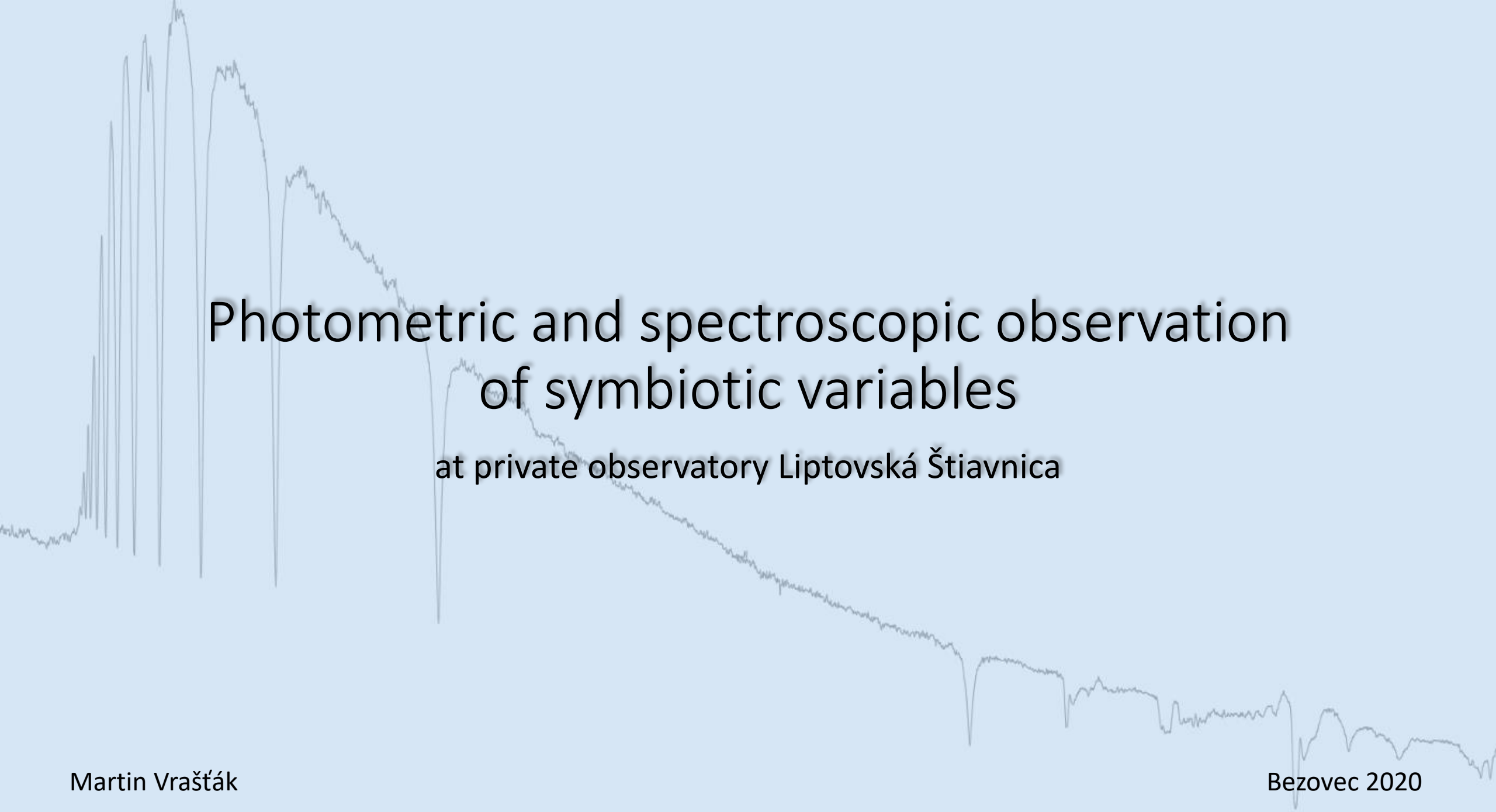


Photometric and spectroscopic observation of symbiotic variables

at private observatory Liptovská Štiavnica

Martin Vrašťák

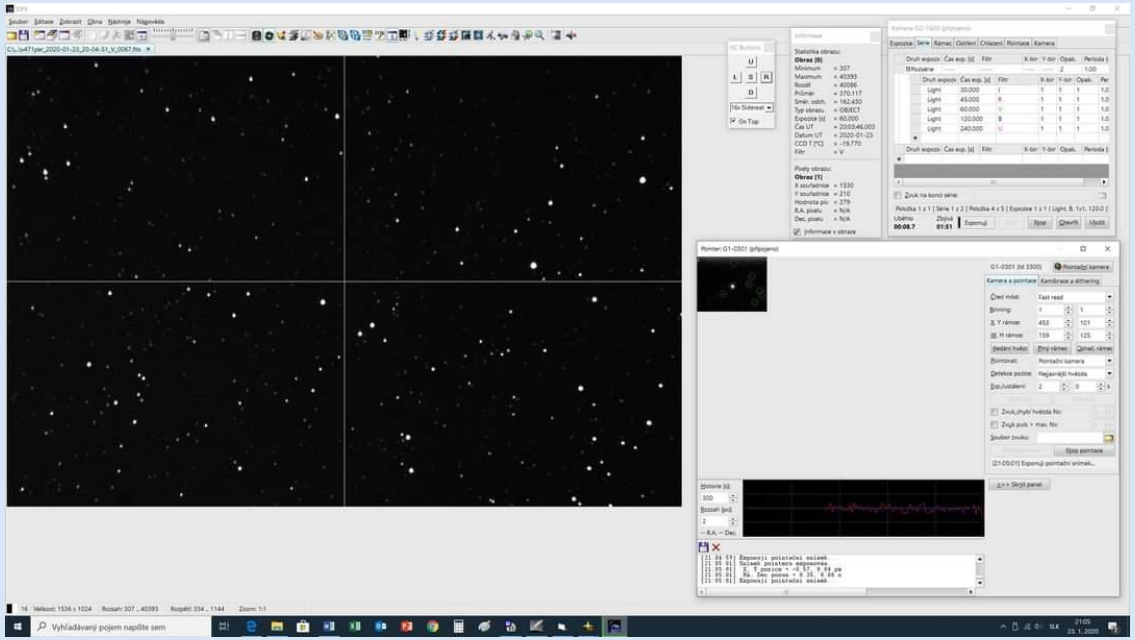
Bezovec 2020

Long-term photometry of selected symbiotic systems

Start of observation
05/2016

Symbiotic stars										
	Symbiotic system	V mag	α(2000)	δ(2000)	P(d)	Orbital elements	Eclipse	Mira pulsations	Flickering	Type
	AX Per	10.9	01 36 22.7	+54 15 02.5	680.8	Min = JD 2436667 + 680.8×E	Yes			Z And
	V0471 Per	13.0	01 58 49.6	+52 53 48.9						
	UV Aur	8.5	05 21 48.8	+32 30 43.1				Max=2441062+395.42*E		
	TX CVn	9.5	12 44 42.0	+36 45 50.6	199.0					Z And
	T CrB	10.1	15 59 30.1	+25 55 12.6	227.6	Min = JD 2435687.6 + 227.67×	No		+	SyRN
	AG Dra	9.1	16 01 40.5	+66 48 09.5	554.0	Max = JD 2443886 + 554×E	No			Z And
	YY Her	12.8	18 14 34.3	+20 59 20.0	590.0	Min = JD 2448945 + 590×E	Yes			Z And
	V0443 Her	11.5	18 22 08.4	+23 27 20.0	594.0	Min = JD 2443660 + 594×E	No			
	BF Cyg	12.3	19 23 53.4	+29 40 25.1	756.8	Min = JD 2415058 + 756.8×E	Yes			Z And
	CH Cyg	7.1	19 24 33.0	+50 14 29.1	756.0	Min = JD 2446275 + 5700×E	Yes		+	
	HM Sge	17.0	19 41 57.1	+16 44 40.0						
	QW Sge	12.8	19 45 49.6	+18 36 50.0						
	CI Cyg	11.0	19 50 11.8	+35 41 03.2	855.3 (853.8)	Min = JD 2442687.1 + 855.6×E	Yes			Z And
	V1016 Cyg	11.2	19 57 04.9	+39 49 33.9				Min=2444852+478*E		SyN
	PU Vul	11.6	20 21 12.0	+21 34 41.9	4900.0	Min = JD 2444550 + 4900×E	Yes			SyN
	LT Del	13.1	20 35 57.3	+20 11 34.0	478.5	Min = JD 2445910 + 478.5×E	No			
	ER Del	10.0	20 42 46.4	+08 40 56.4						
	V1329 Cyg	13.3	20 51 01.1	+35 34 51.2	956.5	Min = JD 2444890.0 + 956.5×E	Yes			SyN
	V0407 Cyg	14.0	21 02 13.0	+45 46 30.0				Max=2429710+745*E		SyN+Z And
	AG Peg	9.0	21 51 01.9	+12 37 29.4	816.5 (818.2)	Max = JD 2442710.1 + 816.5×E	No			SyN
	Z And	10.8	23 33 39.5	+48 49 05.4	758.8	Min = JD 2442666 + 758.8×E	No		+	Z And
Suspected symbiotic stars										
	ZZ CMi	9.9	07 24 13.9	+08 53 51.7						
	NQ Gem	7.9	07 31 54.5	+24 30 12.5						
	V0934 Her	7.8	17 06 34.5	+23 58 18.5						
	V0335 Vul	11.8	19 23 14.2	+24 27 40.2						
	V0627 Cas	12.9	22 57 41.2	+58 49 14.9				per=466 d		

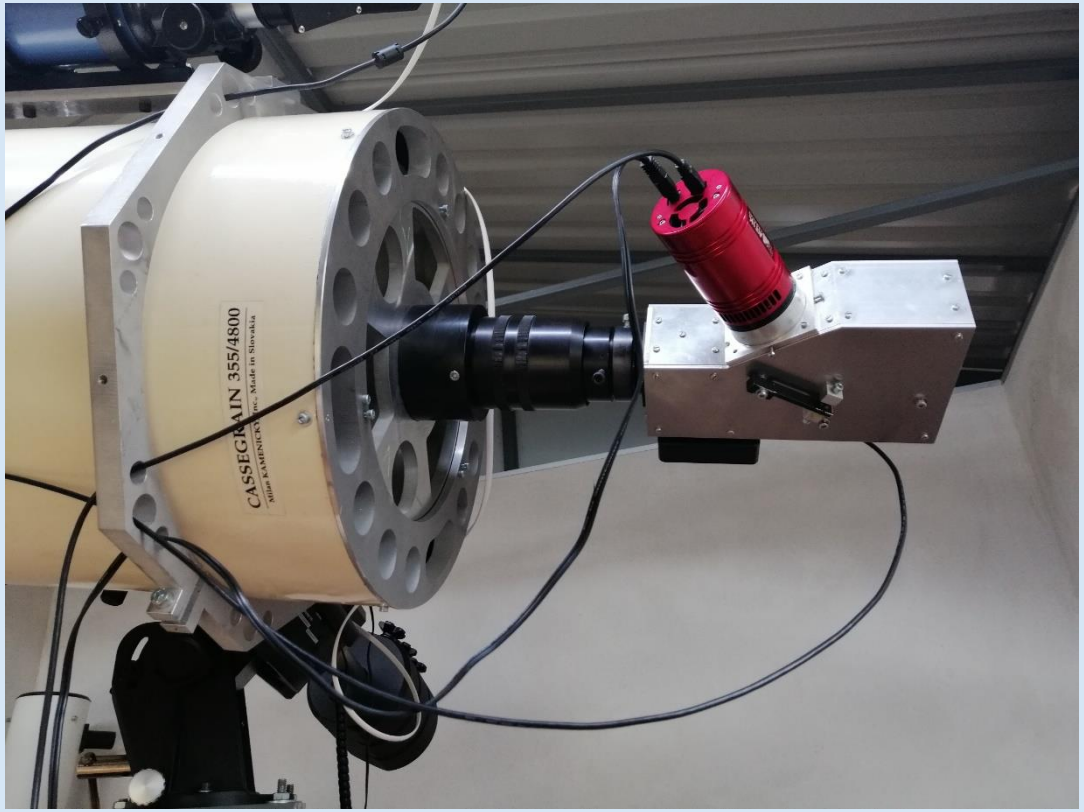
Photometric observation

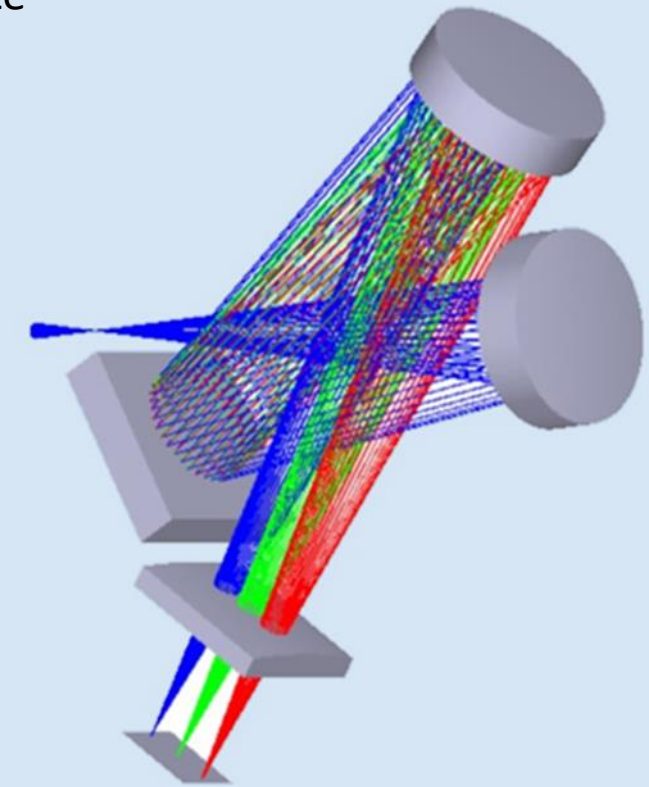


- Newton 355/1600 + CCD G2-1600 UBVRI

Spectroscopic observation

- UVEX - reflection system Czerny-Turner, spectral range 3200 – 9000 Å (near UV, visible and near-infrared)
- dispersion element - optical reflection grating 300 l/mm, 500nm blaze
- 35 µm slit, 3 mm long, resolution 2 Å/px, R=1000 – low

