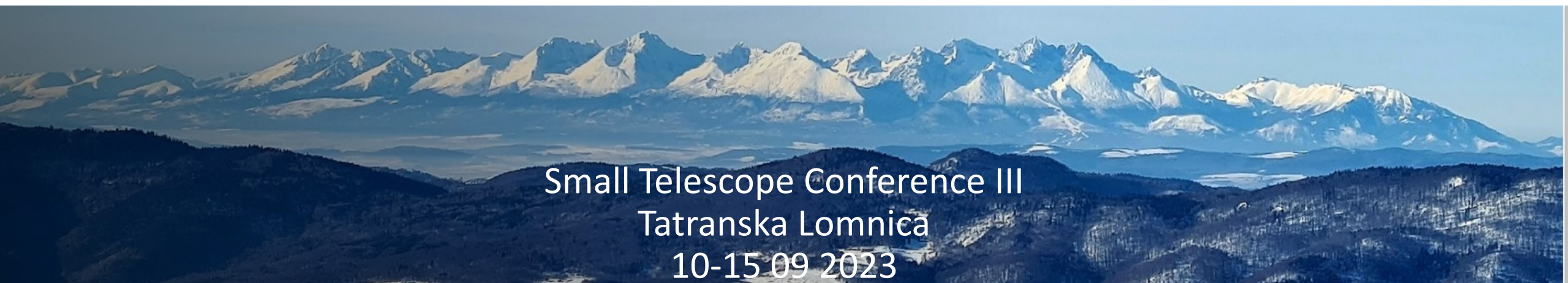


ARAS Eruptive Stars monitoring



Small Telescope Conference III
Tatranska Lomnica
10-15 09 2023

© Credit photo: Astronomical Institute of Slovak Academy of Sciences

Generally : 20-40 cm [ED 76mm – T1000]

Slit and echelle spectrographs R=600 to 15000

Commercial (essentially Shelyak) and Home Made

- Reactivity
- High cadency
- Long term monitoring

1. ARAS program
2. Requests from professional teams

ARAS Eruptive stars DataBase (asdb)

<https://aras-database.github.io/database/symbiotics.html>

Since 2013 (spectra from 2010)

Design and fonctionnalities improved by Joroslav Merc (2022)

- Minimum resolution: 500
- Free access
- Preliminary check

12800 spectra

Symbiotic Stars (N = 103): 8263

Novas (N=65) : 4163

Dwarf Novae (N=33) : 377

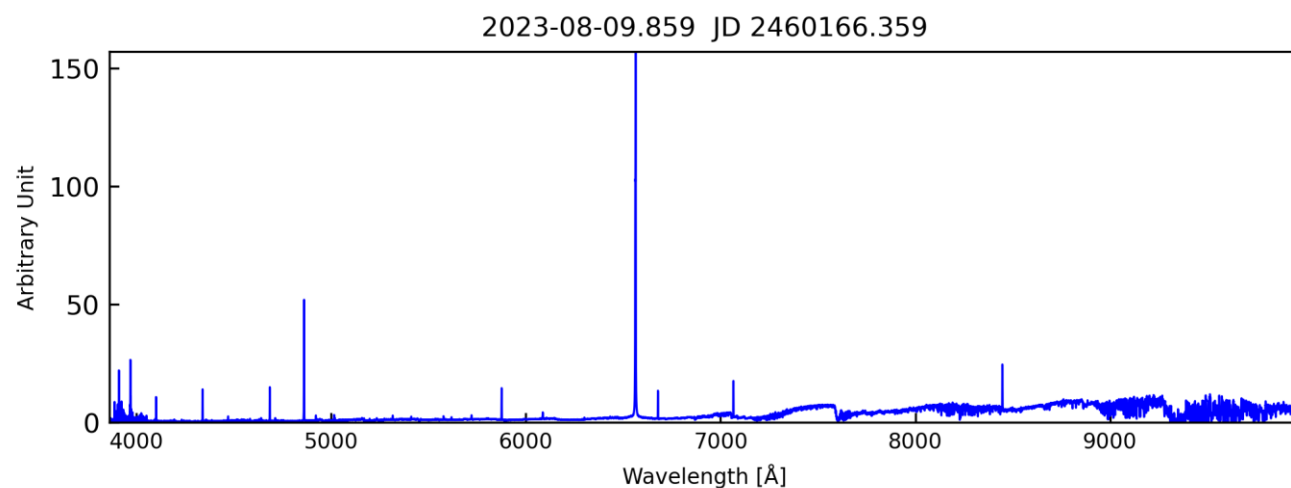
Used in ~100 publications

<https://ui.adsabs.harvard.edu/user/libraries/jd9bULL8SU-uBHbblit3Xw>

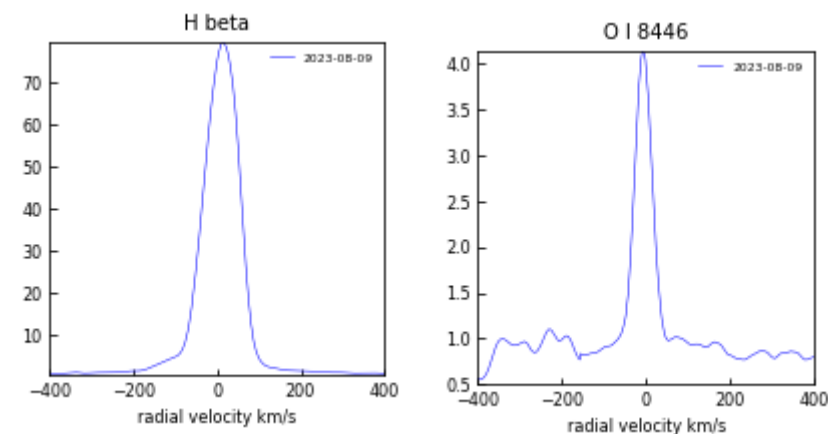
0. Spectroscopy with Very small telescopes

NOUT at Santa Maria de Montmagastrell (SP, Catalunya)

- Remote observatory Joan Guarro Flo
- Meade SC 16" Fork Meade Mount
- NOUT échelle R = 9000 Home made (optical concept: Tim Lester)
At the focus of the telescope
- CMOS ASI 2600MM
- Range 3800-10000 Å



Cl Cyg V = 11.0
4*1800 sec

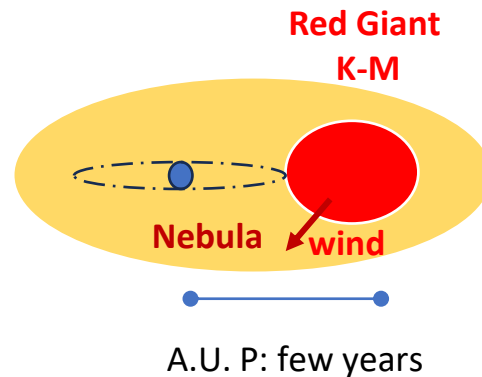
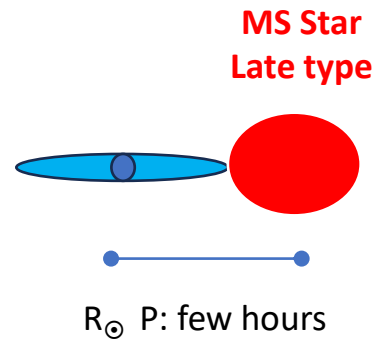
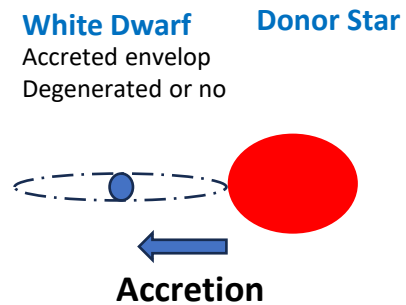


Selected examples

1. Classical nova Cas 2021 (V1405 Cyg): Oscillations at maximum and nebular phase
2. Recurrent nova RS Oph 2021
3. BX Mon: an eclipse in an accretion powered symbiotic star
4. AX Per: classical symbiotic star
5. T CrB: recurrent symbiotic nova before nova event

0. Eruptive Stars

- Dwarf Novae
 - Disk
 - Disk partially or totally disrupted



- Dwarf nova outburst (TS: days to years)
(thermal disk instability)
- Nova events (TS: 1000 years)
(TNR in the accreted degenerated envelop → ejecta)

- Recurrent nova outburst (TS: 10 years)

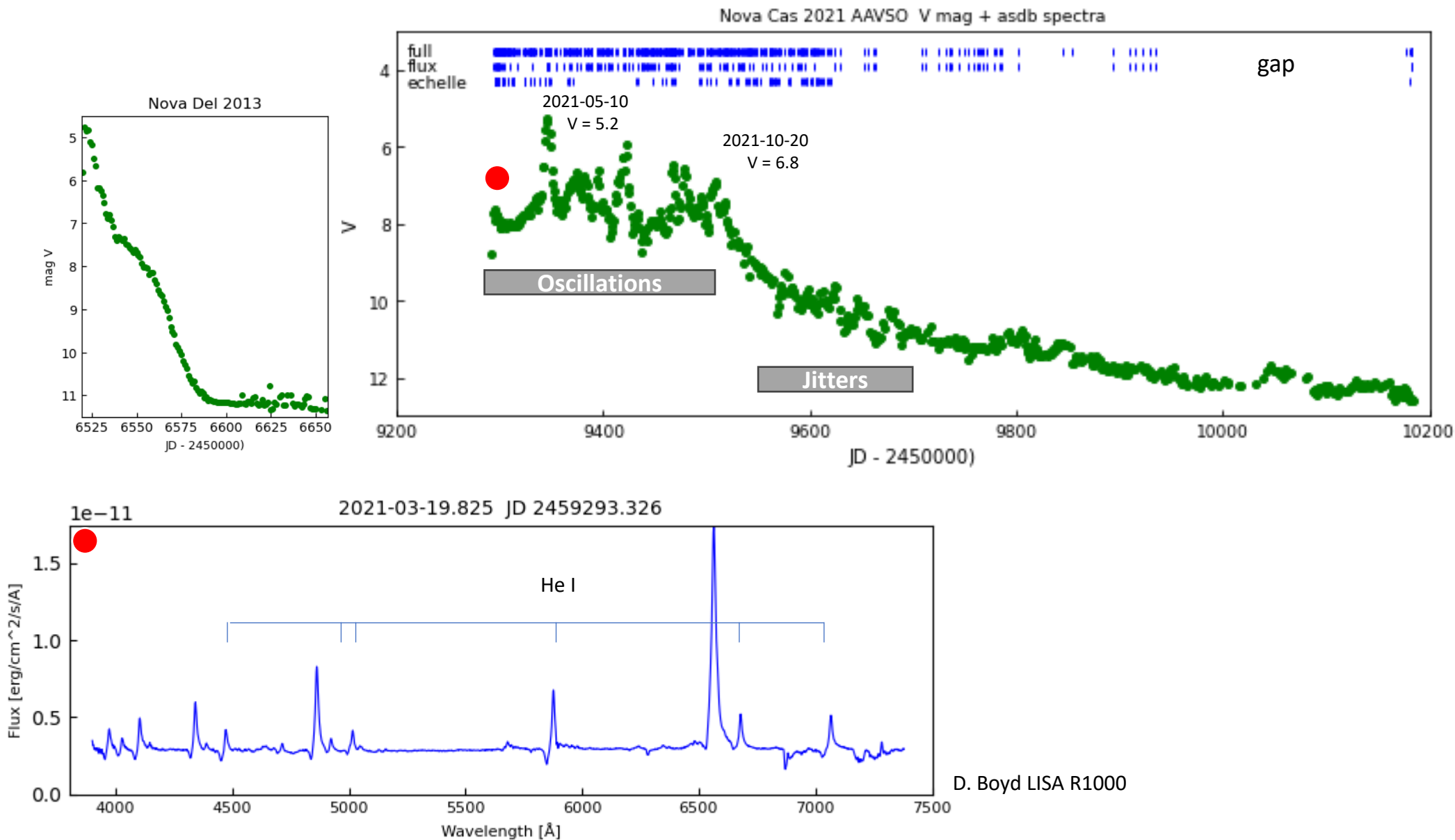
- Symbiotic Stars
 - Accretion powered
 - H steady burning ($L_{\text{hot}} = 100\text{-}1000 L_{\odot}$)

1. Very Slow Nova with multiple rebrightnings

Nova Cas 2021 = V1405 Cas

Classical nova
Oscillations at maximum
Jitters

546 spectra



D. Boyd LISA R1000

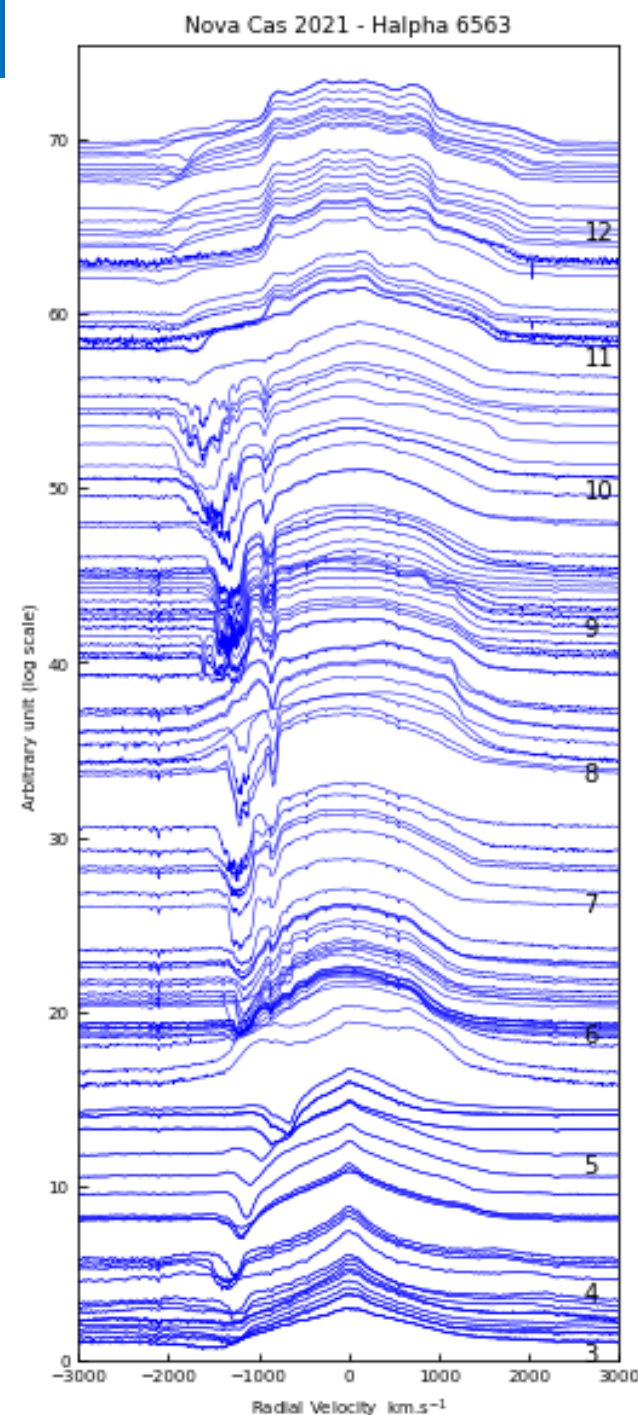
1. Very Slow Nova with multiple rebrightnings

