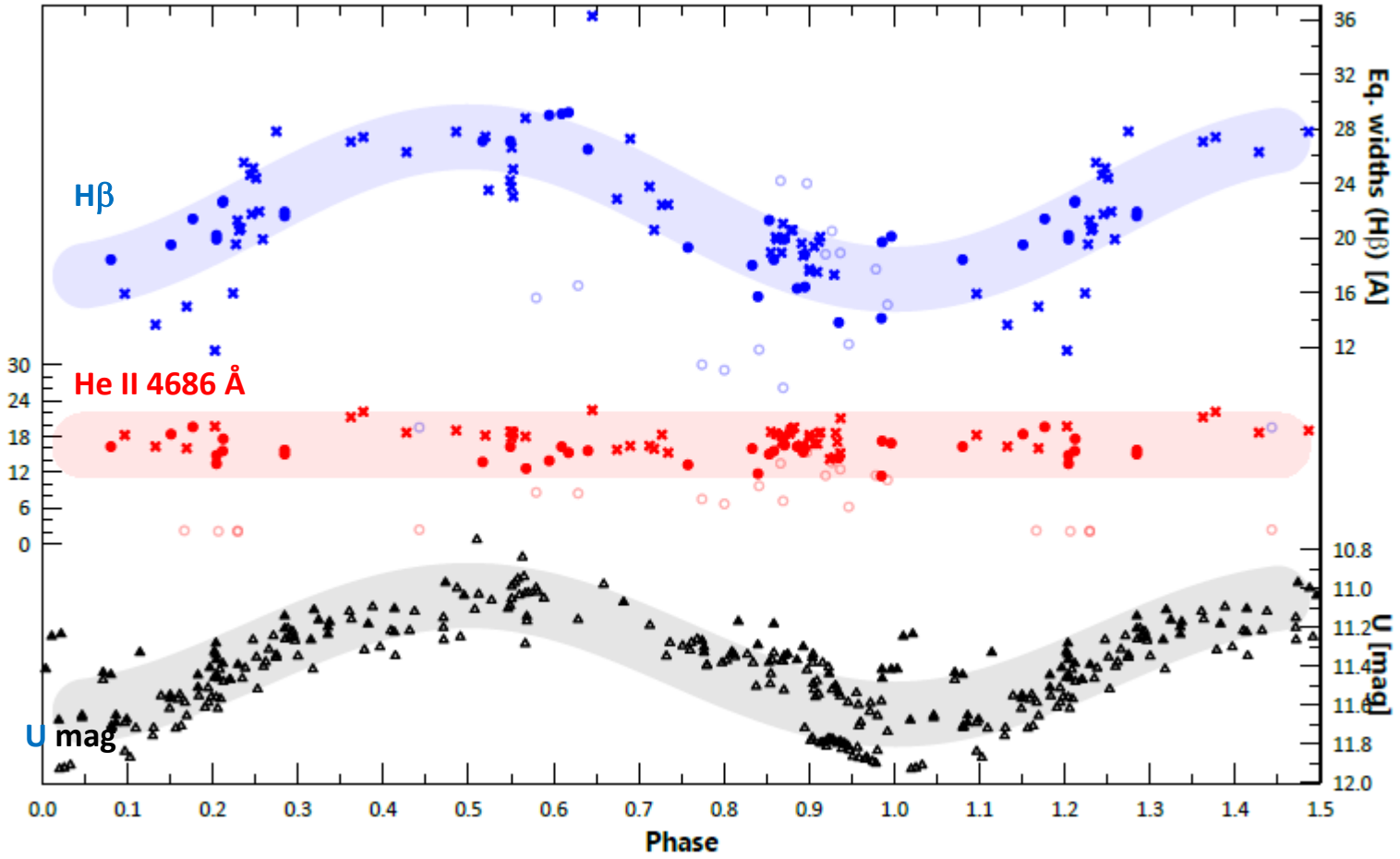


Symbiotic stars monitoring: AG Dra Outbursts and Quiescent states

AG Dra

Merc & al., 2019





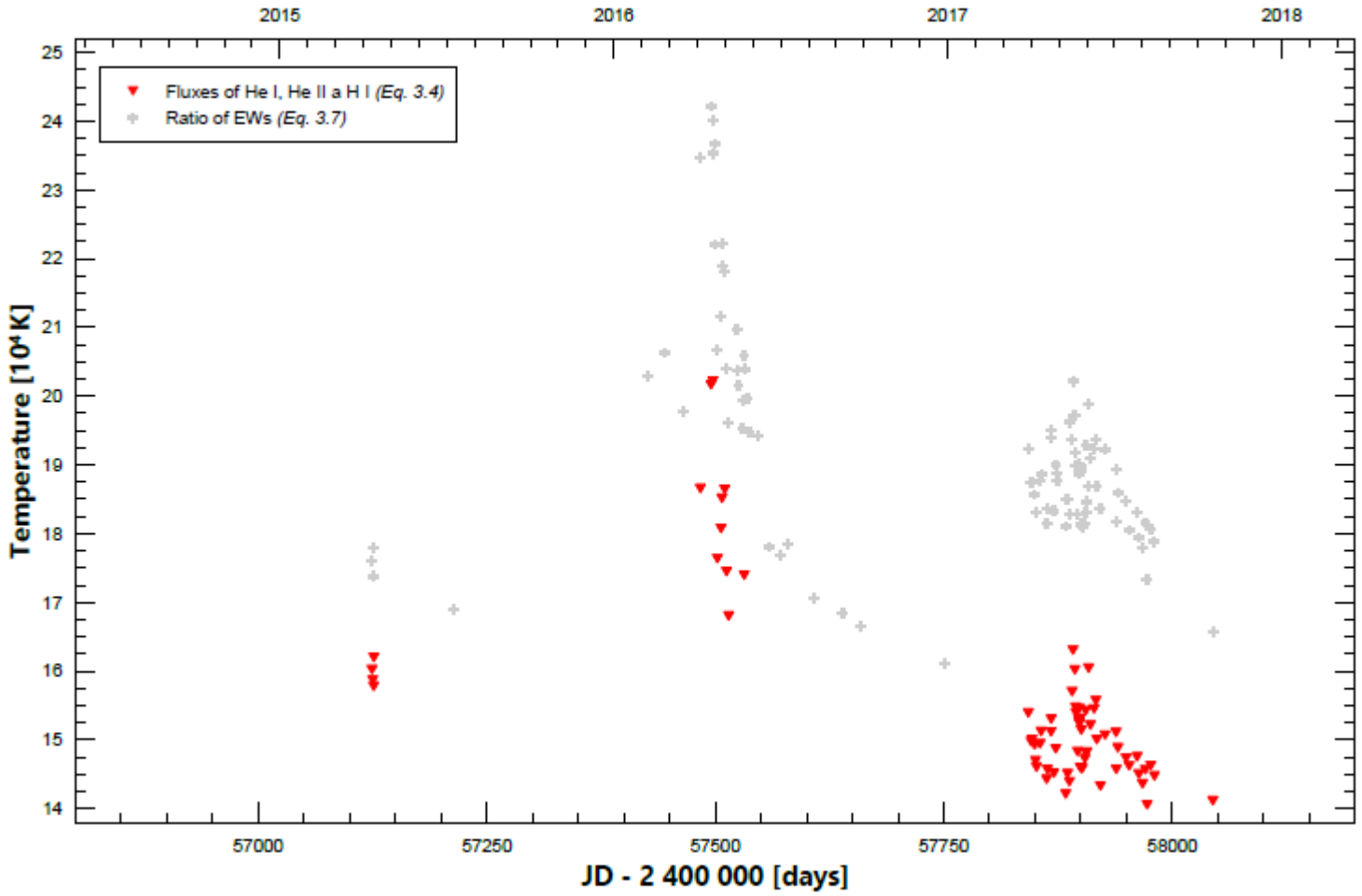
AG Dra

Recent outburst activity of the symbiotic binary AG Draconis

Merc & al., 2019

Evaluation of the temperature of the hot component

- ☐ Fluxes
- ☐ EW

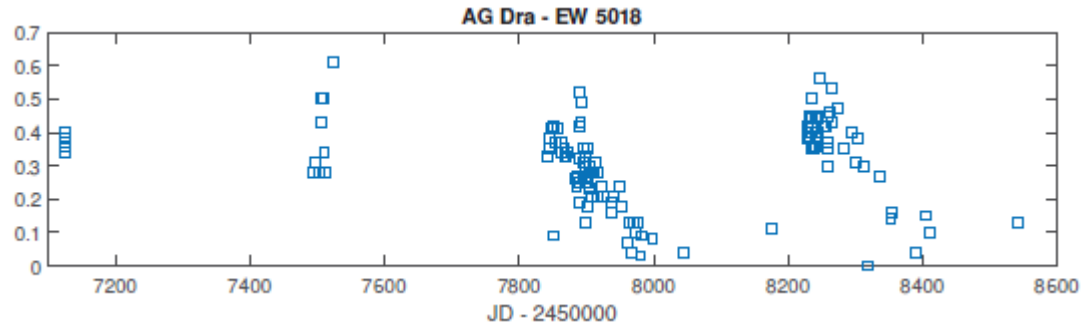


Symbiotic stars monitoring: AG Dra Outbursts and Quiescent states

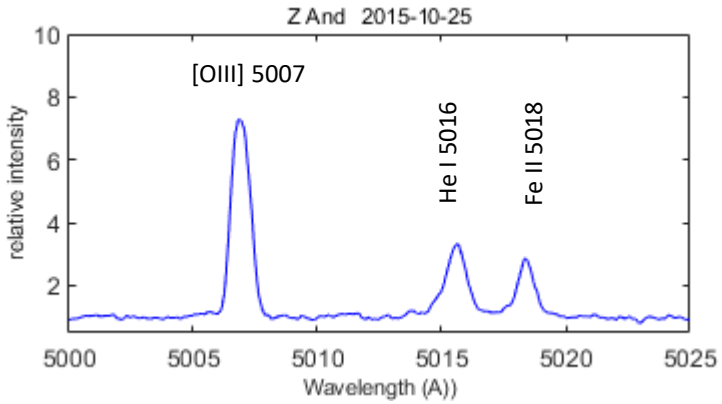
AG Dra

Mysterious λ 5018 line detected during outbursts

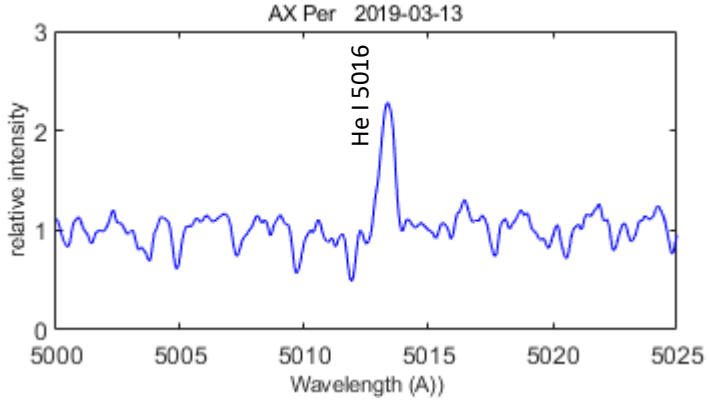
Appears during outbursts
Similar shape to He I λ 5016
Same variation of the EW



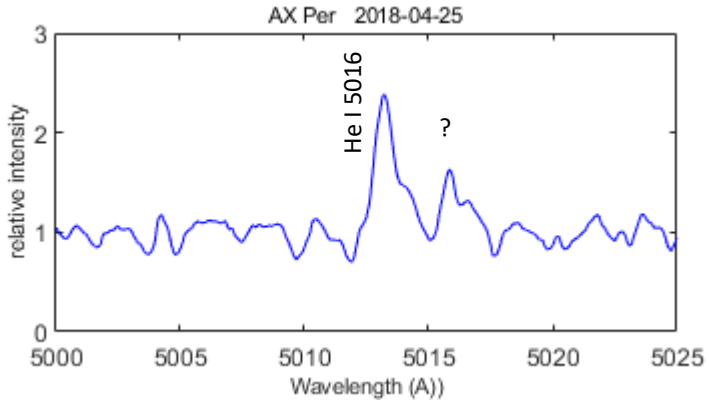
Classical [OIII] range for a symbiotic with normal red giant



