Contribution of emission lines to observed B, V, Rc magnitudes for the active symbiotic binary BF Cygni

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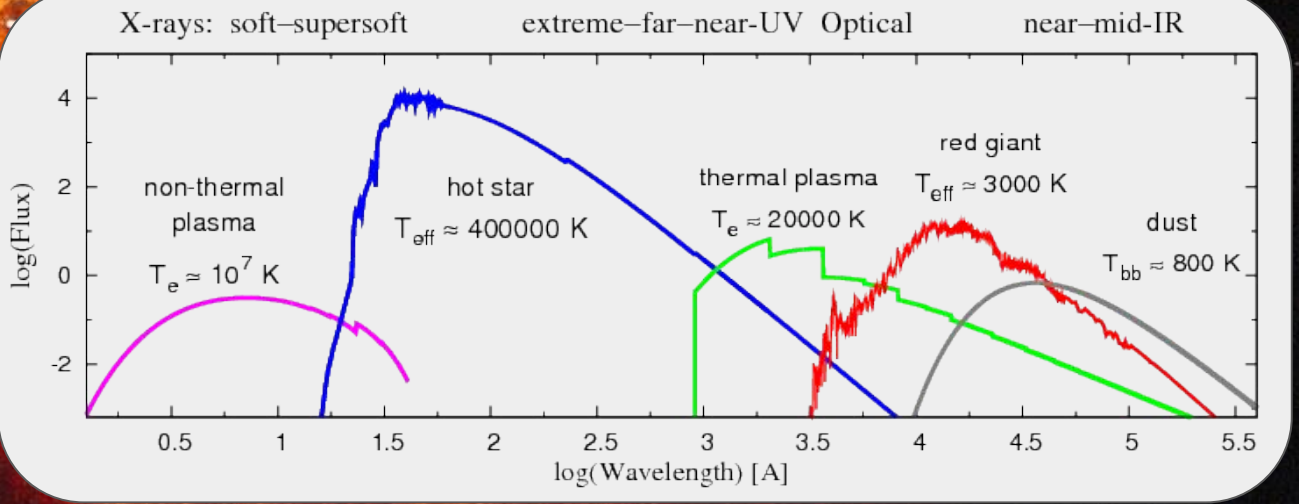
Symbiotic stars:

RG (normal/Mira) +SW

WD +SW: *active phase!*

Symbiotic nebula

- Interaction
- Large Porb
- Emission lines



Quiescent and active phases

Quiescent phase:

- equilibrium (mass loss by RG, accretion, ionization)
- constant energy release, SED

Active phase: brightenings ← increase of mass loss rate

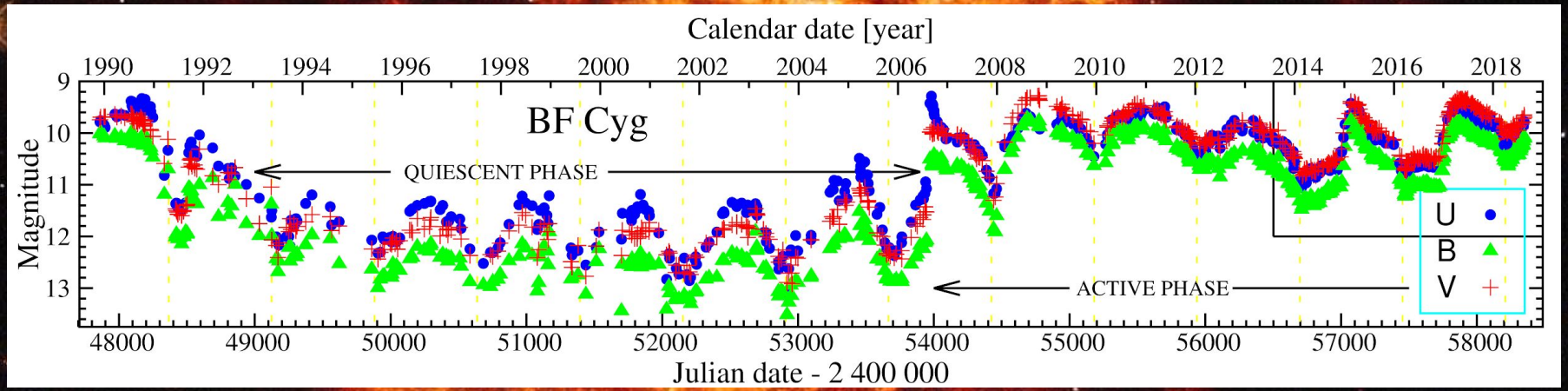
Classical symbiotic	Symbiotic nova
1-3 mag, months – years (Z And)	few mag, ~ decades (V1016 Cyg)

significant spectral changes (wind from WD):