Nova Cas 2021 = V1405 Cas

Classical nova

Oscillations at maximum

Jitters

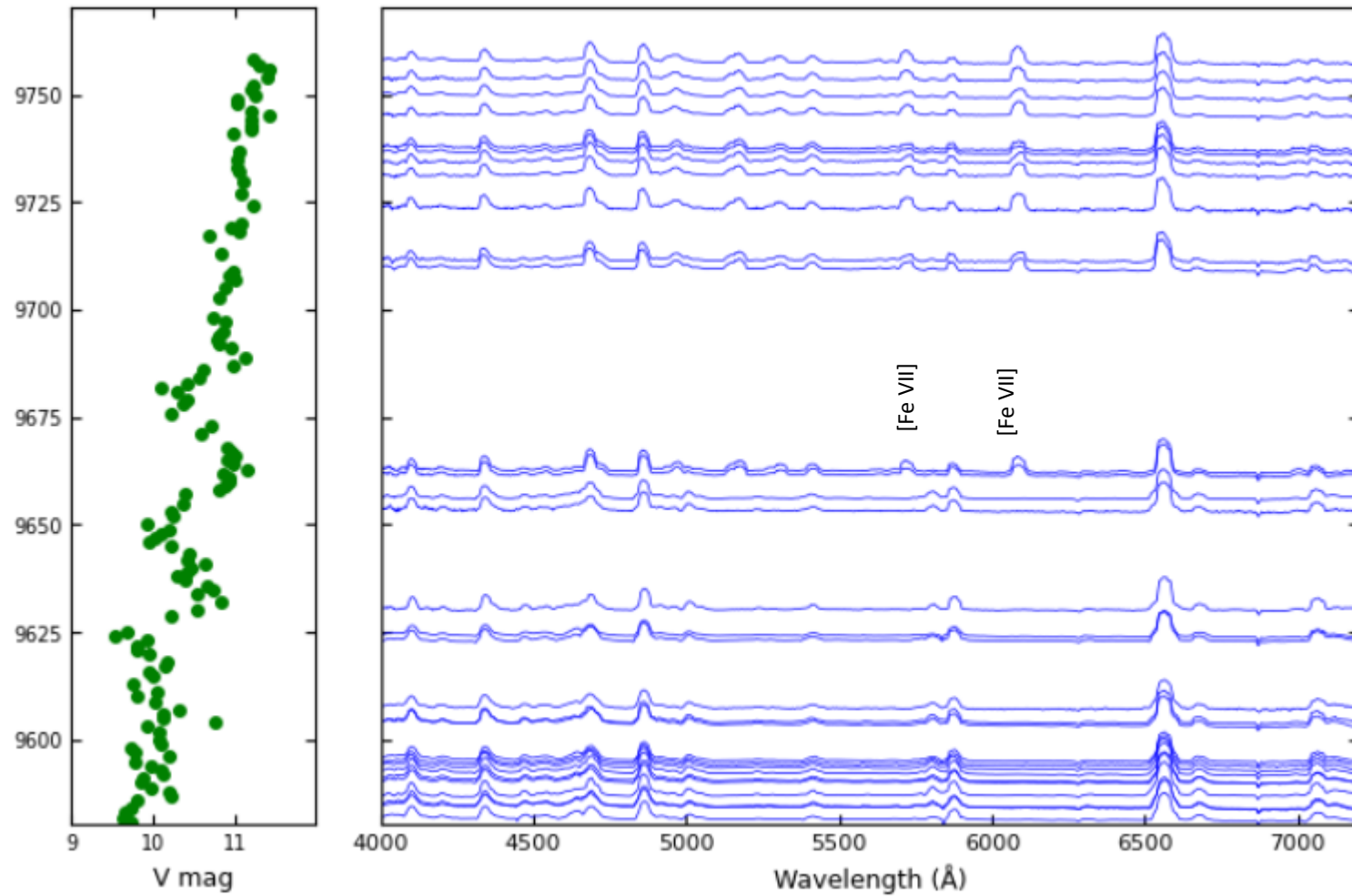


2021

1. Very Slow Nova with multiple rebrightnings

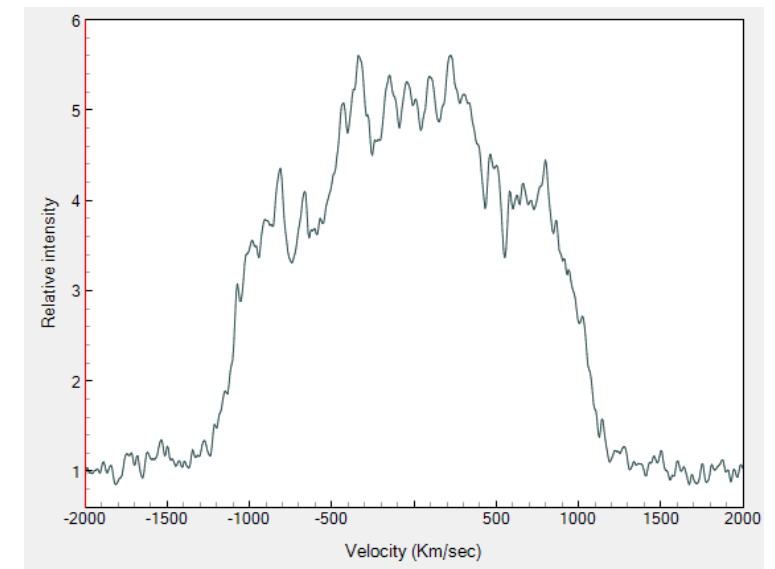
Nova Cas 2021 in nebular phase

2022-01 to 2022-07



H alpha

2023-08-24

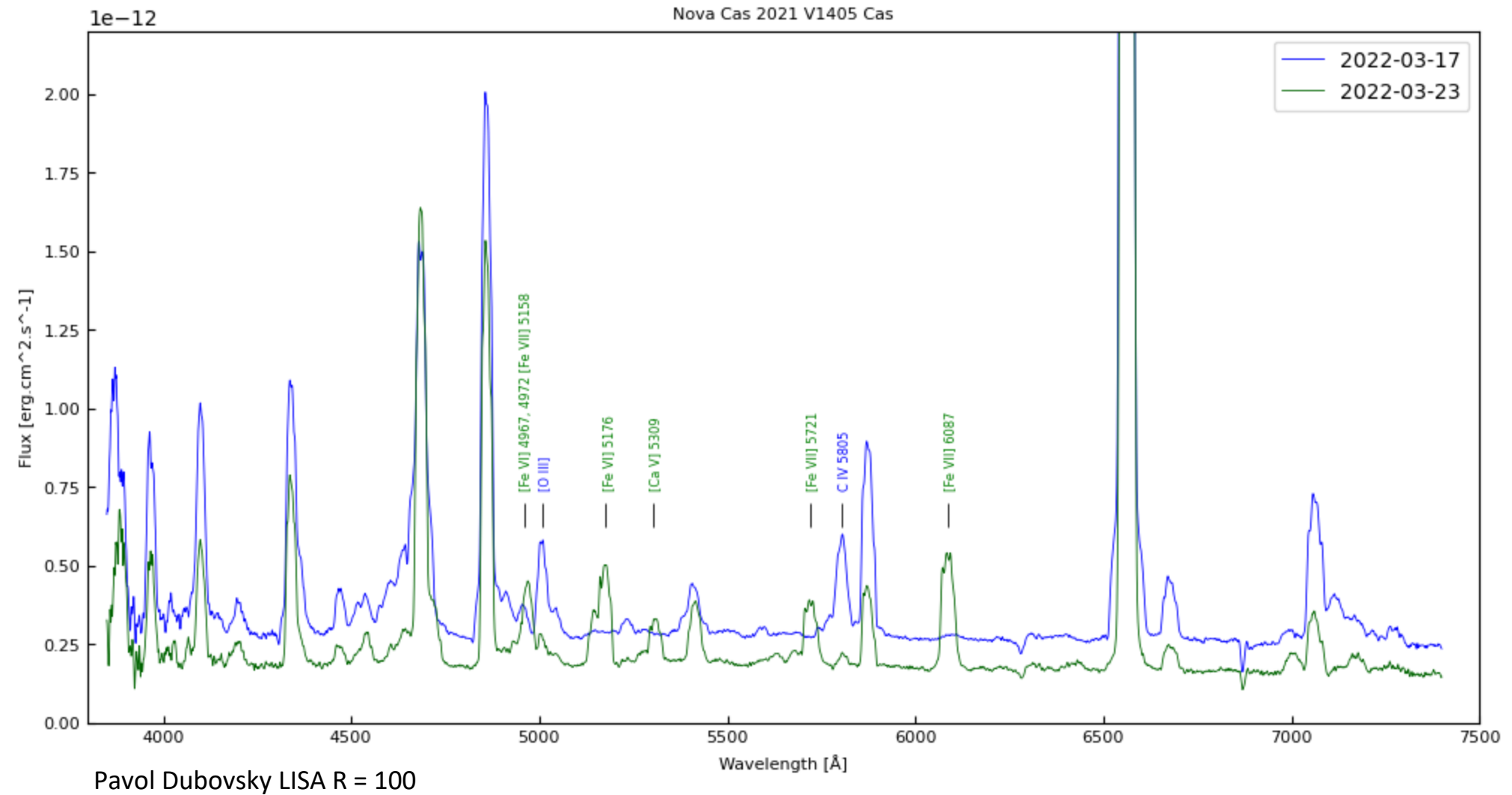


J. Guarro NOUT R = 9000

Spectra: P.A. Dubovsky, H. Allen, K. Shank, F. Sims, T. Medulka R=600 to 1000

1. Very Slow Nova with multiple rebrightnings

Nova Cas 2021 = V1405 Cas



RS Oph

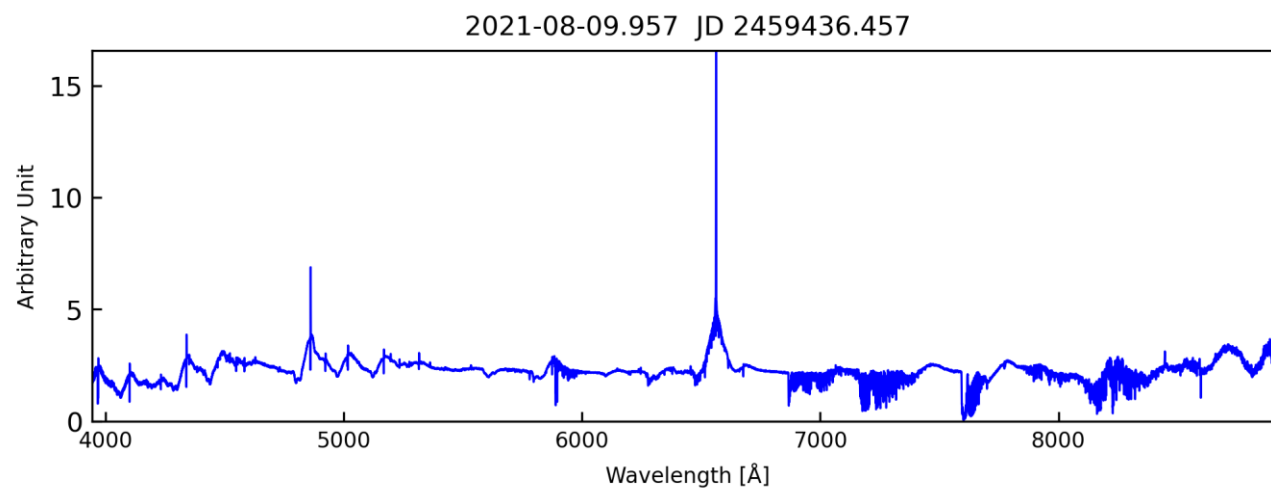
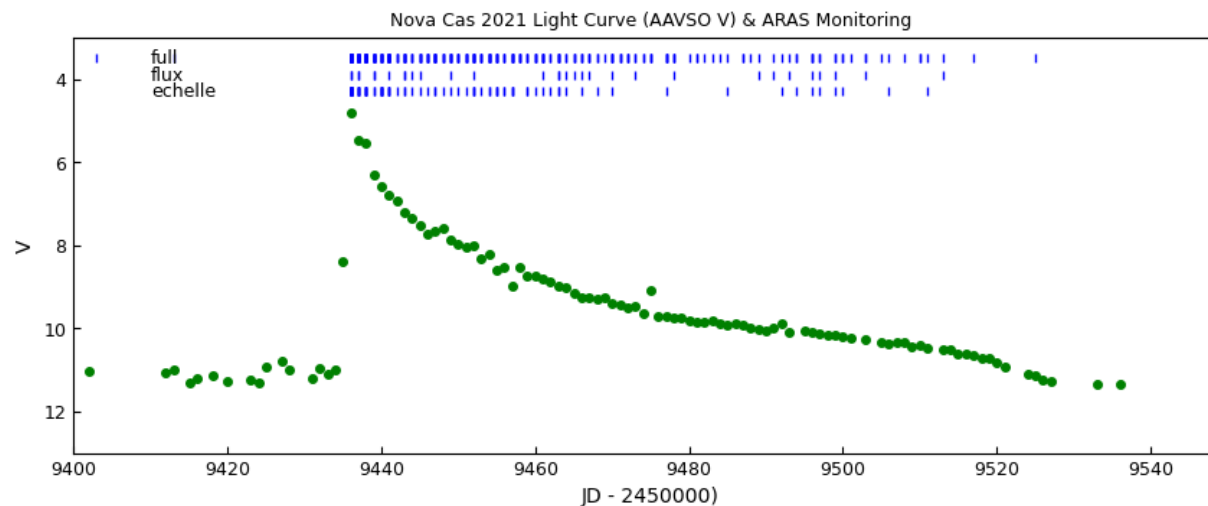
Accretion powered symbiotic

Recurrent nova: 1898, 1933, 1958, 1967, 1985, 2006, **2021**

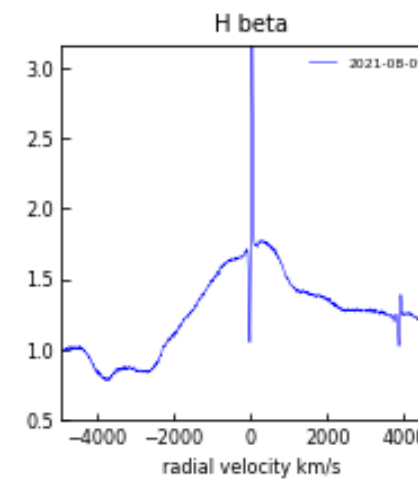
$M_{WD} 1.35 M_{\odot}$

$P_{orb} 453.6 d$

RG M0-2 III



F. Teyssier NOUT R = 9000



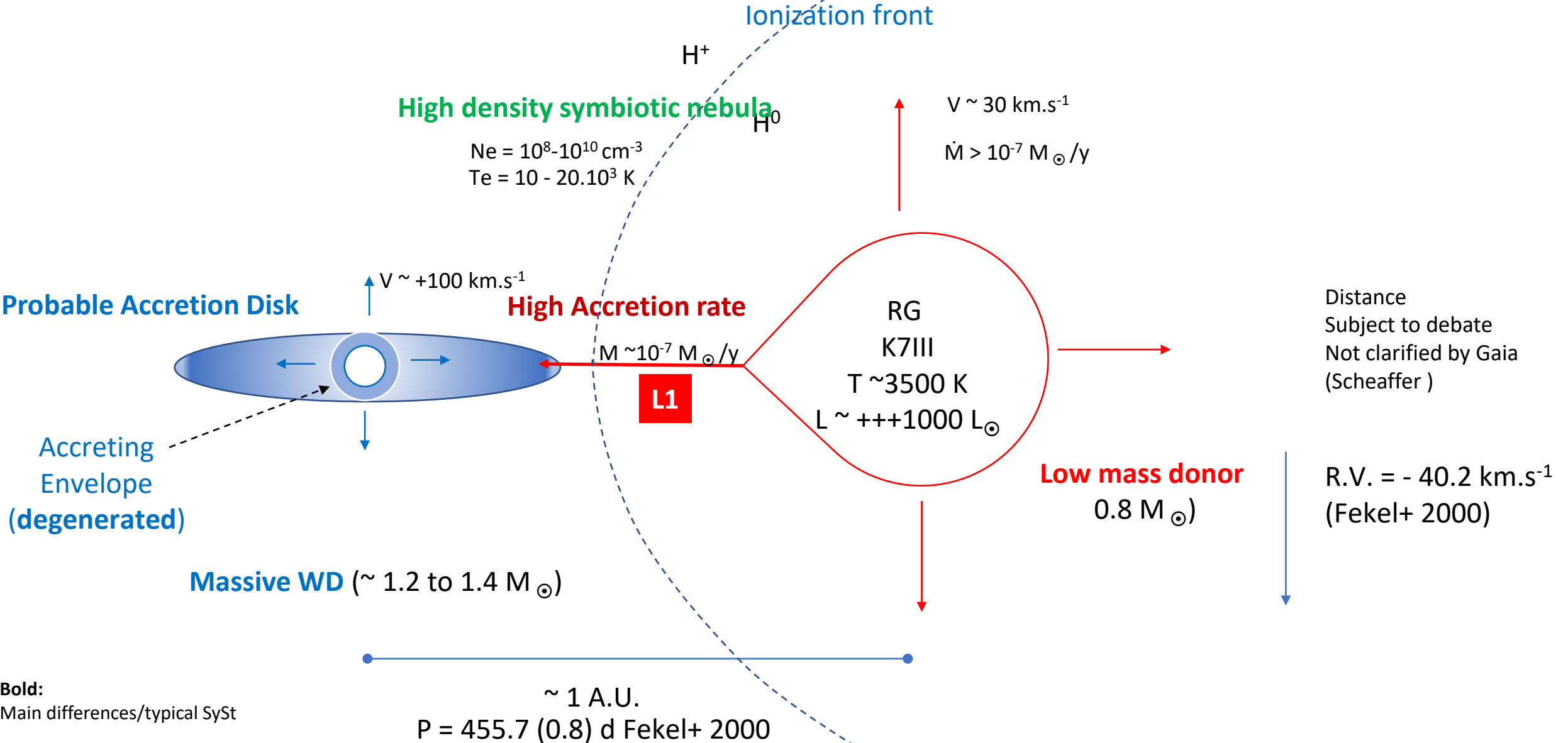
RS Oph 2021
High cadency
Optical spectroscopic monitoring
F. Teyssier, J. Guarro Flo