Quiescence



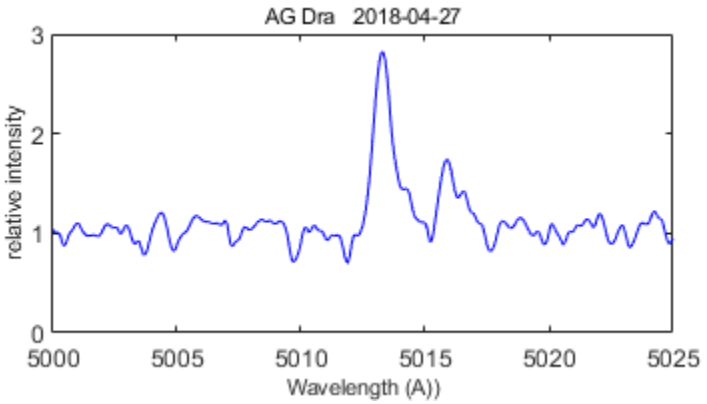
Outburst



Symbiotic stars monitoring: AG Dra Outbursts and Quiescent states

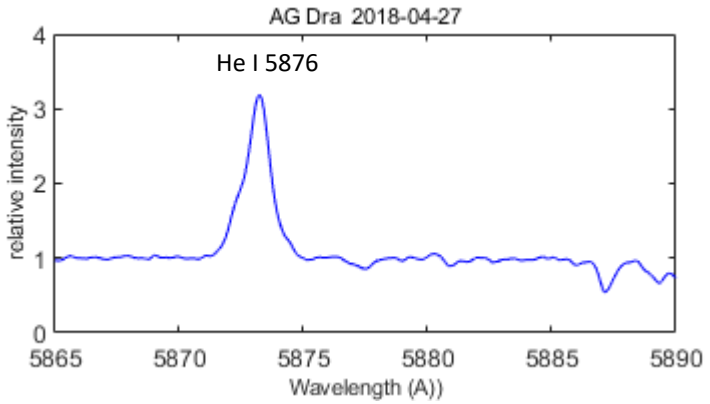
AG Dra

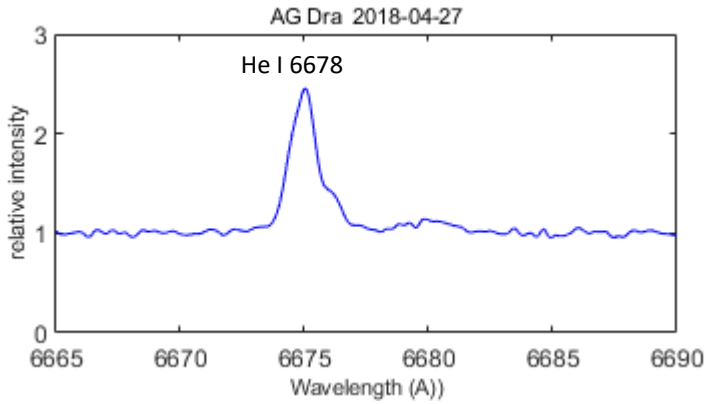
Mysterious λ 5018 line detected during outbursts



He I λ 5016 satellite component:

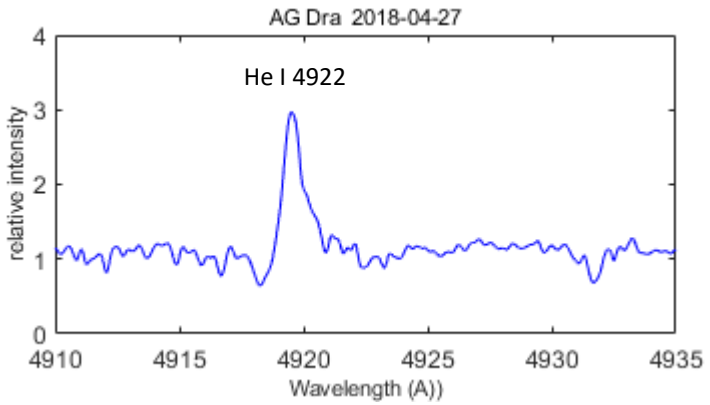
1. no blue shifted counterpart
2. missing in the other He I lines



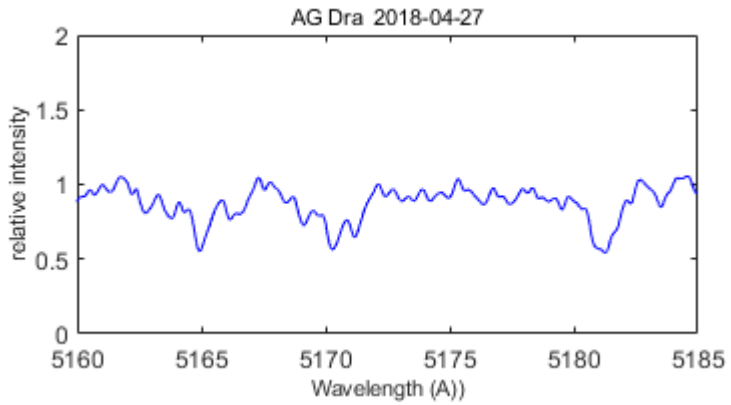


Fe II (42) λ 5018:

missing in the other lines of the multiplet



Fe II (42) 4924 Å



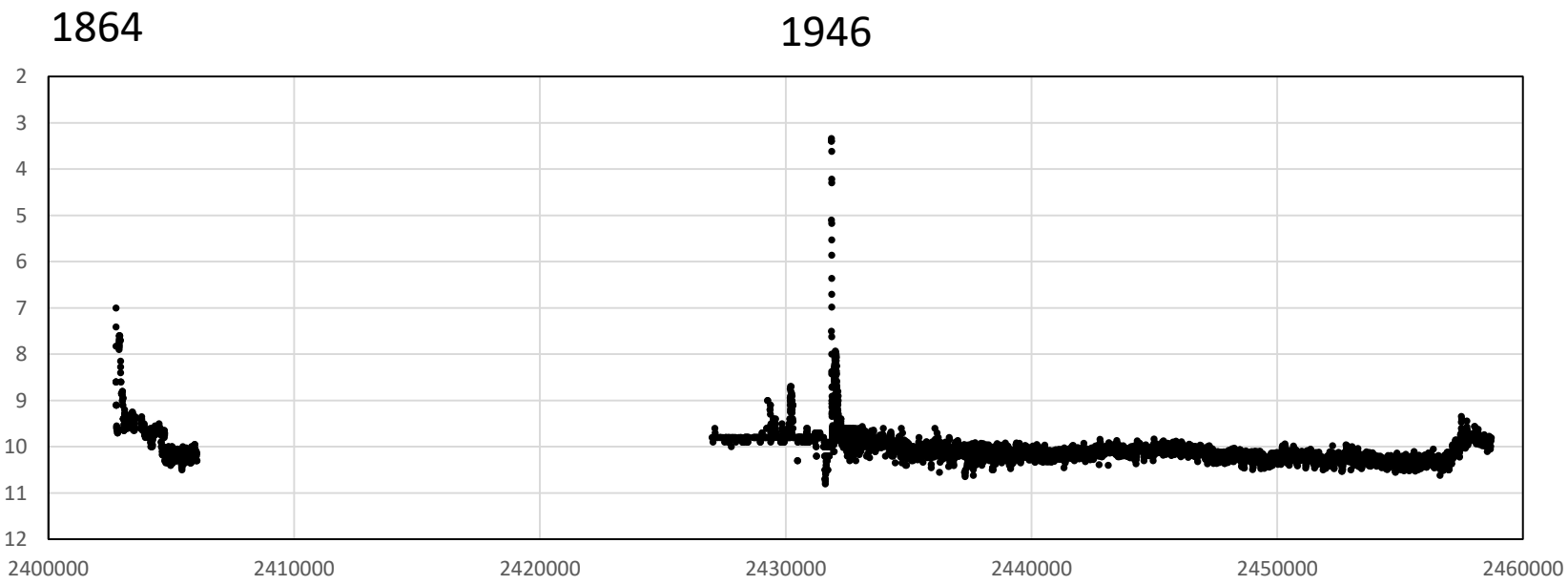
Fe II (42) 5169 Å

Symbiotic stars monitoring: T CrB before nova event

T CrB

Recurent symbiotic nova

T_{WD}		
L_{WD}	40 – 100 $L_{\odot}$	
M_{WD}	1.37 (0.13)	Stanishev 2004
Sp. type	M3III-M4III	
M_{RG}	1.12 (0.23)	
P_{orb}	227.55 d	Fekel & al. (2000)
d	pc	Gaia DR2

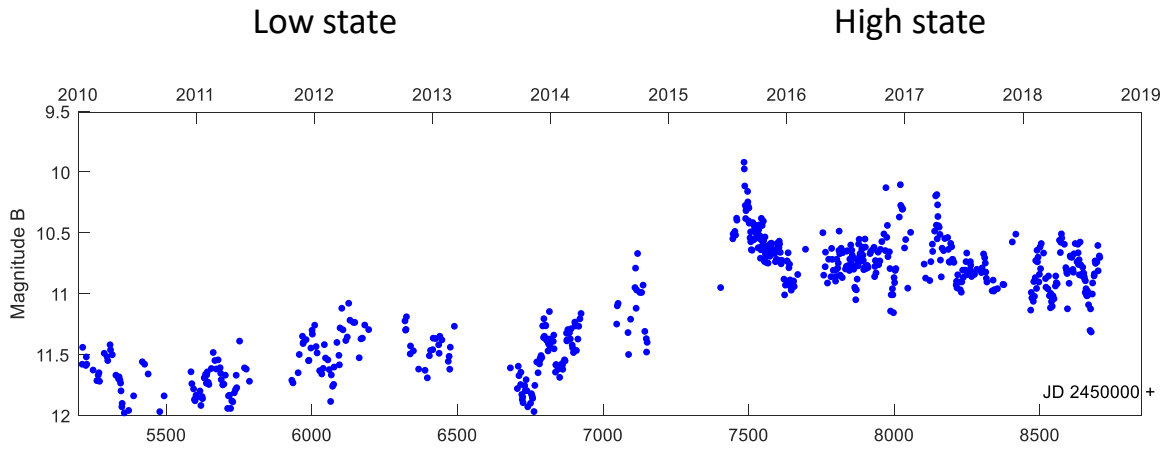


AAVSO Visual lightcurve

M_{WD} near Hhandrashekar limit
RG filling its Roche Lobe
Accretion Disk (very likely)

T CrB

T CrB high state since 2015
(see e.g. Munari & al., 2016)

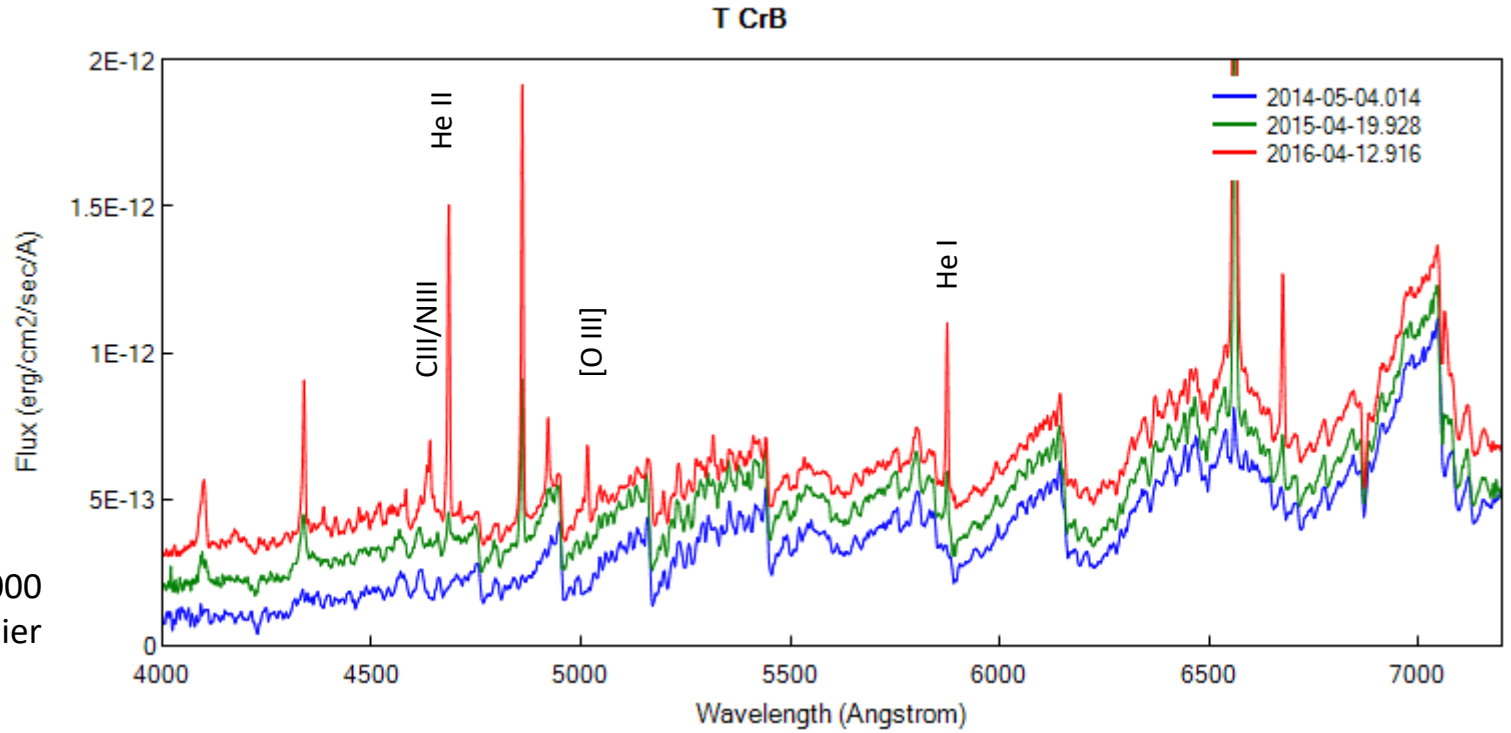


AAVSO B band lightcurve – 1 day mean

- Low state : MIII + weak Balmer lines
- High state

Increase of

- Balmer, He I
- He II, CIII/NIII, [OIII]