- broadening of EL (fast SW)
- P-Cyg type (optically thick expanding shell)
- rare: satellite components to H-Balmer EL (jets)

BF Cygni: Photometry

Porb = 757.2 d, eclipsing (i ~ 80), d = 3.8 kpc, E(B−V) = 0.35



HLC → 3 types of OBs:

- symbiotic nova OB: 1895
- classical symbiotic OBs: 1989
- flares: 2015, 2017

Data are from Sekeras, M. et al., 2019, CoSka, 49, 19

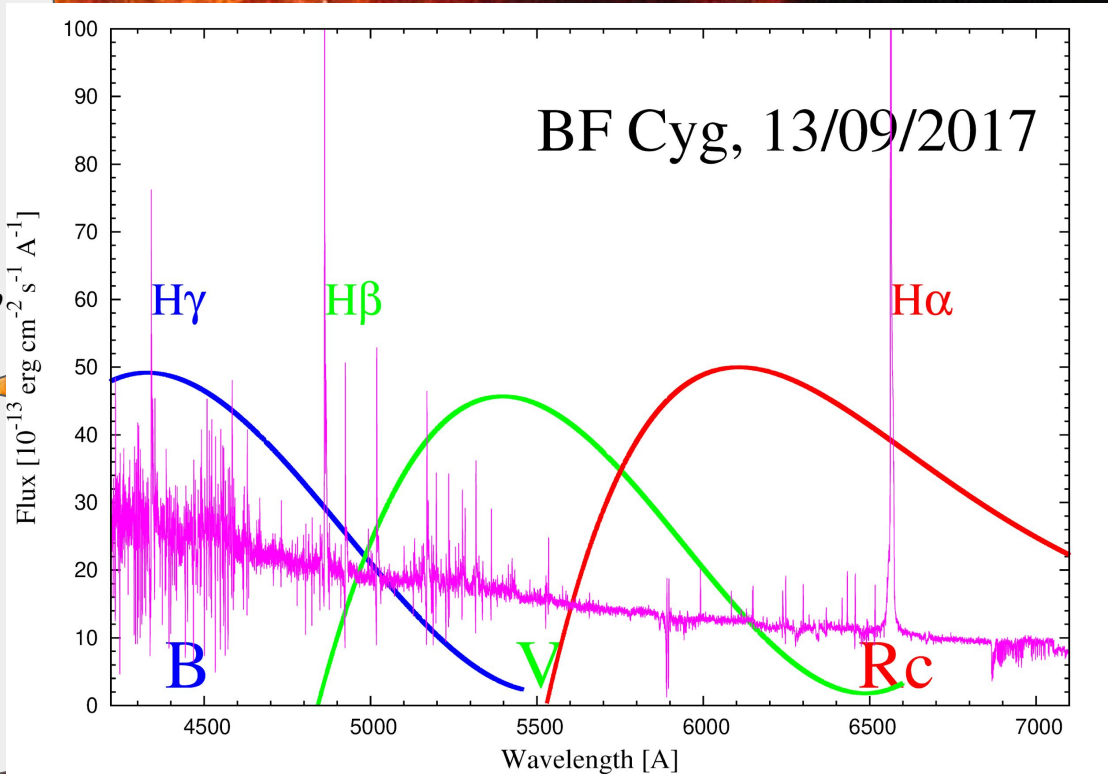
BF Cygni: Spectroscopy

quiescence:

- H I
- He I, weak He II
- [O I], Fe I, Mg I
- Fe II, Ti II, Cr II
- [O III], [Ne III], [Fe III], C III, Si IV, N V

activity:

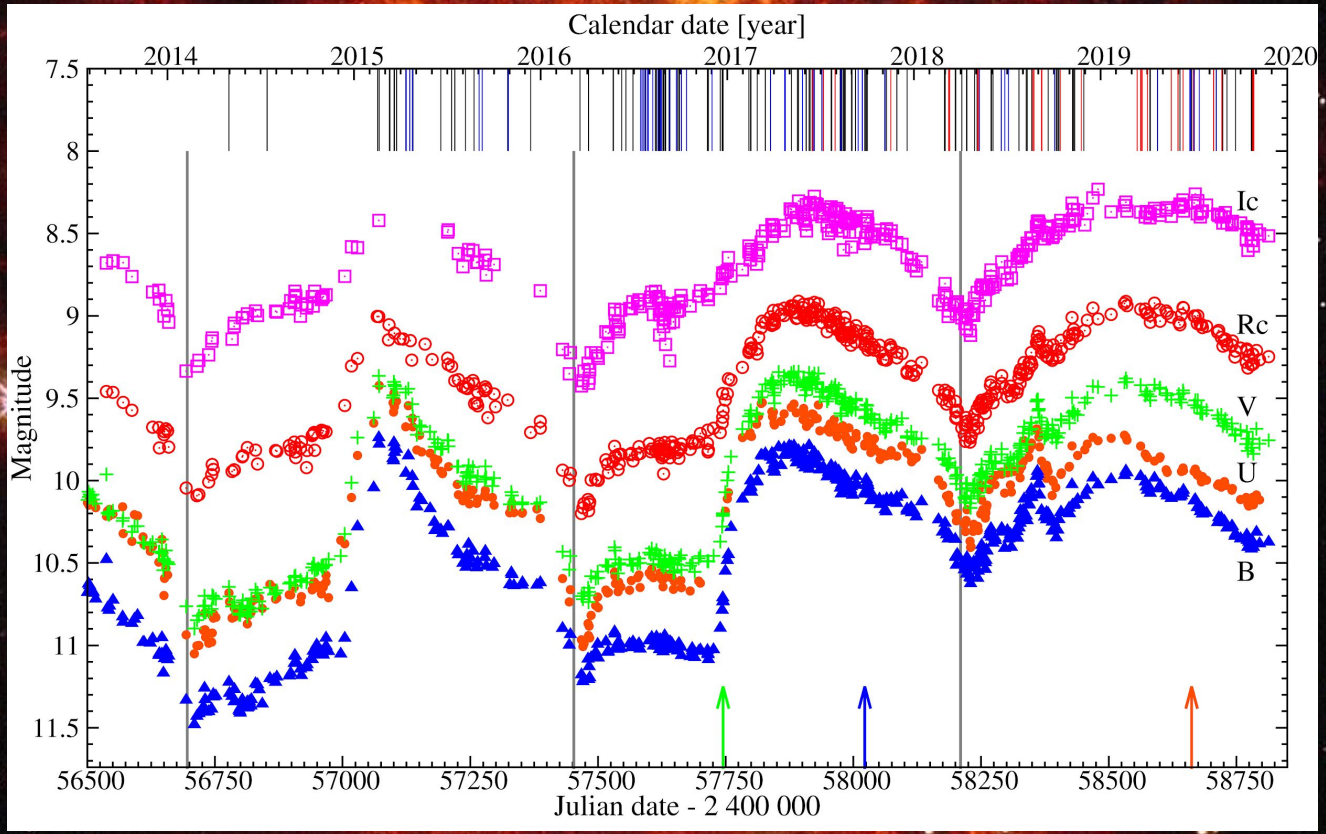
- H I
- He I
- weak Me II
- no highly ionized elements



