Optical observations of the recurrent nova RS Oph

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Compact
White Dwarf
Binaries
Conference
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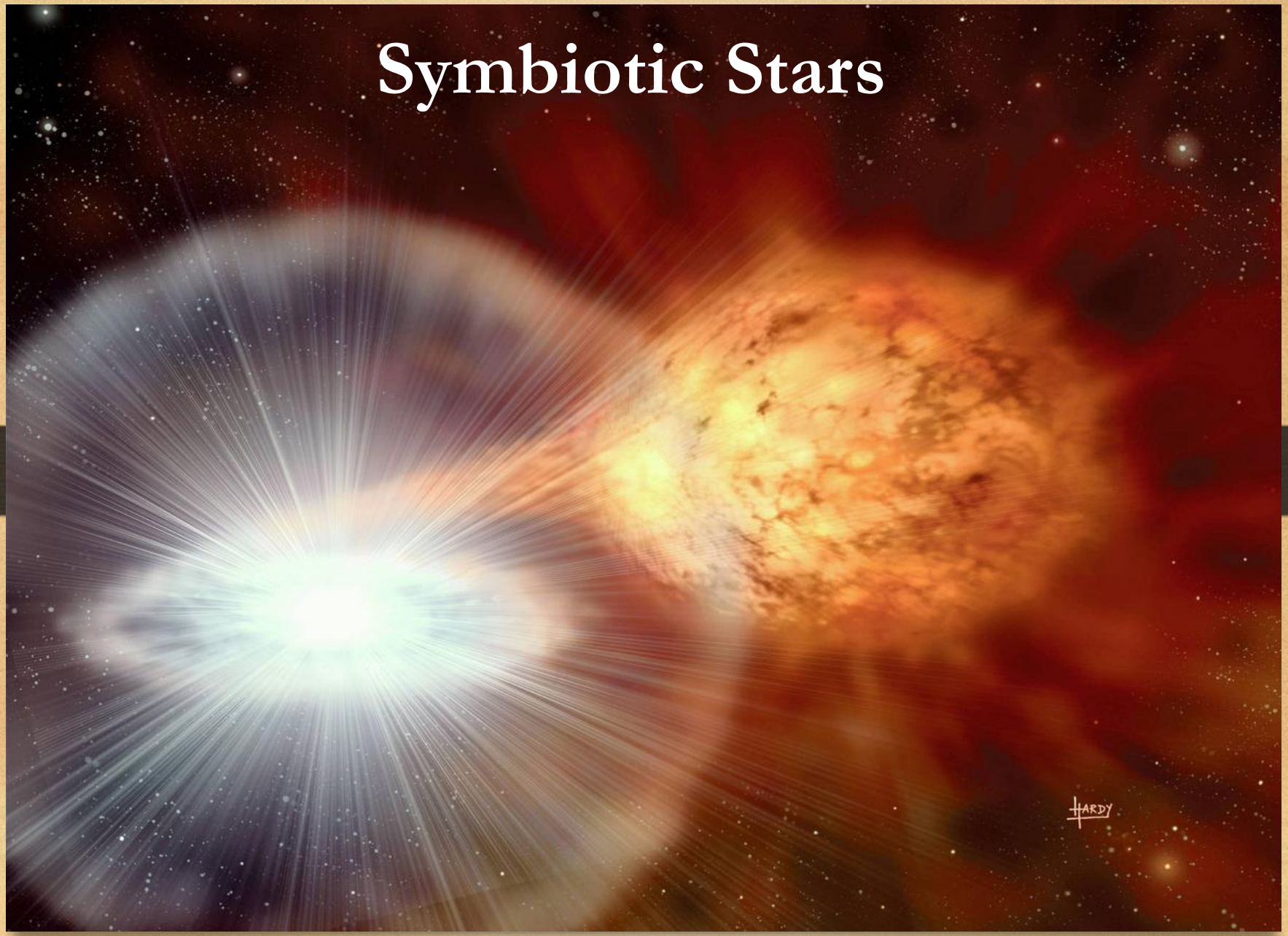
КП-06-Н28

Symbiotic Stars



Recurrent novae among the symbiotics

RS Oph
T CrB
V745 Sco
V3890 Sgr

LMC S154 (Iłkiewicz et al. 2019)

RS Oph

M2 giant ($M \approx 0.8\ M_\odot$) + CO white dwarf ($M \approx 1.2 - 1.4\ M_\odot$)
(Shenavrin et al. 2011) (Mikołajewska & Shara 2017)

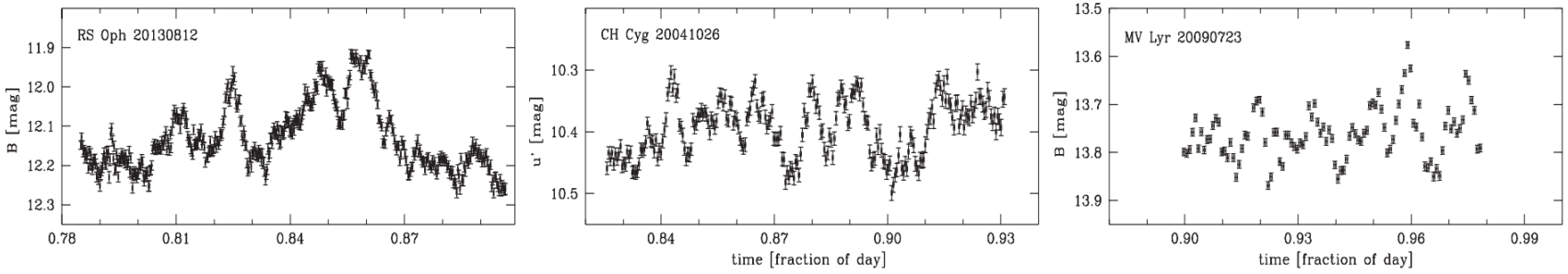
$P_{orb} = 453.6$ d
$e = 0$
(Brandi et al. 2009)