LISA spectroscope R = 1000
D. Boyd, F. Teyssier

T CrB

Collaboration:
Ilkiewicz, Mikolajewska

Active phase

Active phases and flickering
of a symbiotic recurrent nova T CrB
K. Ilkwievicz
MNRAS, 2016

Based on ARAS Spectra and

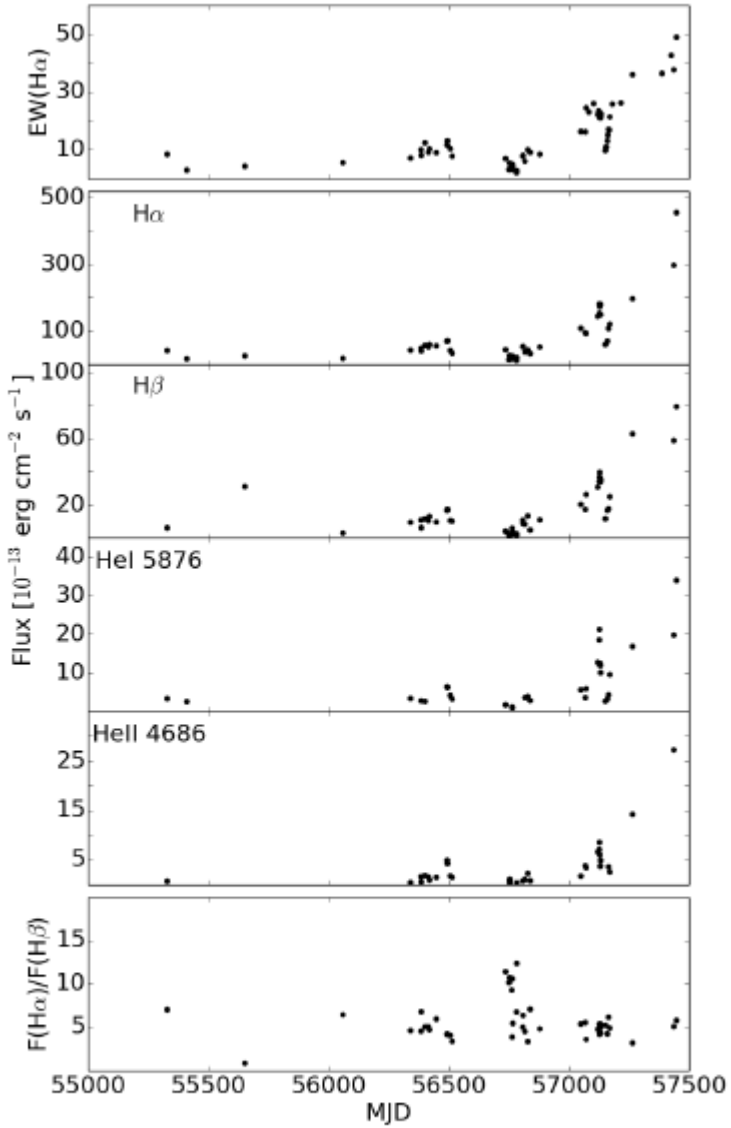


Figure 1. Variability of the equivalent width of Hα, other selected emission line fluxes and the Hα to Hβ flux ratio.

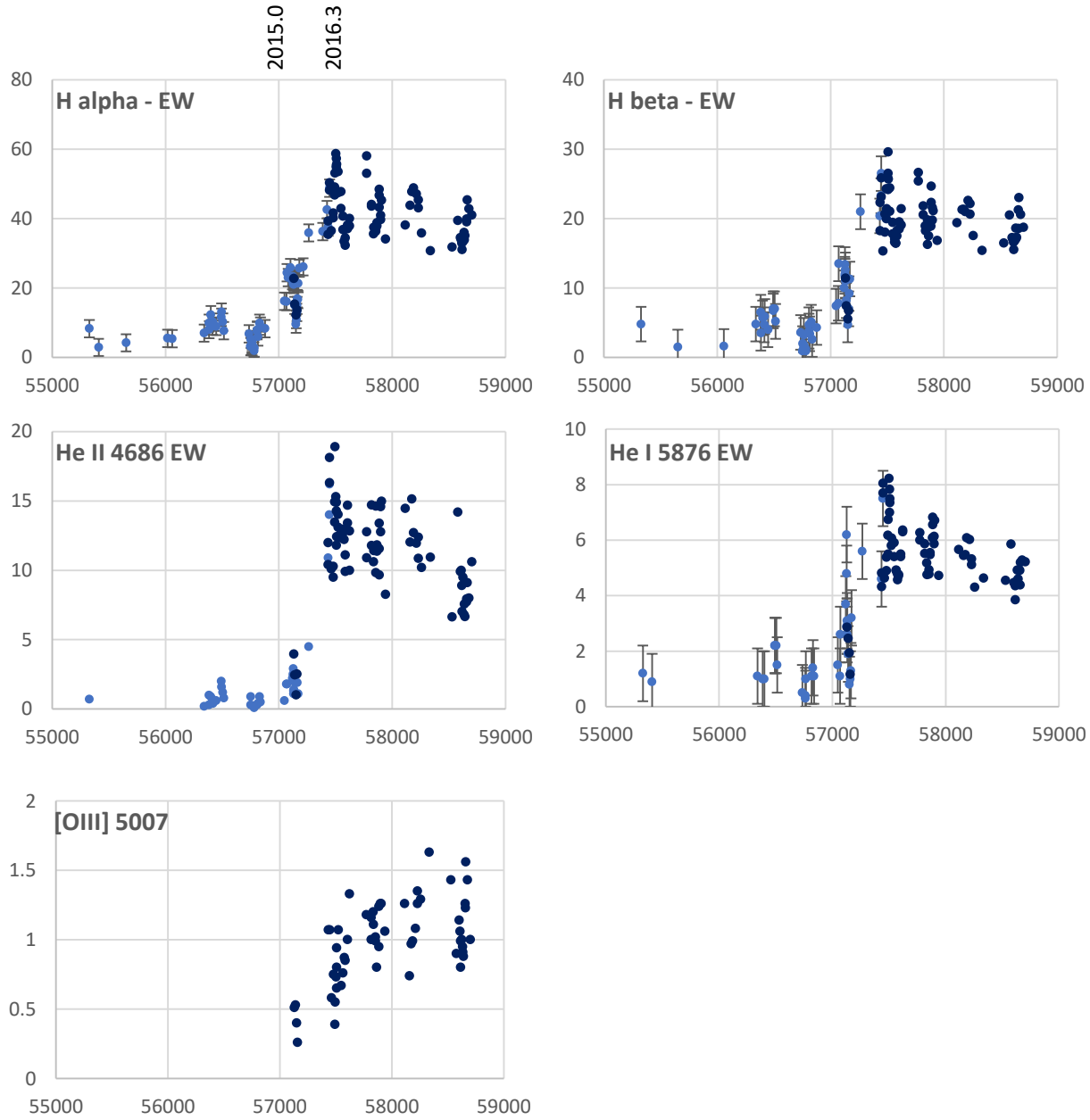
T CrB

Max EW(Hα) = 60

Continuing analysis following Ilkiewicz & al. (2016)

Pale blue: published values
Dark blue: our analysis

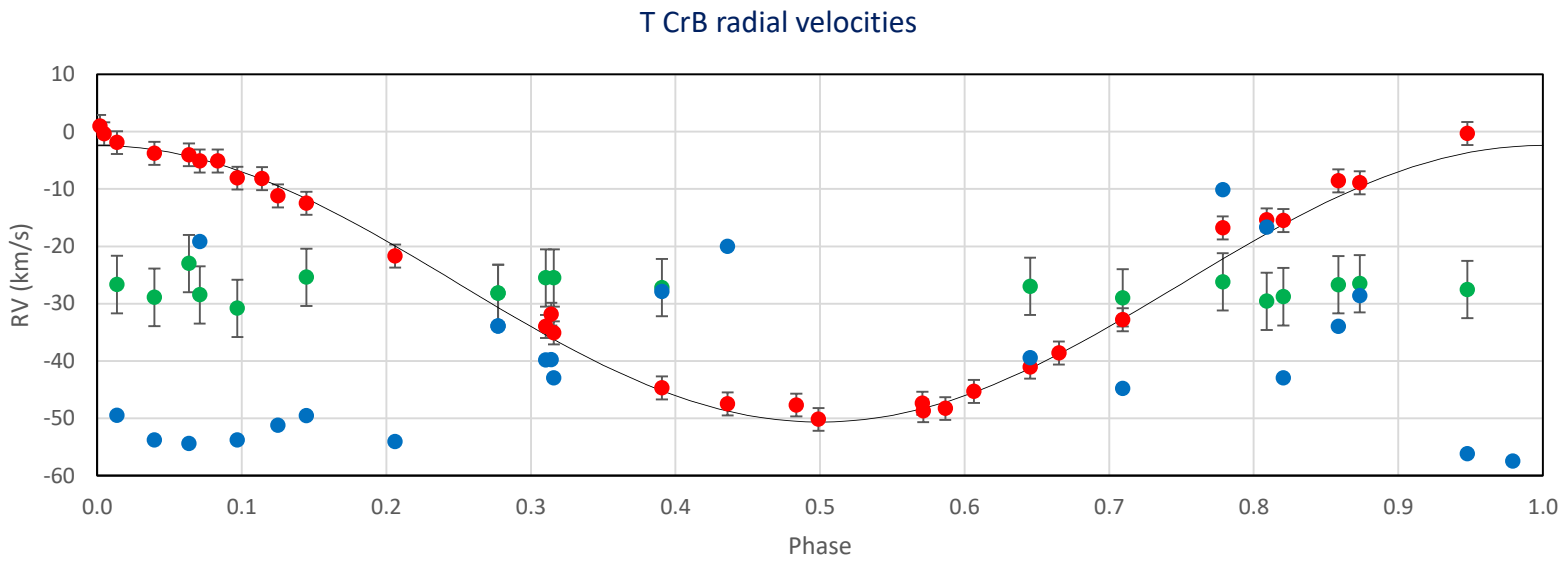
Global trend of decline
In parallel to the fading of the luminosity
BUT
Increase of [OIII]



T CrB

Orbital elements

31 spectra
2015-2019



- RG
- [OIII] 5007: constant - mean = 27.4 km.s^{-1}
- He II: attempt, unsuccessfull

Parameter	ARAS 2019
P (days)	227.27
T_0 (HJD)	2457021.3 +/- 0.4
K_1	24.2 +/-0.3
e	0.0
a_1 sin i (km)	75.7 +/- 1.2 10^6
f(m)	0.34 +/- 0.02