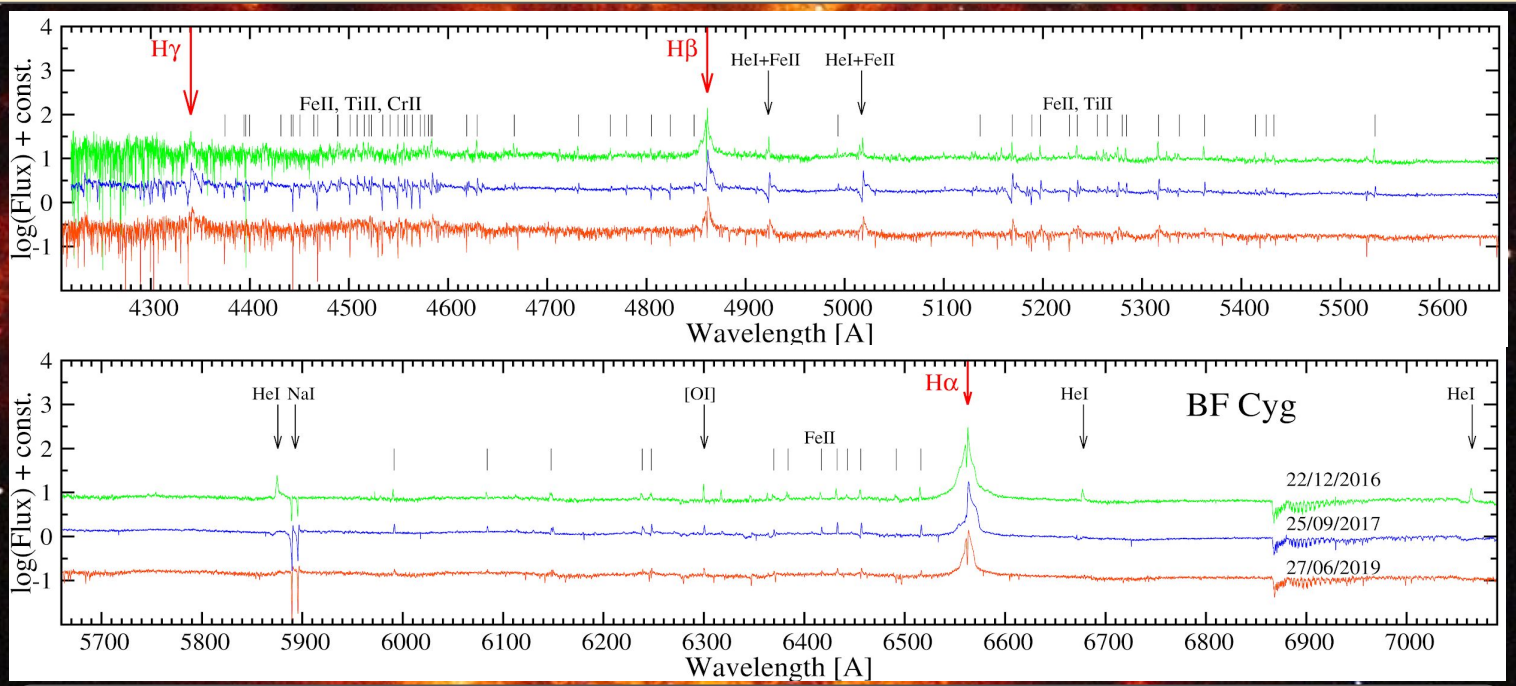
Treatment of observations:

1. Calibration of the Echelle spectra from arbitrary units to units of fluxes (spectroscopy) with the aid of simultaneous multicolor photometry
2. Correction for emission lines → photometric fluxes → magnitudes of true continuum (photometry, spectroscopy)
3. Fitting of the Balmer line profiles using Gaussian curves to extract satellite emission components (spectroscopy)