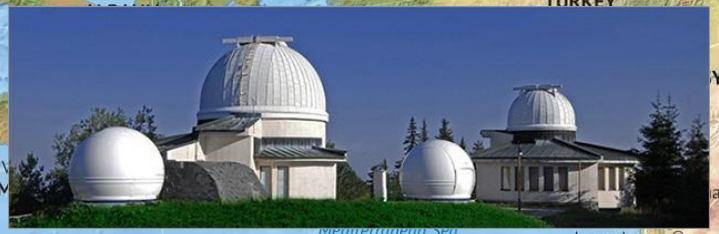
Nova eruptions:
1898, 1907, 1933, 1945, 1958, 1967, 1985, 2006
The next one:
2021 ± 6 (Schaefer 2019)

Flickering

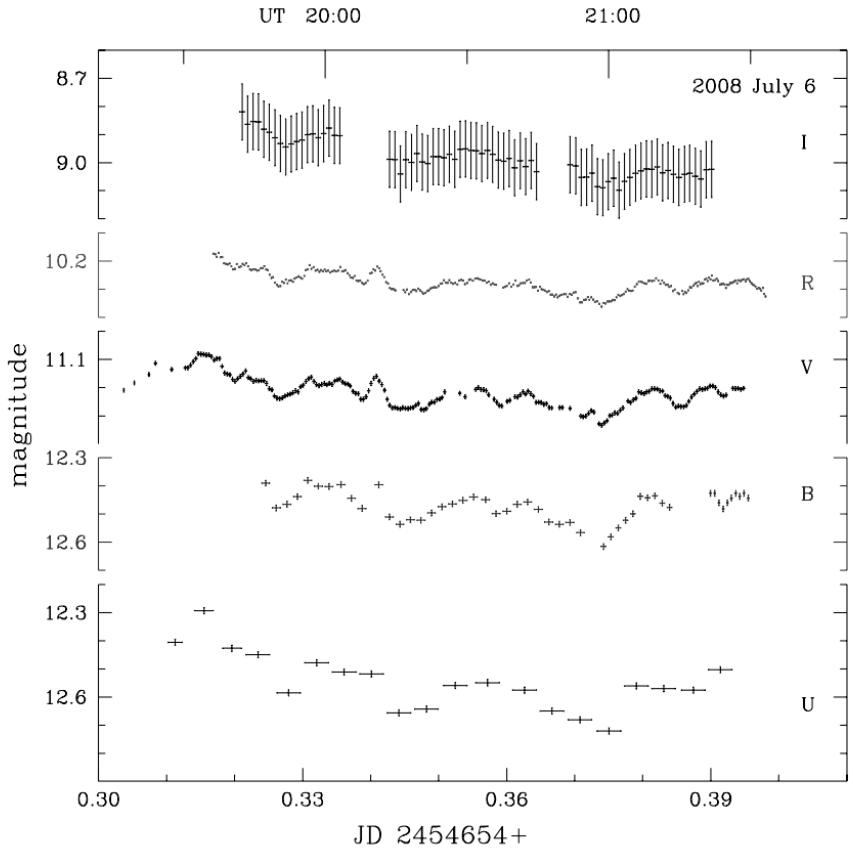
(more details in Simone Scaringi's talk)

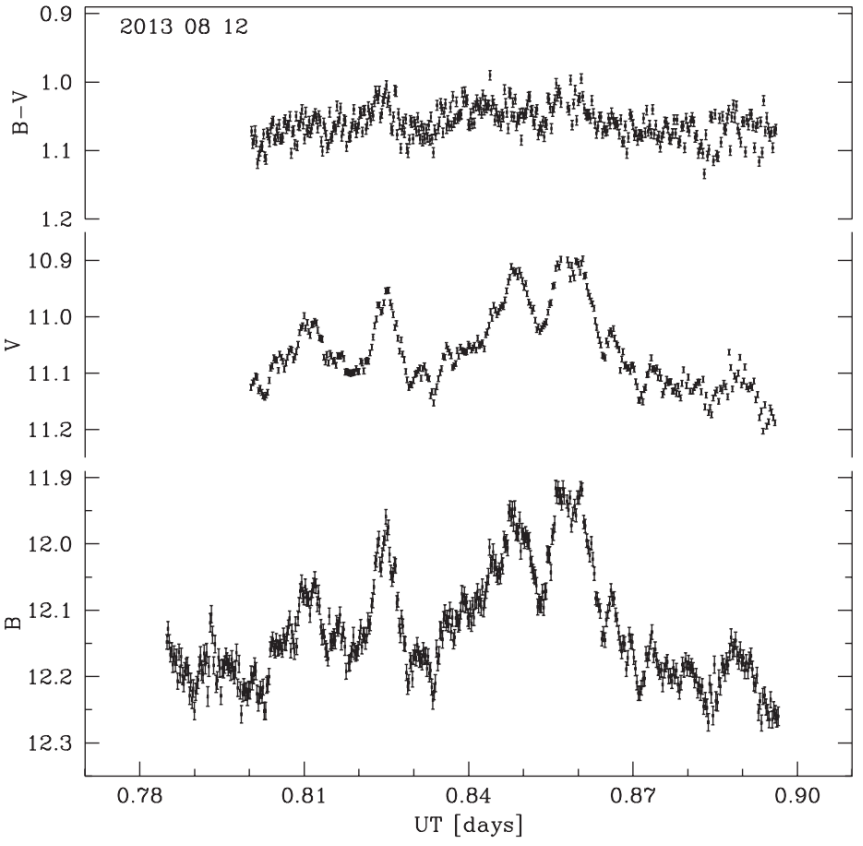
- stochastic photometric variations on timescales of a few minutes with amplitude of a few×0.1 magnitudes
- the source is the accretion disk - either the disk itself or some parts of the disk, e.g. the bright spot or the boundary layer
- T CrB, RS Oph, MWC 560, Z And, V2116 Oph, CH Cyg, RT Cru, o Cet, V407 Cyg, V648 Car and EF Aql