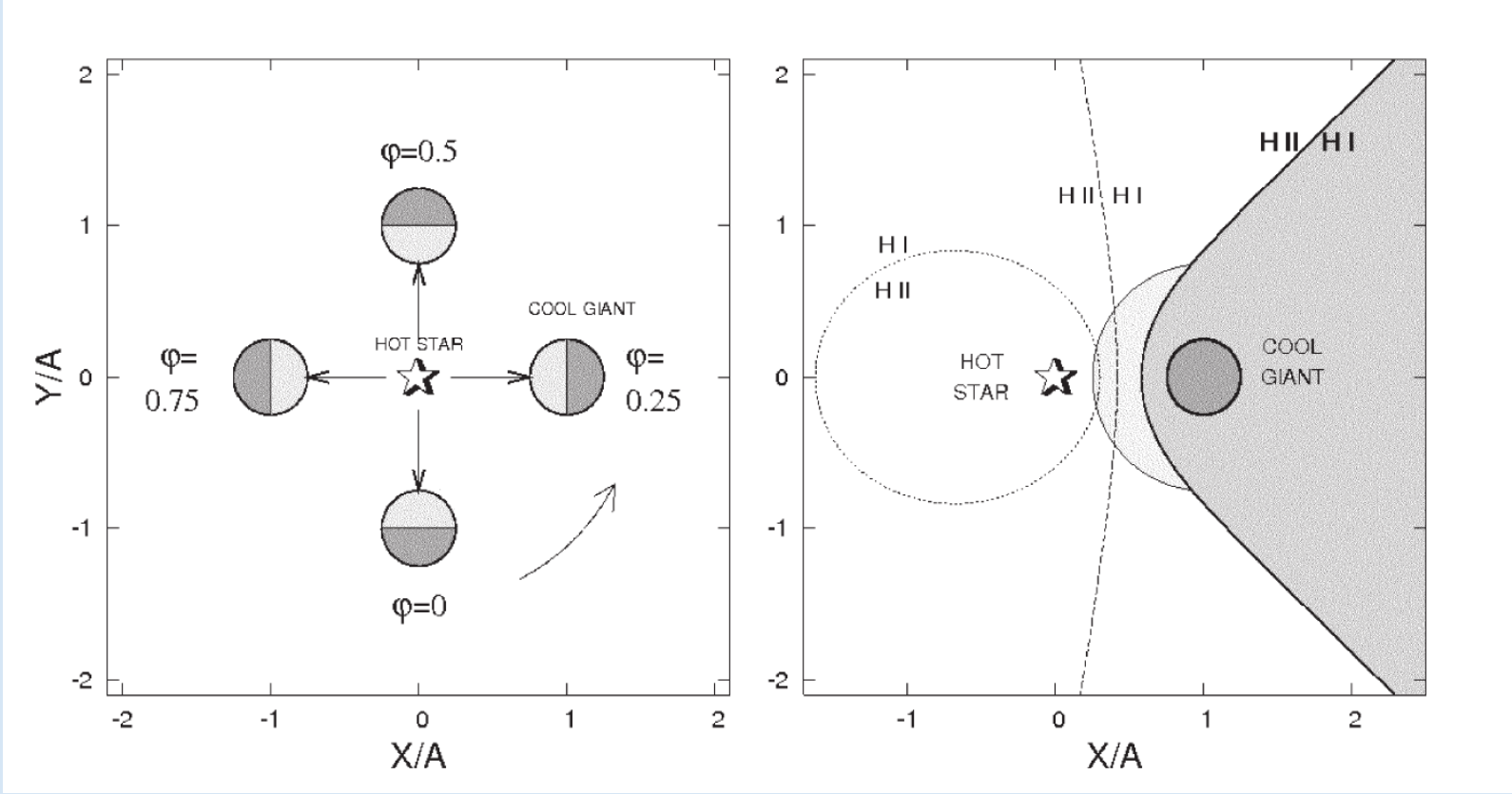




- Cassegrain 355/4800 + spectrograph UVEX

Symbiotic variables

- wide, interacting binary systems
- three basic components of radiation in their spectrum:
- cool component – giant star
- hot component – white dwarf
- nebular from the ionized circumbinary environment
- H I region – neutral hydrogen (excitation/deexcitation)
- H II region – ionized hydrogen (no spectra)
- H II/H I boundary – ionization/recombination



Ionization and excitation energy of atoms

Chemical elemet	H	He	Na	Ar	Ca	Fe
Ionizing energy eV	13.6	24.5	5.1	15.7	6.1	7.8
Wavelenght A	912	506	2431	790	2033	1590

$\lambda = hc/\Delta E$

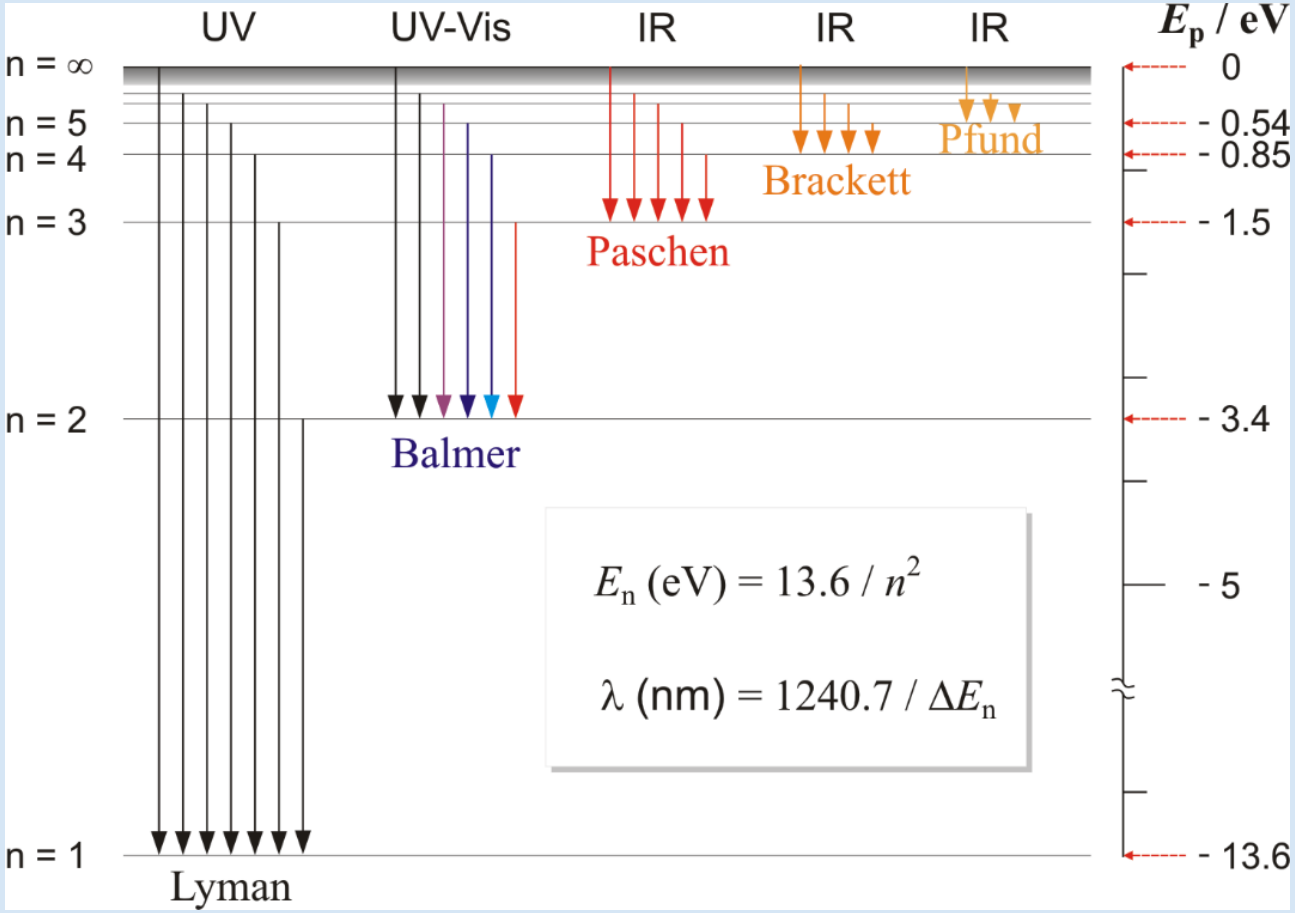
91.2 = 1240.7 /13.6 – Lyman edge

364.7 = 1240.7/3.4 – Balmer edge

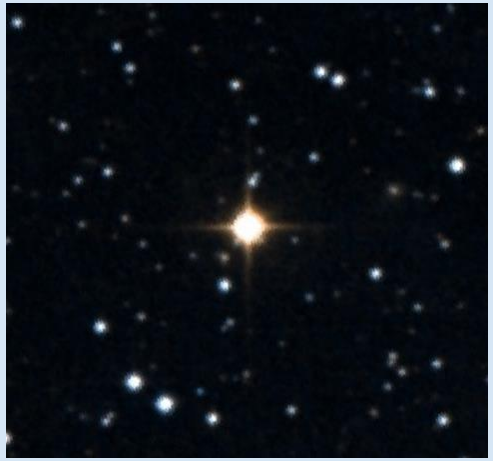
826.7 = 1240.7/1.5 – Paschen edge

Transitions of electron (Hydrogen):

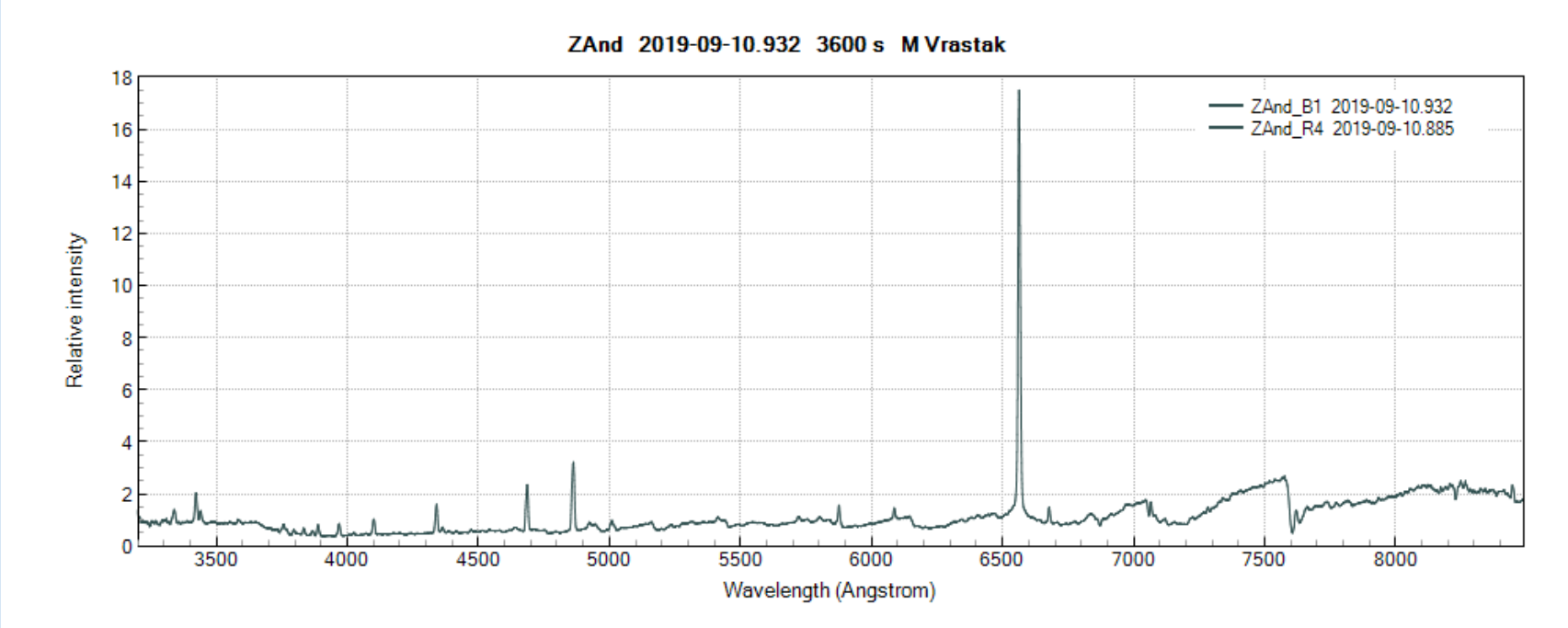
bound – bound: excitation/deexcitation (Balmer lines)
bound – free: ionization (Balmer jump)
free – bound: recombination (Balmer continuum)
free – free: braking radiation