BF Cygni: Recent photometry

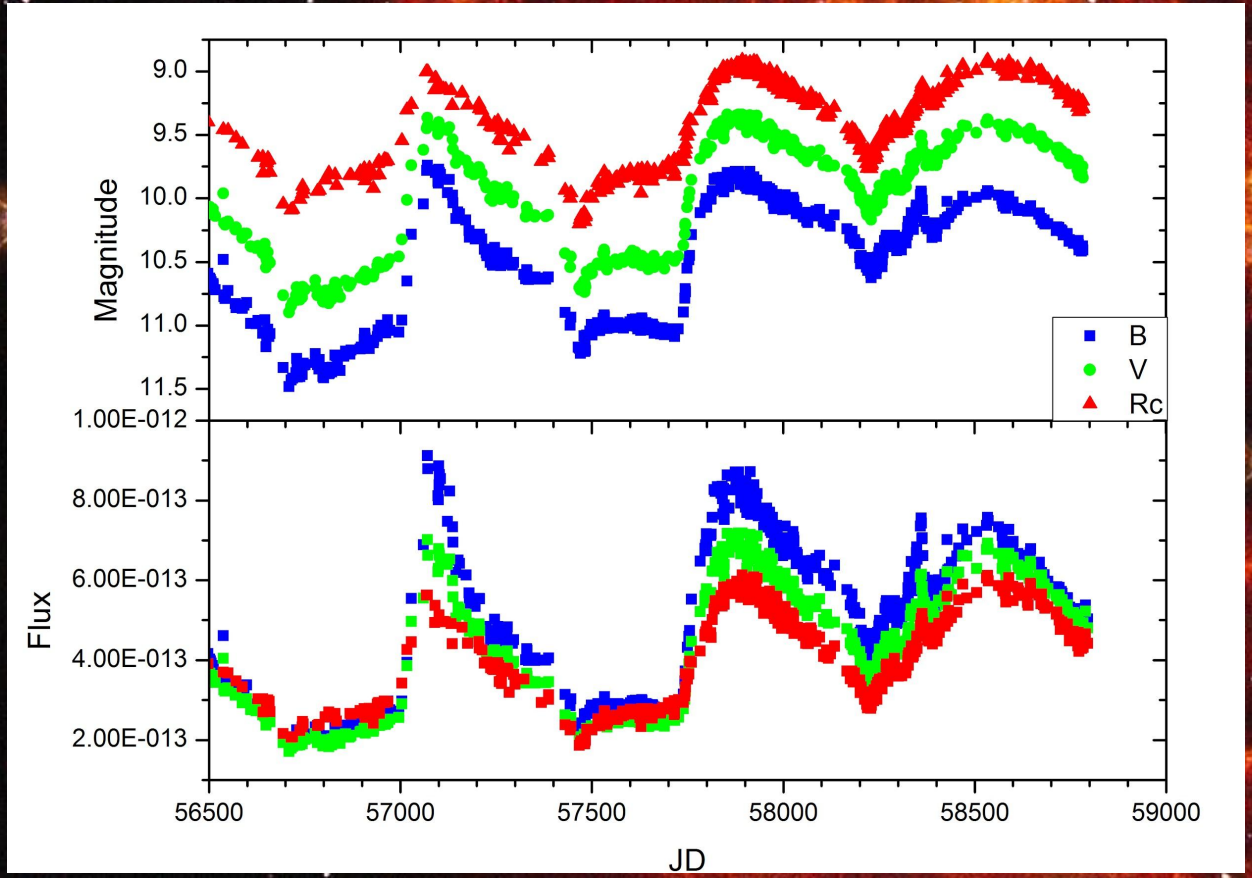


BF Cygni: Recent spectroscopy



Evolution of spectra: prior the 2016/17 burst: 12/2016, after the maximum: 09/2017, recent data: 06/2019

Data processing: Fluxes



$m_\lambda = -2.5 \log(F_\lambda) - q_\lambda$

$\Rightarrow F_\lambda$ [W cm-2 A-1]

$\Rightarrow F_\lambda$ [erg cm-2 s-1 A-1]