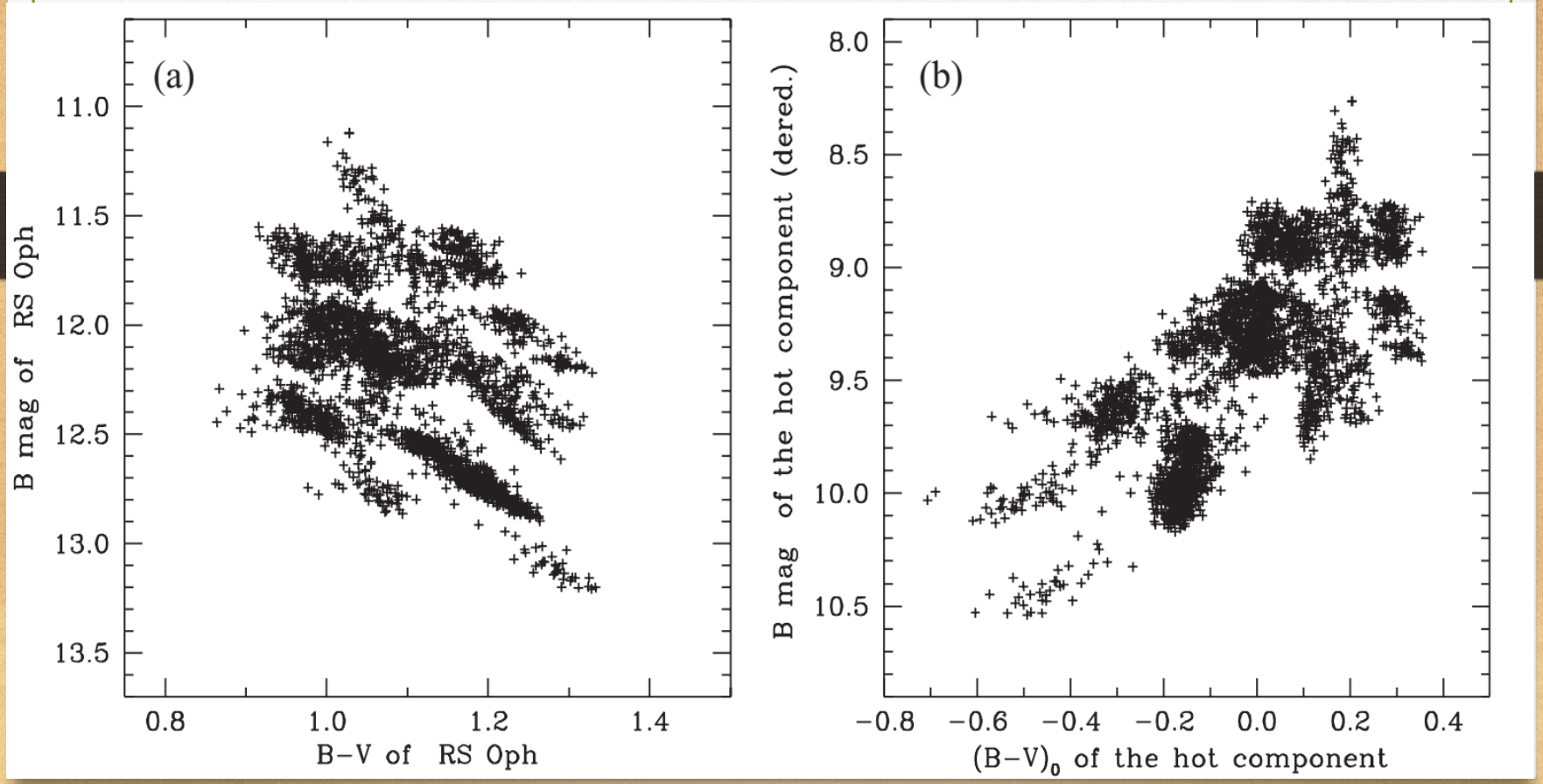
The flickering of RS Oph





colour-magnitude diagram

the hot component becomes redder when it becomes brighter !!!



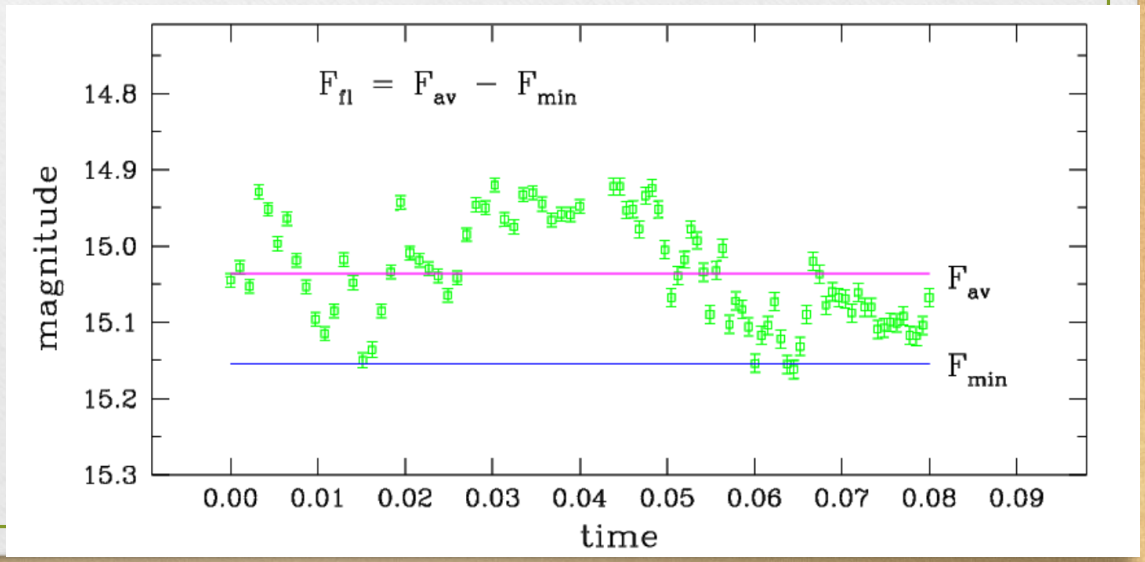
The flickering of RS Oph: Flux

Bruch's (1992) method:

$F_{fl1} = F_{av} - F_{min}$

Nelson's et al. (2011) method:

$F_{fl2} = F_{max} - F_{min}$



from Georgi Latev's PhD thesis (2016)

The flickering of RS Oph: Flux

Bruch's (1992) method:

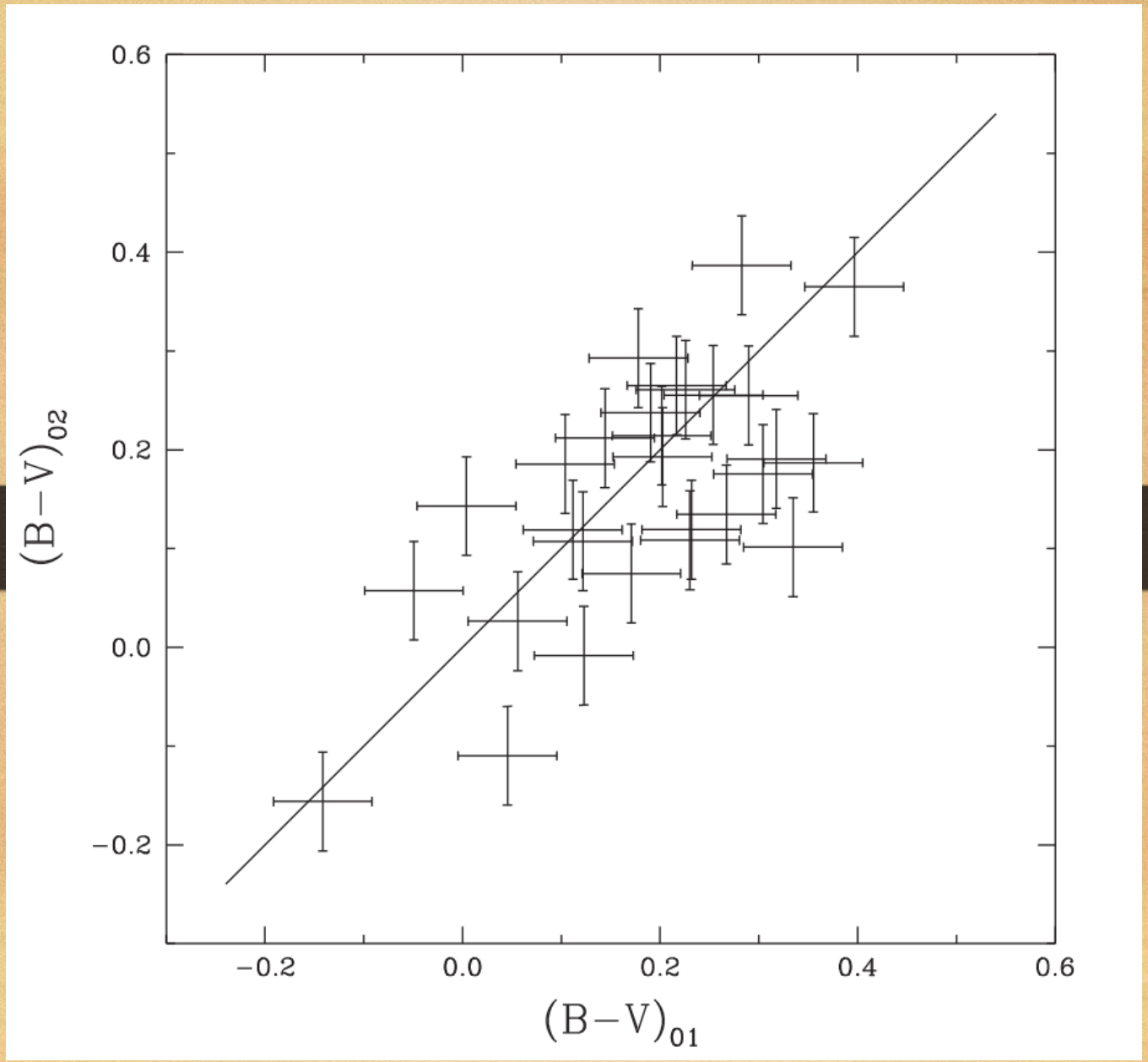
$F_{fl1} = F_{av} - F_{min}$

$F_{fl1}/F_{av} = 0.06 - 0.24$ B band
$F_{fl1}/F_{av} = 0.05 - 0.19$ V band

Nelson's et al. (2011) method:

$F_{fl2} = F_{max} - F_{min}$

$F_{fl2}/F_{max} = 0.13 - 0.42$ B band
$F_{fl2}/F_{max} = 0.10 - 0.36$ V band


0.6
0.4
0.2
0.0
−0.2
(B−V)02
−0.2
0.0
0.2
0.4
0.6
(B−V)01

Physical parameters of the flickering source

The average temperatures of the flickering source:
$T_1 = 9835 \pm 2400$ K and $T_2 = 10\,306 \pm 2693$ K

Radius of the flickering source:
$R_{fl} = 0.92 - 5.6\ R\odot$

Luminosity of the flickering source:
$L_{fl} = 89 \pm 35\ L\odot$

Temperature and Radius of the flickering source

The average temperatures of the flickering source:
$T_1 = 9835 \pm 2400$ K and $T_2 = 10\,306 \pm 2693$ K

Temperature of the bright spot in CVs:

OY Car T = 8 600 ÷ 15 000 K	(Wood et al. 1989)
U Gem T = 11 600± 500 K	(Zhang & Robinson 1987)
WZ Sge T = 16 000 K	(Robinson et al. 1978)
IP Peg T = 7 000 ÷ 13 000 K	(Copperwheat et al. 2010)