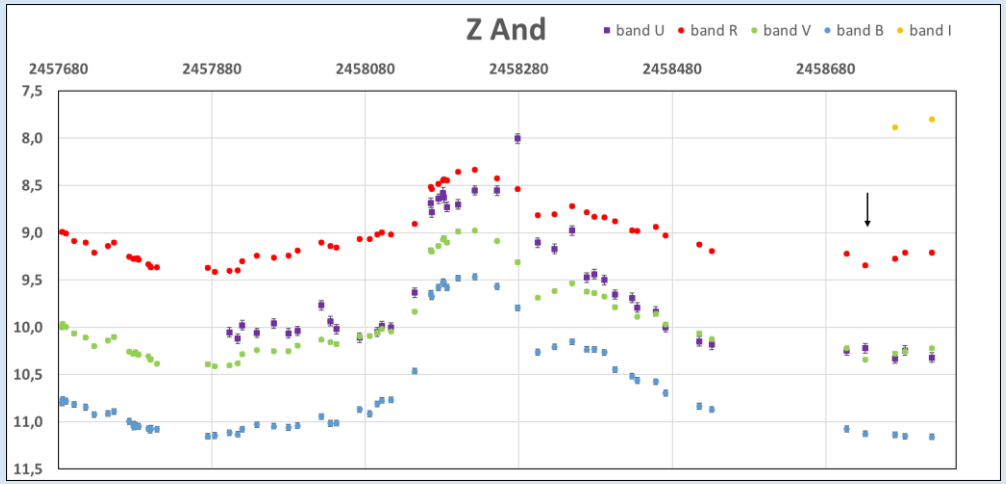


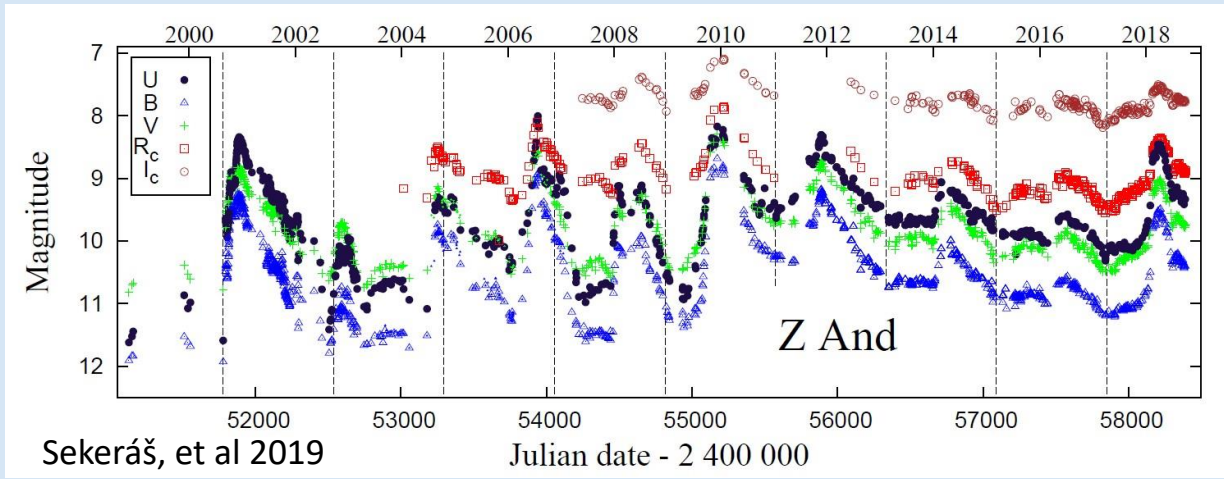
Z And (prototype)



Type: ZAnd
Spec.type: M4.5 III + WD
V = 10.1 mag
P = 758.8 d







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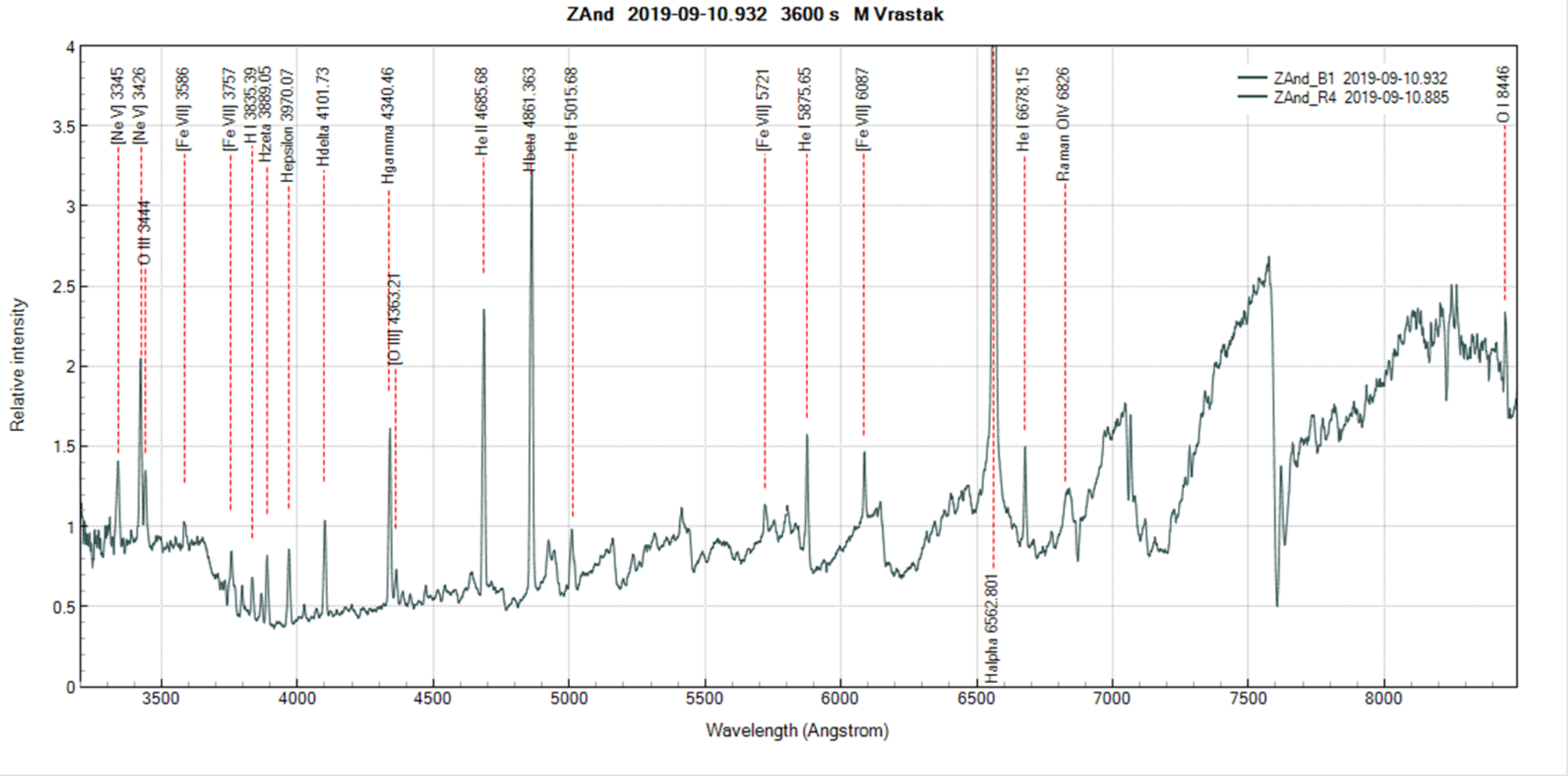
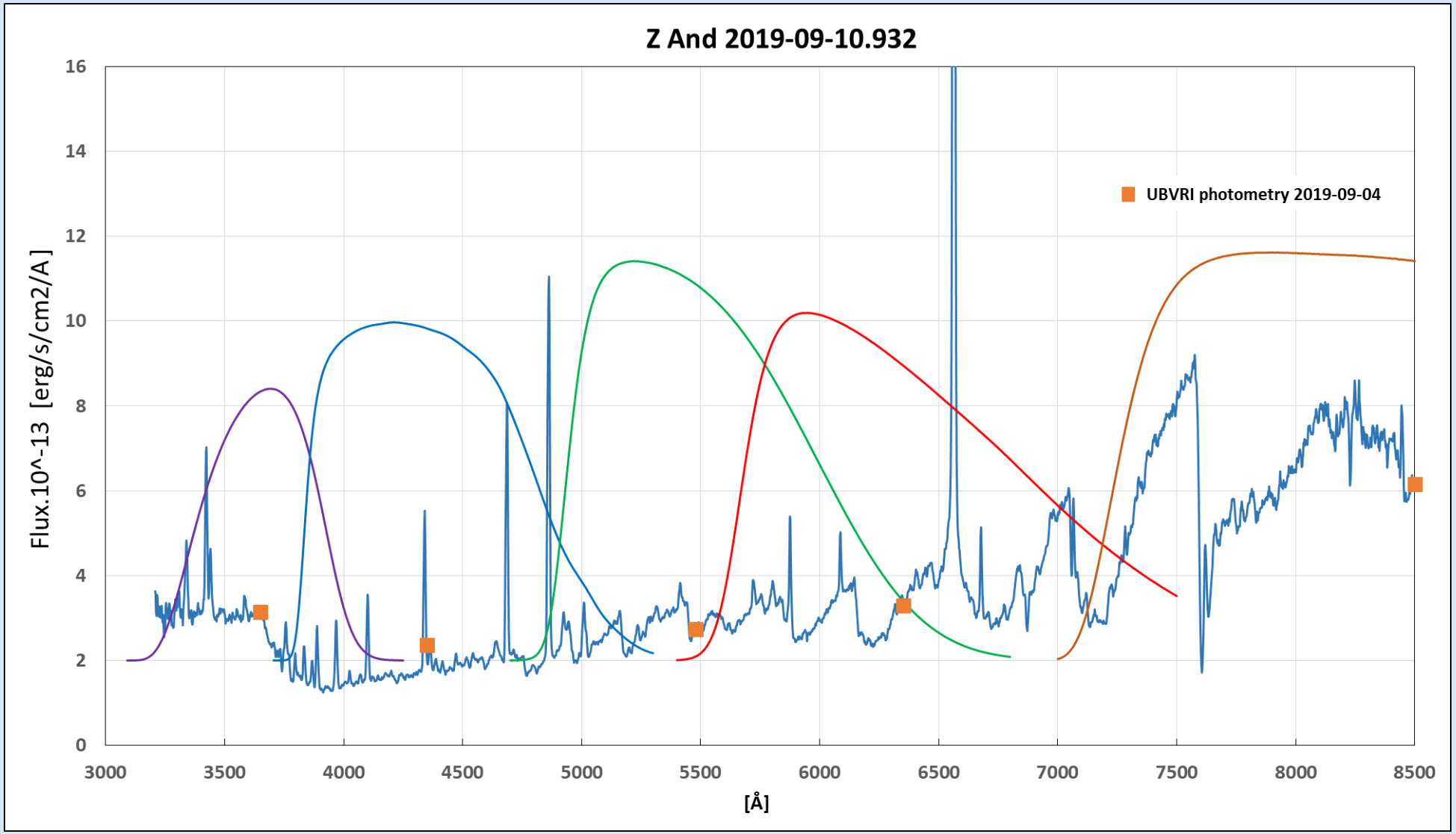
Z And – spectral lines identification



Z And – UBVRcIc (Johnson – Cousins)



Z And – Spectral energy distribution (SED)