$q(U) = 38.40$

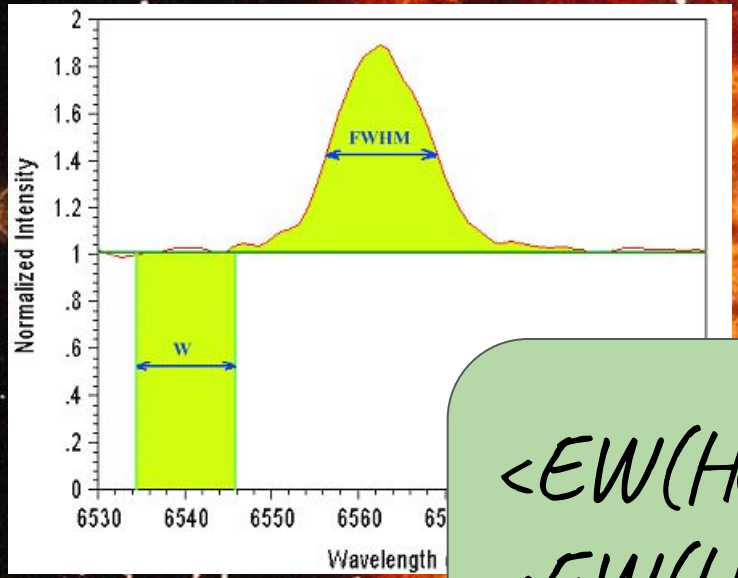
$q(B) = 37.86$

$q(V) = 38.52$

$q(Rc) = 39.12$

$q(Ic) = 39.78$

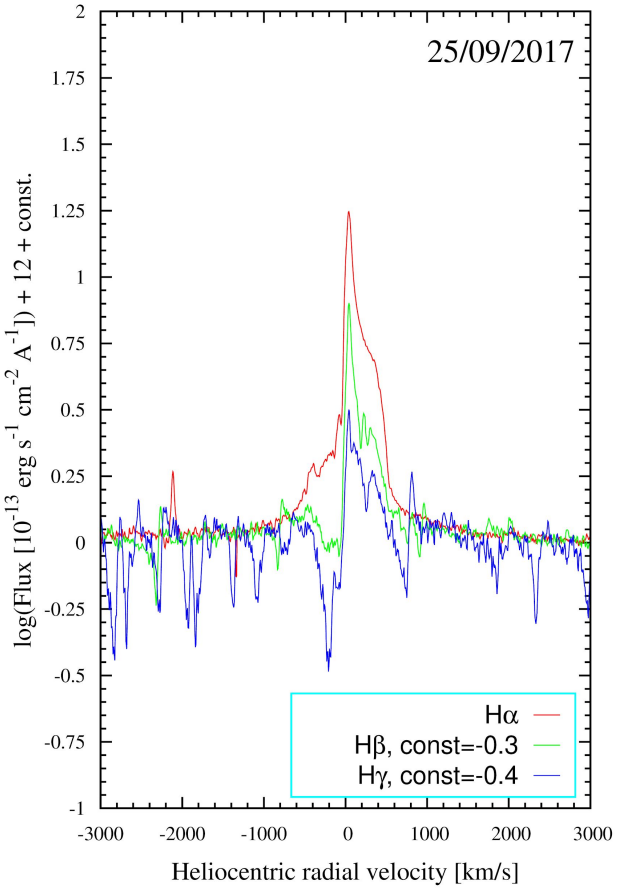
Data processing: Equivalent widths



$\langle EW(H\alpha) \rangle = 140\ A$

$\langle EW(H\beta) \rangle = 30\ A$

$\langle EW(H\gamma) \rangle = 6\ A$