Special session RS Oph 2021

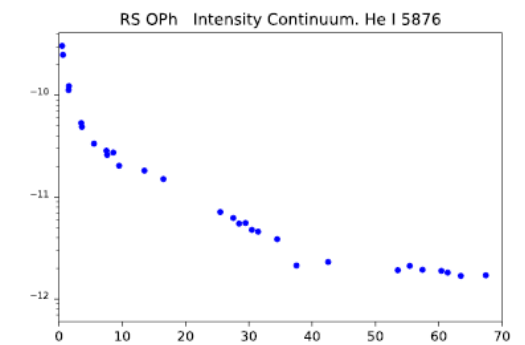
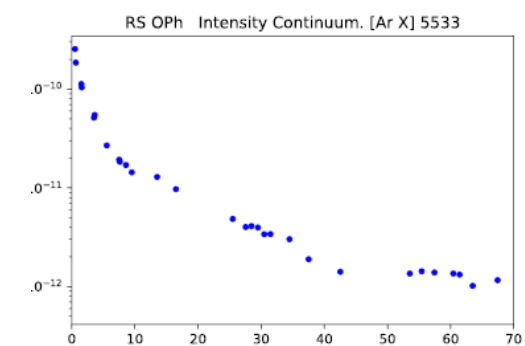
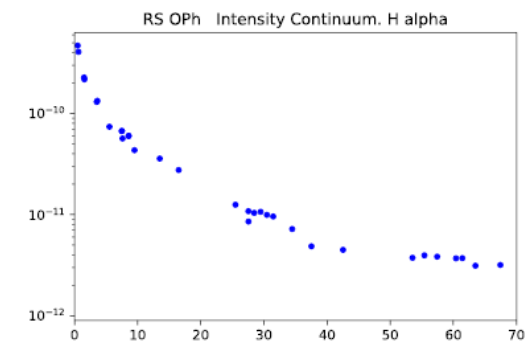
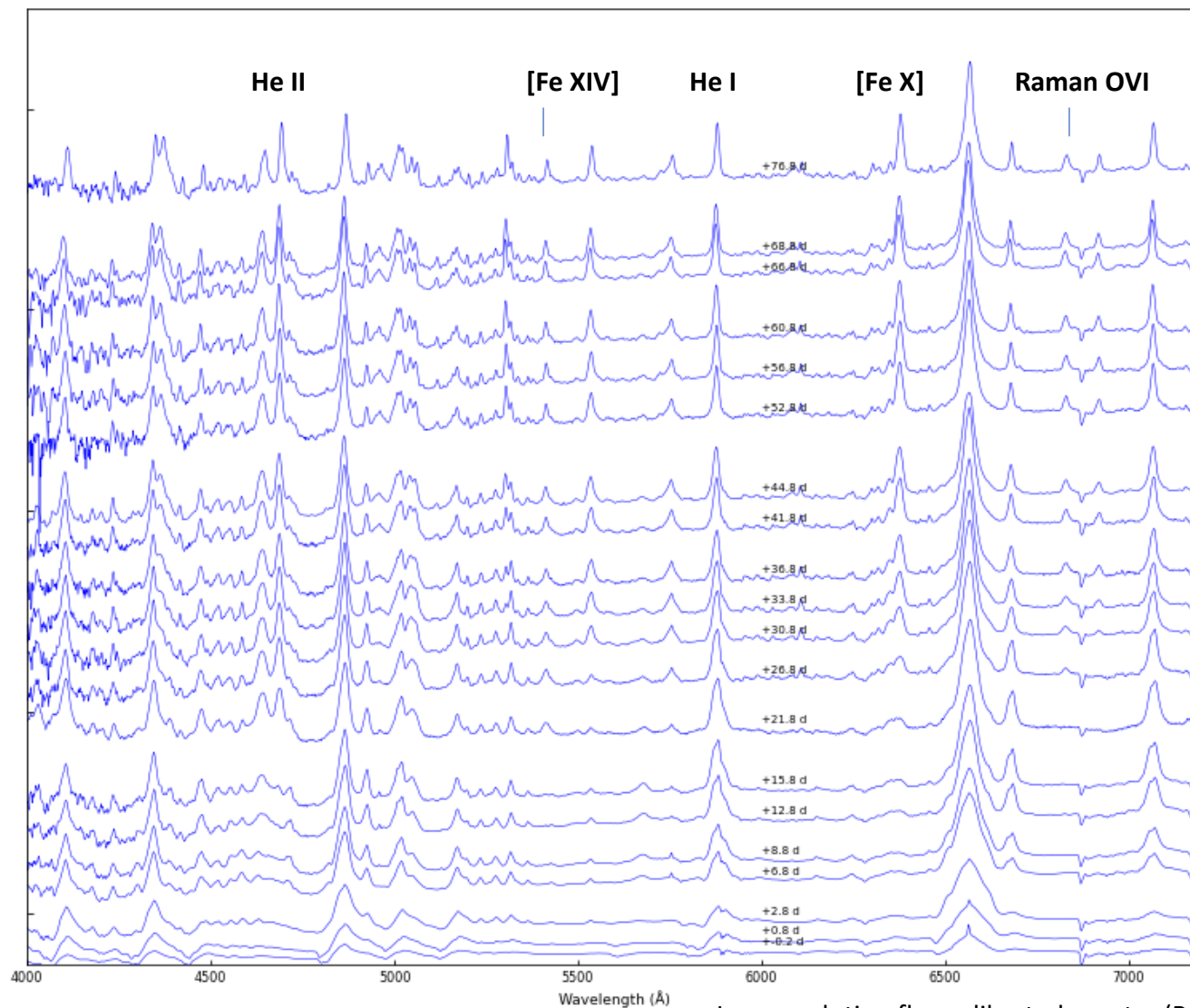
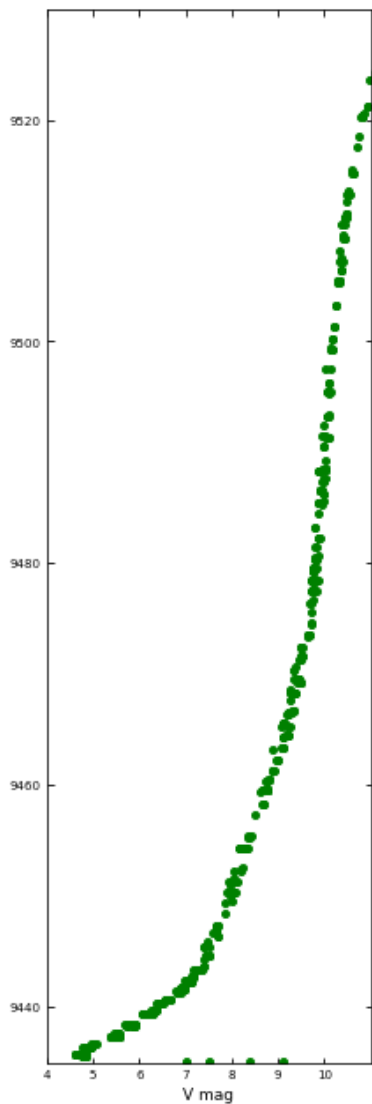
[http://www.astronomie-amateur.fr/
Documents%20Symbiotic%20Stars/
ROOM9_SS18b_1215_Teyssier.pdf](http://www.astronomie-amateur.fr/Documents%20Symbiotic%20Stars/ROOM9_SS18b_1215_Teyssier.pdf)

RS Oph in quiescence - simplified model



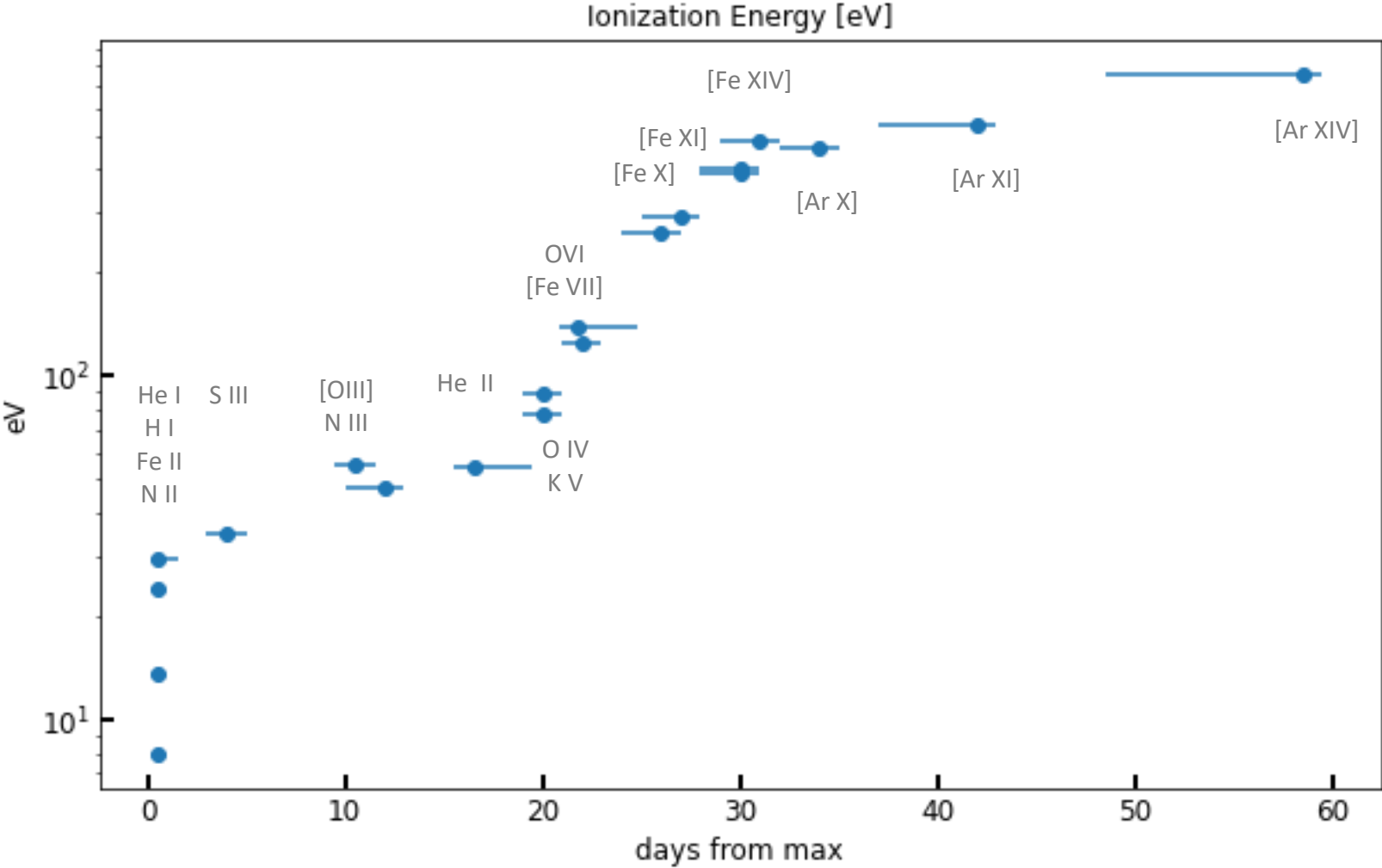
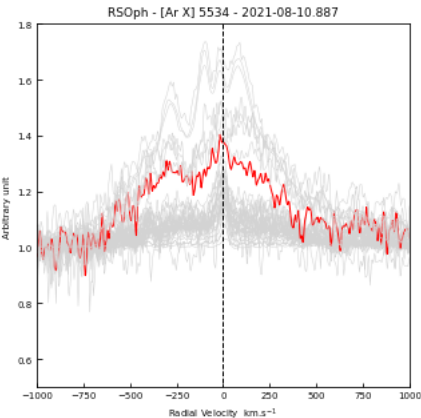
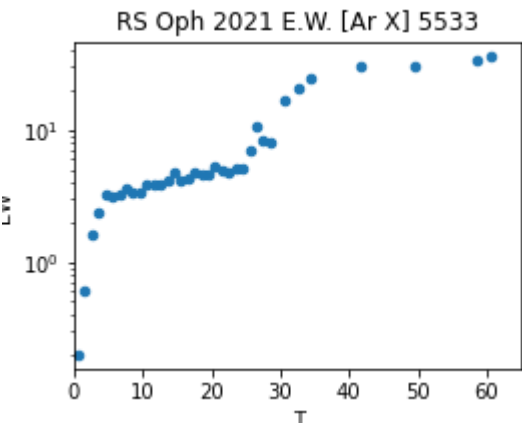
Bold:
Main differences/typical SySt

2. Recurrent symbiotic nova RS Oph

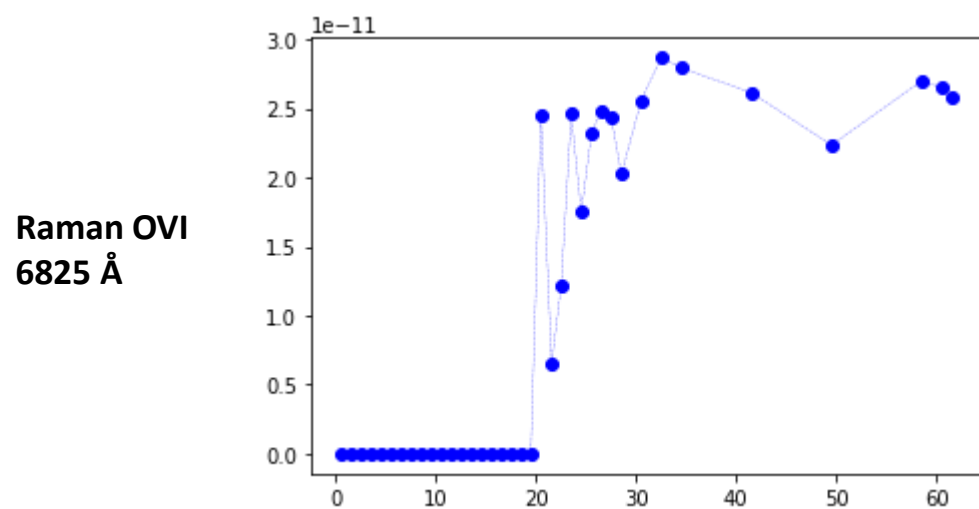
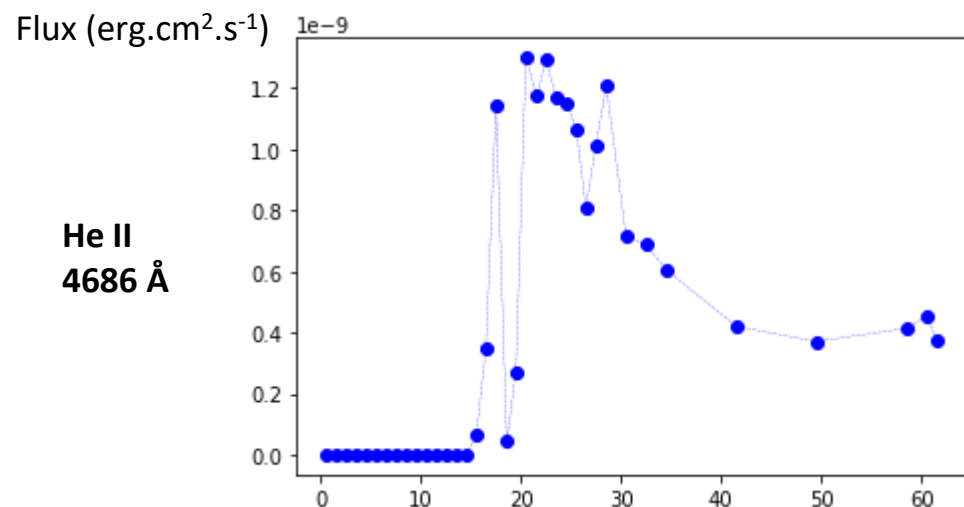


Low resolution flux calibrated spectra ($R = 1000$)
Secured by F. Sims, P. Dubovky, D. Boyd
V band light curve: AAVSO

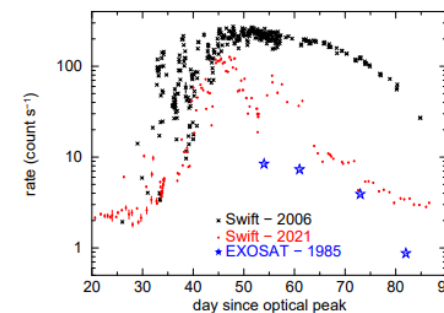
Method



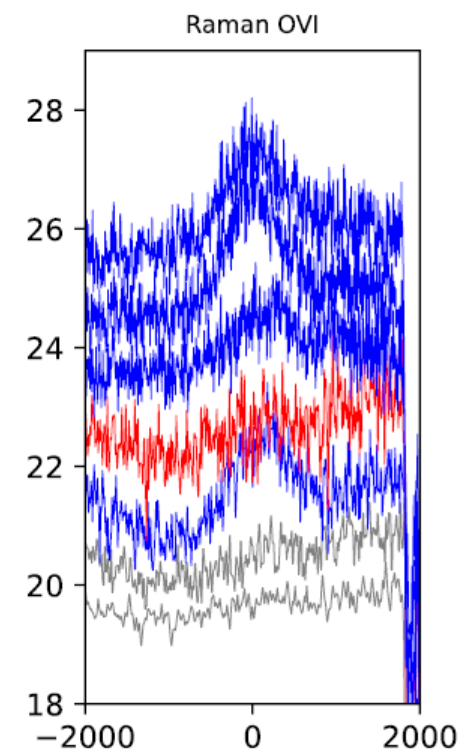
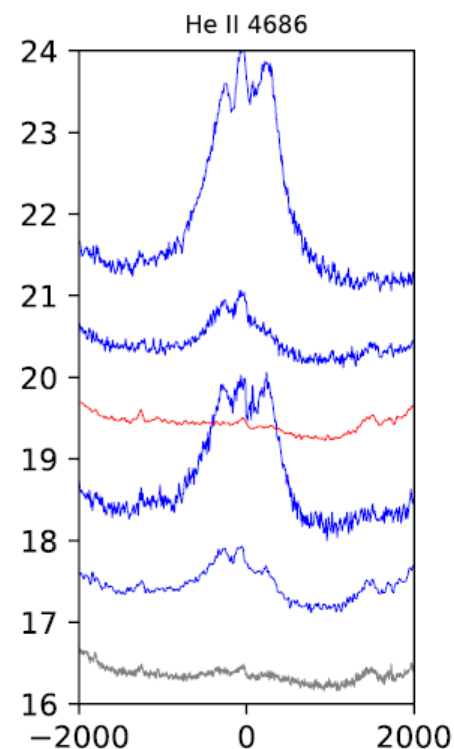
2. Recurrent symbiotic nova RS Oph