- Dereddenig spectra E(B-V)=0.30
- V photometry flux-points

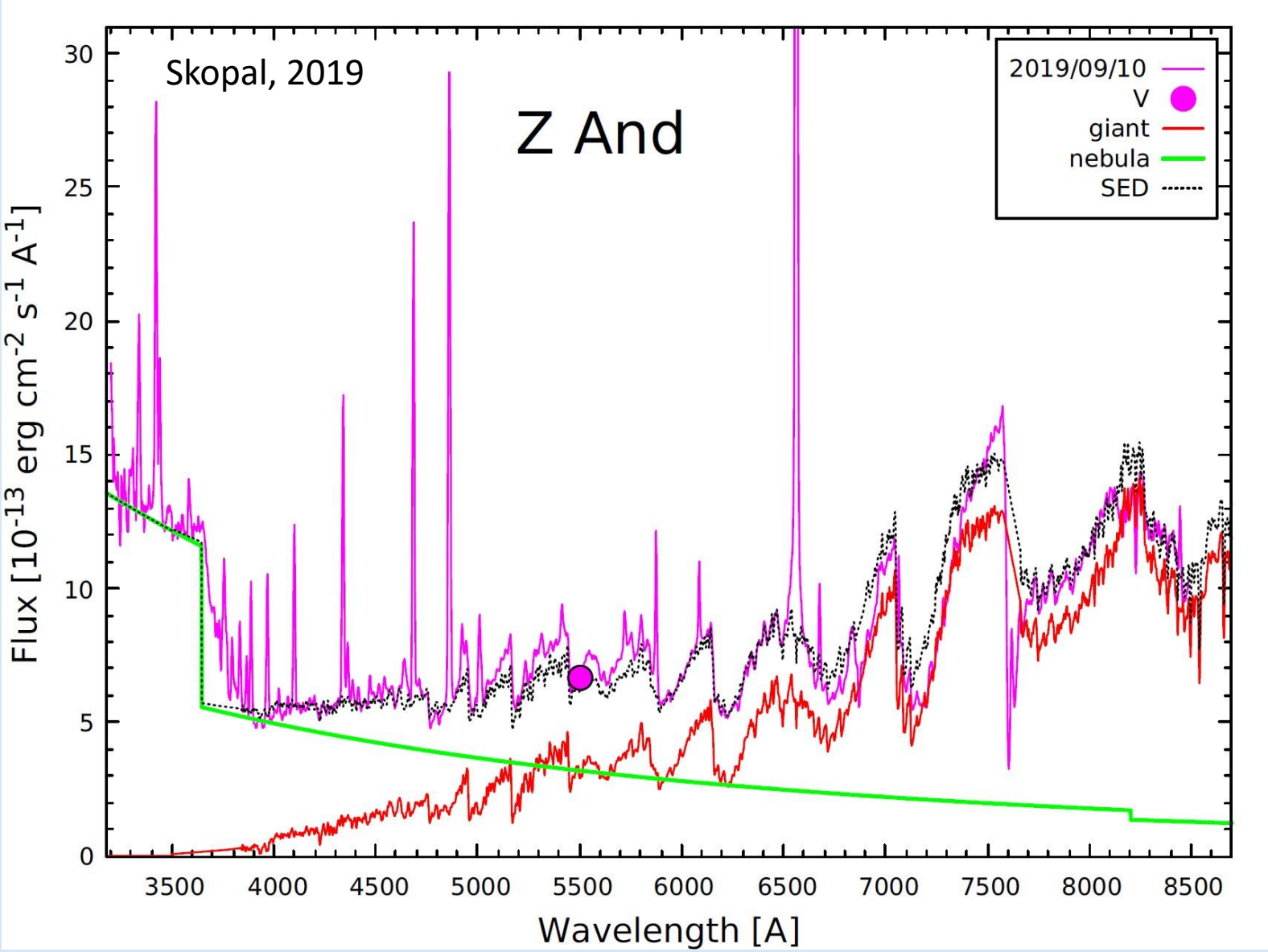
(no emission lines effect corrected)

- Red giant spectra
- Nebula emission spectra
- SED

Results:

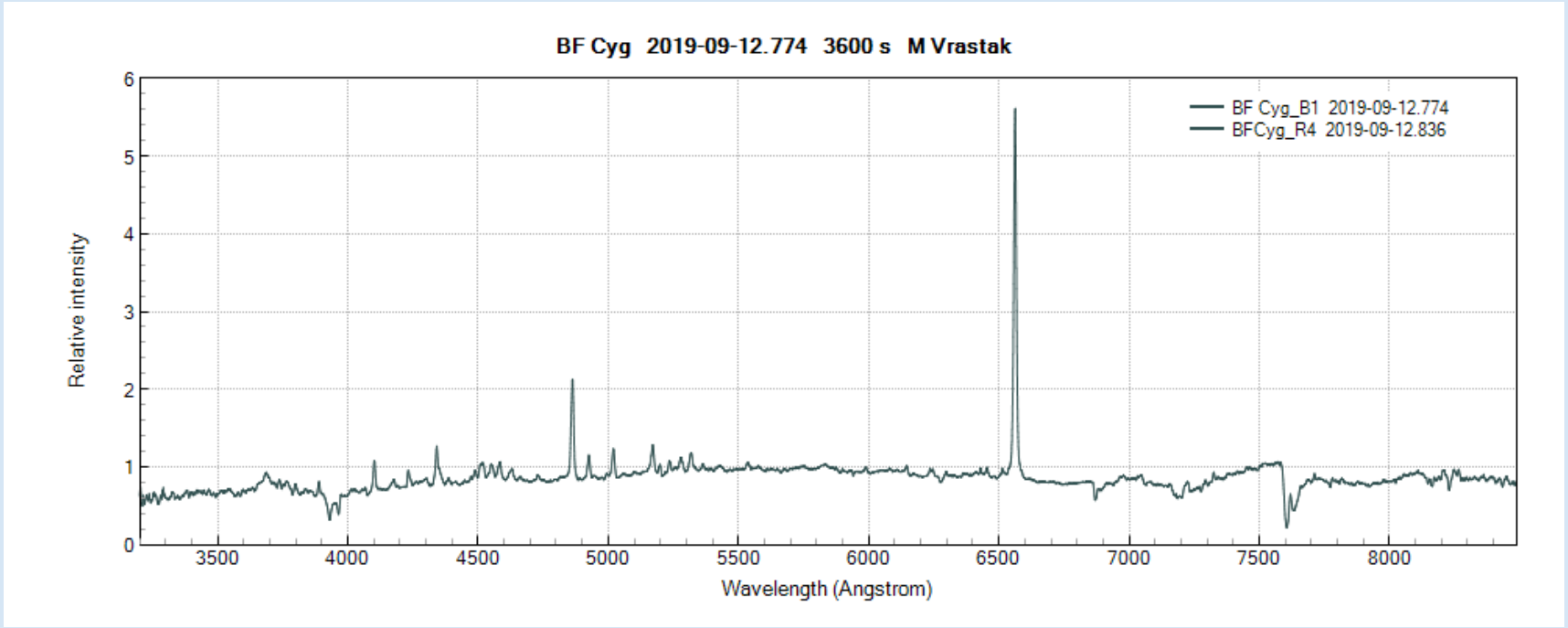
- Quasi quiescent phase
- Teff(WD) > 100 kK
- Strong nebular emission
- Te=50 000 K

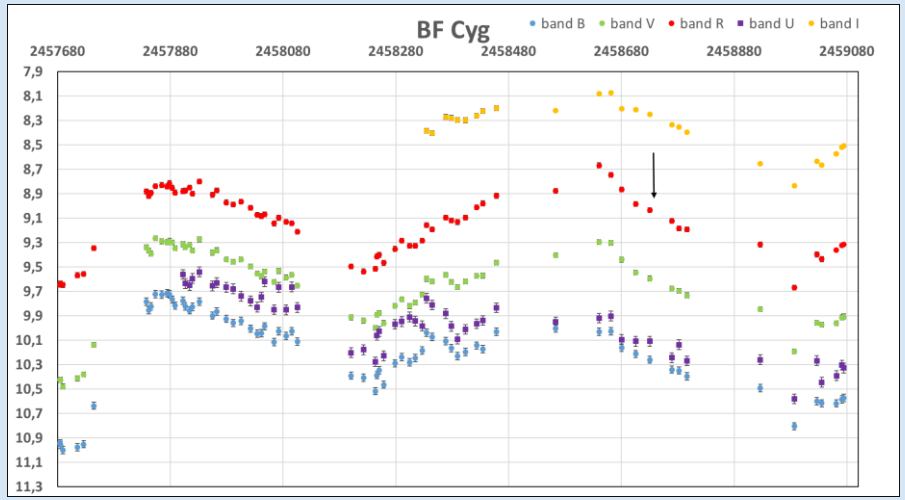
HeII 4686/Hbeta 4861 ratio = 0,57→
(Ijima 1981) Teff(WD) = 158 kK

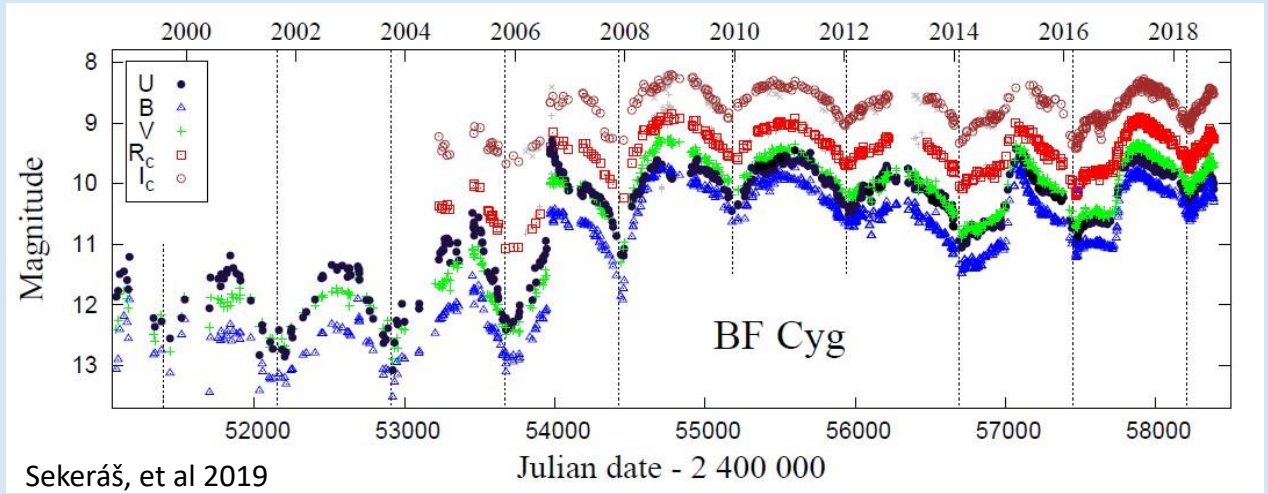


BF Cyg (Z And-type)

Type: Zand+E
Spec.type: M5 III + WD
V = 9.5 mag
P = 757.2 d







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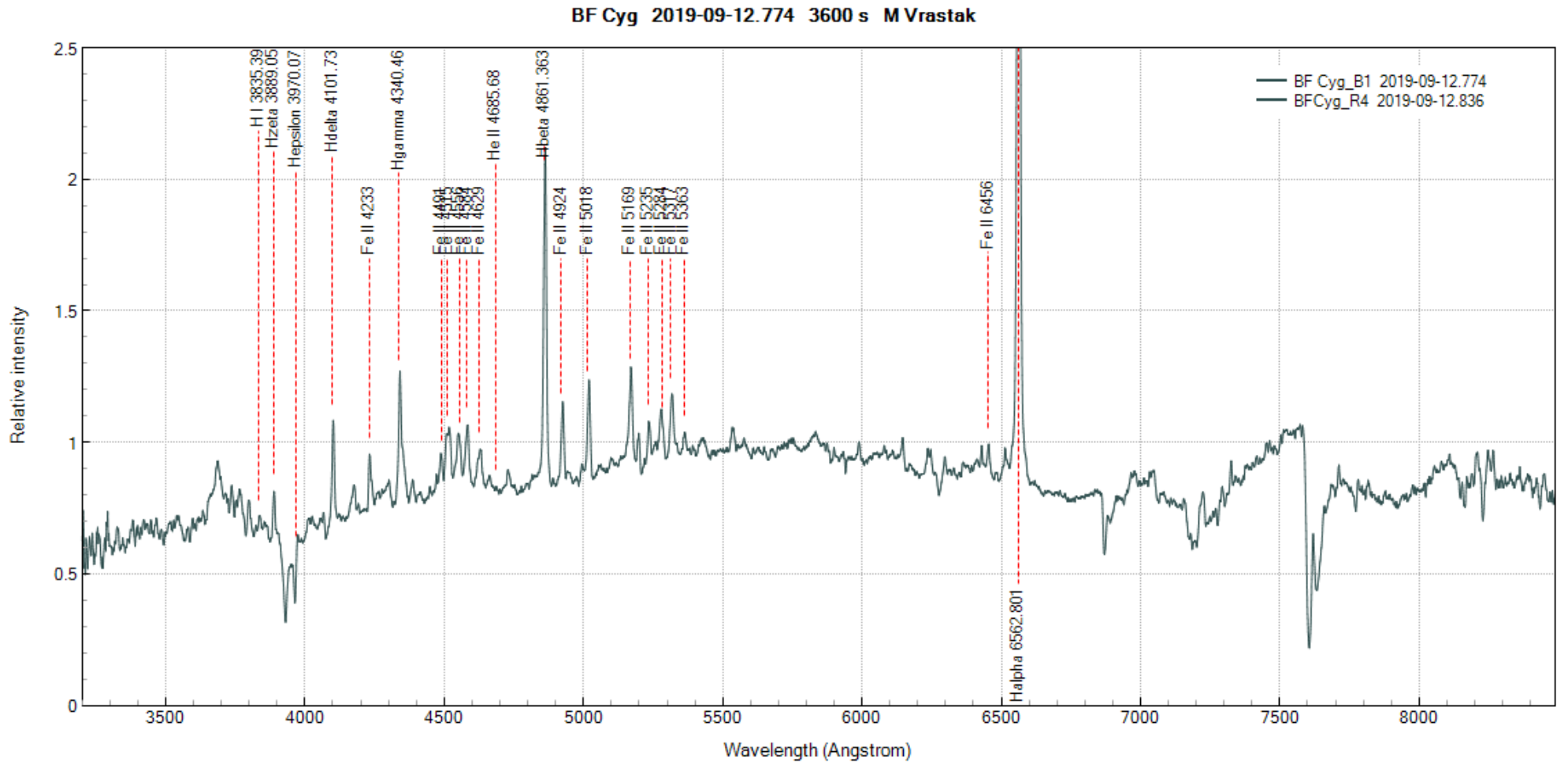
BF Cyg – spectral lines identification