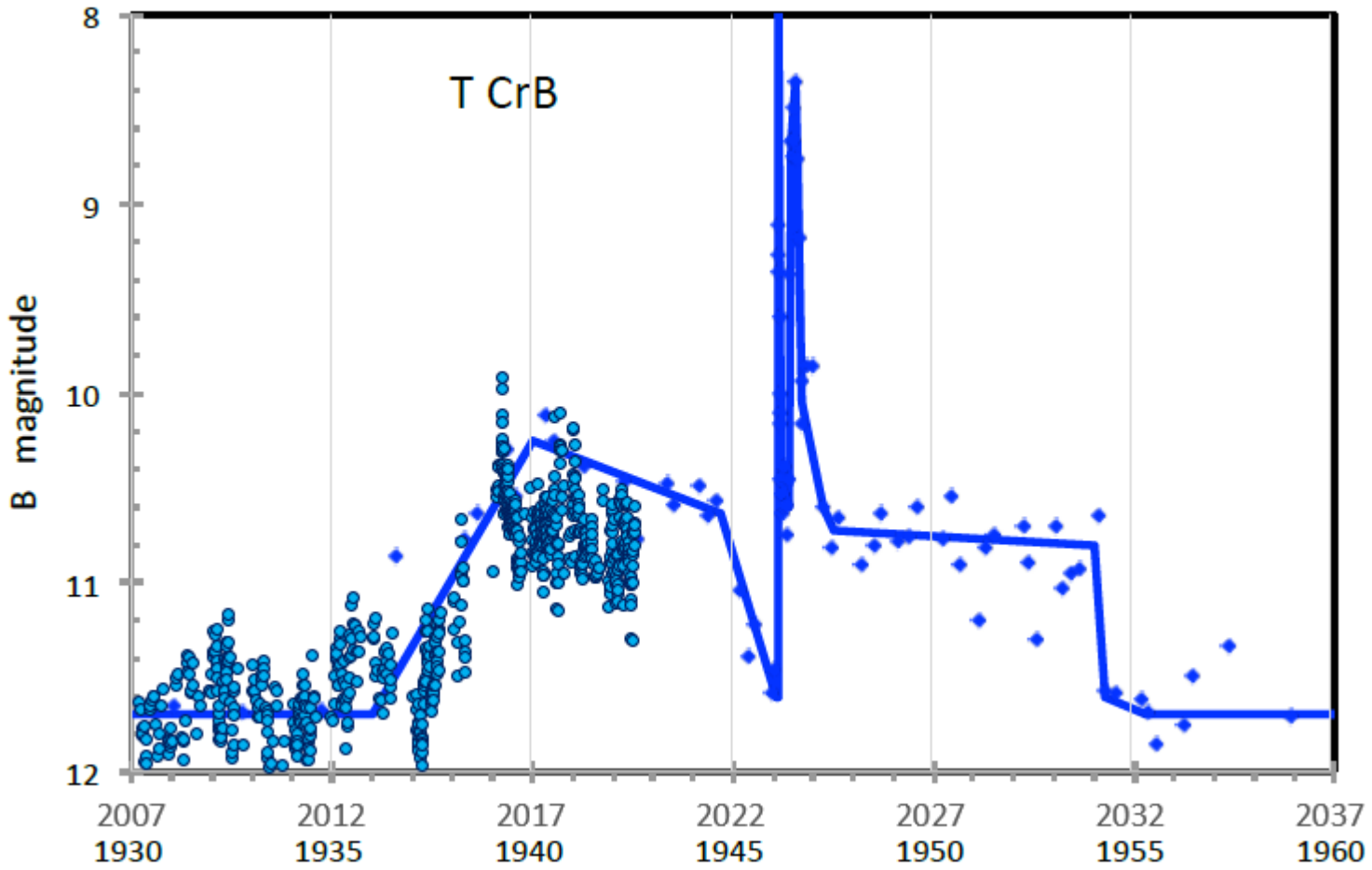
Orbital Elements of T Coronae Borealis

Parameter	Kenyon & Garcia 1986	KPNO-Data Solution	Final Solution
P (days)	227.53 ± 0.02	227.53 (fixed)	227.5687 ± 0.0099
T_0 (HJD)	2,431,990.71 ± 0.13	2,451,104.6 ± 0.3	2,447,918.62 ± 0.27
γ (km s^{-1})	−27.89 ± 0.06	−27.9 ± 0.2	−27.79 ± 0.13
K_1 (km s^{-1})	23.32 ± 0.16	24.2 ± 0.2	23.89 ± 0.17
e	0.0	0.0	0.0
ω_1 (deg)	...	...	...
$a_1 \sin i$ (km)	73.0 ± 0.6 × 10^6	75.9 ± 0.7 × 10^6	74.77 ± 0.53 × 10^6
$f(m)$	0.299 ± 0.006	0.34 ± 0.01	0.3224 ± 0.0068

Fekel & al., 2000

T CrB

Pre-nova outburst monitoring



Adapted from Brad Shaeffer

Diamonds : 1946 Brad Shaefer data

Dots : AAVSO B band - 1 day mean

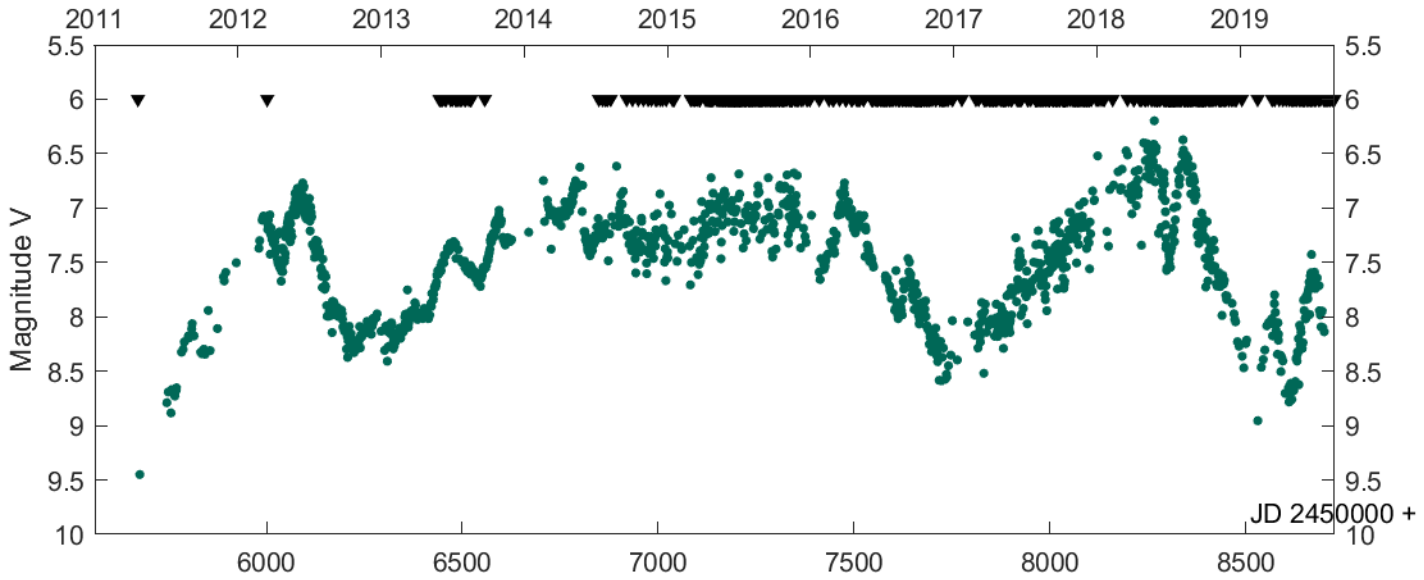
Outburst predicted : 2023.6 +/-1

CH Cyg

Collaborations:
M. Karovska
A. Skopal
G. Luna

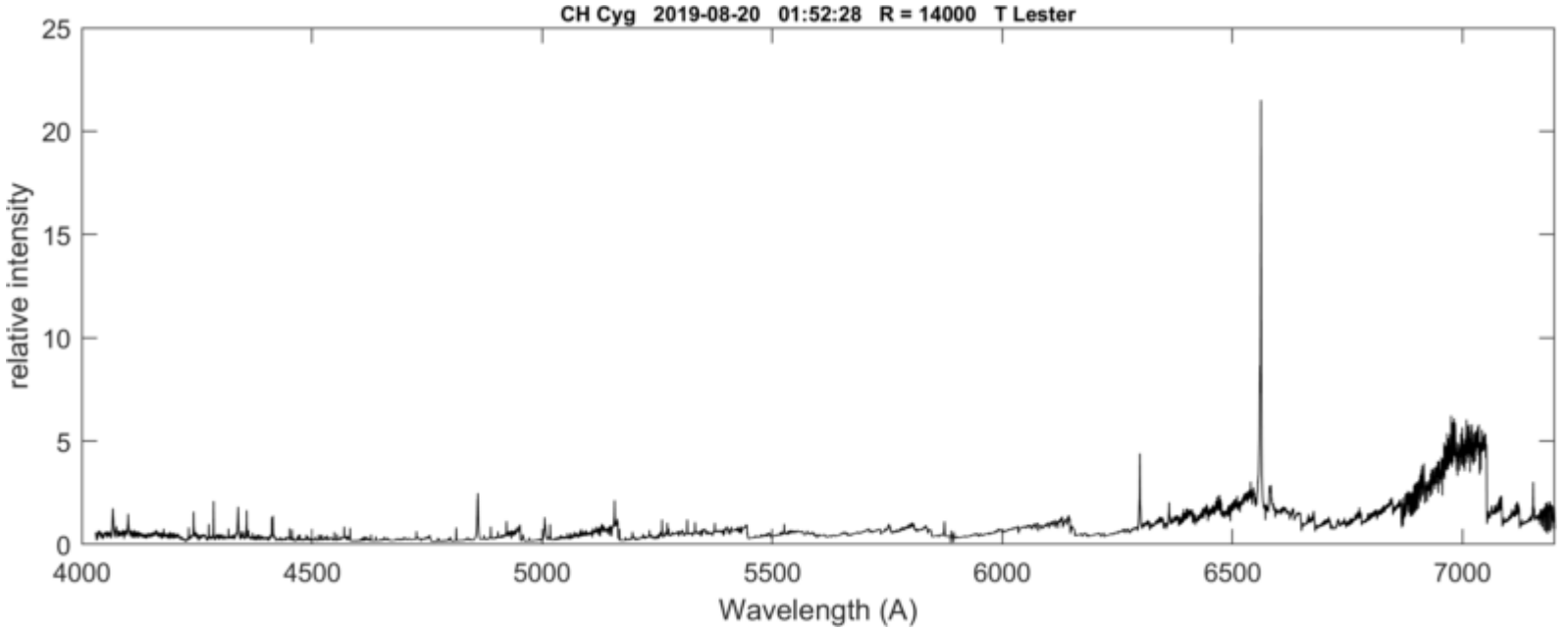
Symbiotics: complex
Complex symbiotic: CH Cyg