RS Oph vs. T CrB

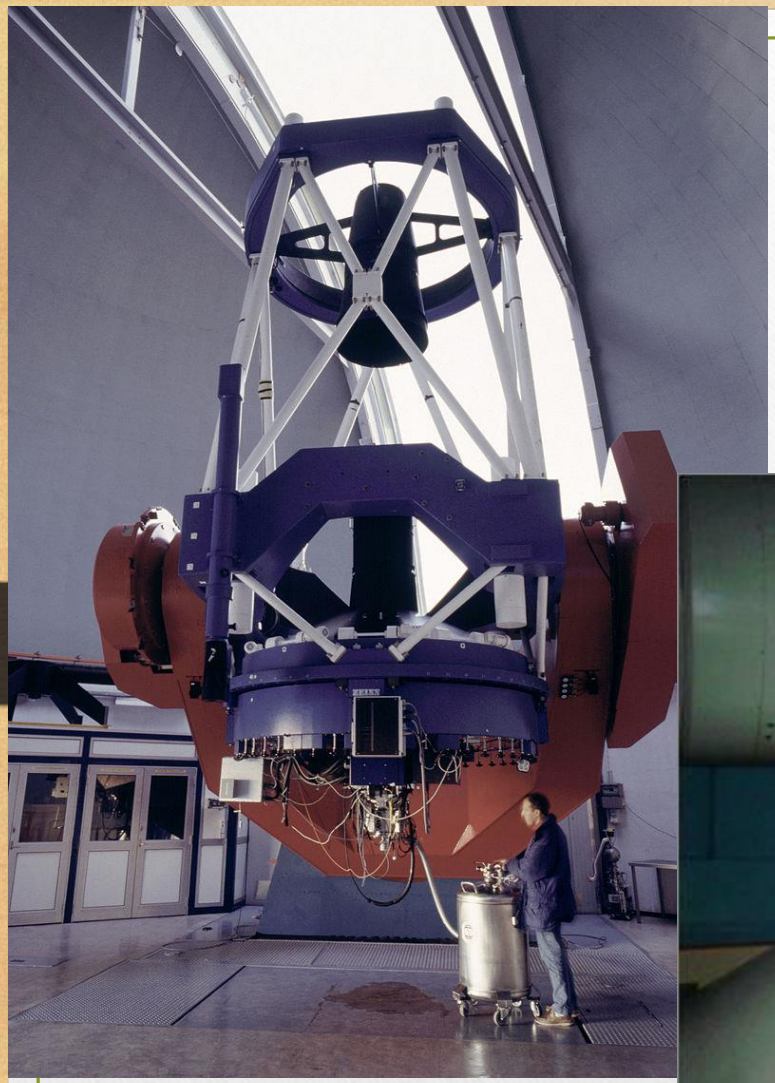
R and I bands flickering of RS Oph > 0.2 mag
R and I bands flickering of T CrB < 0.03 mag

V band flickering of RS Oph > 0.3 mag
V band flickering of T CrB ≤ 0.05 mag

If the boundary layer of RS Oph is completely optically thick, this could explain why RS Oph is X-ray-faint. In this case, the radius of the flickering source measured in the optical bands could represent the radius up to which the hard X-rays generated from the boundary layer are effectively processed by the inner parts of the accretion disc and the accretion disc corona.

Conclusions from the photometry:

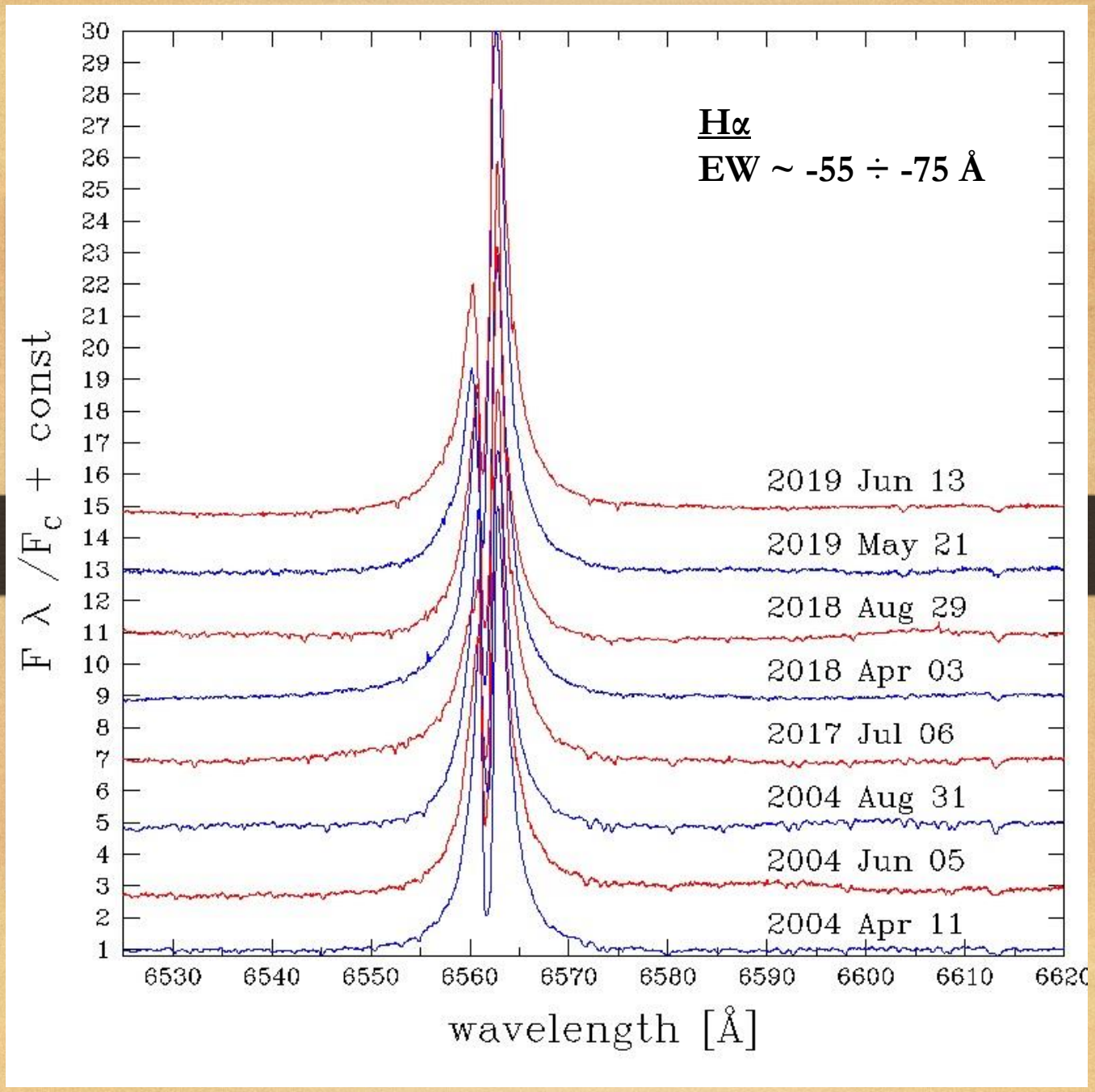
- we estimate an average $(B - V)_0 = 0.18 \pm 0.12$ for the flickering source
- we estimate $T_{fl} = 9800 \pm 2400$ K, which is similar to the temperature of the bright spot in cataclysmic variables.
- its average radius is $R_{fl} = 3.6 \pm 1.4\ R_{\odot}$
- if the flickering is coming from the bright spot, as the brightness increases the size of the spot also increases.