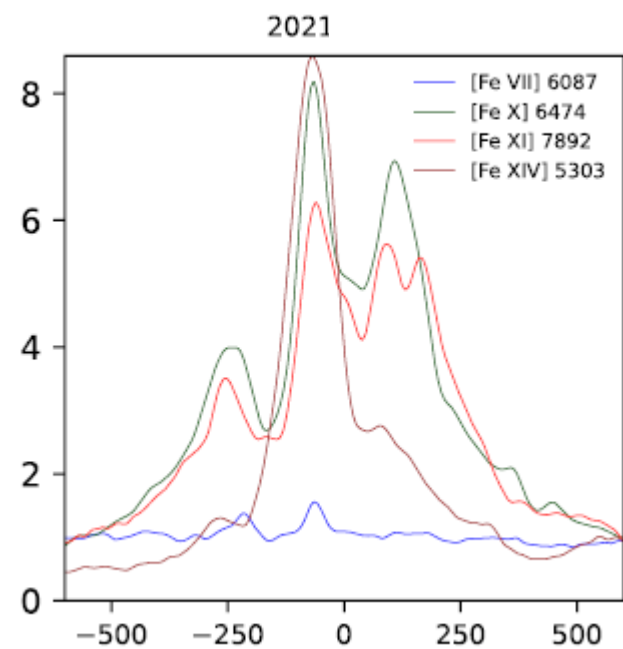
Echelle spectra: J. Guarro Flo (16), F. Teyssier (13), S. Charbonnel (6), C. Elridge (3), O. Thizy (2)
Flux calibration with spectra secured by F. Sims, P. Dubovky, D. Boyd



Soft X-rays
Page+, 2022

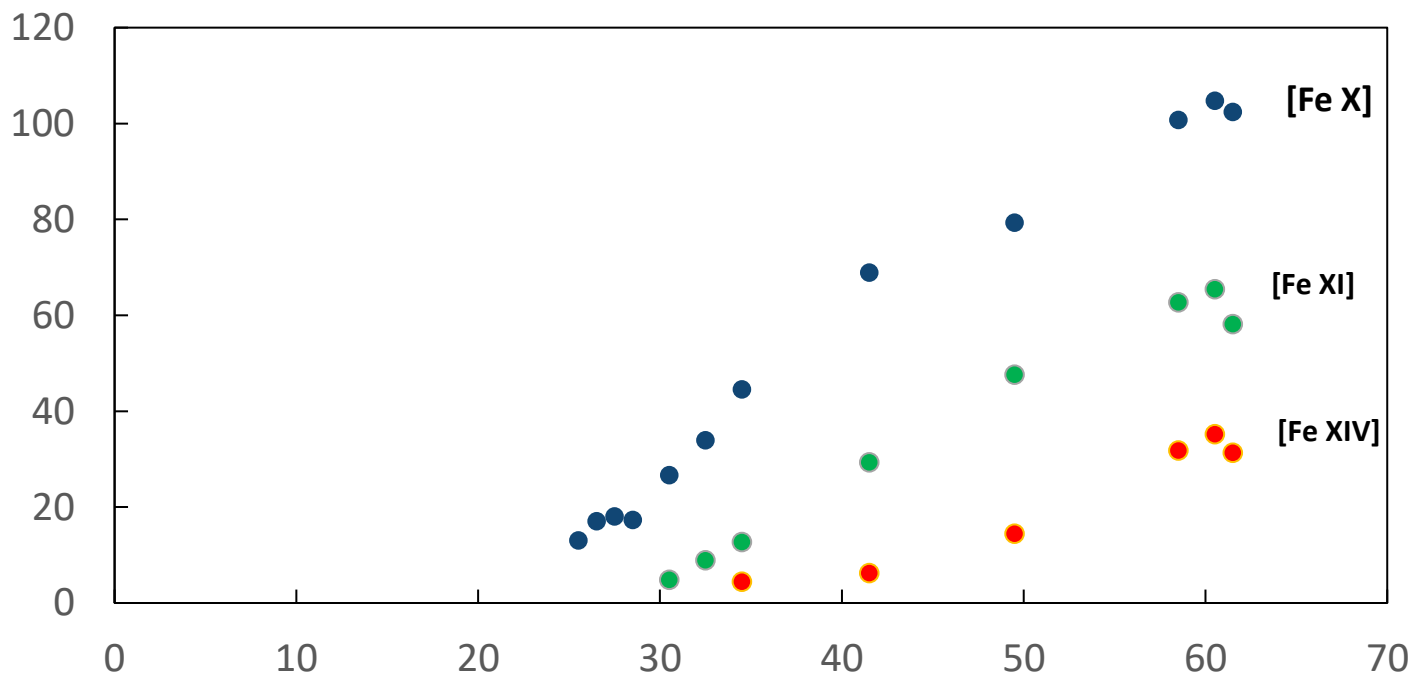


2. Recurrent symbiotic nova RS Oph



Ejecta components at $E_{\max} \sim 300$ eV

Equivalent Width



3. Long term monitoring of AX Per, classical symbiotic star

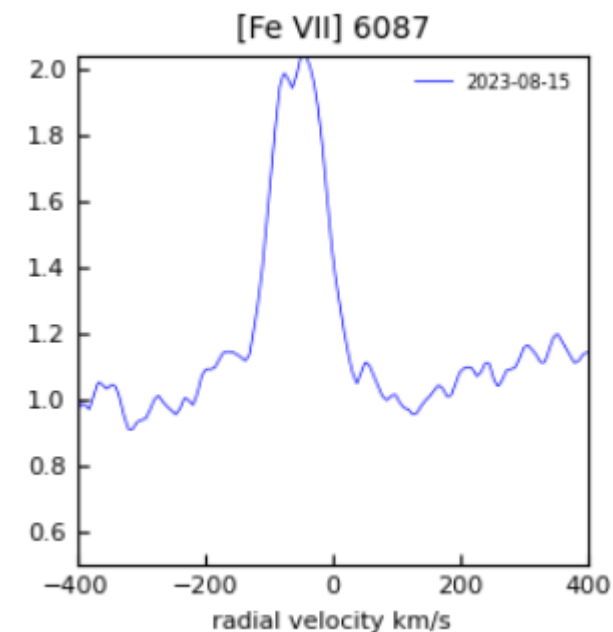
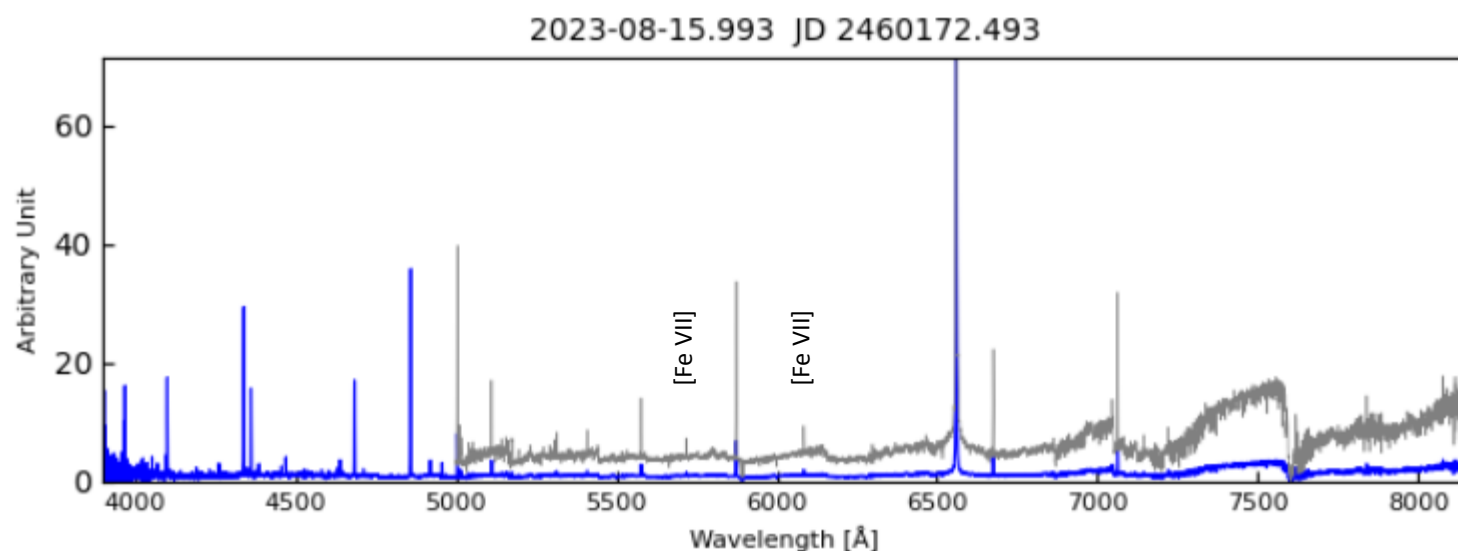
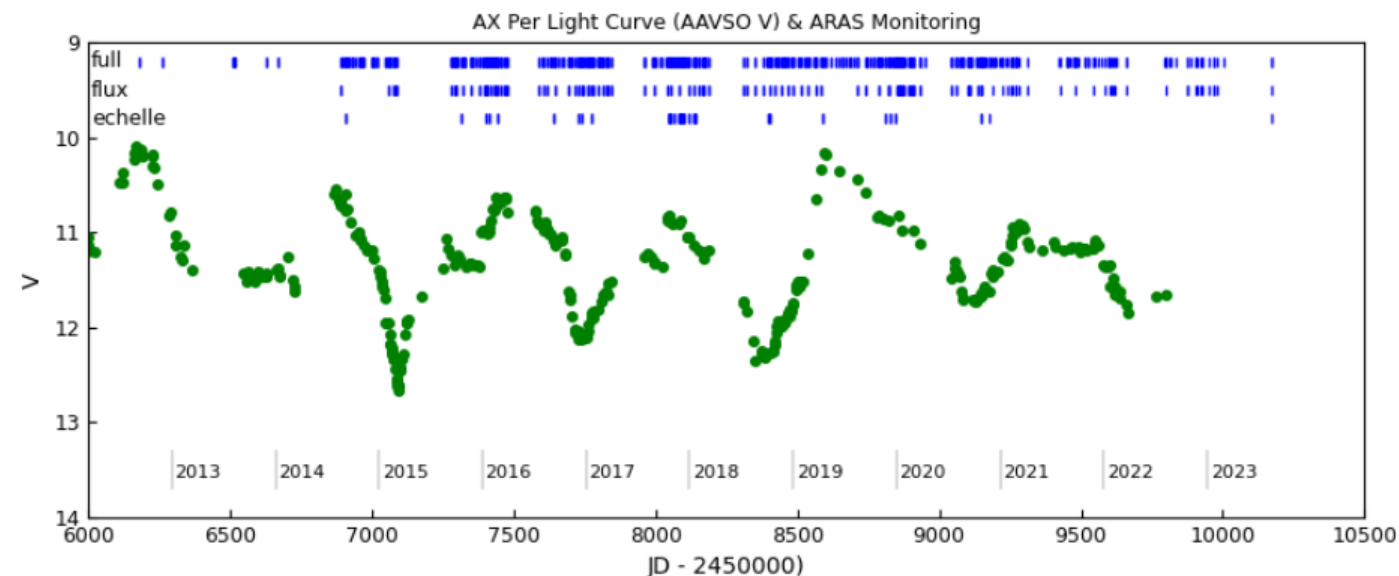
Classical Symbiotic