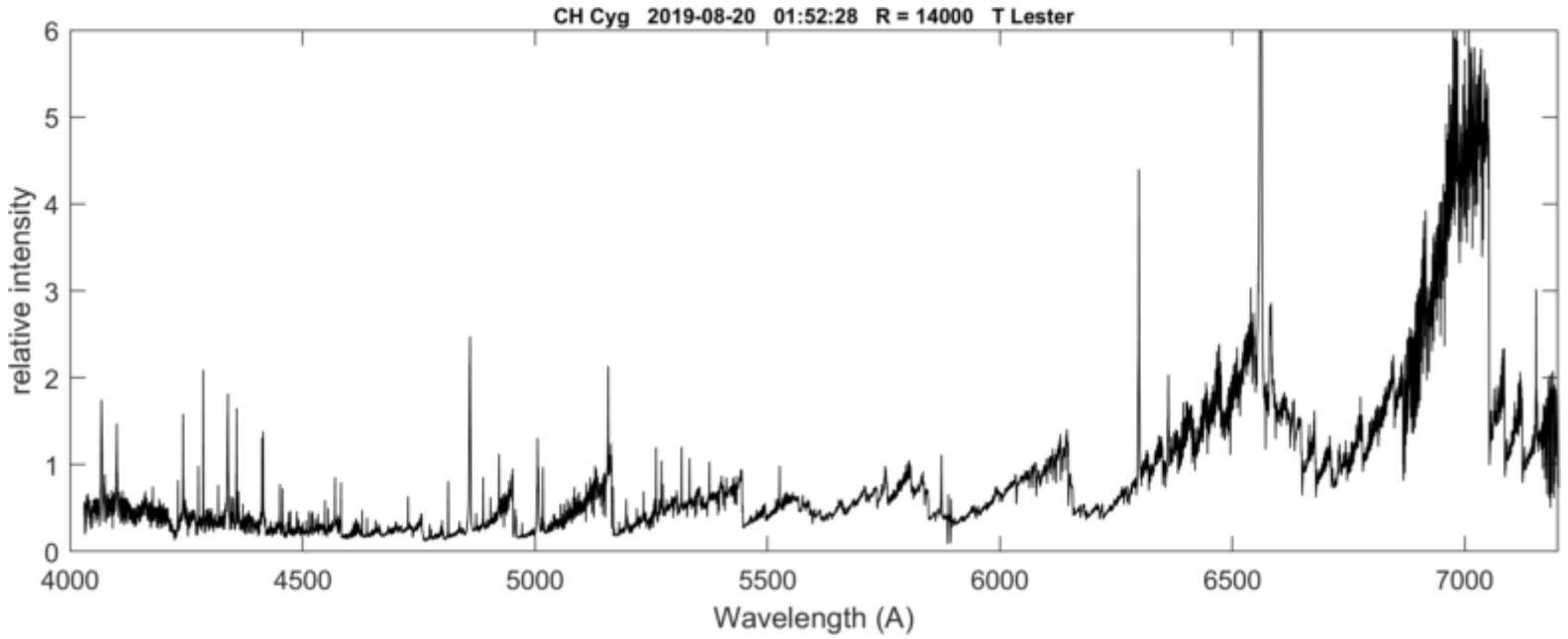
Standard M6III until the ‘60



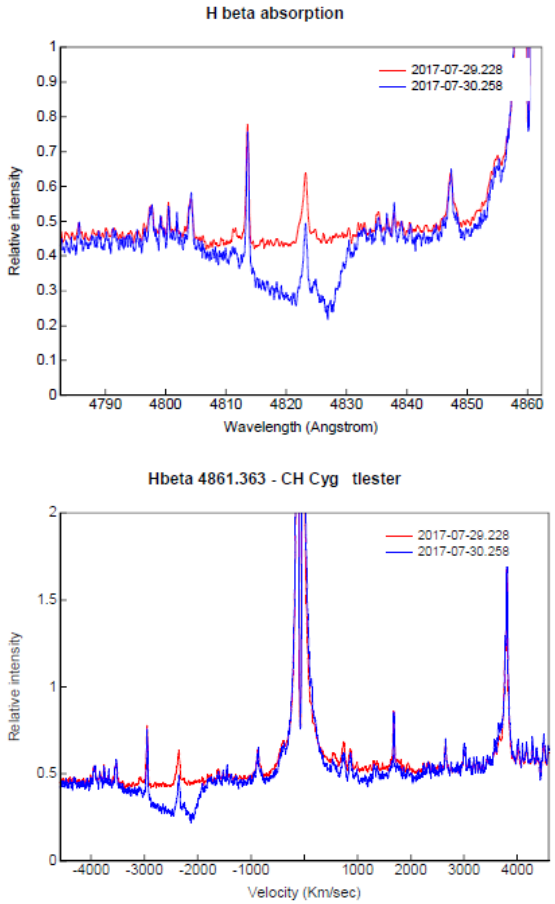
AAVSO V light curve
ARAS Spectra (> 700): continuous monitoring since 2014.5

CH Cyg

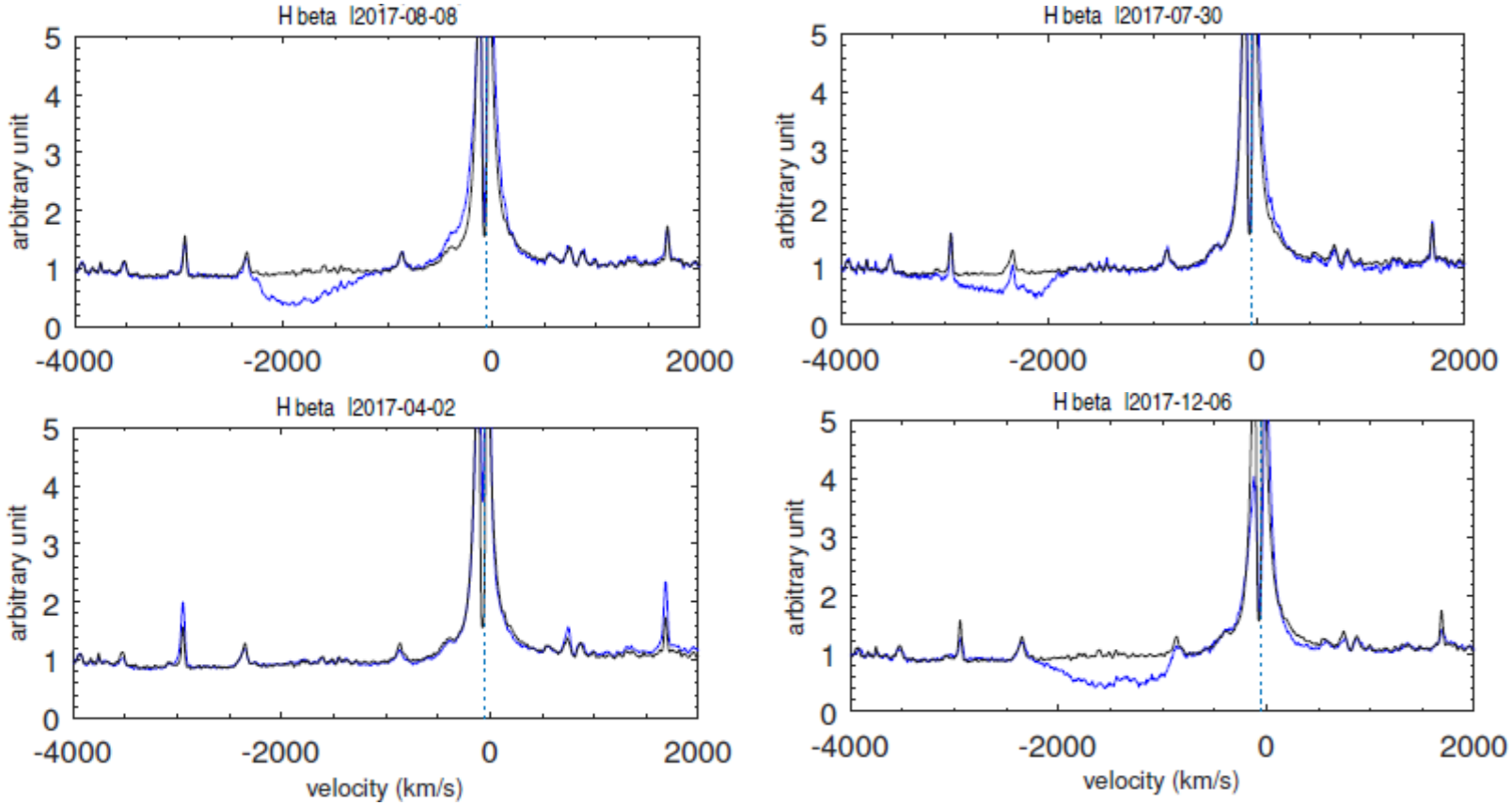

CH Cyg 2019-08-20 01:52:28 R = 14000 T Lester
relative intensity
Wavelength (A)
0
5
10
15
20
25
4000
4500
5000
5500
6000
6500
7000


CH Cyg 2019-08-20 01:52:28 R = 14000 T Lester
relative intensity
Wavelength (A)
0
1
2
3
4
5
6
4000
4500
5000
5500
6000
6500
7000

CH Cyg



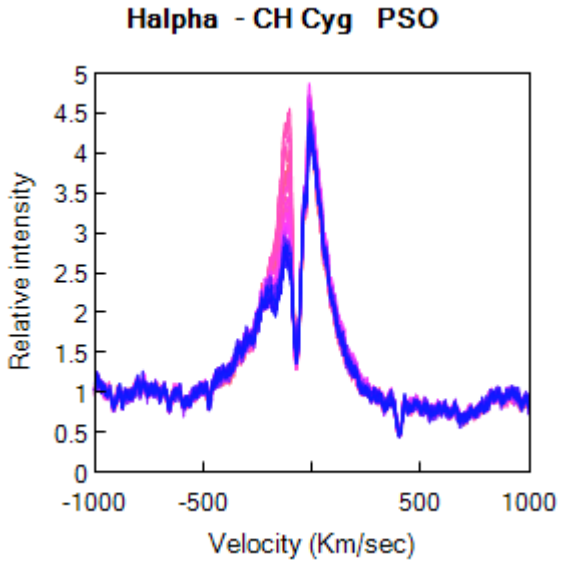
Absorption in Hβ at 1 day interval
Spectra: Tim Lester (R = 13000)

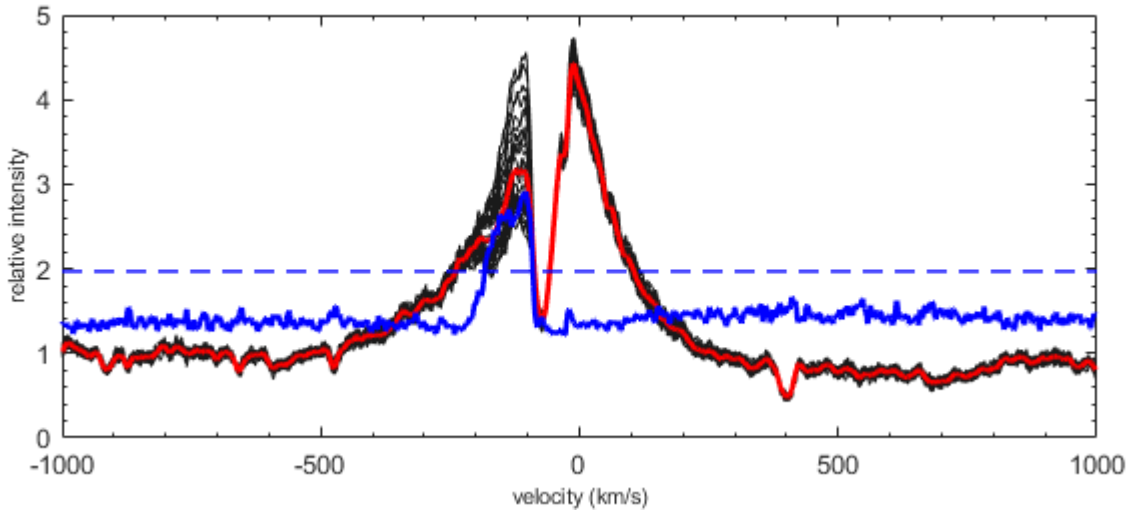


Various profiles of the absorption in Hβ
Spectra: Joan Guarro (R = 9000) – Tim Lester (R = 13000)
Grey: reference spectrum (2017-07-29)

CH Cyg

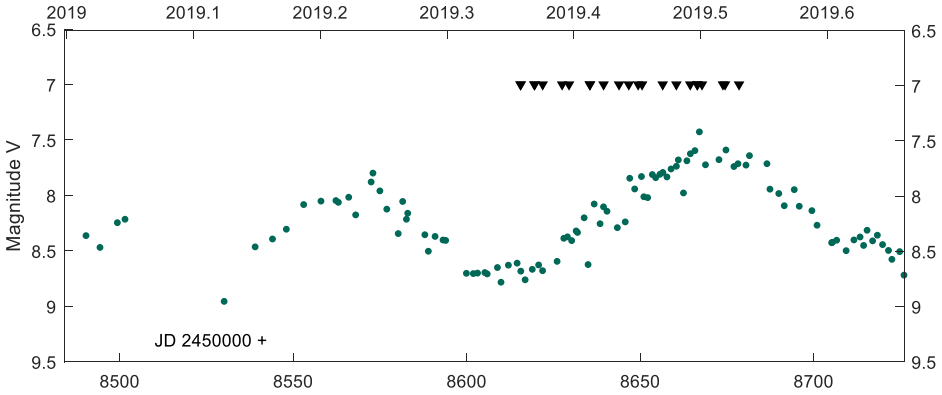
Flickering at short time scale





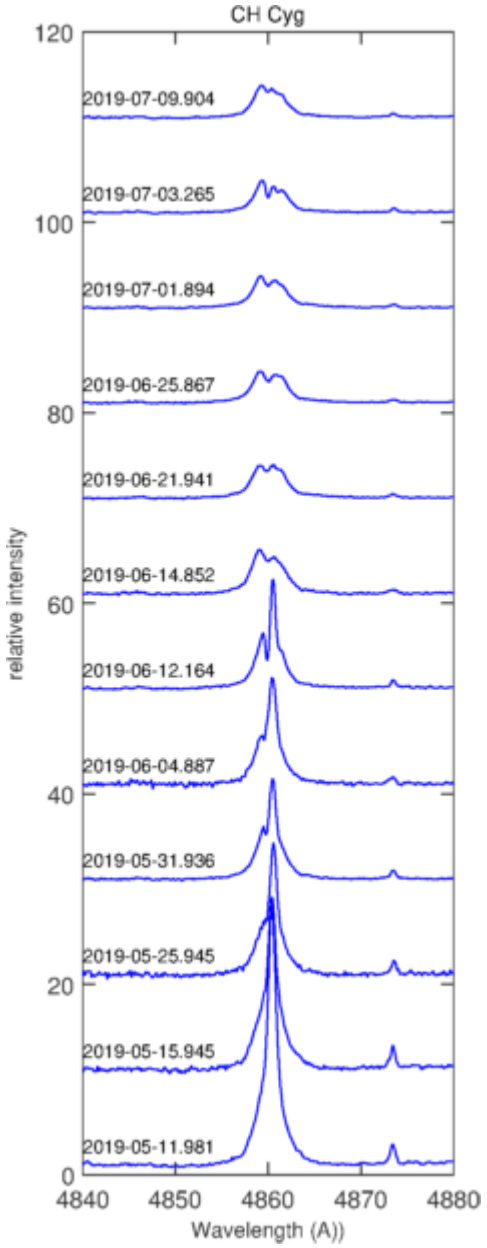
P. Somogyi (HU)
Lhires III 2400 l/mm R = 15000
2015-09-20
31 spectra 300 sec.
From UT 19:50 to 21:50