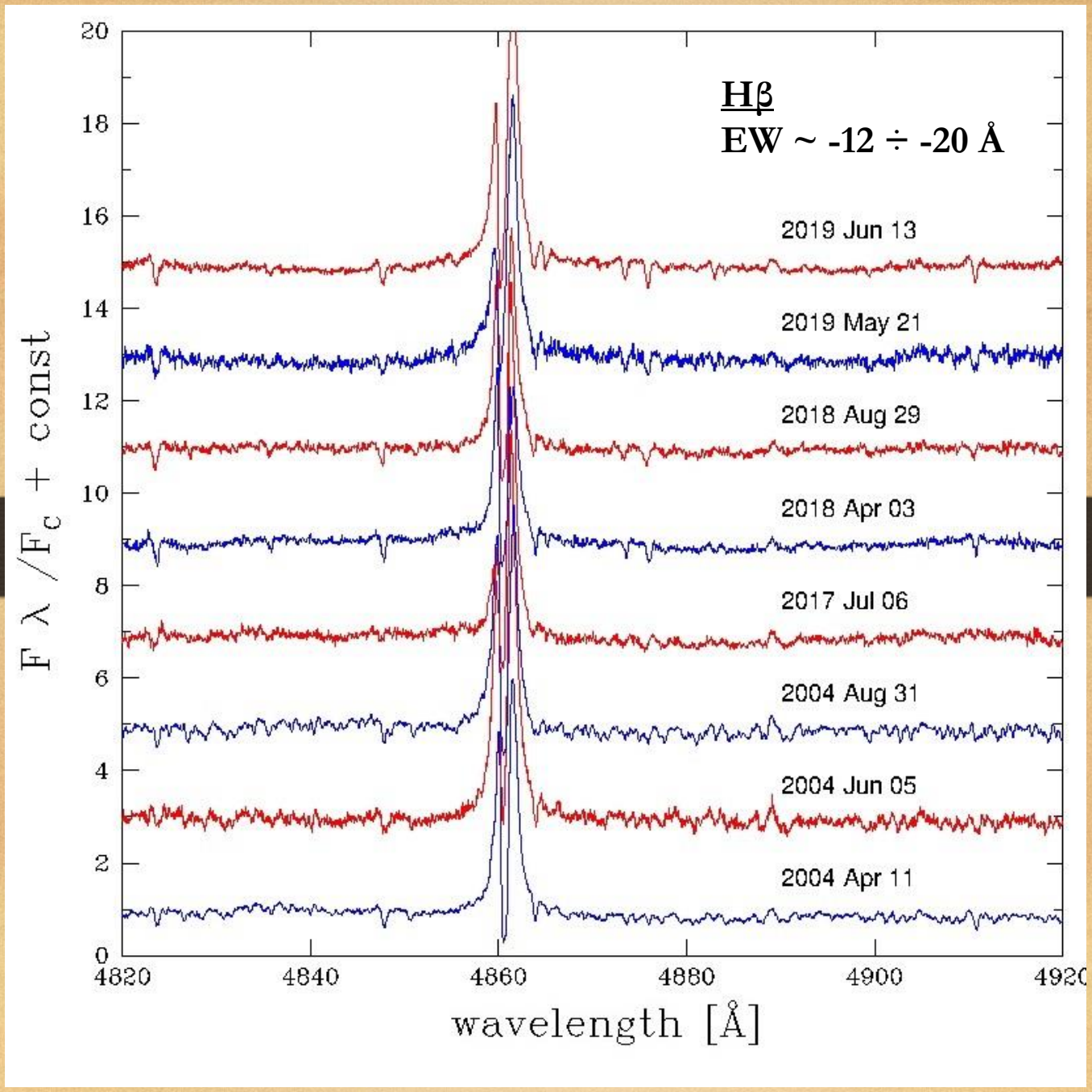


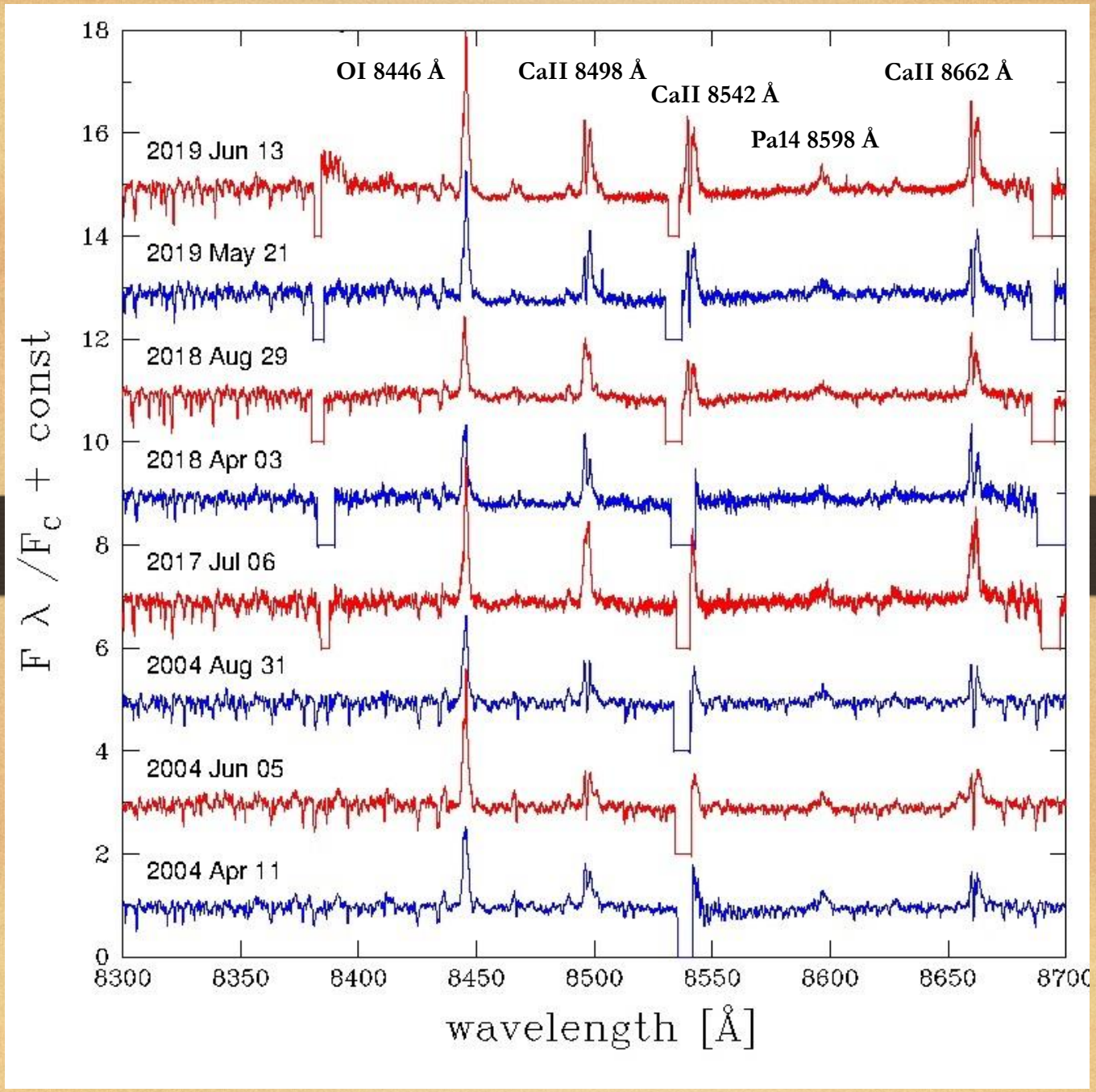
Spectral observations of RS Oph:

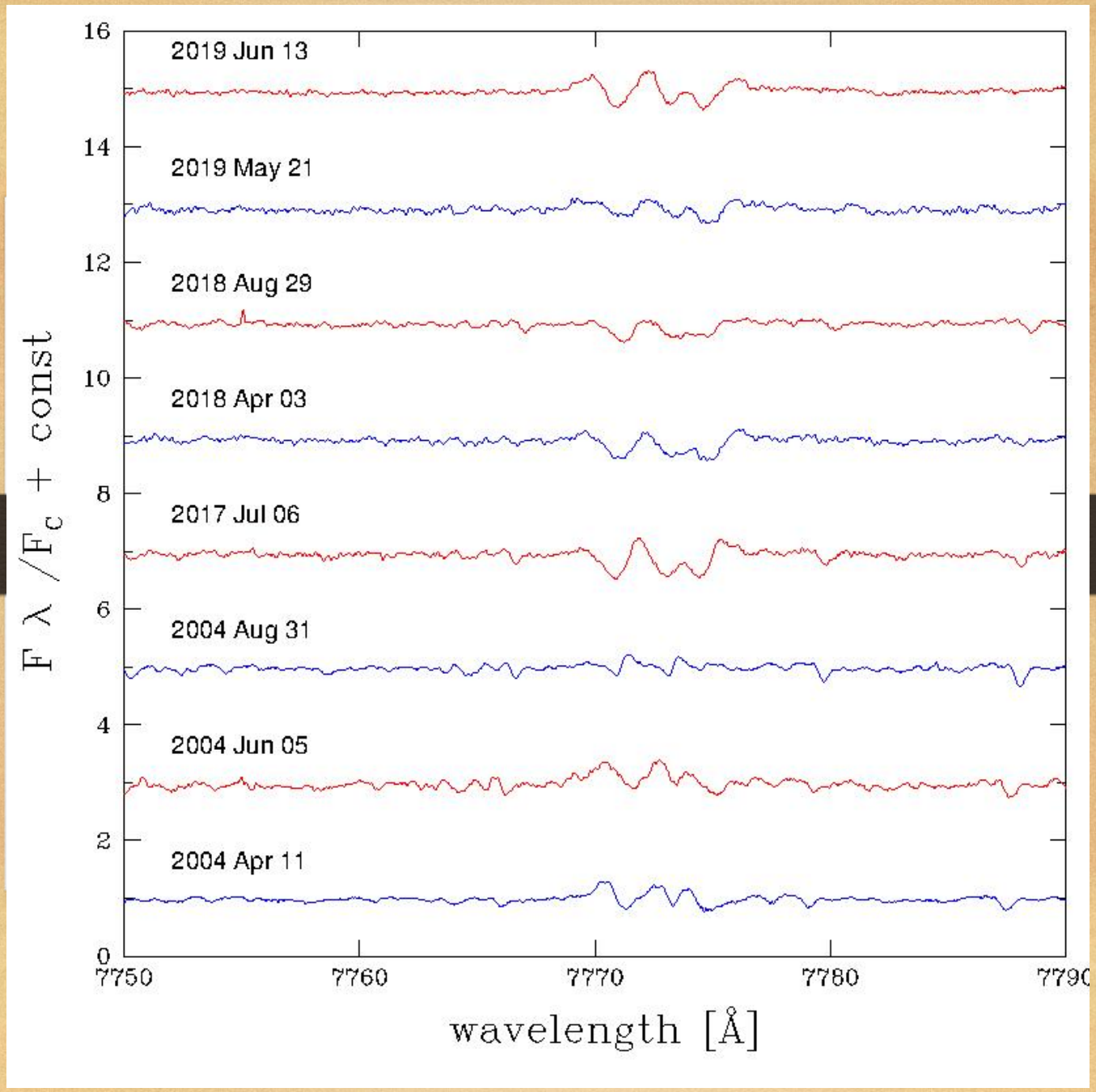
2004 – 2.2m ESO + FEROS

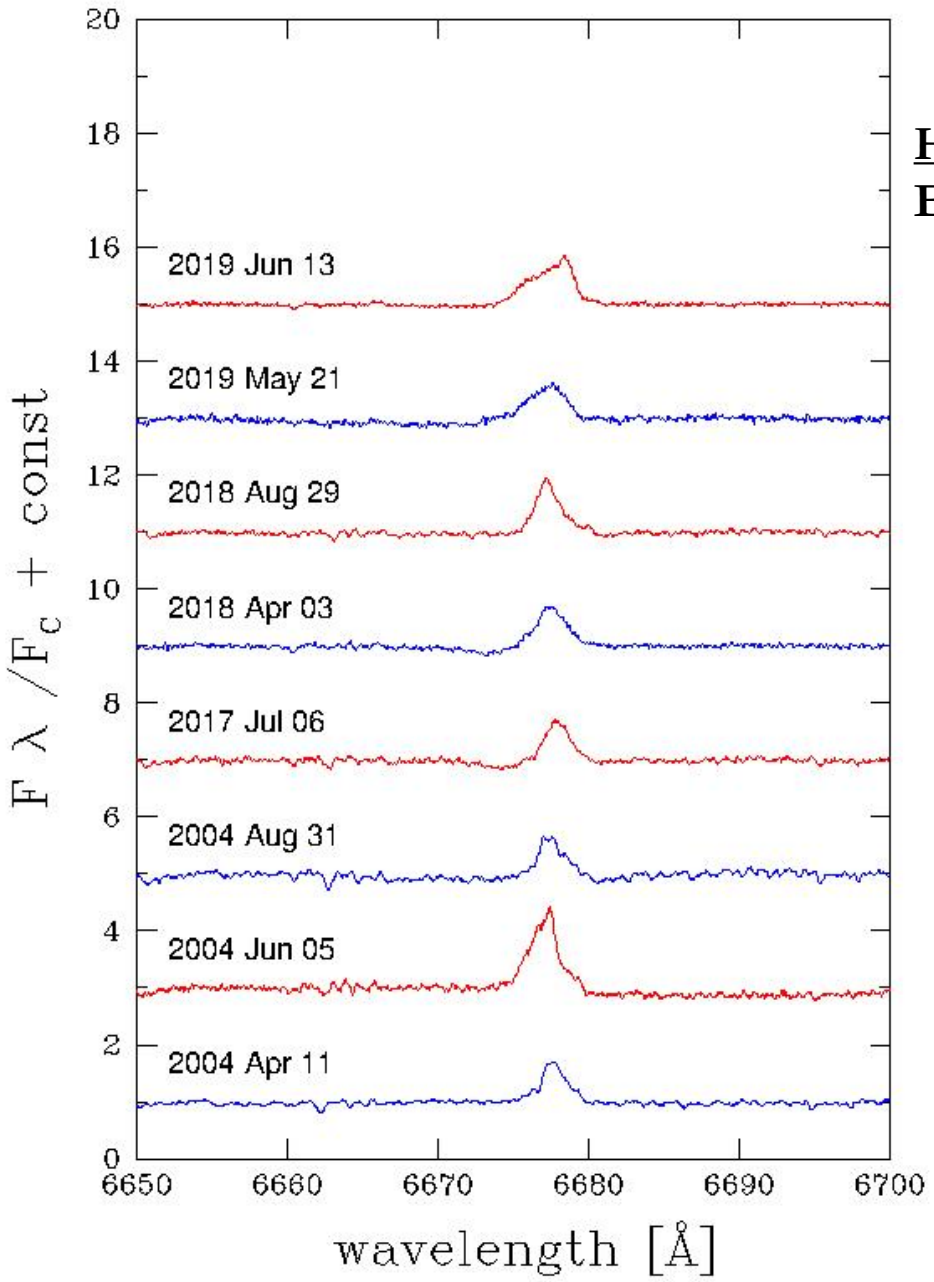
2017 – 2019 – 2m Rozhen NAO + ESPERO


Hα
EW ~ -55 ÷ -75 Å
2019 Jun 13
2019 May 21
2018 Aug 29
2018 Apr 03
2017 Jul 06
2004 Aug 31
2004 Jun 05
2004 Apr 11
F λ /F_c + const
wavelength [Å]
6530
6540
6550
6560
6570
6580
6590
6600
6610


Hβ
EW ~ -12 ÷ -20 Å
2019 Jun 13
2019 May 21
2018 Aug 29
2018 Apr 03
2017 Jul 06
2004 Aug 31
2004 Jun 05
2004 Apr 11
F λ /F_c + const
wavelength [Å]
0
2
4
6
8
10
12
14
16
18
20
4820
4840
4860
4880
4900
4920


OI 8446 Å
CaII 8498 Å
CaII 8542 Å
Pa14 8598 Å
CaII 8662 Å
2019 Jun 13
2019 May 21
2018 Aug 29
2018 Apr 03
2017 Jul 06
2004 Aug 31
2004 Jun 05
2004 Apr 11
F λ /F_c + const
wavelength [Å]
0
2
4
6
8
10
12
14
16
18
8300
8350
8400
8450
8500
8550
8600
8650
8700


2019 Jun 13
2019 May 21
2018 Aug 29
2018 Apr 03
2017 Jul 06
2004 Aug 31
2004 Jun 05
2004 Apr 11
F λ /F$_c$ + const
wavelength [Å]
0
2
4
6
8
10
12
14
16
7750
7760
7770
7780
7790



HeI 6678 Å

EW ~ -1.5 ÷ -2.7 Å

Conclusions from the spectroscopy:

- the Hα and Hβ lines have a double peaked structure.
- the OI 8446 Å have a double-peaked structure, differs from the OI 7774 Å triplet. Probably OI 8446 Å is excited by Lyβ fluorescence. Clear evidence for [OI] 6300 Å and 6364 Å, no [OIII] 4363 Å, 4959 Å and 5007 Å.
- the HeI 5876 Å and 6678 Å lines have single-peaked structure. No detection of HeII 4686 Å.
- no Raman scattered lines at 6830 Å and 7088 Å are detected.

Thank you!

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