Steady burning

High states and outbursts

Eclipsing

806 spectra

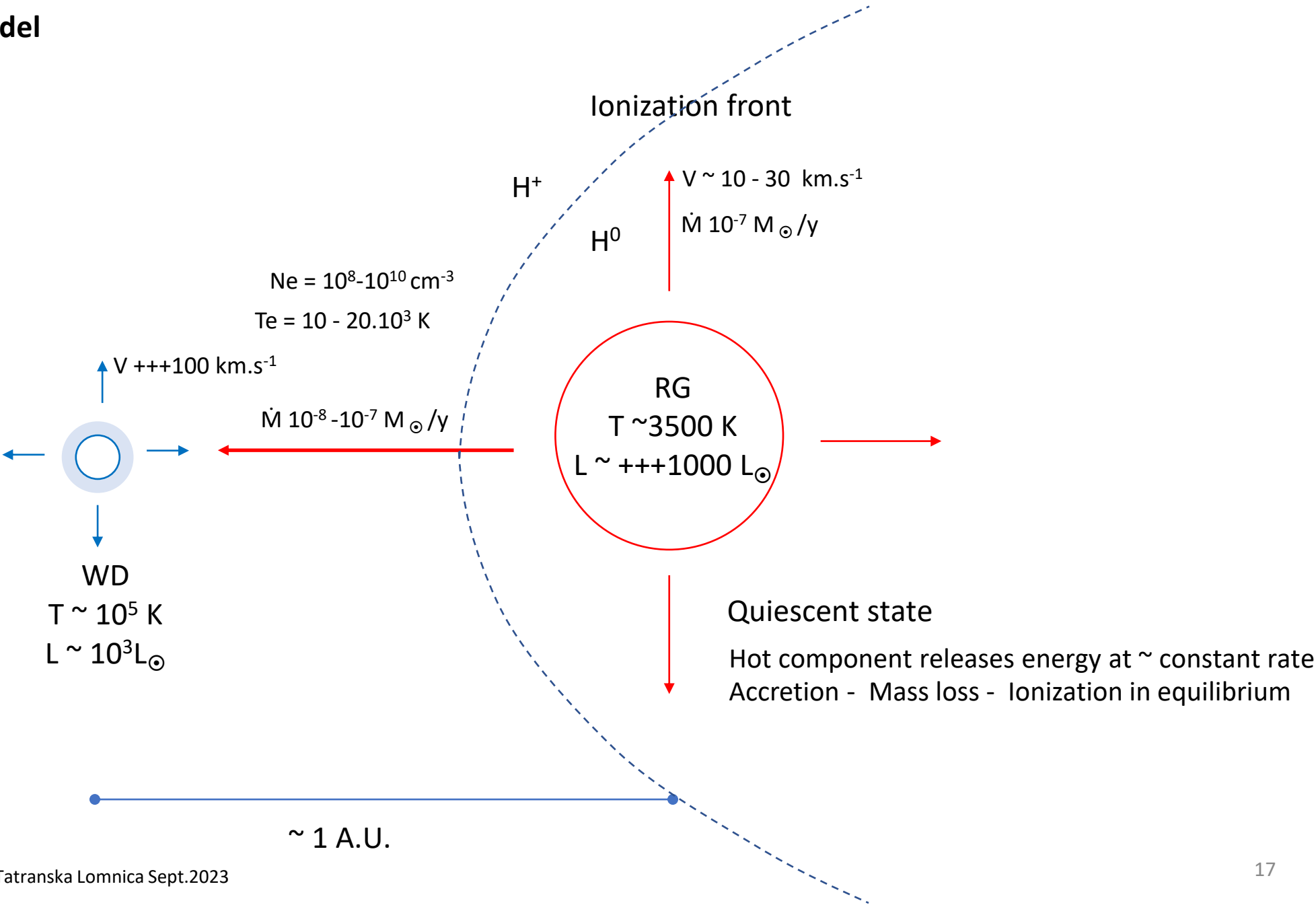


3. Long term monitoring of AX Per, classical symbiotic star

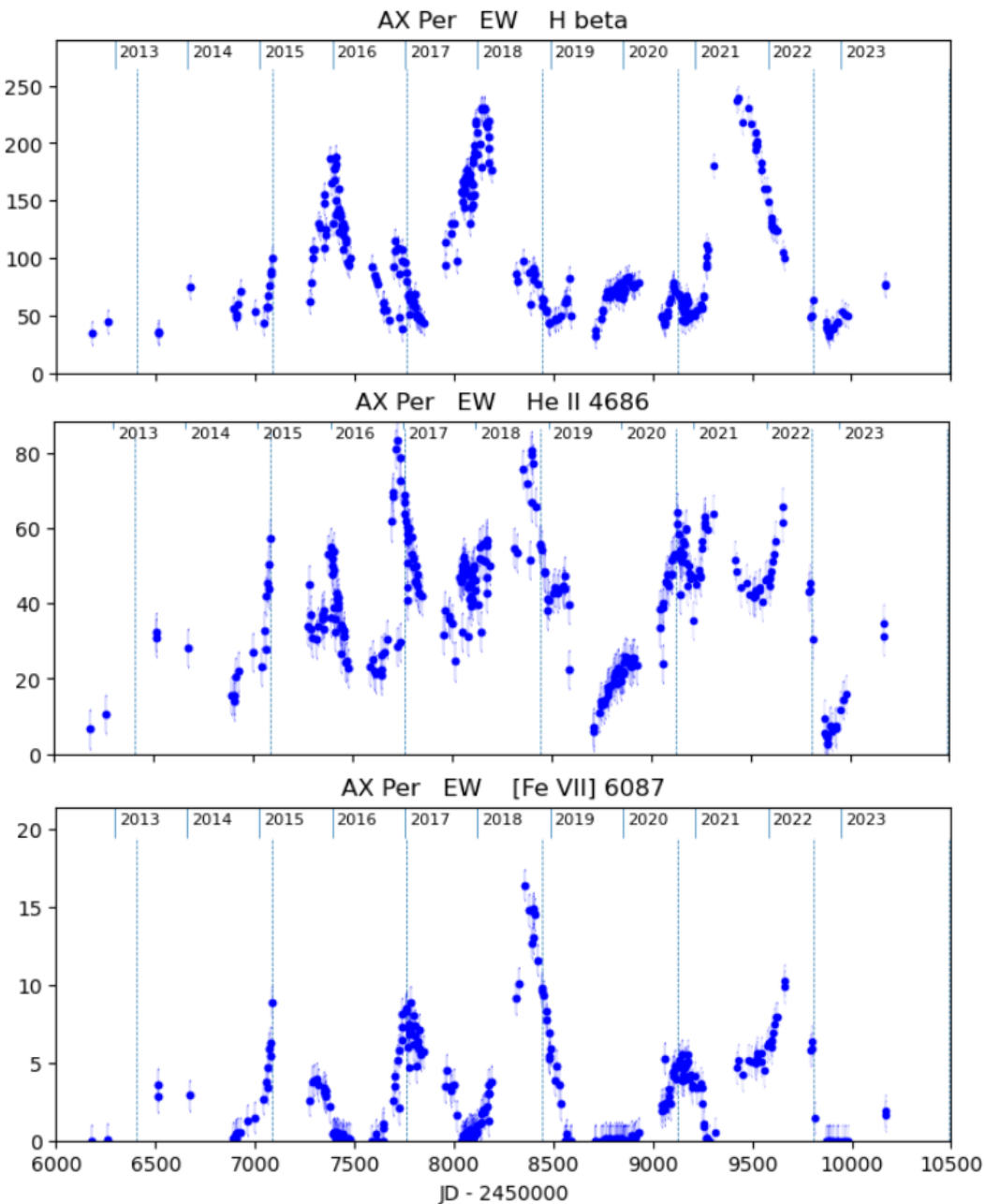
Classical Symbiotic model

AX Per in quiescence

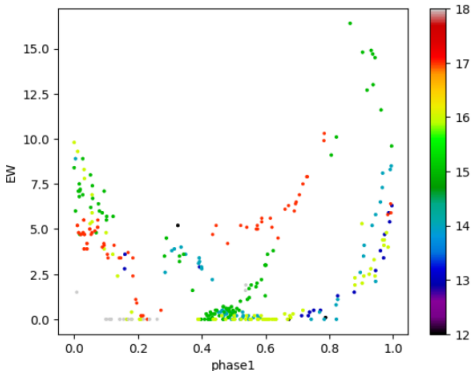
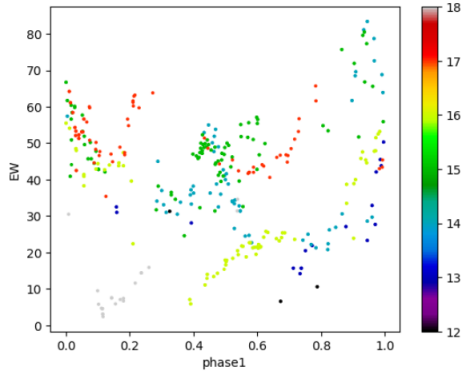
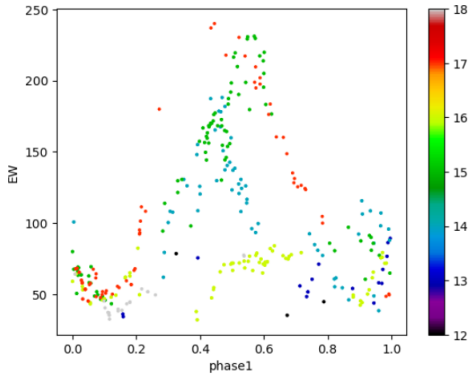
T_{WD}	105 000 K
L_{WD}	710 $L_{\odot}$
M_{WD}	0.4 $M_{\odot}$
$\dot{M}_{WD}$	$3 \cdot 10^{-7} M_{\odot}/y$
RG	M5 III
M_R	1.1 $M_{\odot}$
P_{orb}	682.1 d
e	0
d	3357 pc



3. Long term monitoring of AX Per, classical symbiotic star



Dashed line:
Eclipse
[Skopal, 2011]



4. An eclipse in BX Mon

BX Mon

Spectroscopic orbit RG

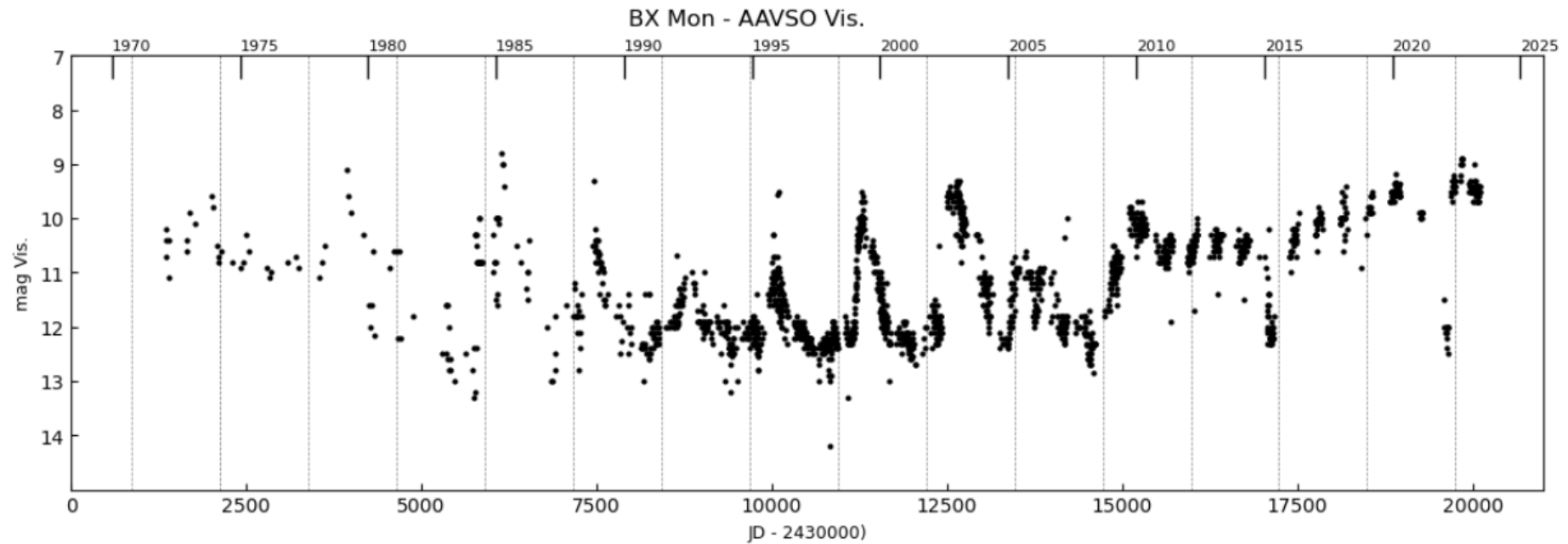
P = 1259 d

e = 0.44

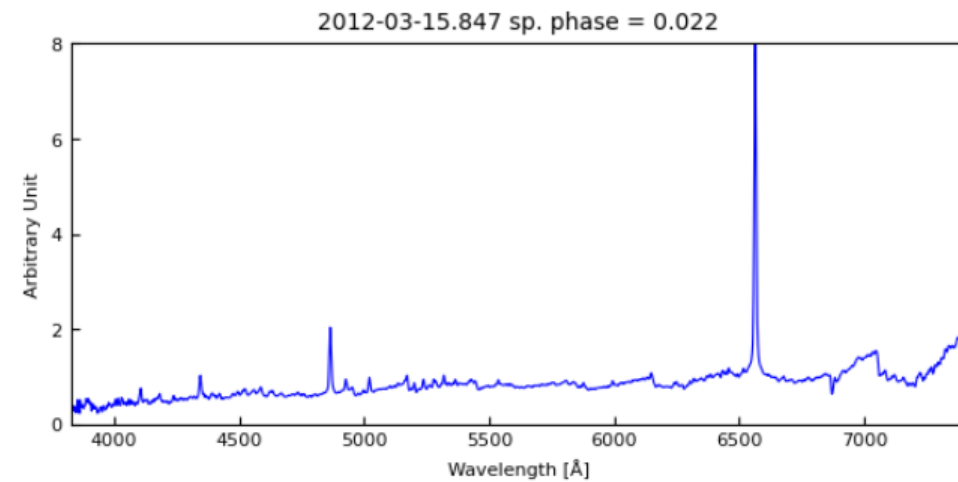
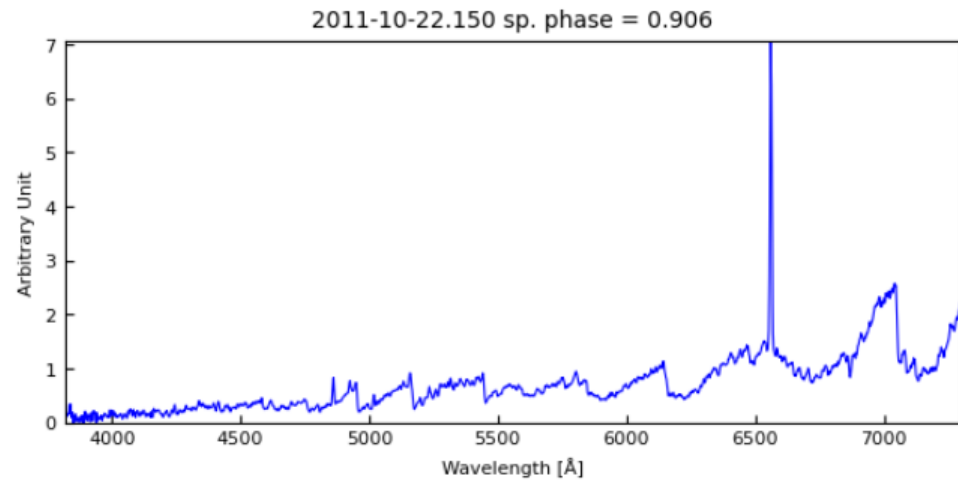
[Fekel+,2000]

Photometric periods

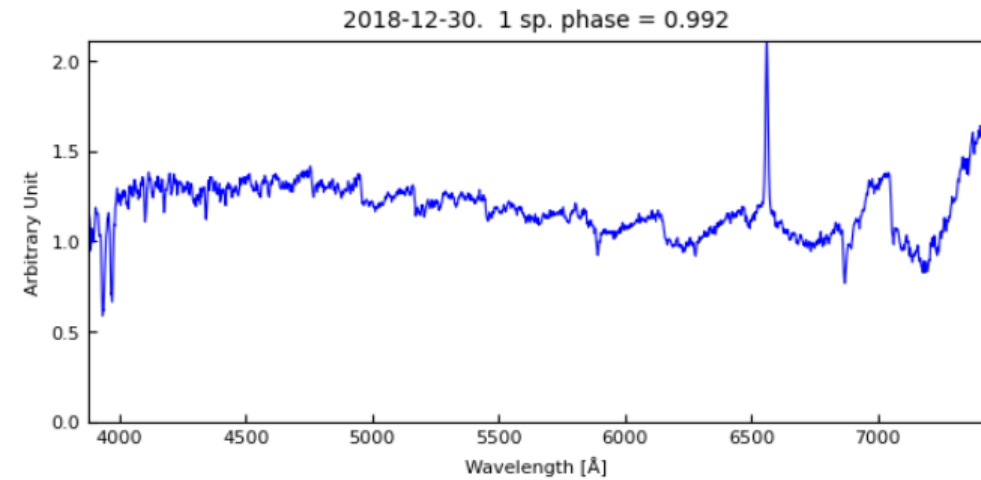
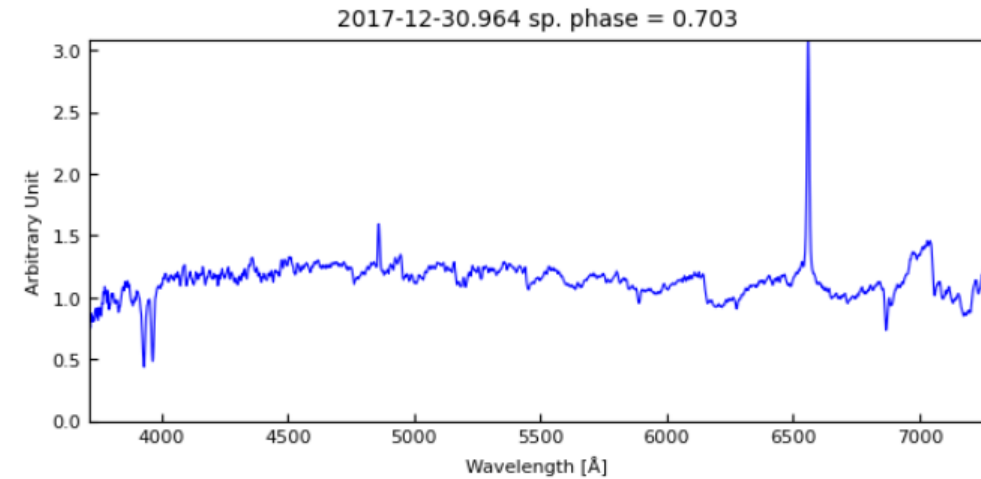
P = 1250 to 1400d