BF Cyg – Spectral energy distribution (SED)

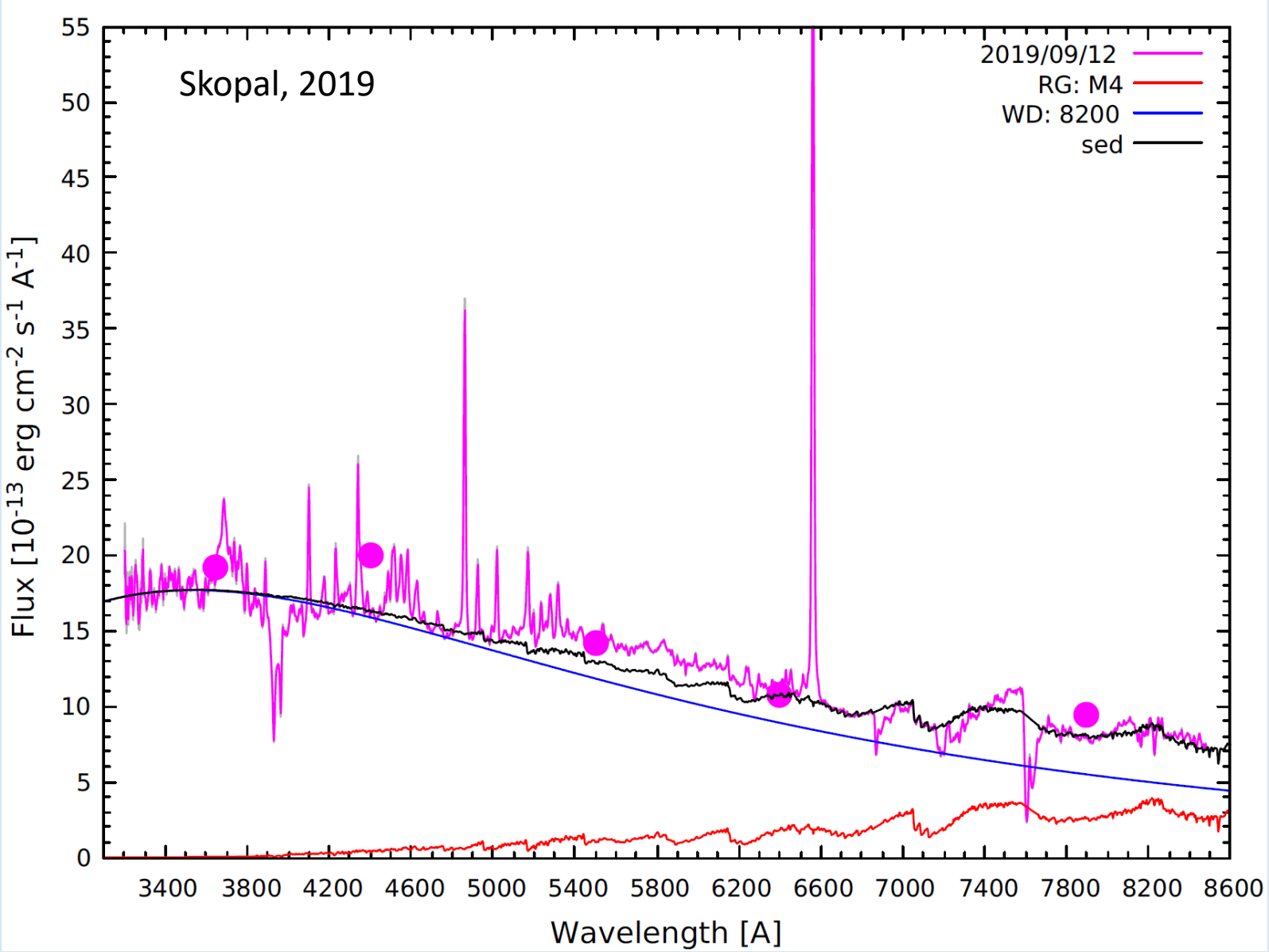
- Dereddenig spectra E(B-V)=0.35
- UBVRI photometry flux-points

(no emission lines effect corrected)

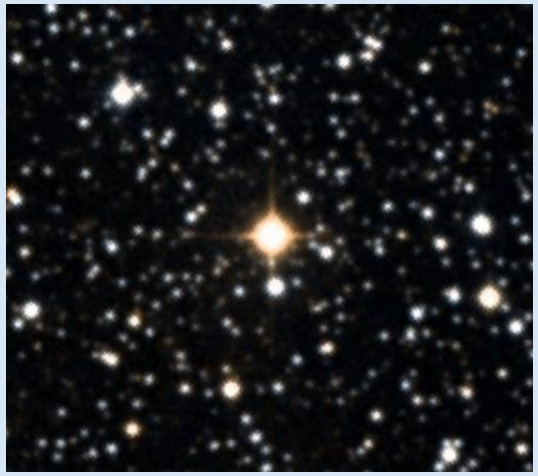
- Red giant spectra
- White dwarf spectra
- SED

Results:

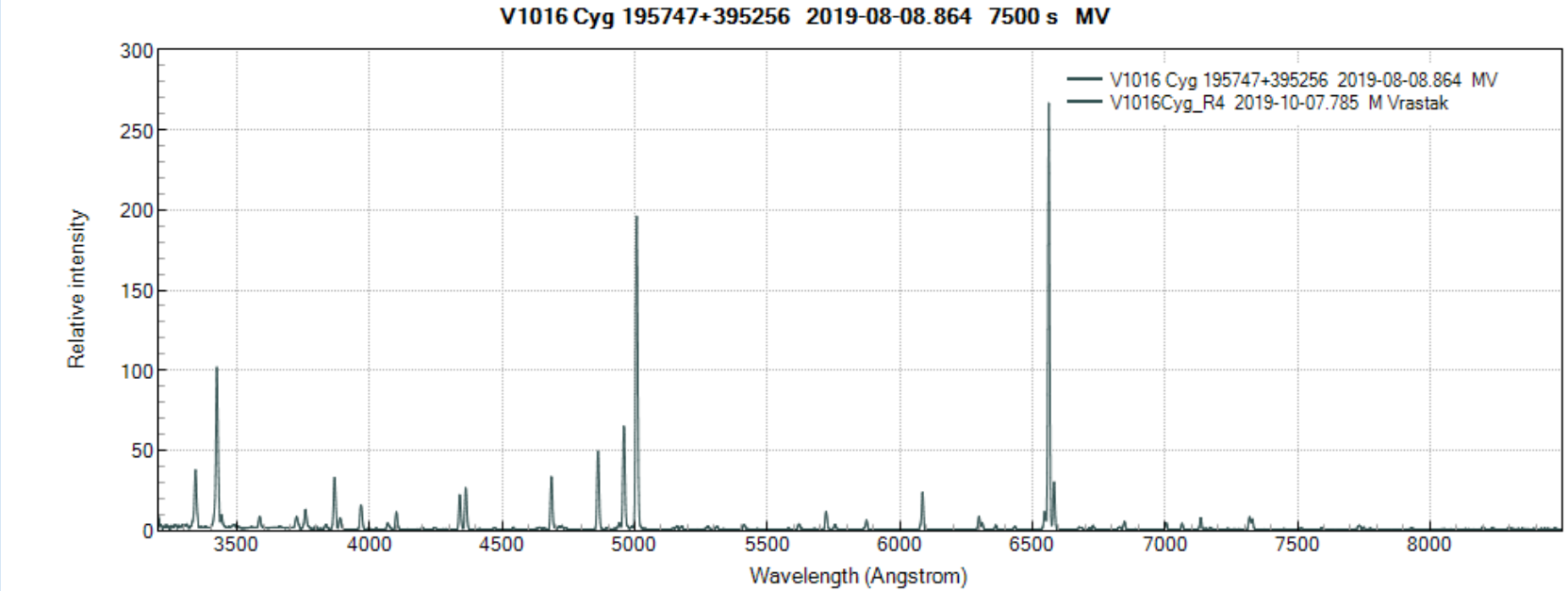
- Active phase
- Teff(WD)=8200 K
- Decrease temperature of WD in active phase
- Low nebular emission

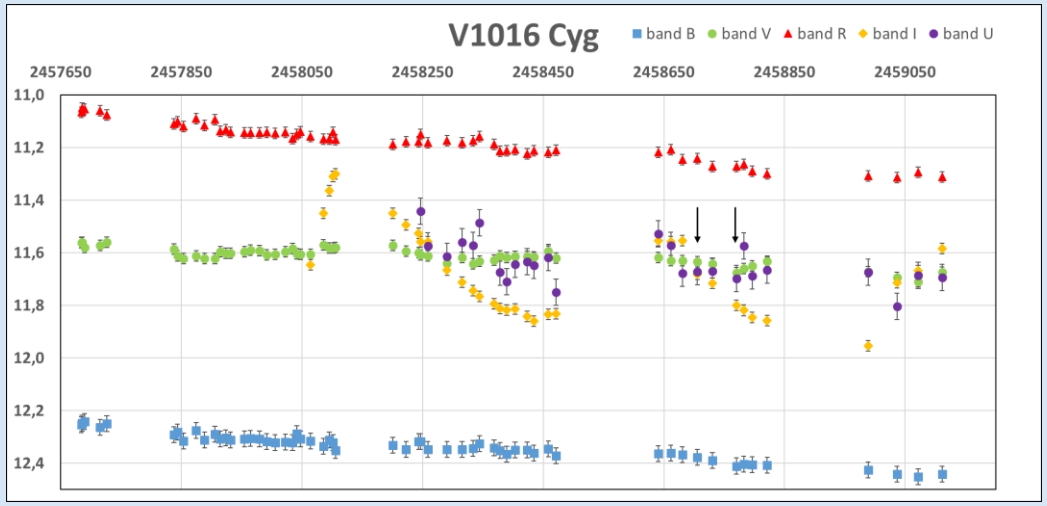


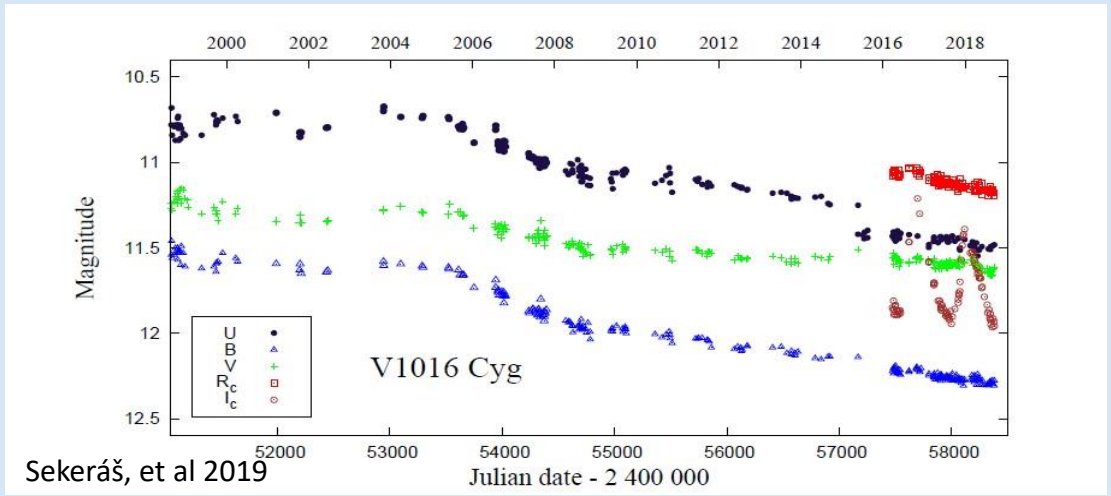
V1016 Cyg (symbiotic nova)