CH Cyg

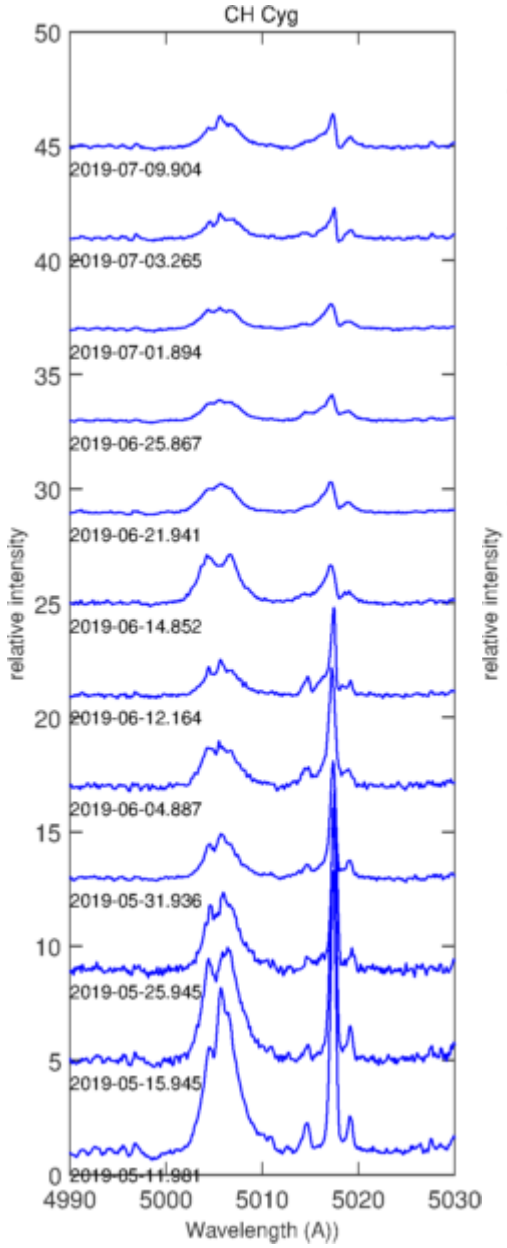


2019: oscillations at low luminosity

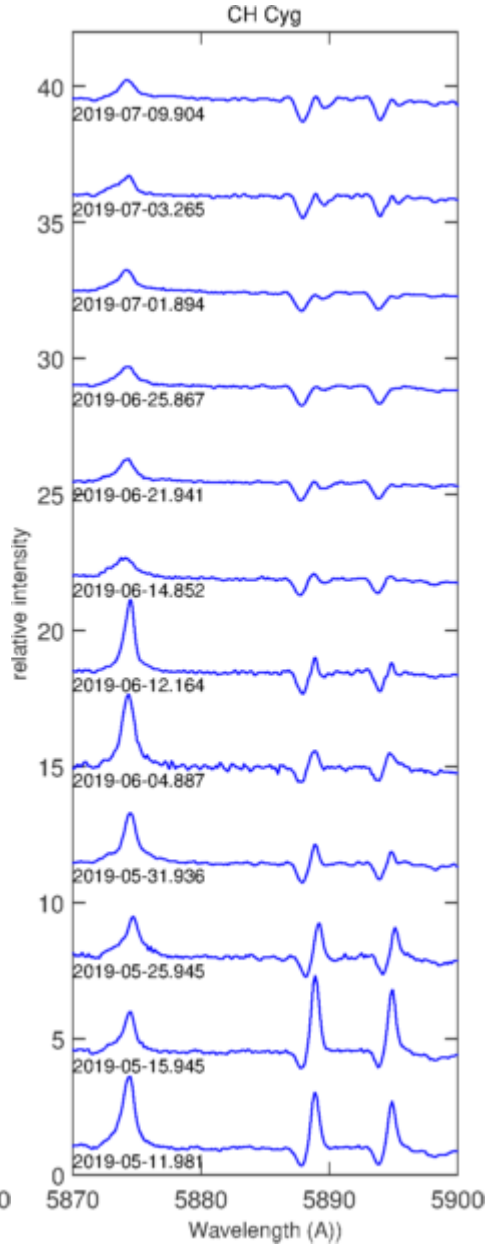
Echelle spectra
R = 9 to 13 0000
J. Guarro
T. Lester
F. Teyssier



H beta



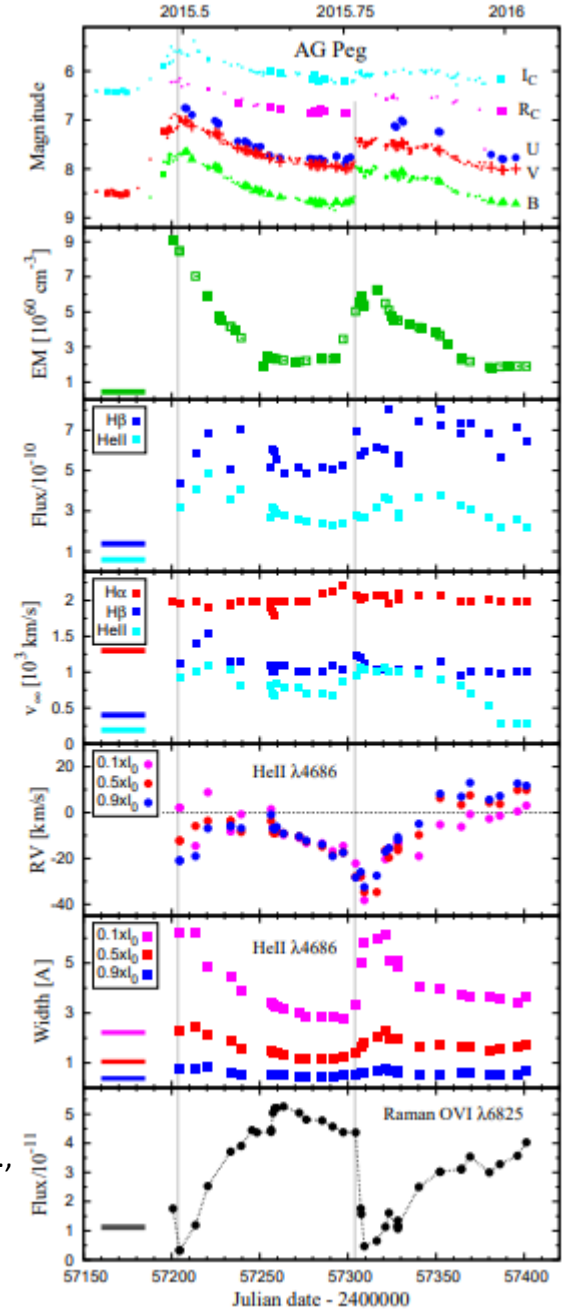
[OIII] region



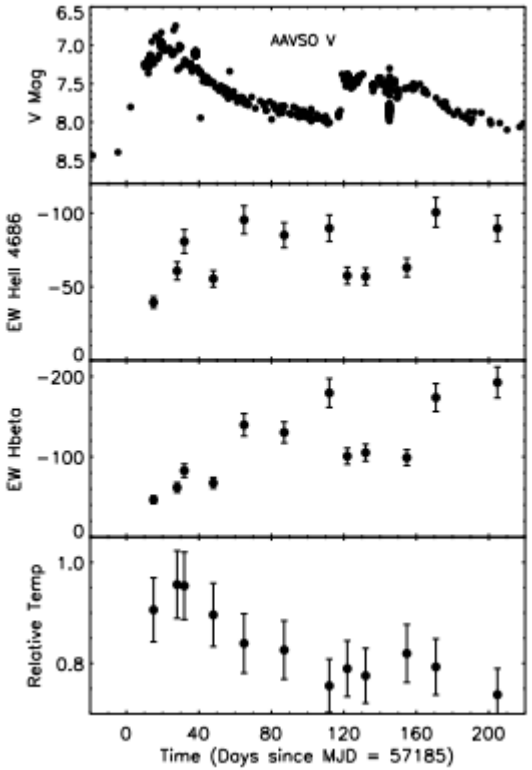
Na I D

AG Peg 2015 outburst

First Z And-type outburst
In the slowest nova



Swift observations of the 2015 outburst of AG Peg from slow nova to classical symbiotic outburst.
RAMSAY G., SOKOLOSKI J.L., LUNA G.J.M. and NUNEZ N.E.
Mon. Not. R. Astron. Soc., 461, 3599-3606 (2016/October-1)

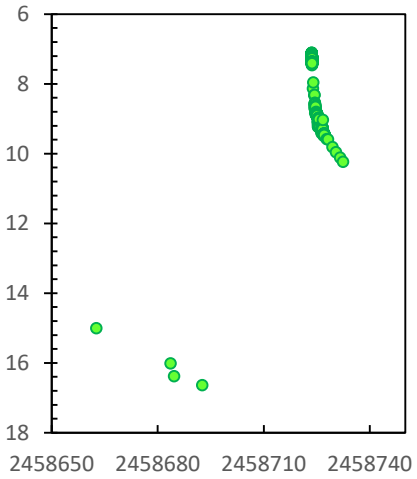


New outburst of the symbiotic nova AG Pegasi after 165 yr.
SKOPAL A., SHUGAROV S.Y., SEKERAS M., WOLF M., TARASOVA T.N., TEYSSIER F., FUJII M., GUARRO J., GARDE O., GRAHAM K., et al.
Astronomy and Astrophysics, volume 604A, 48-48 (2017/8-1)