4. An eclipse in BX Mon

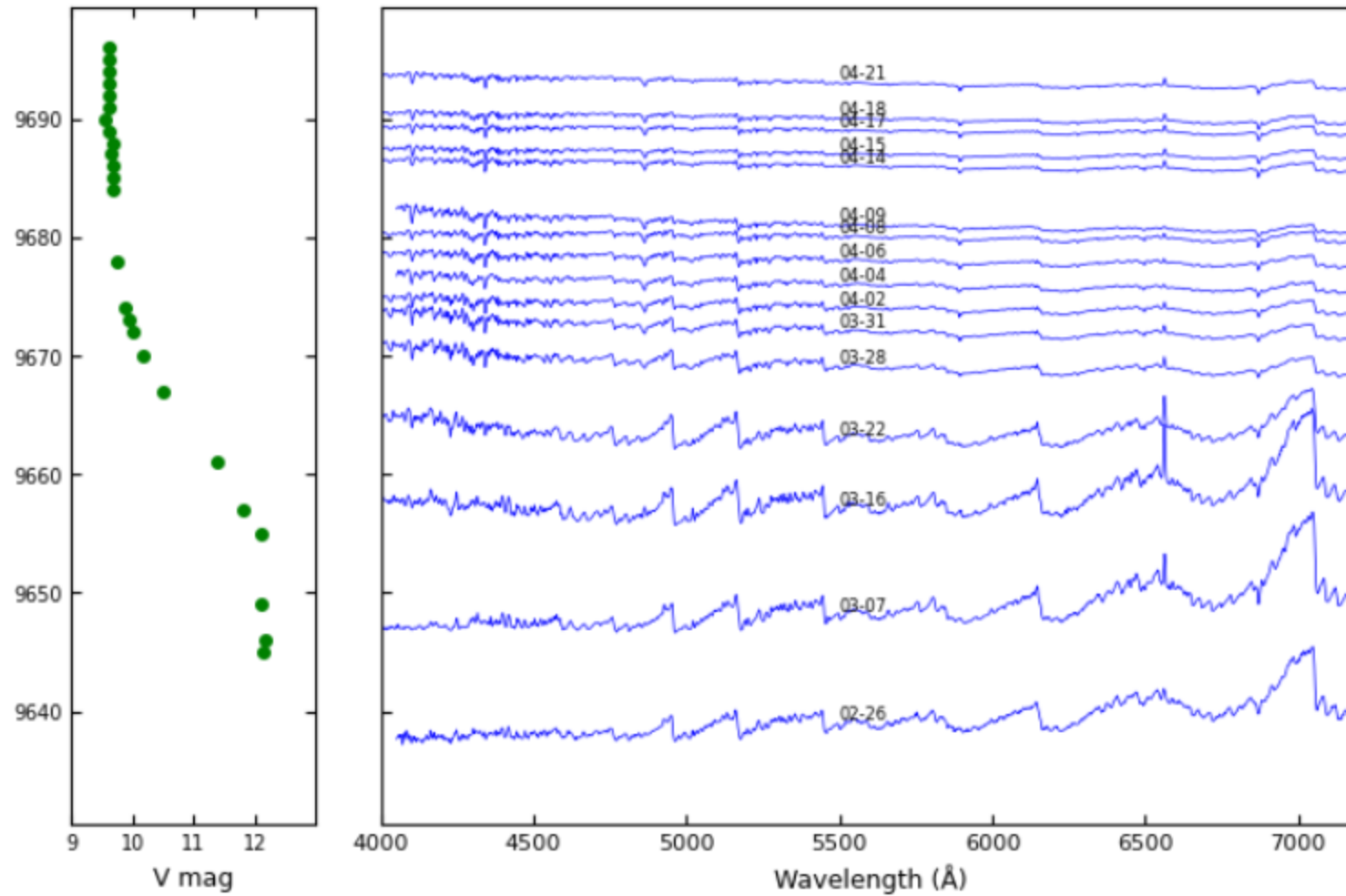


Spectra: C. Buil, Thierry Lemoult LISA R = 1000



Spectra: F. Campos

4. An eclipse in BX Mon

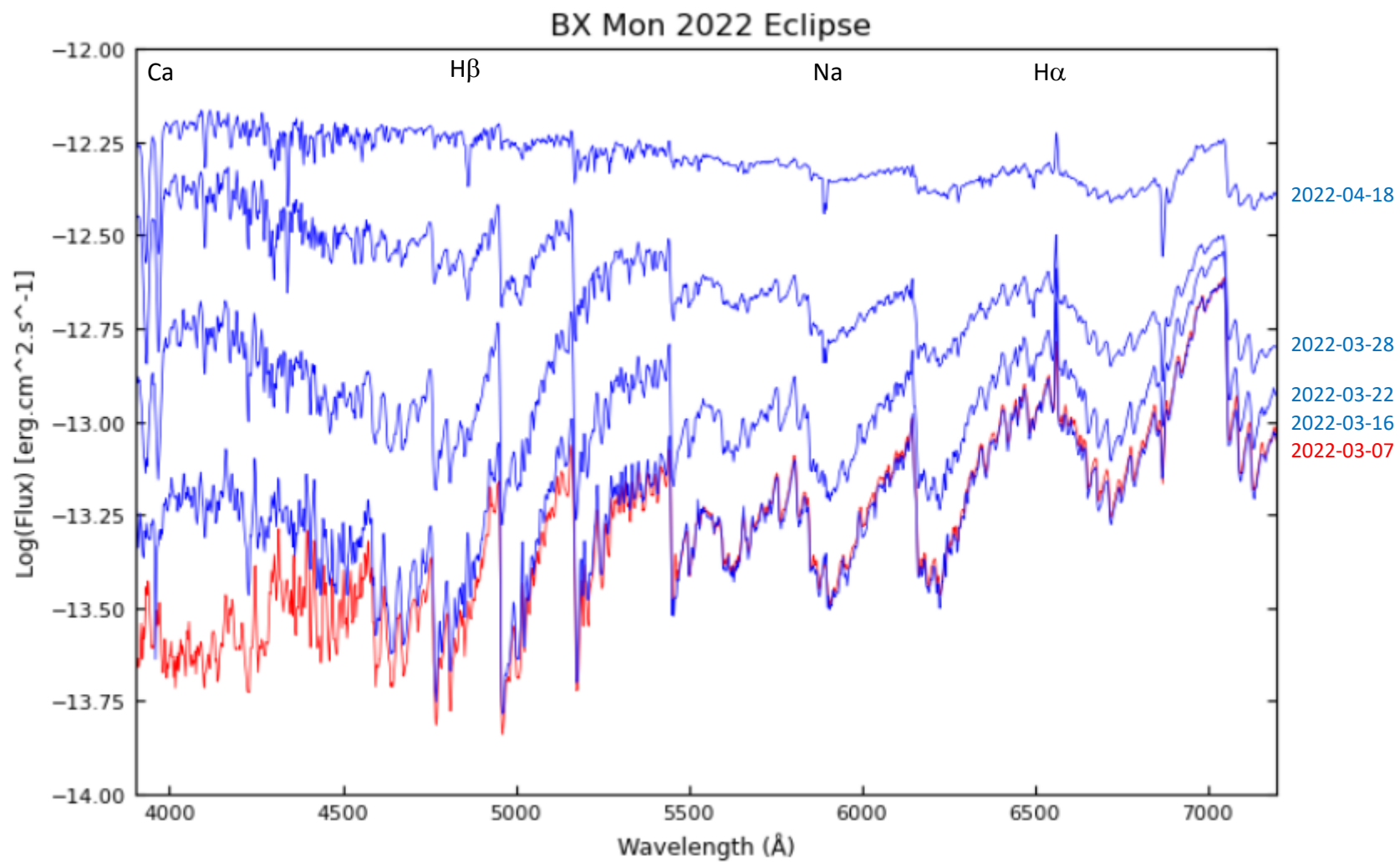


le

Spectra: F. Sims, F. Boubault, D. Boyd LISA R = 1000

4. An eclipse in BX Mon

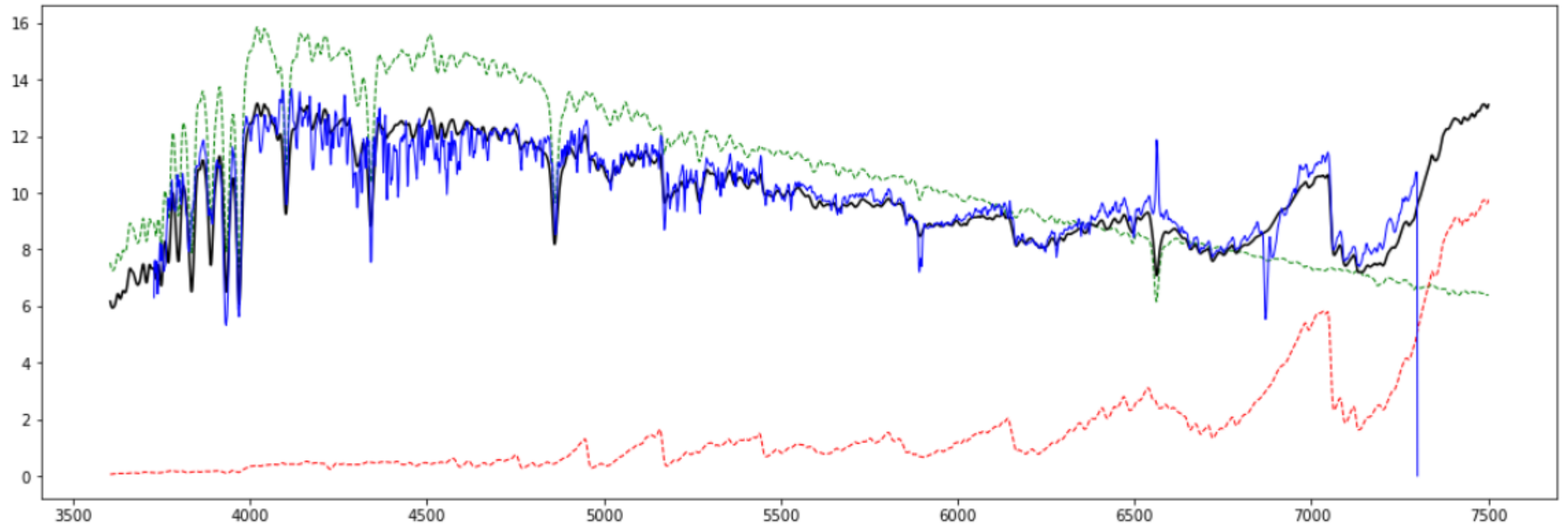
2022-03-07T03:12:32 -inf -12.614923 2022-03-16T03:30:07 -inf -12.621252 2022-03-22T02:50:58 -inf -12.543375 2022-03-28T03:44:12 -inf -12.318023 2022-04-18T03:16:41 -inf -12.164275



Selected flux calibrated spectra F. Sims LISA R = 1000

4. An eclipse in BX Mon

Synthetic spectrum



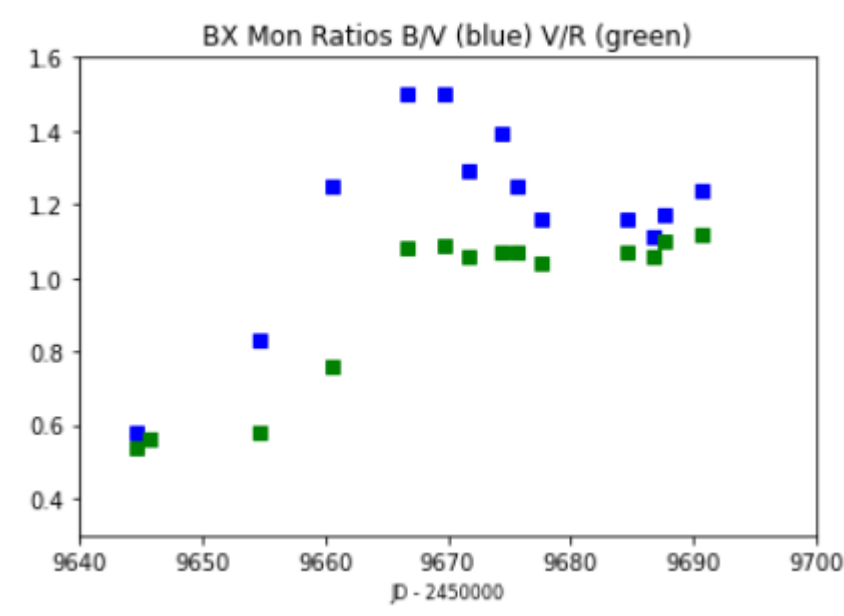
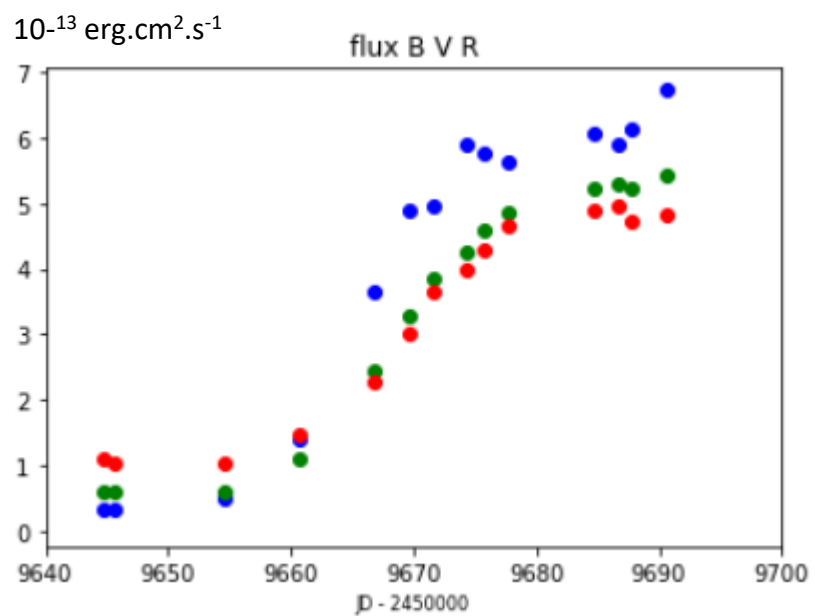
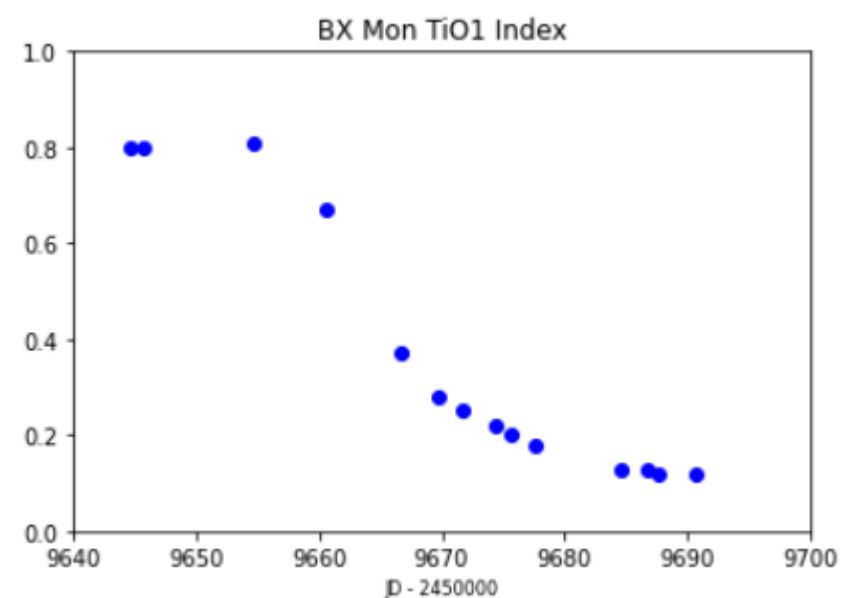
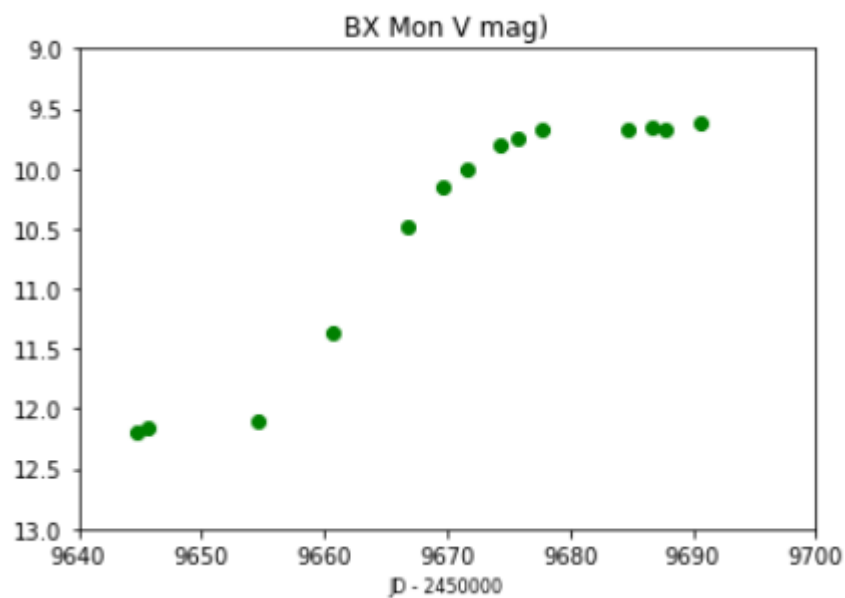
Observed

M6III RG

F4 III Hot component (Flux factor x 10)