Type: SyN
Spec.type: Mira + WD
V = 11.6 mag
P = ? d







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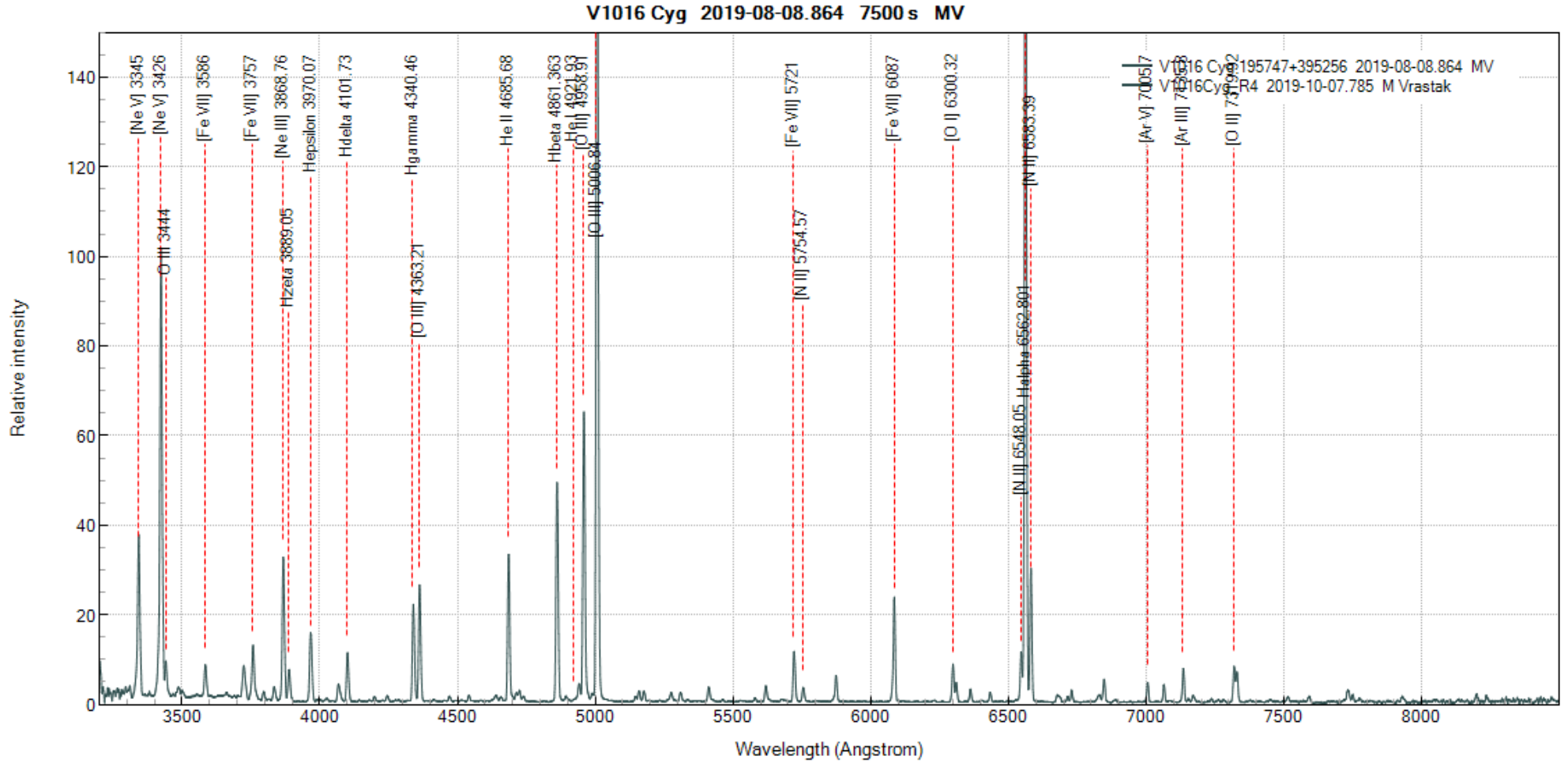
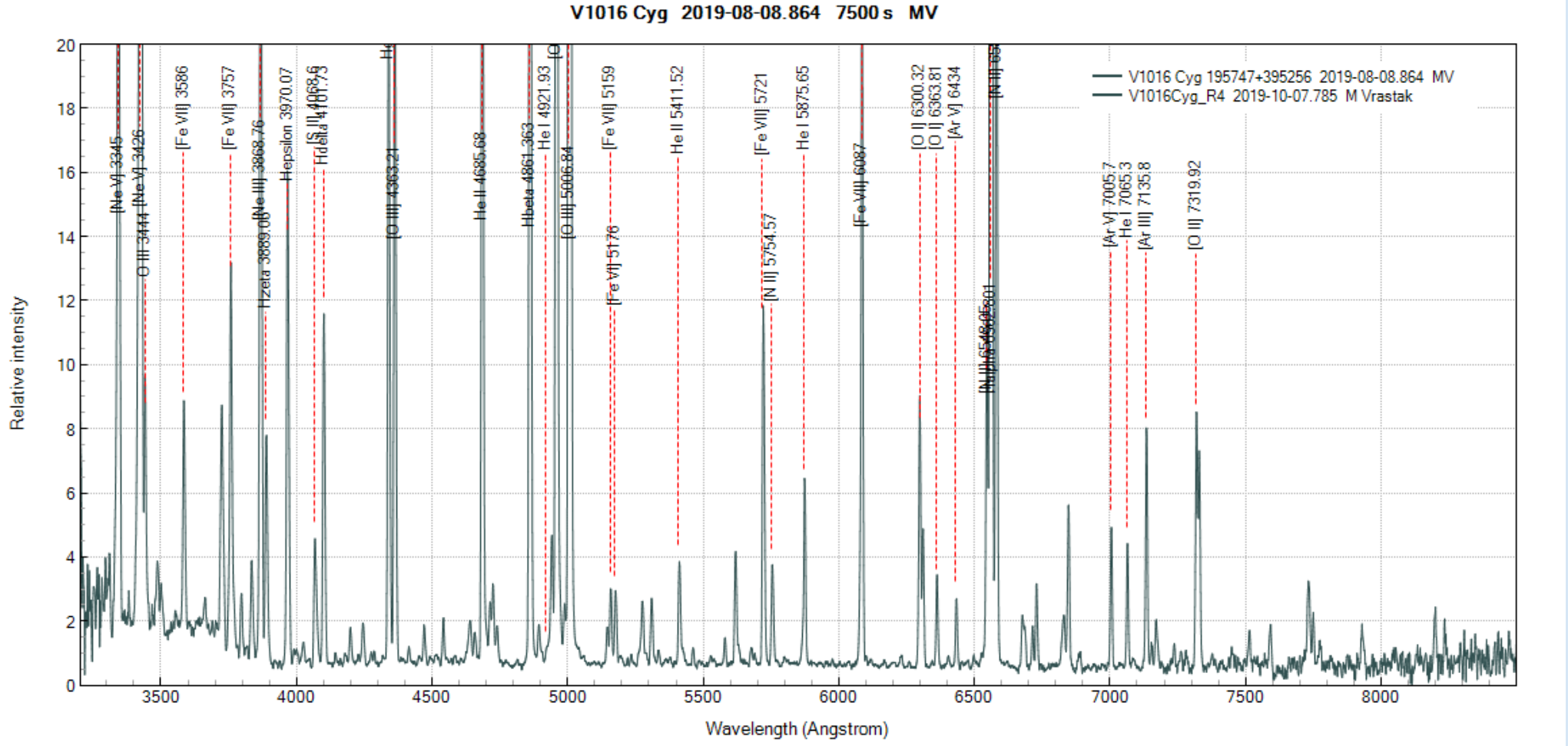
V1016 Cyg – spectral lines identification



V1016 Cyg – spectral lines identification



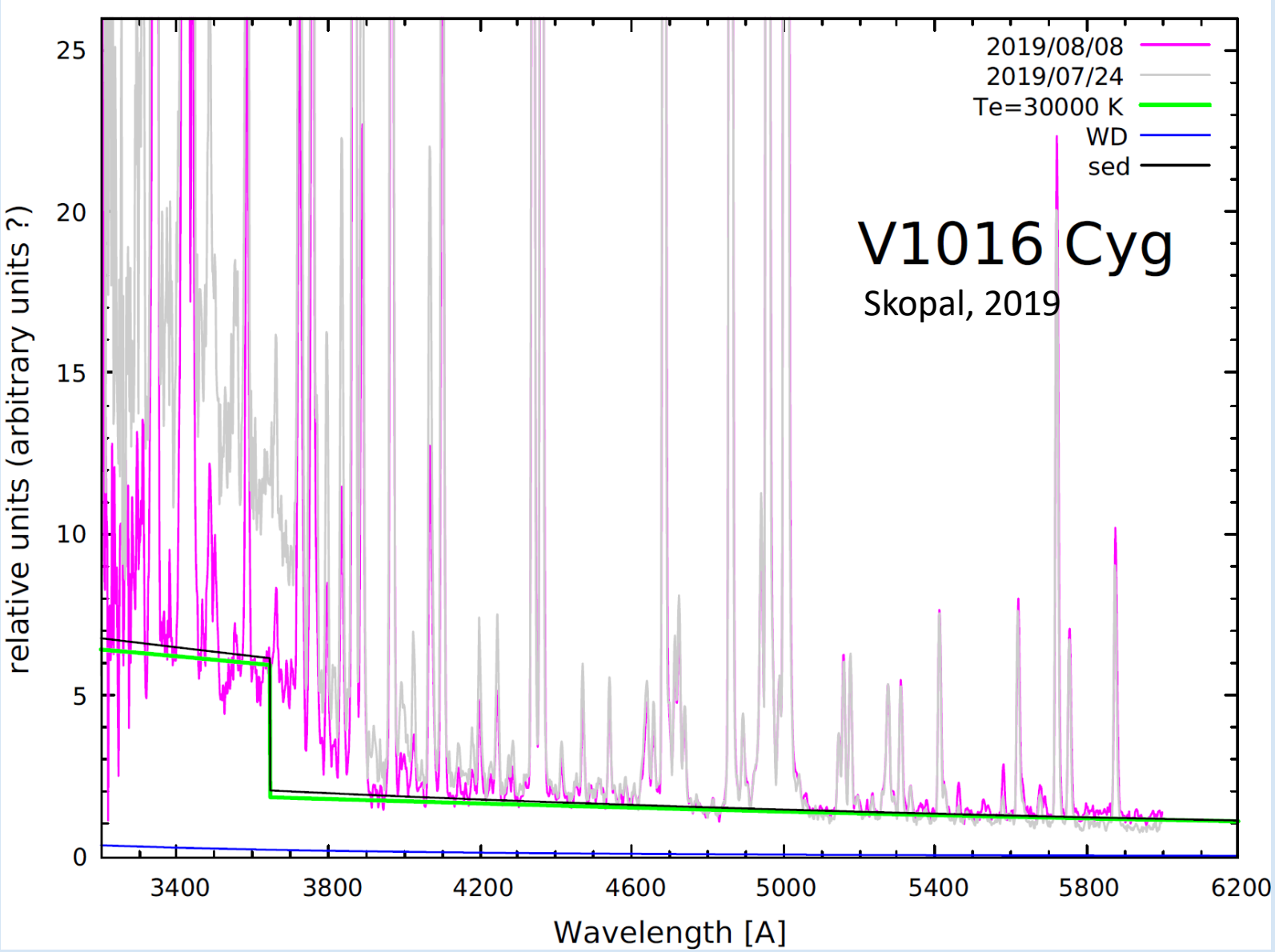
V1016 Cyg – Spectral energy distribution (SED)

- Dereddenig spectra
- Nebula emission spectra
- White dwarf spectra
- SED

Results:

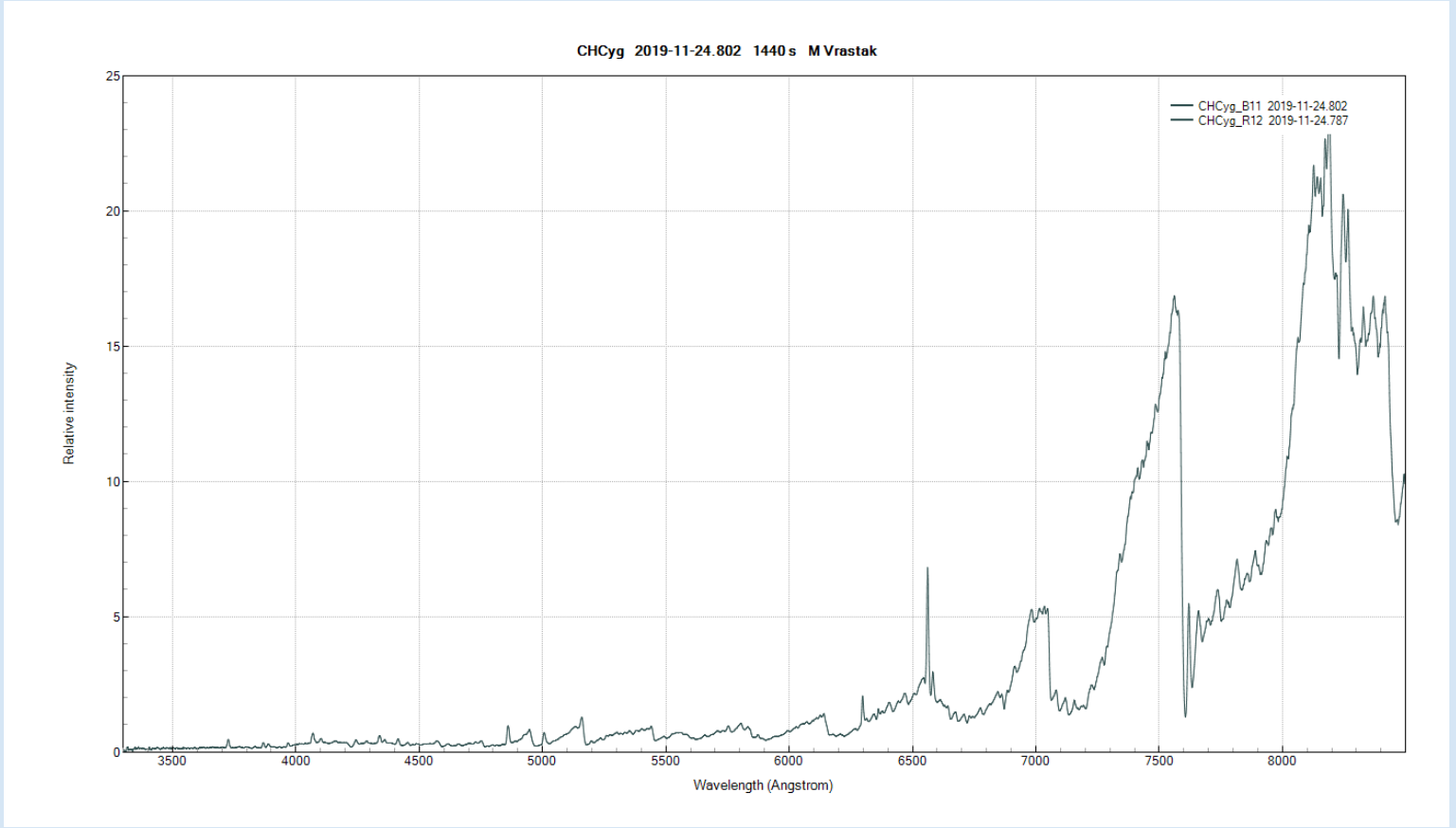
- Nebular phase
- Teff(WD) > 100 kK
- Strong nebular emission
- Te = 30 000 K

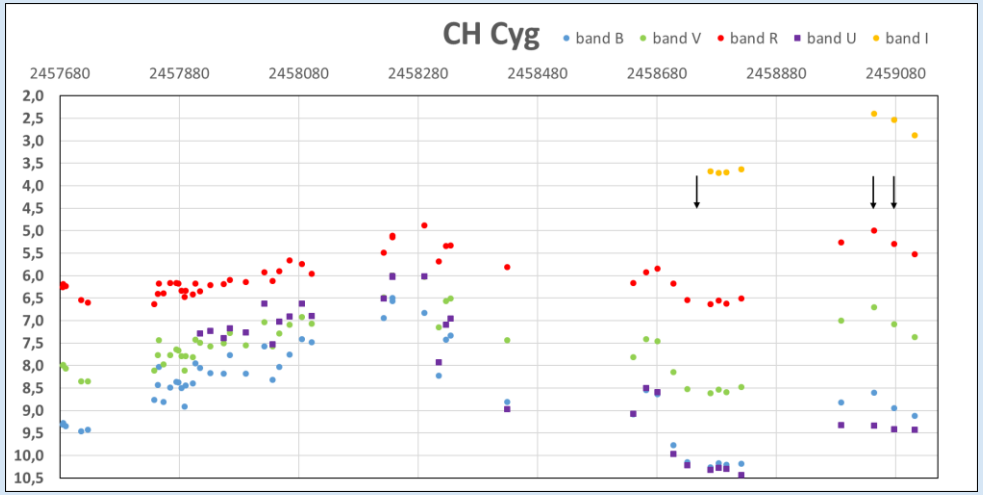
HeII 4686/Hbeta 4861 ratio = 0,39→
(Ijima 1981) Teff(WD) = 140 kK

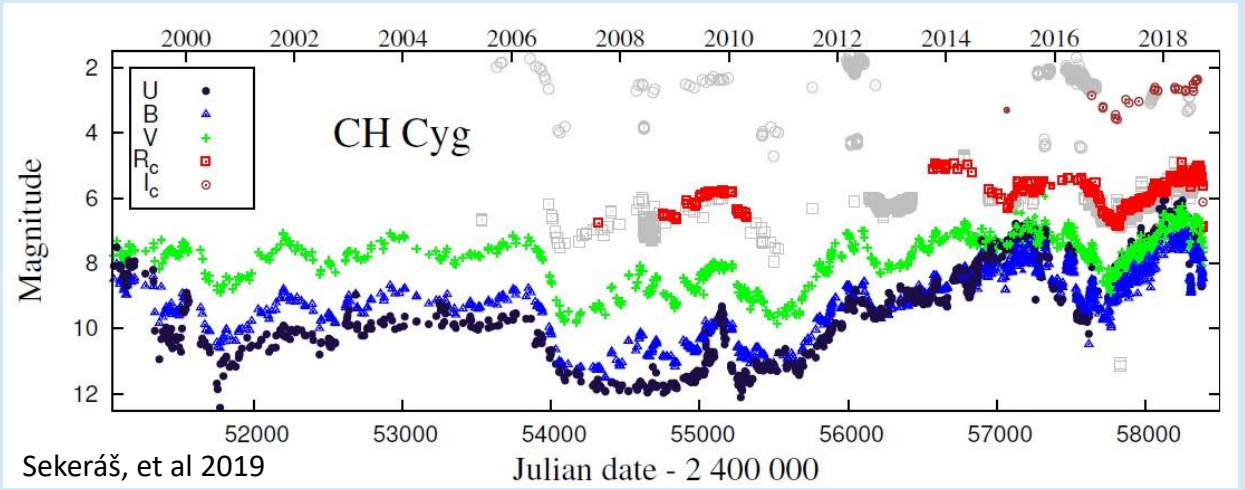


CH Cyg

Type: Z And+SR+E+Xray
Spec.type: M7.5 + WD
V = 7.1 mag
P = 756 d







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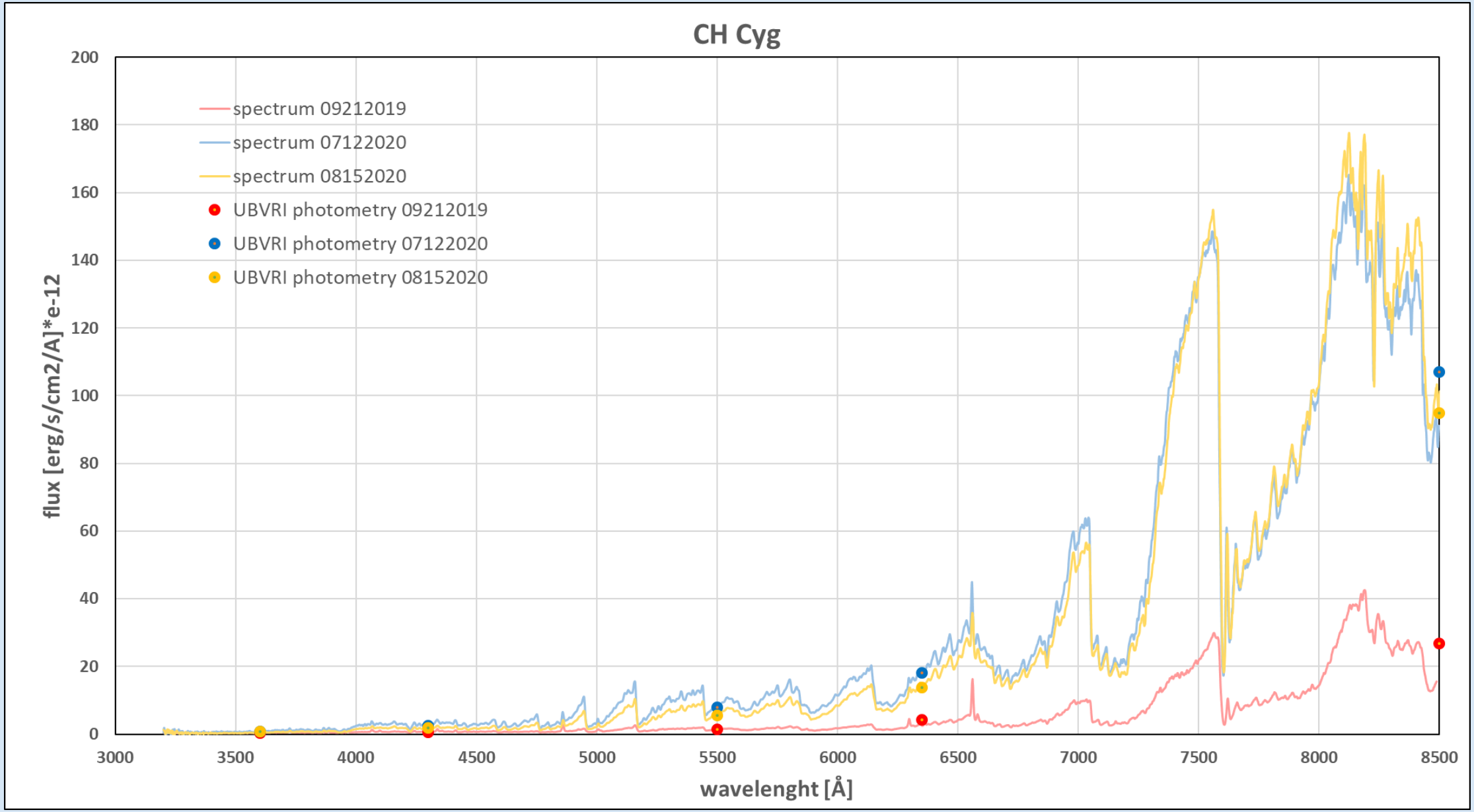
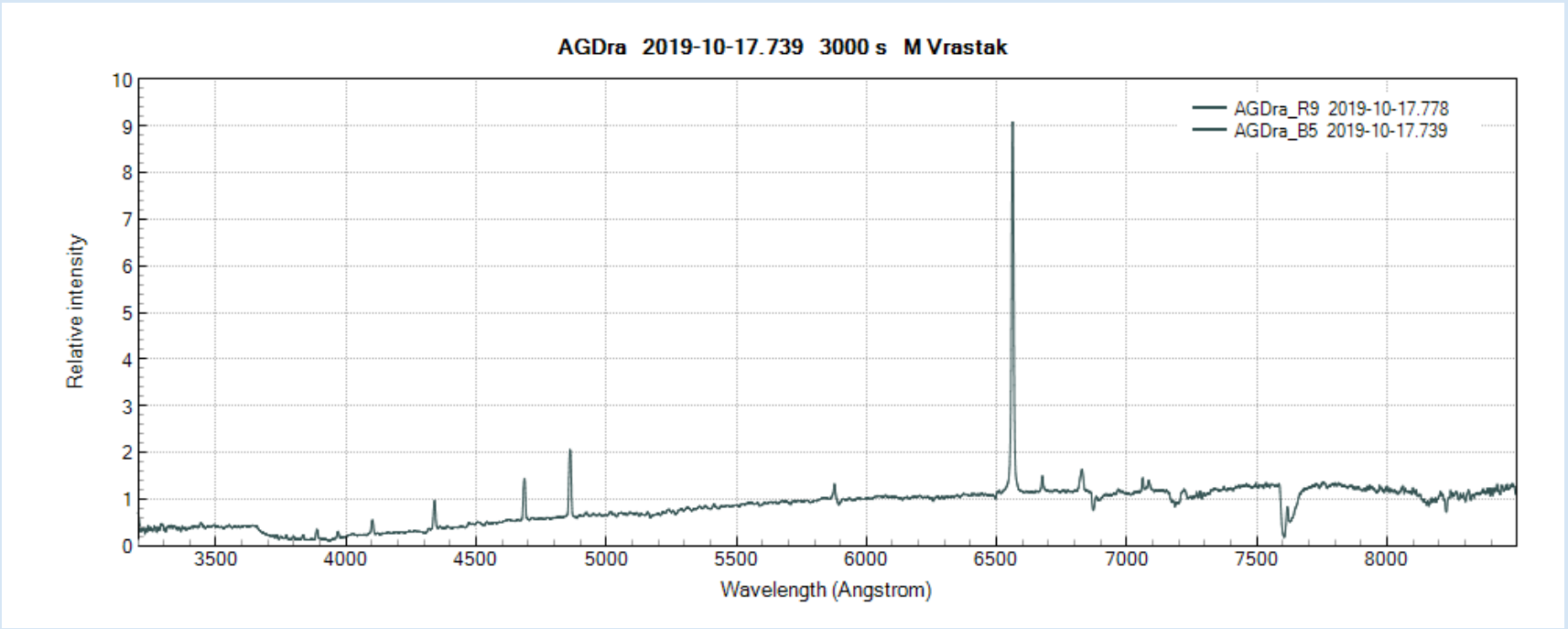
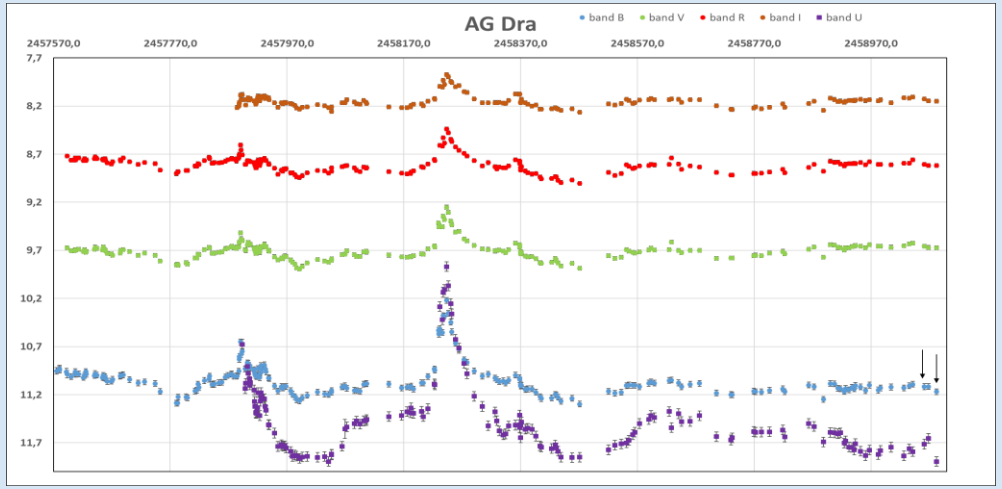
CH Cyg – changes of spectra