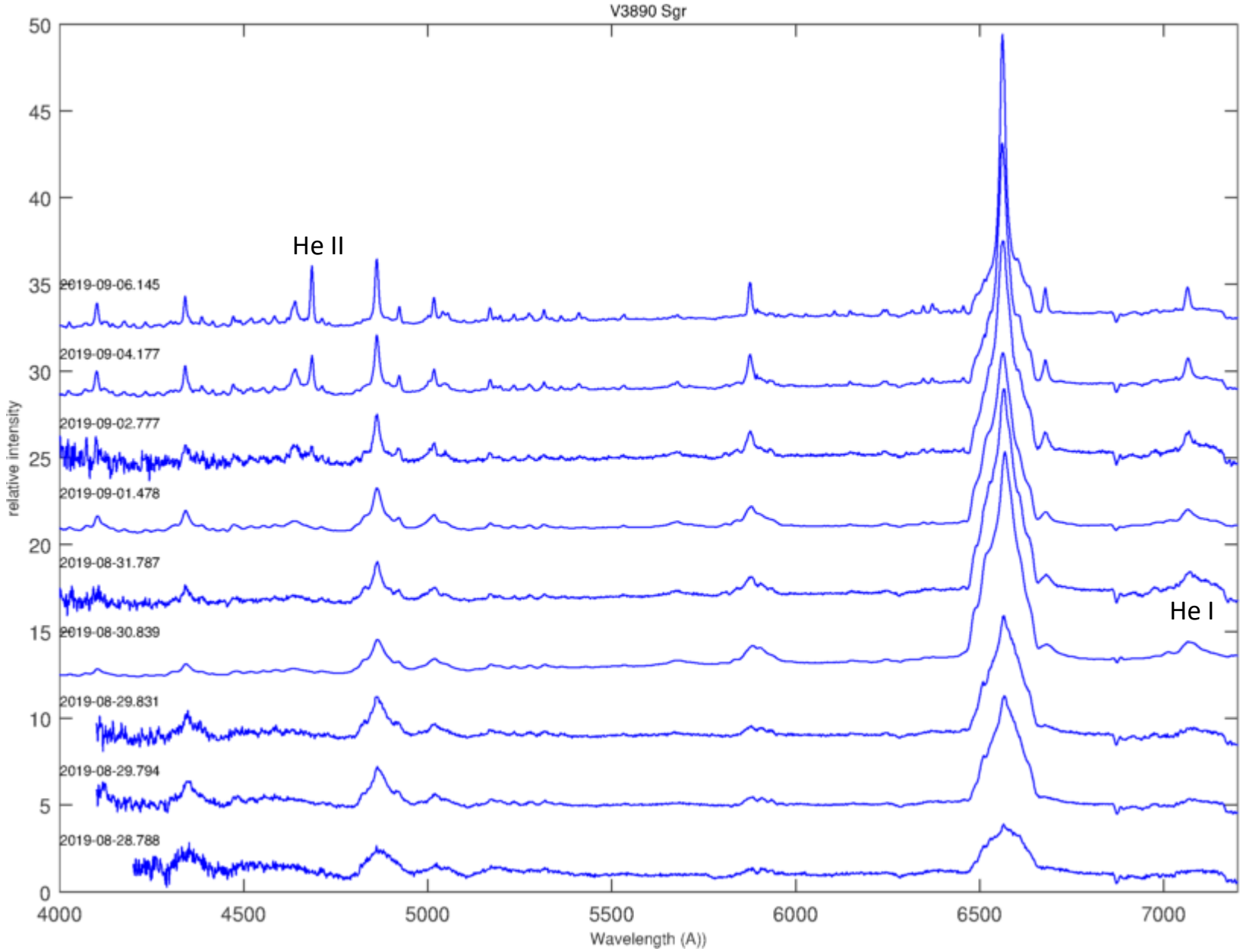
V3890 Sgr

Symbiotic Recurrent nova

Outbursts : 1962 1990 2019

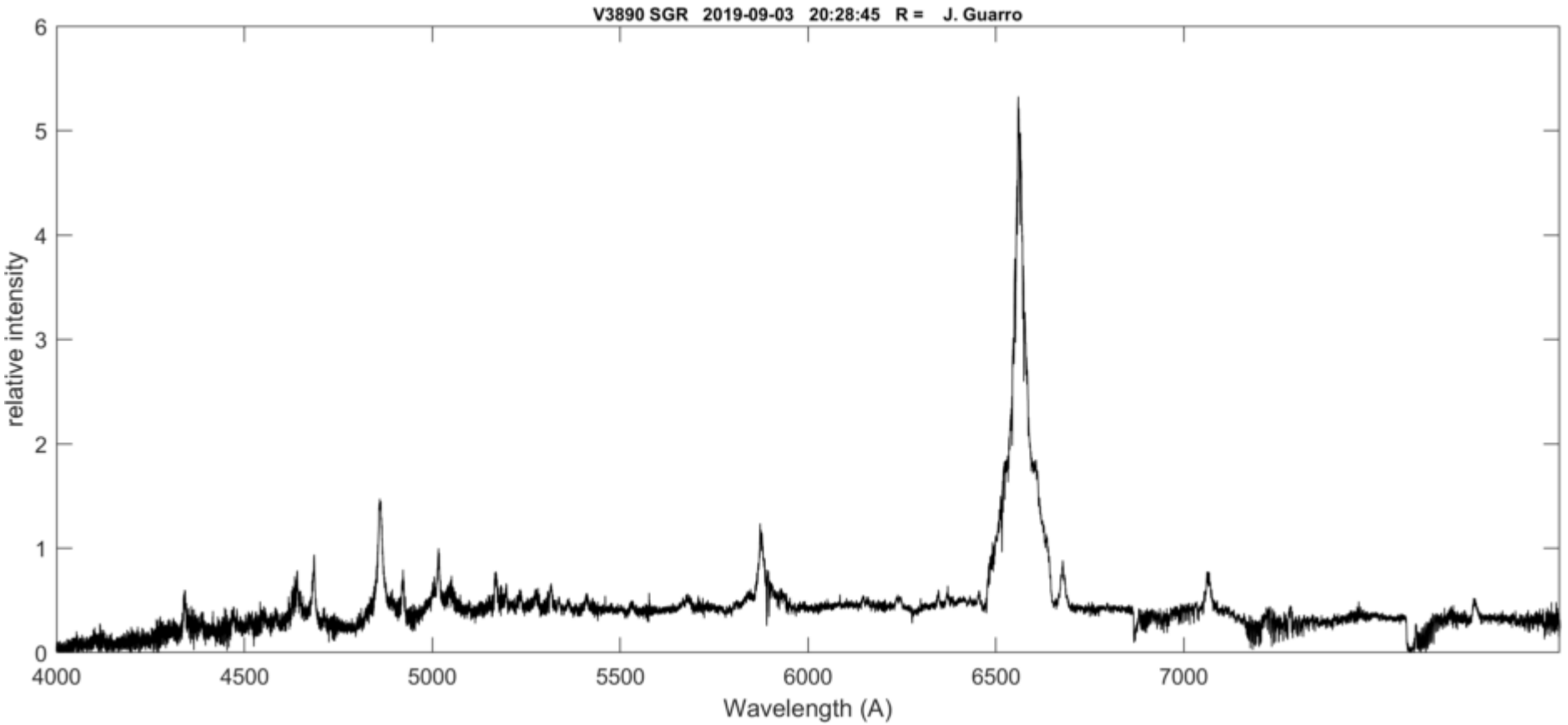


AAVSO V



Spectra:
P. Dubovski (LISA R = 1000)
P. Luckas (Alpy R = 600)
W. Sims (LISA R = 1000)

V3890 Sgr


V3890 SGR 2019-09-03 20:28:45 R = J. Guarro
relative intensity
Wavelength (A)
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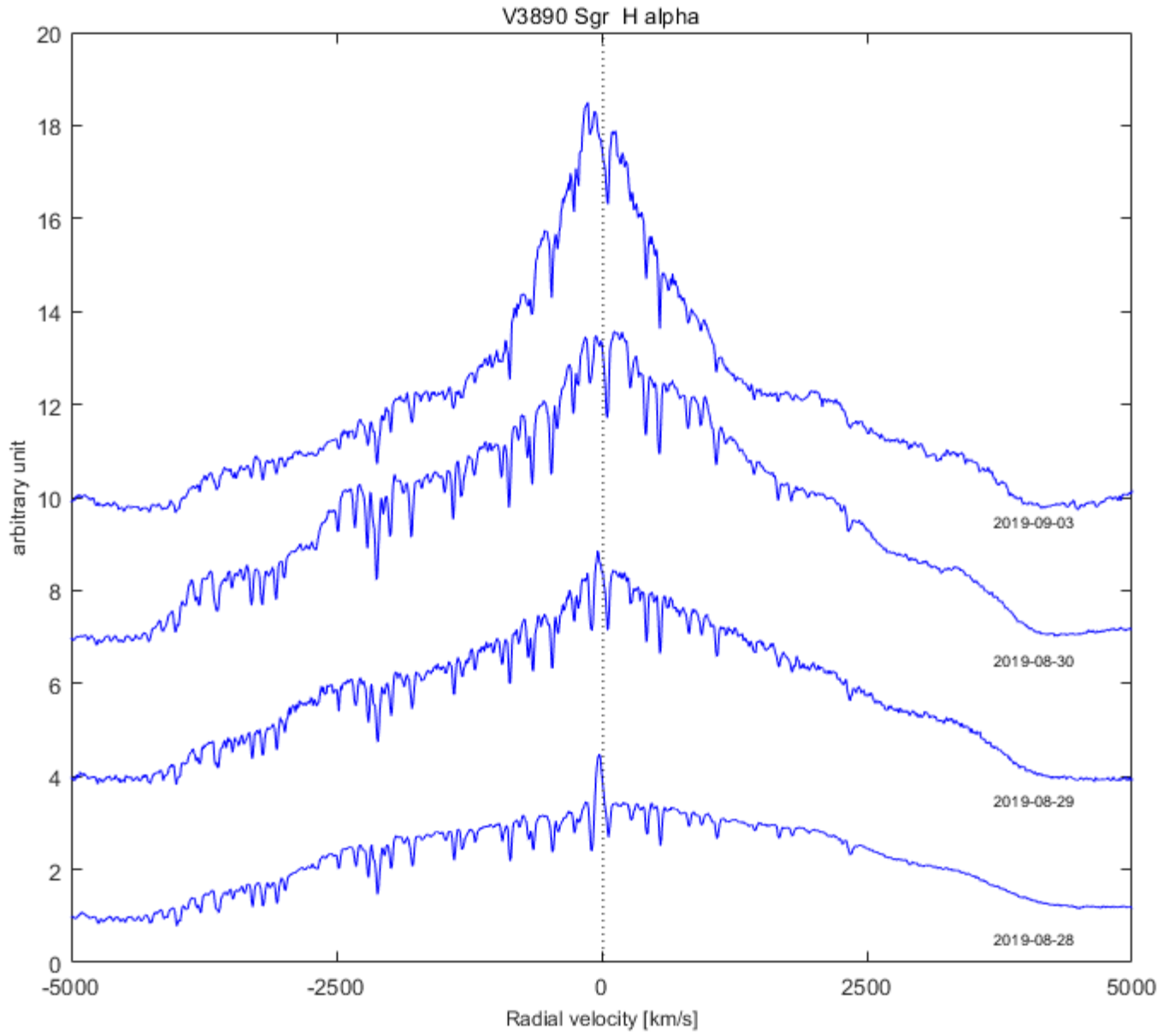
1
2
3
4
5
6
4000
4500
5000
5500
6000
6500
7000

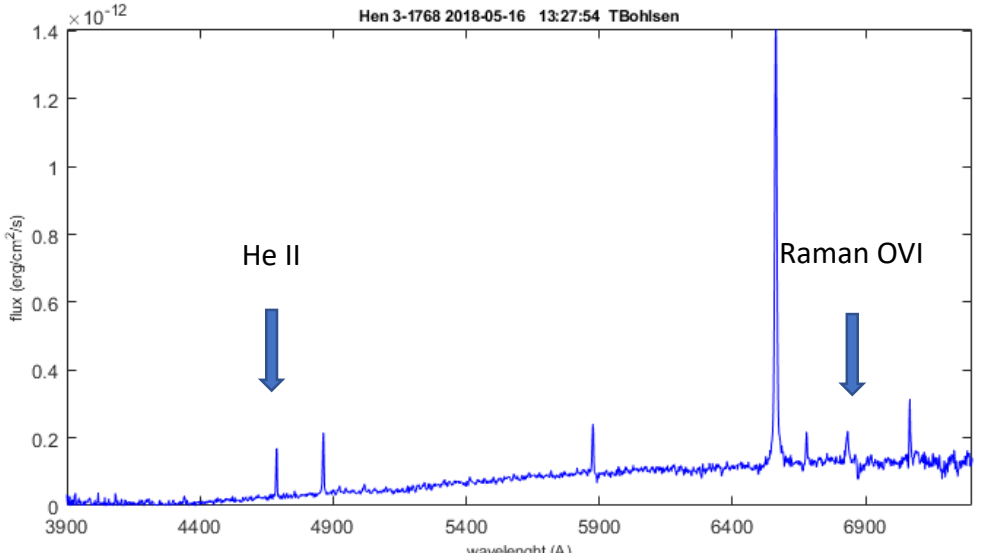
V3890 Sgr


V3890 Sgr H alpha
arbitrary unit
Radial velocity [km/s]
2019-09-03
2019-08-30
2019-08-29
2019-08-28
0
2
4
6
8
10
12
14
16
18
20
-5000
-2500
0
2500
5000

Observing program

On the request of Adrian Lucy and Jennifer Sokoloski (Columbia University)

Hen 3-1768 identified as a symbiotic star by Terry Bohlsen



Discovery of a Hot Symbiotic Star in the Cold Antarctic Sky: Symbiotics Are Outliers in SkyMapper *uvgriz* Photometry