Synthetic spectrum

4. An eclipse in BX Mon



Flux of the continuum

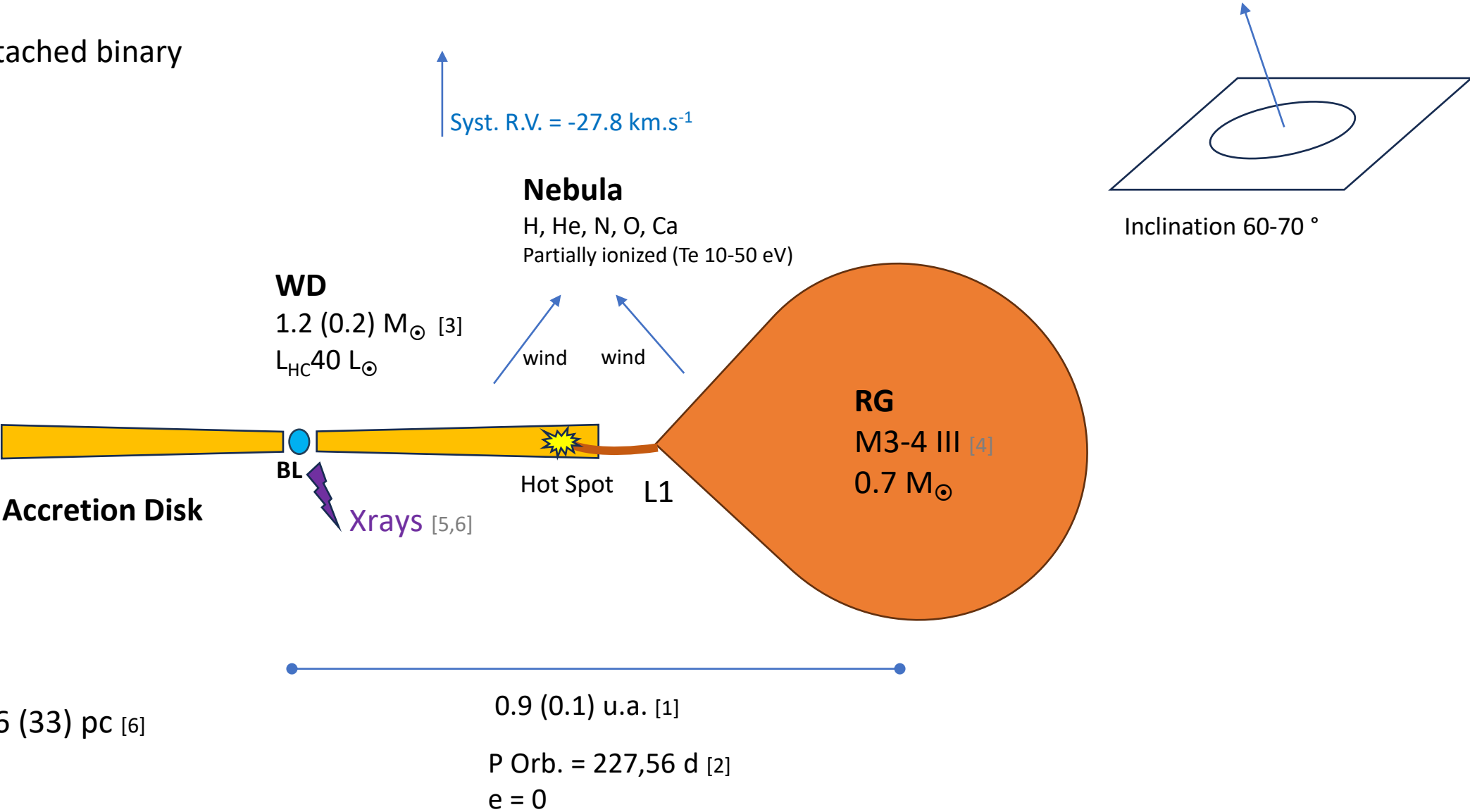
4367 (10) Å

5448 (10) Å

6704 (10) Å

6. Preoutburst monitoring of the recurrent symbiotic nova T CrB

Interacting semi-detached binary



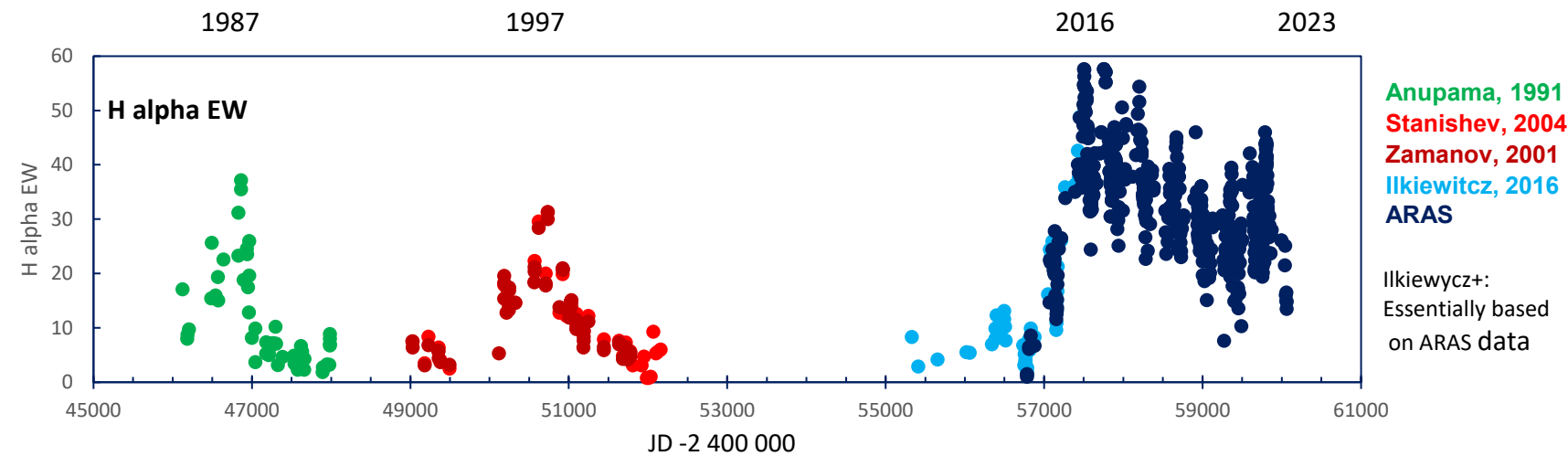
6. Preoutburst monitoring of the recurrent symbiotic nova T CrB

T CrB

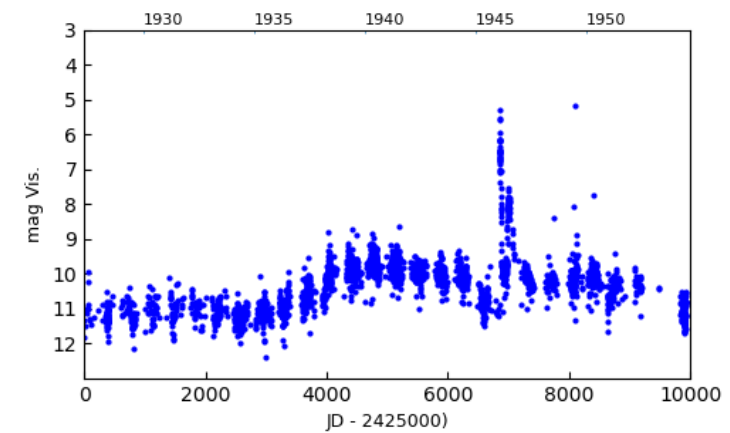
Accretion powered symbiotic $L_{\text{hot}} =$

$P = 228 \text{ d}$

Recurrent symbiotic nova (1866-1946- from now)



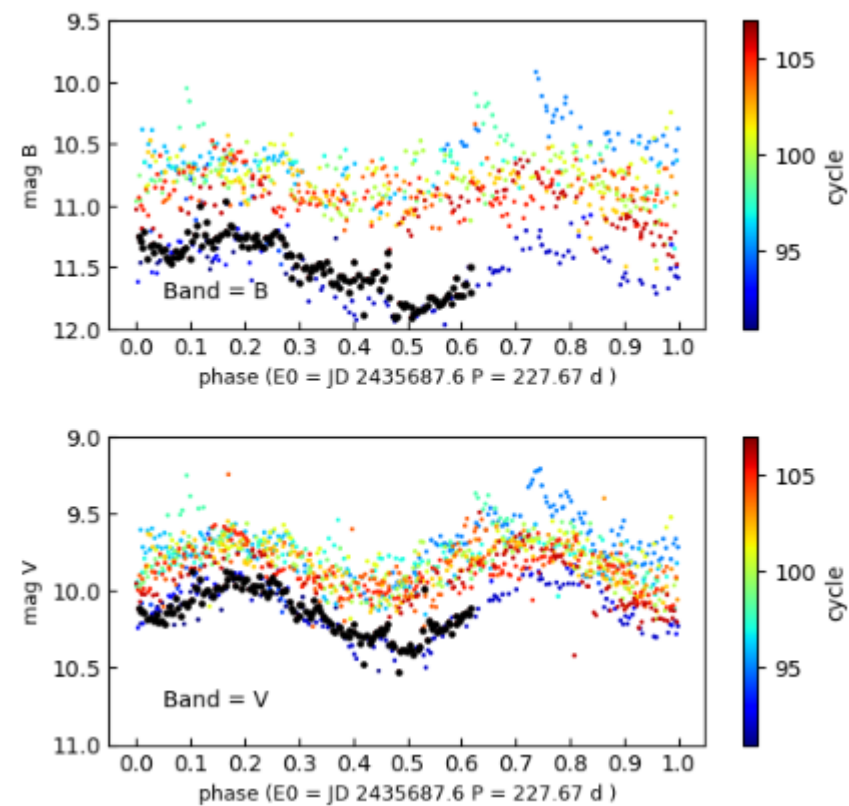
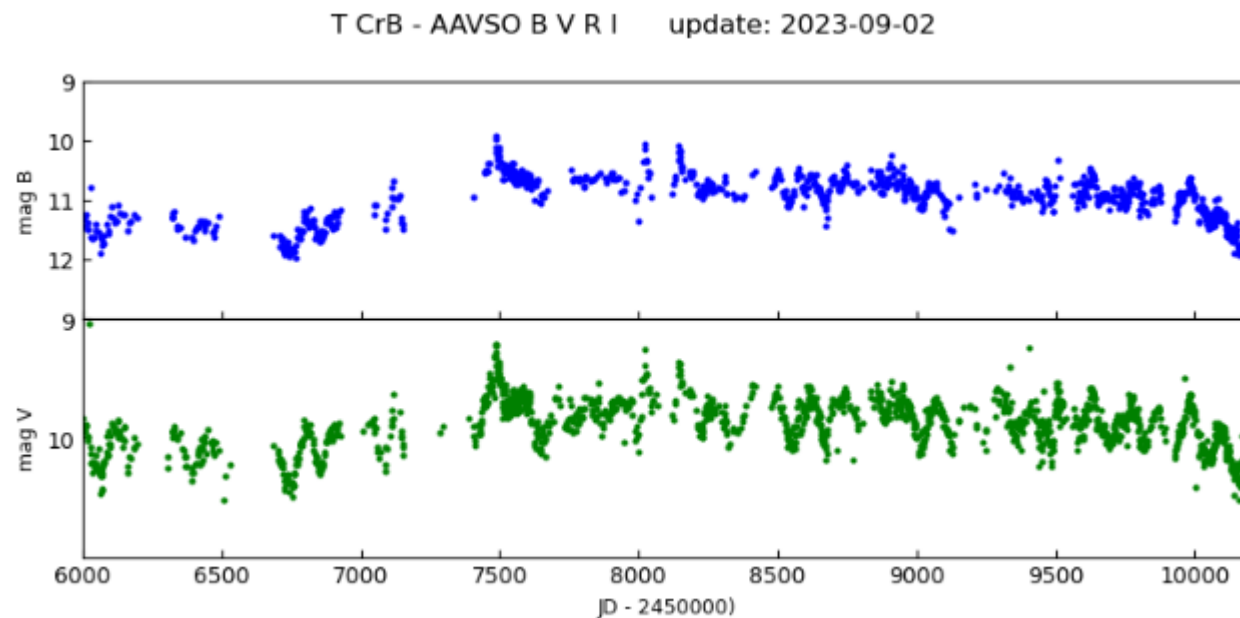
① Low & High States: increase of M'_{acc} from $10^{-9} M_{\odot} \text{ yr}^{-1}$ to $\approx 10^{-8} M_{\odot} \text{ yr}^{-1}$ [Luna+,2020]



② 1946 outburst (DASH archives)
 $P_{\text{env}} > P_{\text{crit}}$ ($M_{\text{env}} \approx 10^{-6} M_{\odot}$)

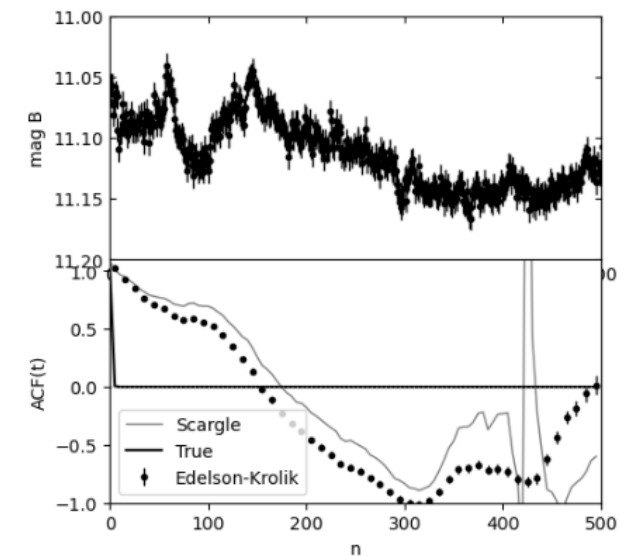
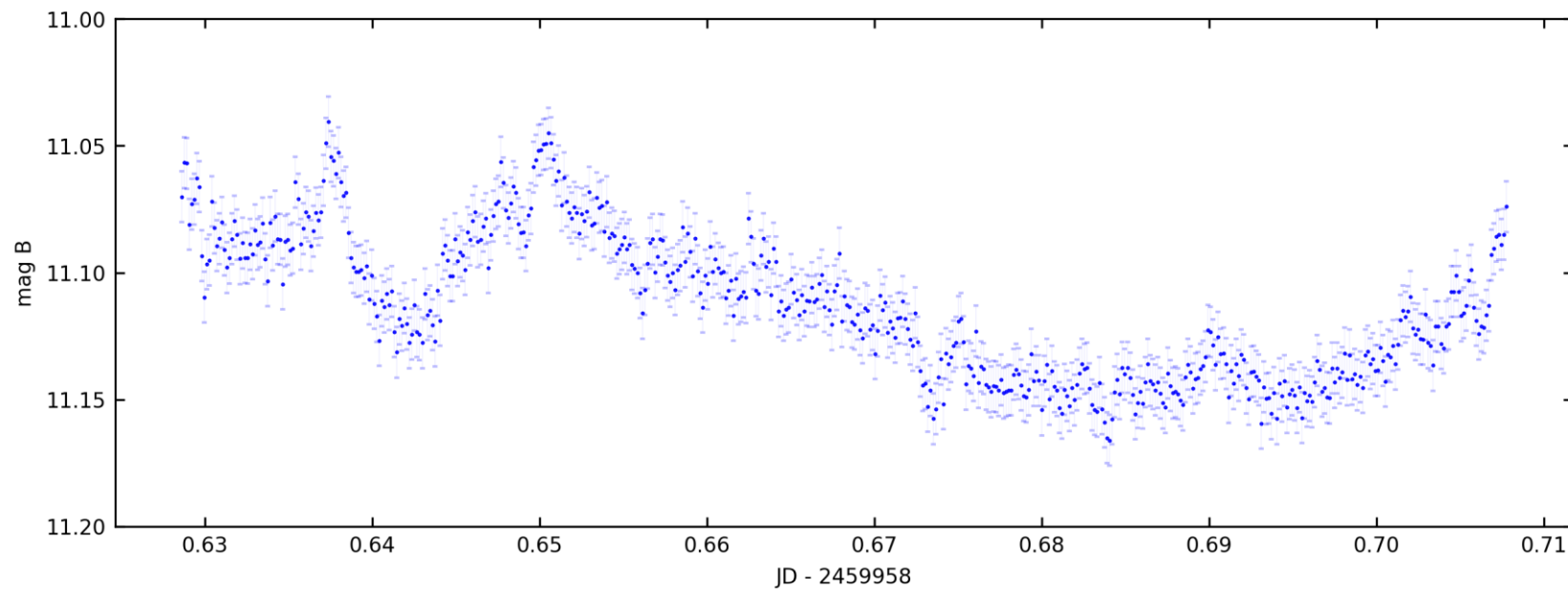
We have not the full story: only 3 episodes in season 2
What is the current M_{env} ?

6. Preoutburst monitoring of the recurrent symbiotic nova T CrB

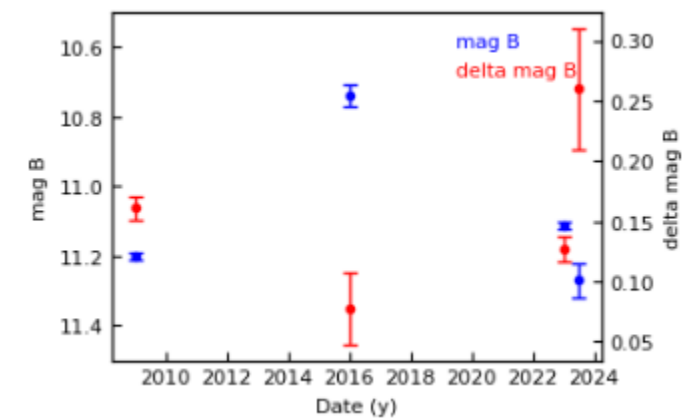


③ Ellipsoïdal modulation: RG filling the Lobe Roche

④ Flickering

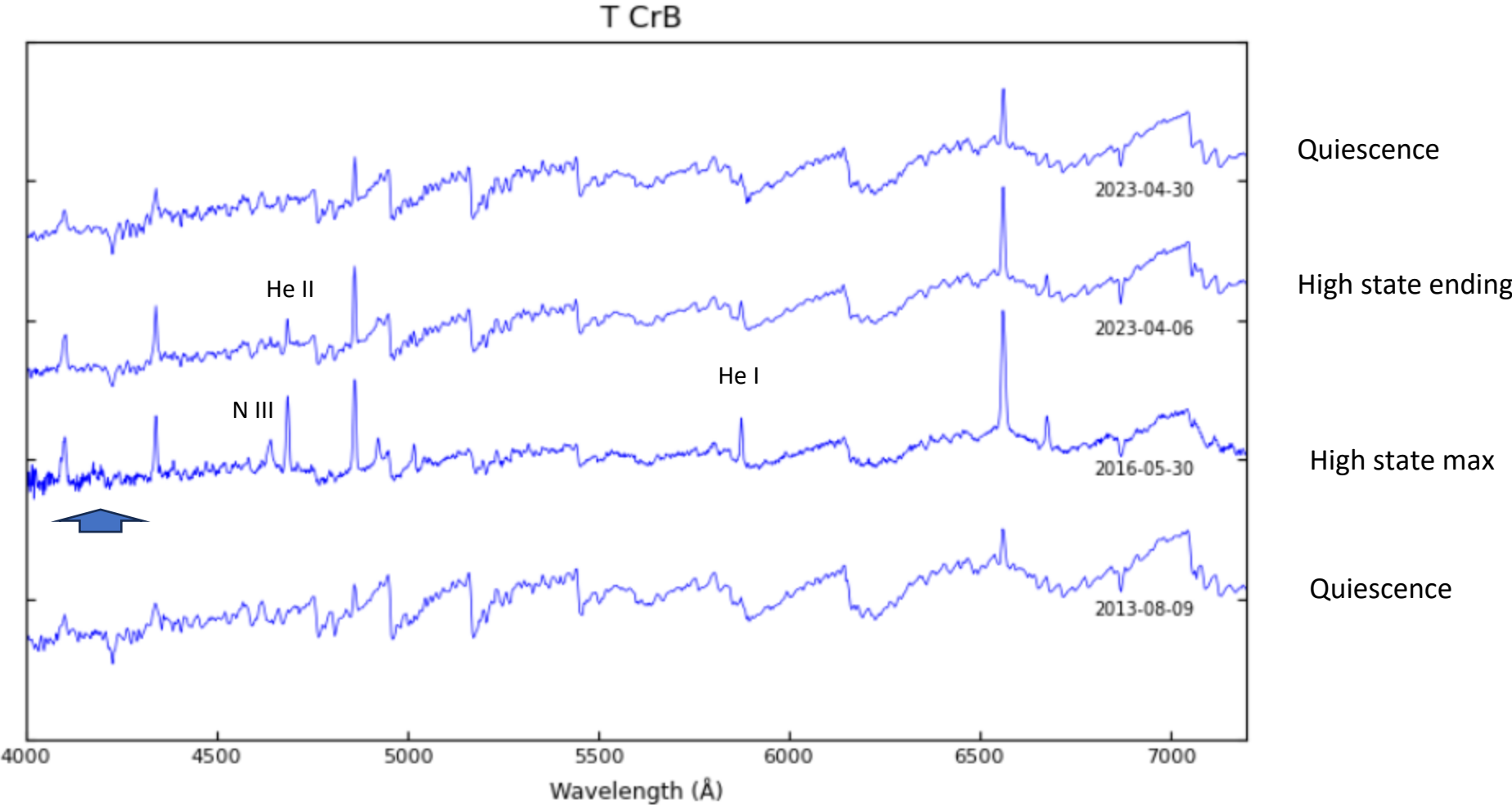


F. Teyssier T1M C2PU (FR) Epsilon telescope
2023 January
B band - Exposures: 10 seconds
<https://www.astronomerstelegam.org/?read=15916>