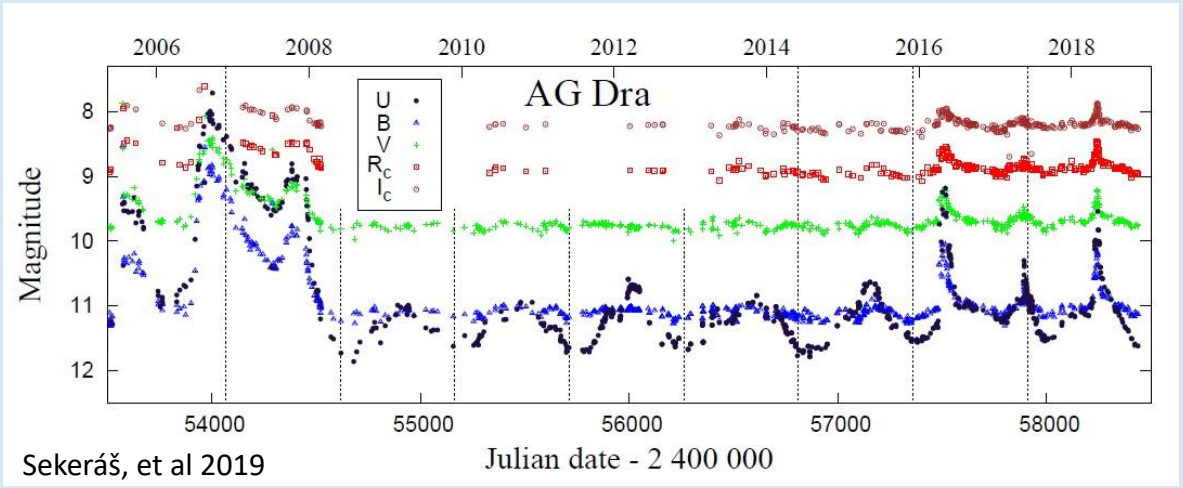


AG Dra

Type: Z And
Spec.type: K4III + WD
V = 9.7 mag
P = 554 d







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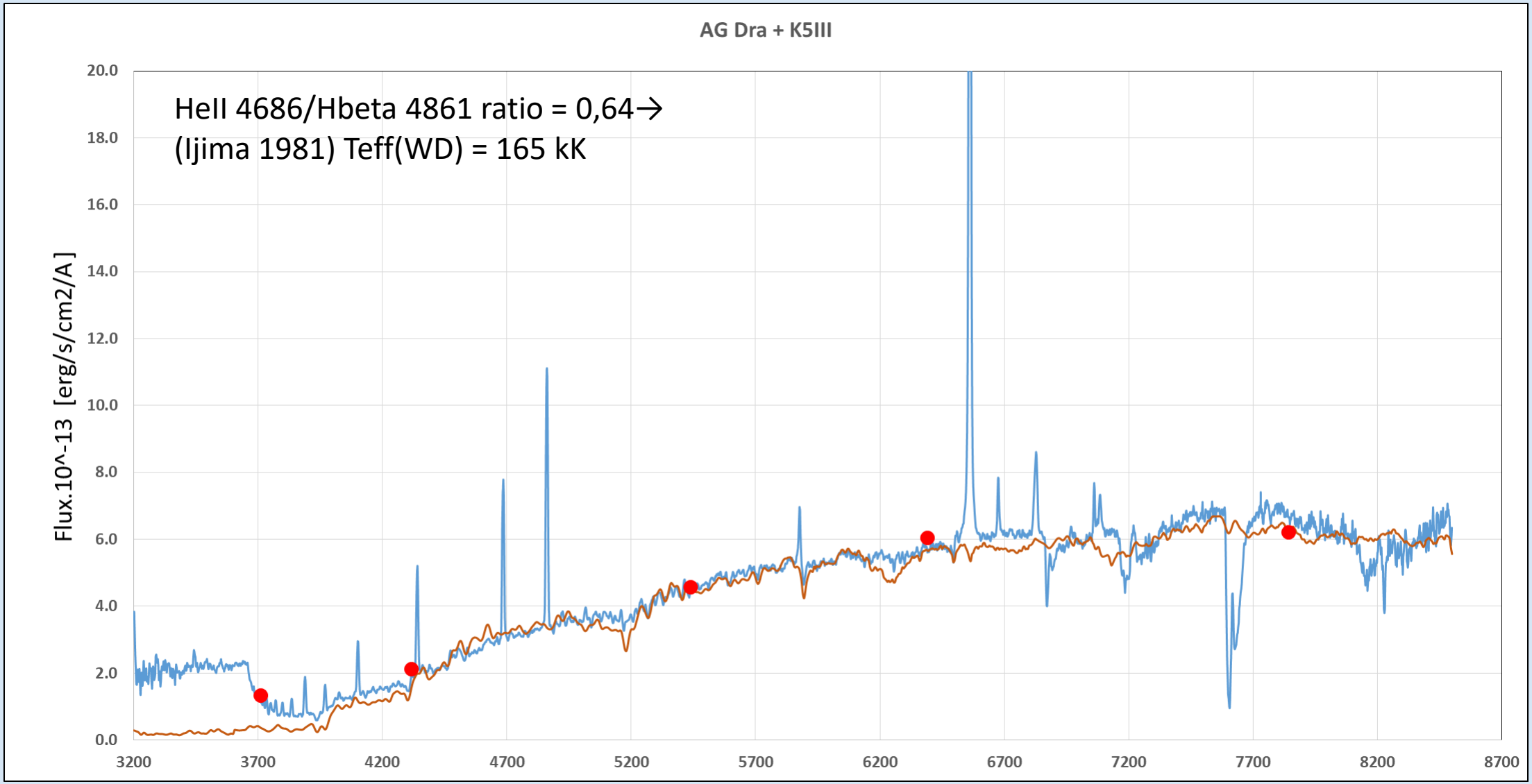
AG Dra


AG Dra + K5III
HeII 4686/Hbeta 4861 ratio = 0,64→
(Ijima 1981) Teff(WD) = 165 kK
Flux.10^-13 [erg/s/cm2/A]
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
3200
3700
4200
4700
5200
5700
6200
6700
7200
7700
8200
8700

AG Dra – Raman scatering lines OVI

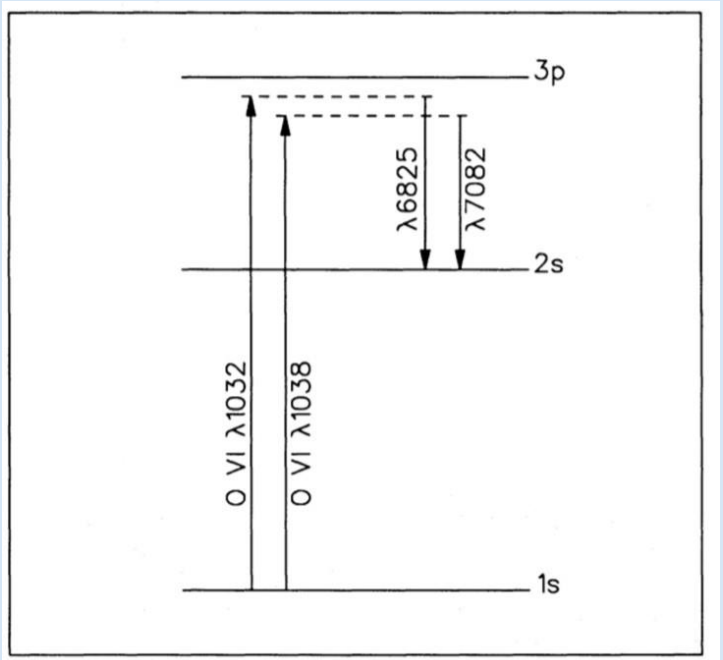
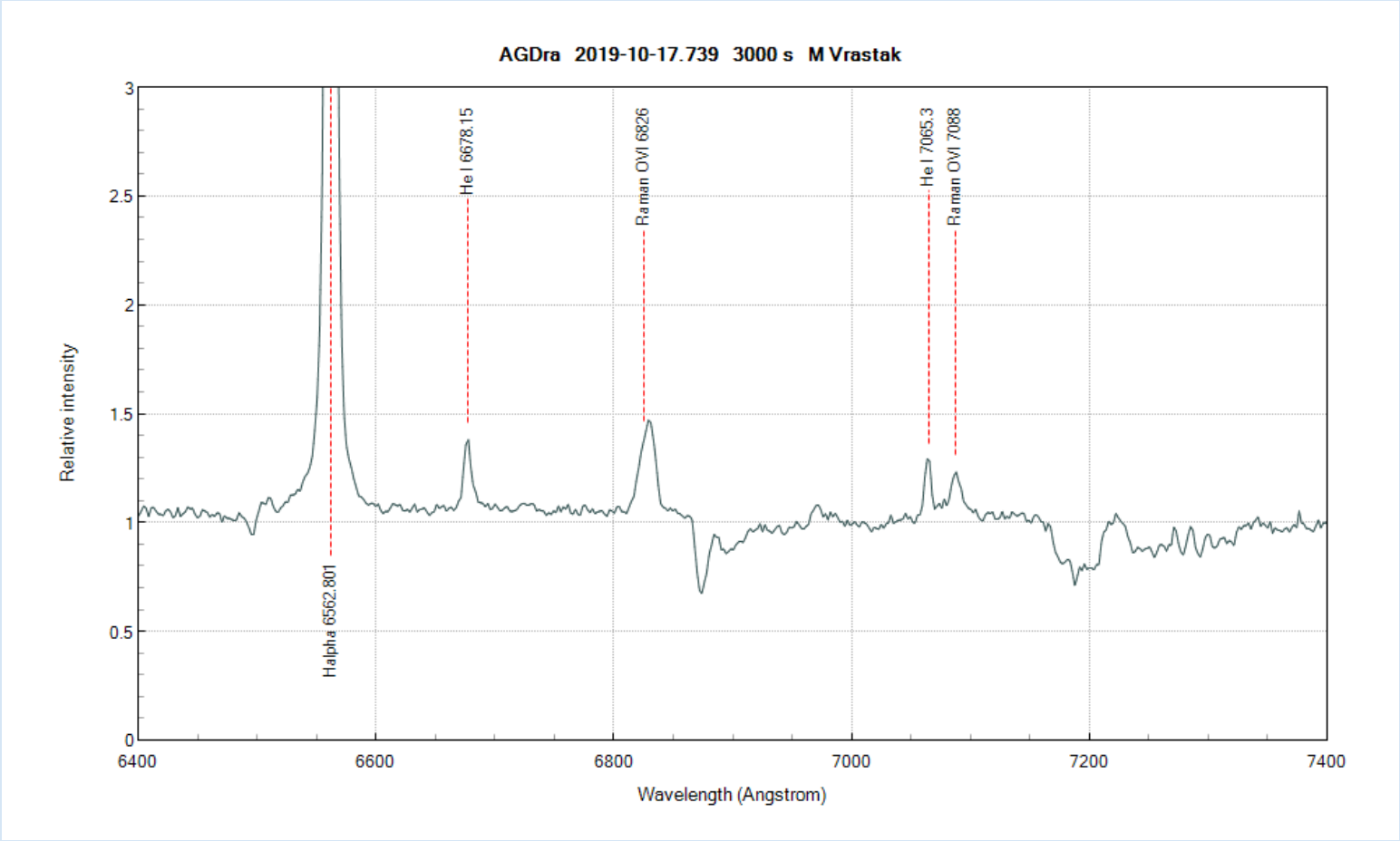


Fig.2. Schematic energy level diagram for Raman scattering of OVI photons by neutral hydrogen.



Raman scattering of O VI resonance photons at 1032, 1038 A by neutral hydrogen.

Thank You

References

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