Adrian B. Lucy[1,10], J. L. Sokoloski[1,2], N. E. Nuñez[3], C. Wolf[4,5], T. Bohlsen[6], and G. J. M. Luna[7,8,9]

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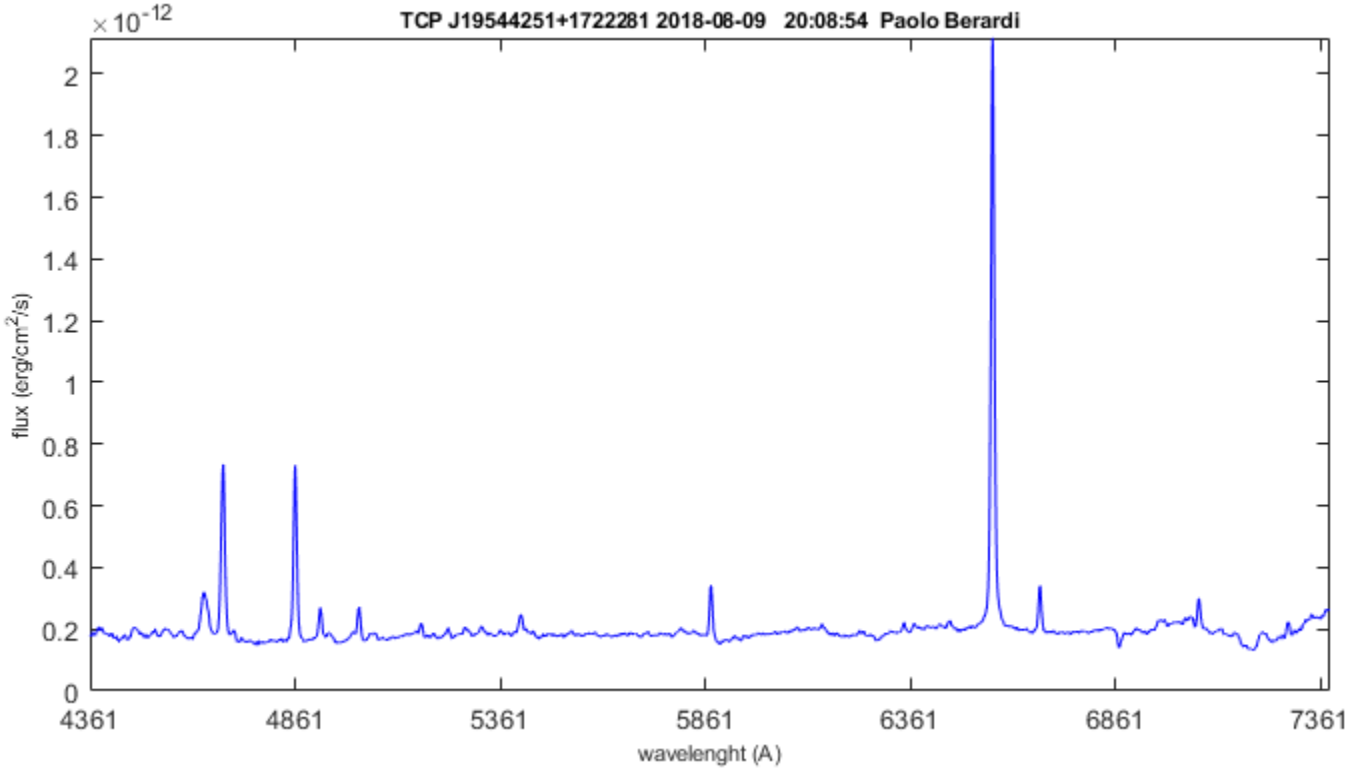
Research Notes of the AAS, Volume 2, Number 4

Suspected Symbiotics Stars
Summary of Observations

	Name	RA (2000.0)	Dec (2000.0)	V mag*	M giant	Em. Lines	Observations 2018 05	09	10	11	12	2019 01	02	03	04
1	GAIA DR2 4636654969717900032	01 50 49.53	-76 49 42.6	12.9		no					1				
2	*UCAC3 157-43452*	06 55 51.36	-11 44 05.3	12.3		no					1				
3	GDS J0731468-195434	07 31 46.82	-19 54 34.5	13.2								1			
4	ASASSN-V_J081823.00-111138.9	08 18 23.00	-11 11 38.9	12.5		no						1			
5	*UCAC3 80-46364*	08 34 45.15	-50 26 58.2	13.7		no					1				
6	GSC9507:2249	11 03 10.83	-83 57 11.3	11.2									1		
7		12 01 20.93	-79 20 14.7	12.3											
8	GAIA DR2 4131587500273361280	16 39 59.65	-18 44 38.1	13.9									1		
9	ASASSN-V J164007.54-382216.1	16 40 07.54	-38 22 16.1	13.86-14.74											
10	GAIA DR2 6019720819446985984	16 45 31.78	-36 22 31.6	12.9											
11	V2096 Oph	16 56 05.46	-24 06 37.0	12.9-14.0											
12	ER Oph	17 00 42.14	-26 10 12.4	11.8-<14.8											
13	ASASSN-V J170231.98-275954.2	17 02 31.98	-27 59 54.4	13.98-14.94											
14	GAIA DR2 4334886650491663104	17 06 08.44	-10 58 33.0	14.3											
15	SS 295	17 07 38.16	-07 44 48.6	13.1					1				1		
16	V2525 Oph	17 15 05.27	-09 23 50.1	11.9-<15.1									1		
17	GAIA DR2 4115021291723497088	17 17 45.67	-21 31 16.9	13.7											
18	GSC 09276-00130	17 18 09	-67 57 26.0	13.6										1	
19	GAIA DR2 4168021909706732672	17 25 26.34	-07 48 27.5	14.3									1		
20	GAIA DR2 4111779763989583232	17 26 18.27	-22 12 46.4	14.1											
21	GAIA DR2 4120809606303456896	17 27 08.69	-21 39 04.5	13.1											
22	GAIA DR2 5919388180059095296	17 30 58.39	-56 29 53.4	12.6		no		1							
23	ASASSN-V J173832.43-492840.2	17 38 32.42	-49 28 40.1	13.96-14.55											
24	FASTT 1100	17 53 45.30	-01 07 46.8	14.04-14.30		H a			1				1		
25	GAIA DR2 4150446010182968192	17 56 04.34	-13 10 03.4	13.1	M4				1						
26	GAIA DR2 4150099732733146112	17 59 43.87	-13 58 32.0	13.9											
27	SY Cra	18 03 21.54	-42 37 56.8	13.0-16.5p											
28	GAIA DR2 6345873798283774848	18 14 18.07	-85 59 06.5	11.7		no		1							
29	GAIA DR2 4048168377818693632	18 28 31.28	-28 45 02.9	11.9		no		1							
30	ASASSN-V J185421.70-274827.4	18 54 21.70	-27 48 27.8	12.89-13.63											
31	EN Sgr	19 22 42.08	-13 59 56.5	11.95-14.61		H I		2	2						
32	ASASSN-V J192916.53-224040.3	19 29 16.53	-22 40 40.3	12.52-13.02	M 3.5	Ha Hb		1							
33	ASAS J195948-8252.7	19 49 48.4	-82 52 37.5	11.6		yes	2								

Identification of new stars (SN, DN, Symbiotics)

First spectra of TCP J19544251+1722281
identified as HbHa 1704-05 in outburst, obtained by Paolo Berardi



The Astronomer's Telegram

HBHa 1704-05: a bright and newly discovered symbiotic star, currently undergoing an "hot-type" outburst

ATel #11937; *U. Munari (INAF Padova), S. Dallaporta, P. Valisa (ANS Collaboration), P. Ochner (Univ. Padova), R. Fidrich (HAA/VSS), P. Berardi, O. Garde, C. Buil (ARAS Group)*
on 11 Aug 2018; 11:20 UT

R. Gàlis & al, 2019

… the presented results showed also the importance of professional/amateur collaborations. ARAS Group is a perfect example that such collaboration can be very successful and can bring important results. Thanks to amateur photometric and spectroscopic data, we are now able to monitor the evolution of symbiotic systems **on timescales which were not previously available.**

K. Ilkiewicz & al, 20xxx

we are thankful to members of the ARAS group for their wonderful work.

ARAS Eruptive stars database

A.R.A.S Spectral Data Base - Eruptive stars section

Symbiotic stars

Names	Belczynski K. & al. 2000					Aras Spectral Data Base
Number of stars	64					
Number of spectra	4606					Observers codes
						Observatories codes
Current campaigns	CH Cyg	AG Dra	SU Lyn	Z And	R Aqr	RS Oph
Current surveys	CI Cygni	T CrB	BF Cyg	AX Per	AG Peg	
Stars of interest						
Outbursts	AX Per					

send spectra to : francoismathieu.teyssier at bbox.fr
Updated
27/07/2019

#	Name	AD (2000)	DE (2000)	Nb. Of spectra	First spectrum	Last spectrum	Days Since Last	Frequency
1	EG And	0 44 37.1	40 40 45.7	126	12/08/2010	18/02/2019	159	30
2	AX Per	1 36 22.7	54 15 2.5	285	04/10/2011	05/07/2019	22	8
3	V471 Per	1 58 49.7	52 53 48.4	30	06/08/2013	14/02/2019	163	30
4	Omi Cet	2 19 20.7	-2 58 39.5	33	28/11/2015	09/02/2019	168	30
5	BD Cam	03 42 9.3	63 13 0.5	47	08/11/2011	02/07/2019	25	30
6	StHa 32	04 37 45.6	-01 19 11.8	5	02/03/2018	25/01/2019	183	8
7	UV Aur	05 21 48.8	32 30 43.1	81	24/02/2011	28/03/2019	121	30
8	V1261 Ori	05 22 18.6	-8 39 58	17	22/10/2011	29/12/2019	-155	30
9	StHA 55	05 46 42	6 43 48	10	17/01/2016	08/02/2019	169	30
10	SU Lyn	06 42 55.1	+55 28 27.2	164	02/05/2016	30/04/2019	88	15
11	77 CMi	07 24 13.9	8 53 51.7	61	29/09/2011	21/04/2019	97	30

Open database
56 objects
4600 spectra (R = 500 to 15000)

First check
- Identification
- Calibration
- Atmospheric response

Conditions of use:
- Aknowledgement to observers and ARAS database with a list of observers and Journal observation
- Observers included as co-authors if pivotal observations or contribution to the analysis

Reference

Contrib. Astron. Obs. Skalnaté Pleso **49**, 217 – 227, (2019)

Eruptive stars monitoring and the ARAS database

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https://ui.adsabs.harvard.edu/abs/2019CoSka..49..217T/abstract

Information letter

Eruptive stars spectroscopy
Cataclysmics, Symbiotics, Novae

Eruptive Stars
Information Letter n° 41 #2019-01 18-05-2019
Observations of Jan. - Mar. 2019

Main results in a quaterly newsletter
42 issues downloadable: http://www.astrosurf.com/aras/novae/InformationLetter/InformationLetter.html

Indexed in NASA/ADS since January, 2019

Spectroscopic observations of symbiotic stars in 2019-Q1

Show affiliations

Teyssier, F.; Boyd, D.; Guarro, J.; Sims, F.; Campos, F.; Lester, T.; Sollecchia, U.; Boussin, C.; Charbonnel, S.; Garde, O.; Somogyi, P.; Buil, C.; Berardi, P.; Marik, V.; Martineau, G.; Buchet, Y.; Diarrassouba, I.; Michelet, J.

198 spectra of 23 symbiotic stars at resolution from 500 to 15000 were obtained during 2019-Q1 by 18 observers. AG Dra is monitored before the expected outburst in 2019. At the current date (2019-05-18) no sign of outburst has been detected. From medium resolution spectra we have detected the appearence of an emission line in the red edge of He I 5016 during outbursts. The identification of the line is discussed. AX Per soon after the end of its eclipse has been detected in strong classical outburst, characterized by the weakening of high emission lines [Fe VII]. CH Cyg is in low luminosity, several spectra have been obtained during a short flare. V694 Mon, in high luminosity, has been monitored at high cadence during the season. The profiles of Balmer and Fe II lines is unusual, showing a classical P Cygni profile and the disappearance of the broad blue absorption lines.

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Education of the observers:

Texts from
Steve Shore
Agustin Skopal, Natalia Shagatova
Rudolf Gàlis, Jaroslav Marc, Leedjarv
Margarita Karovska
….