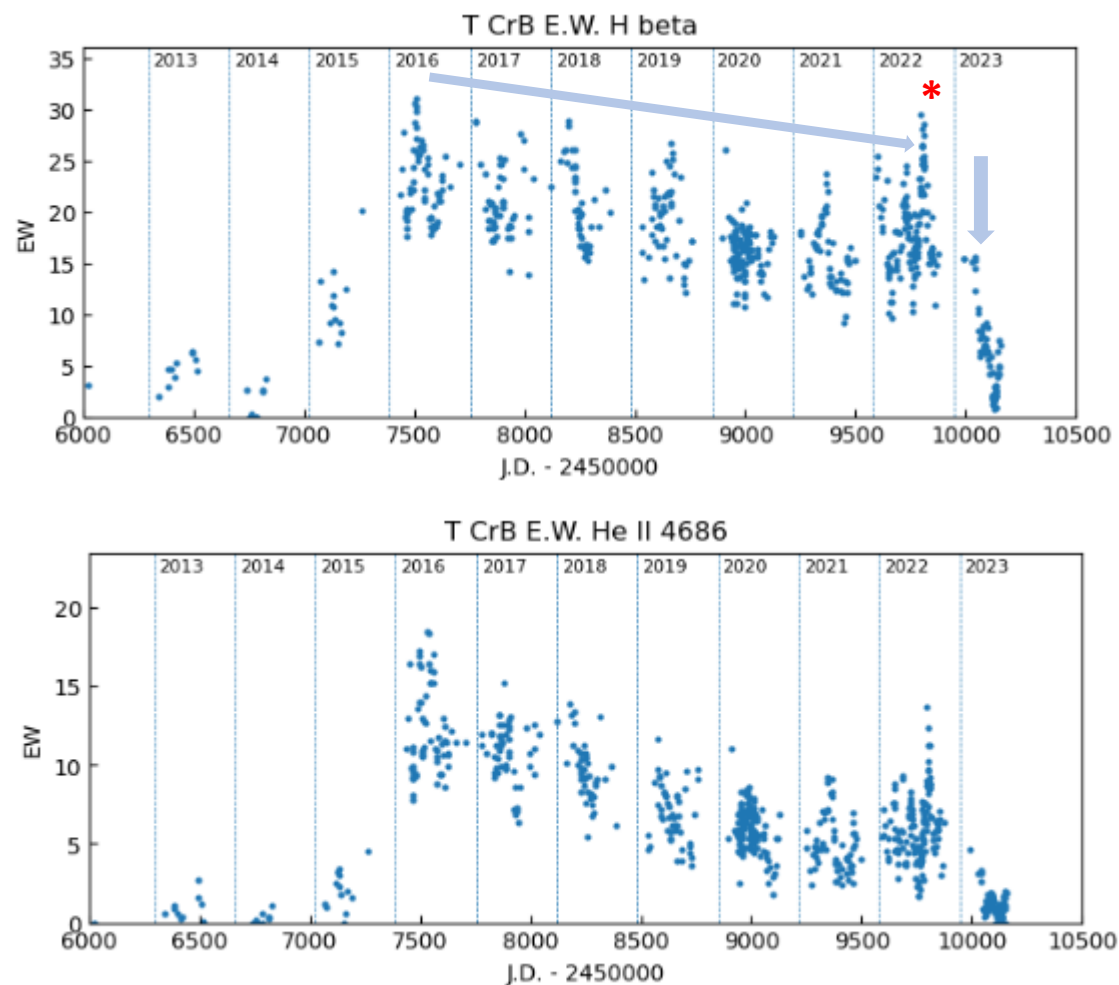
6. Preoutburst monitoring of the recurrent symbiotic nova T CrB

Spectroscopic evolution

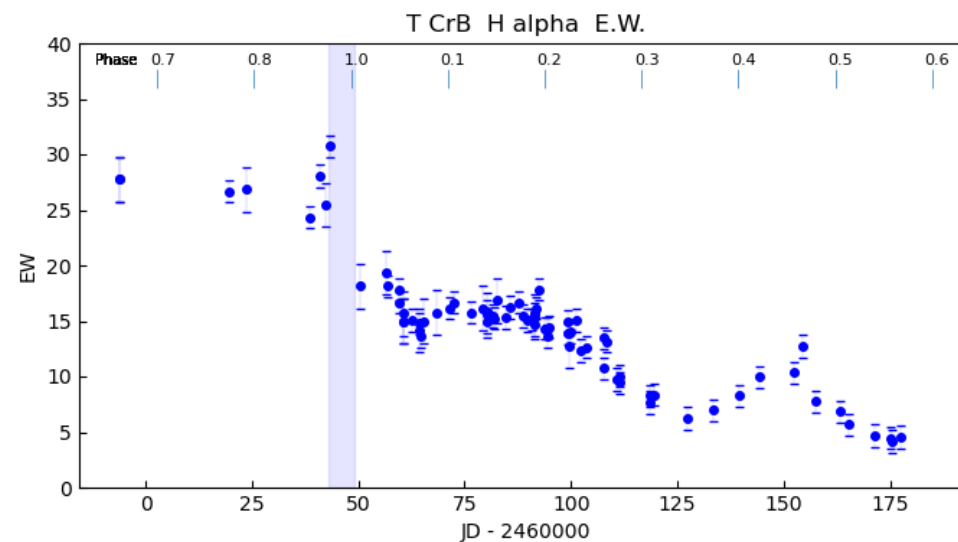


6. Preoutburst monitoring of the recurrent symbiotic nova T CrB

The high state 2015-2023 is over



2023



T CrB: the active spectroscopic state (2014-2023) is over

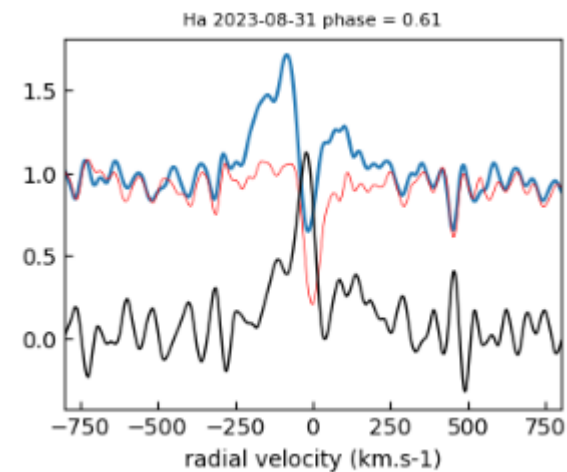
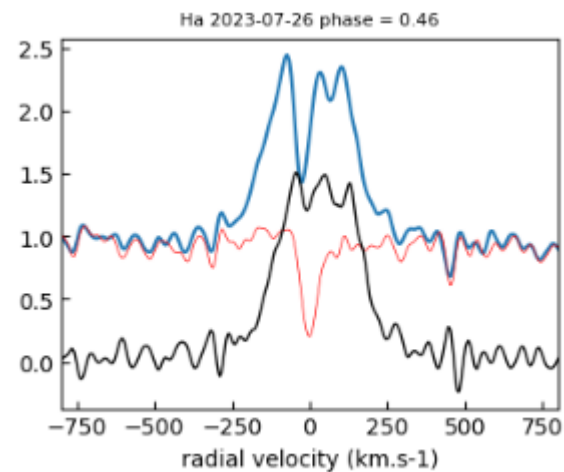
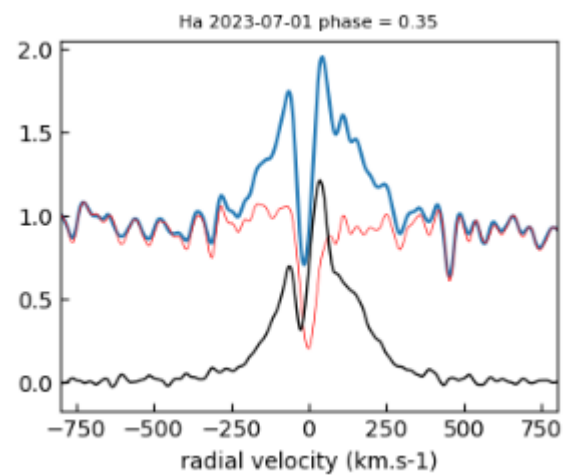
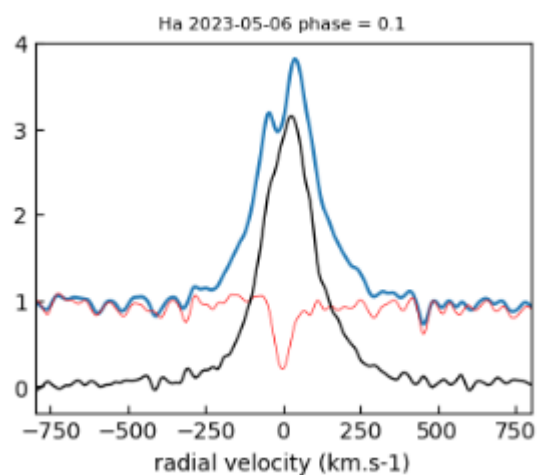
F. Teyssier, J. D. Hinnefeld, C. Boussin, I. Diabassoura, J. Guarro Flo, F. Sims,
A. Leduc, S. Curry, D. Boyd, D. Cujedo (ARAS Group), S. N. Shore (Univ. of Pisa)
on 30 Jun 2023; 18:29 UT

<https://www.astronomerstelegram.org/?read=16109>

6. Preoutburst monitoring of the recurrent symbiotic nova T CrB

Current status: H alpha

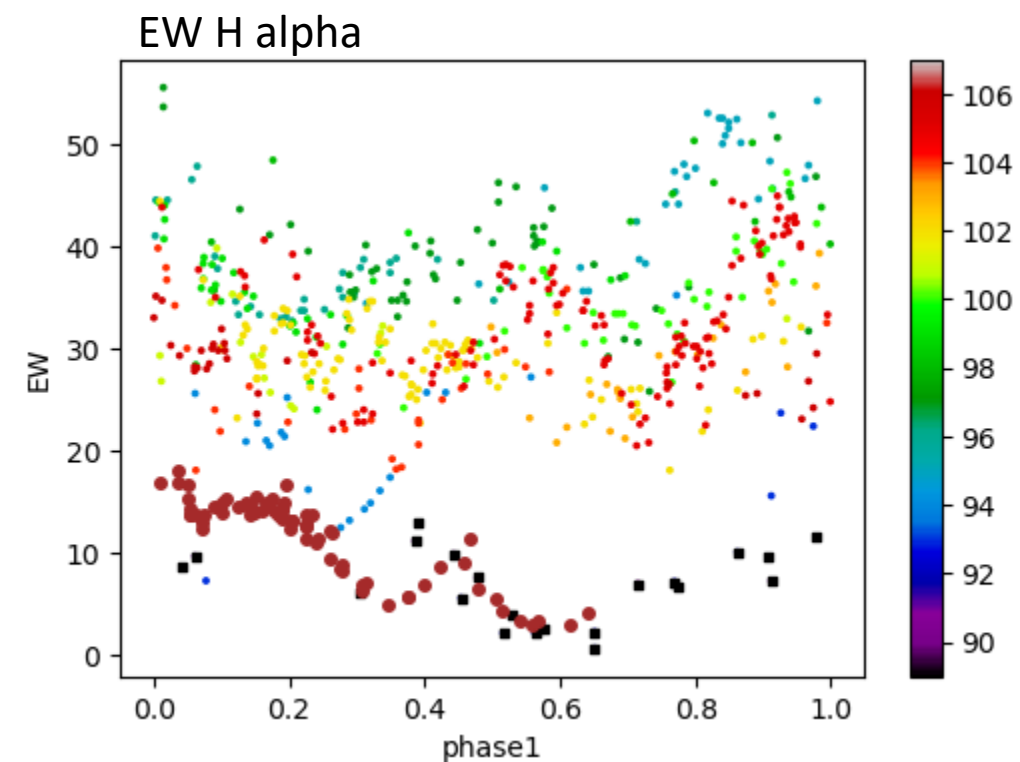
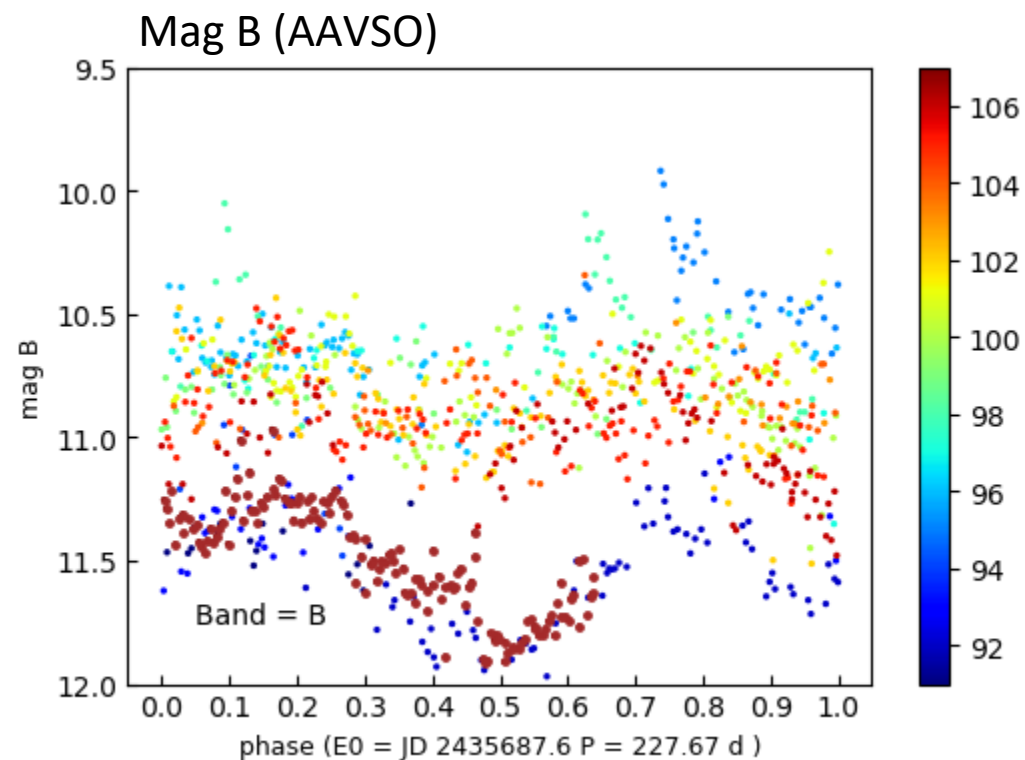
_blue: line
_red: HD147232
_black: profile (b-r)



Réf. HD147232: shifted by the orbital motion of the TCrB RG

6. Preoutburst monitoring of the recurrent symbiotic nova T CrB

Current status: back to quiescence



Next nova outburst: $P_{\text{env}}(M_{\text{env}}) > P_{\text{crit}}(M_{\text{WD}} L_{\text{WD}} T_{\text{WD}}, \text{mixing}, \dots)$

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