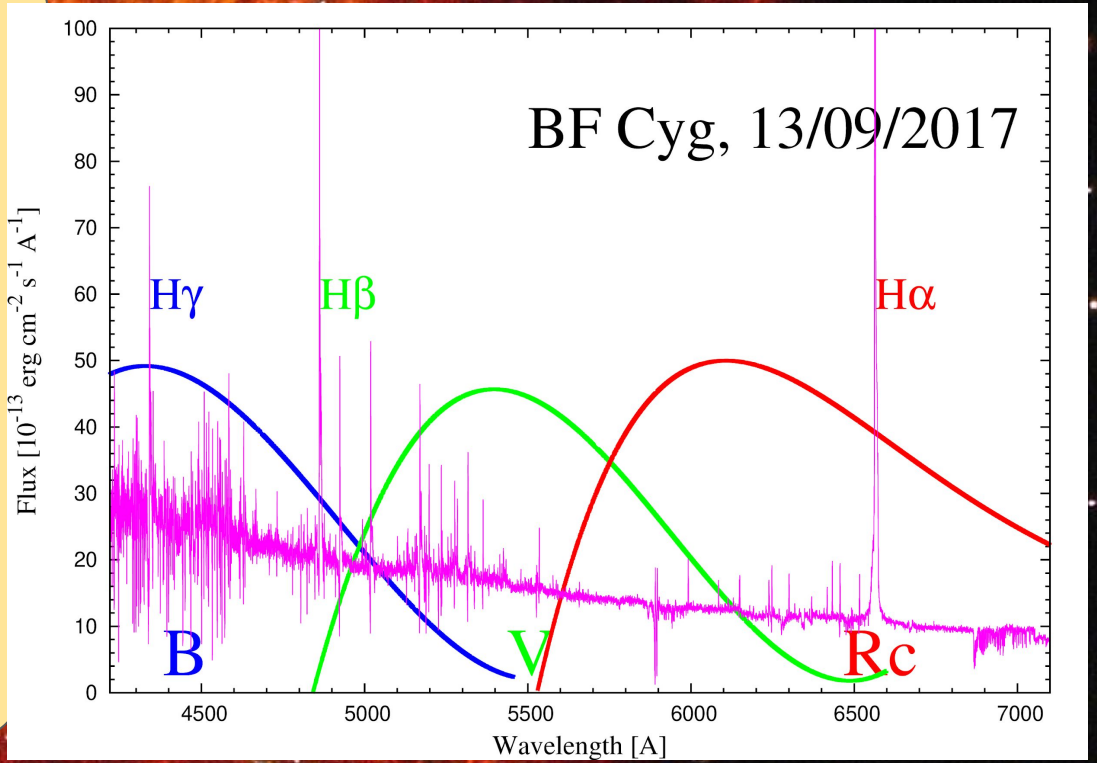


Data processing: Corrections for lines Δm

Δm depends on

- EW, continuum level
- position λ

Polynomial approximations of the transmission functions: B3(λ), V3(λ), Rc5(λ)
Skopal, A., 2007, New Astron., 12, 597



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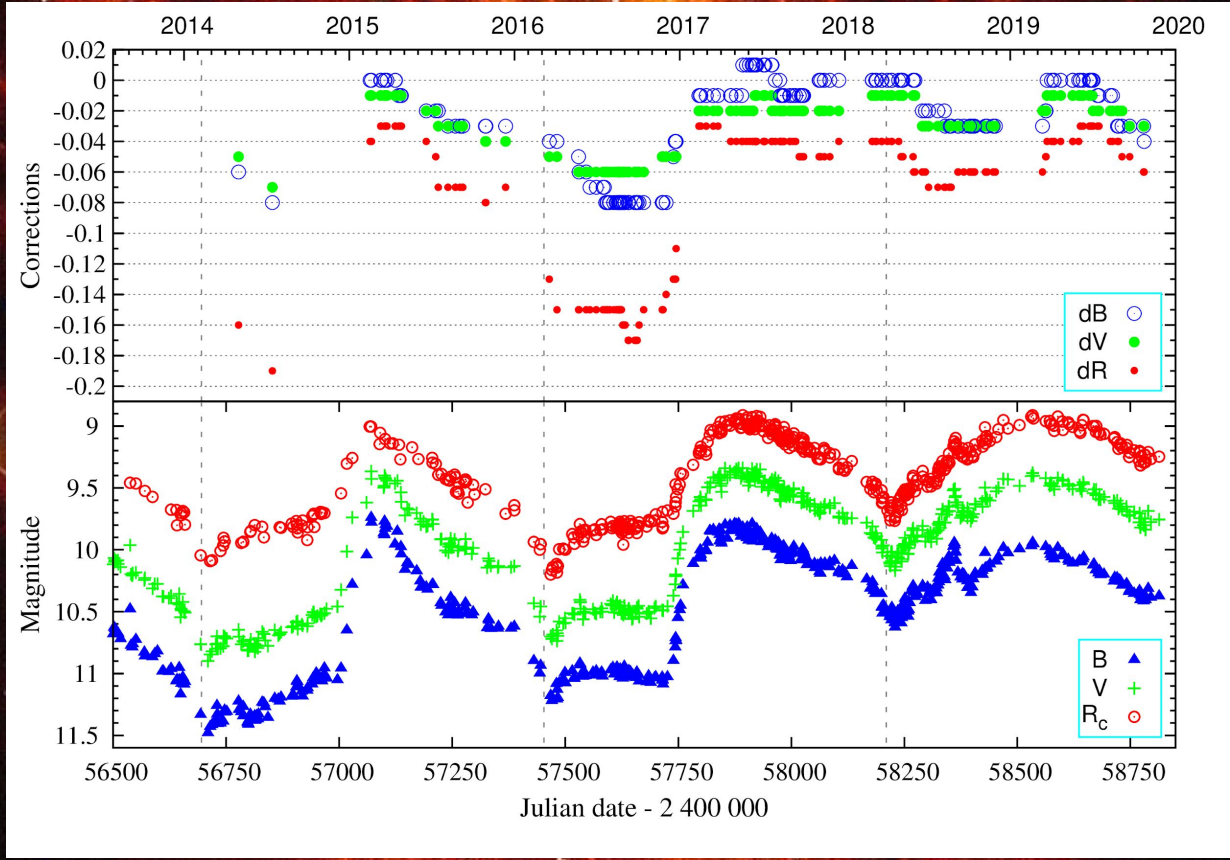
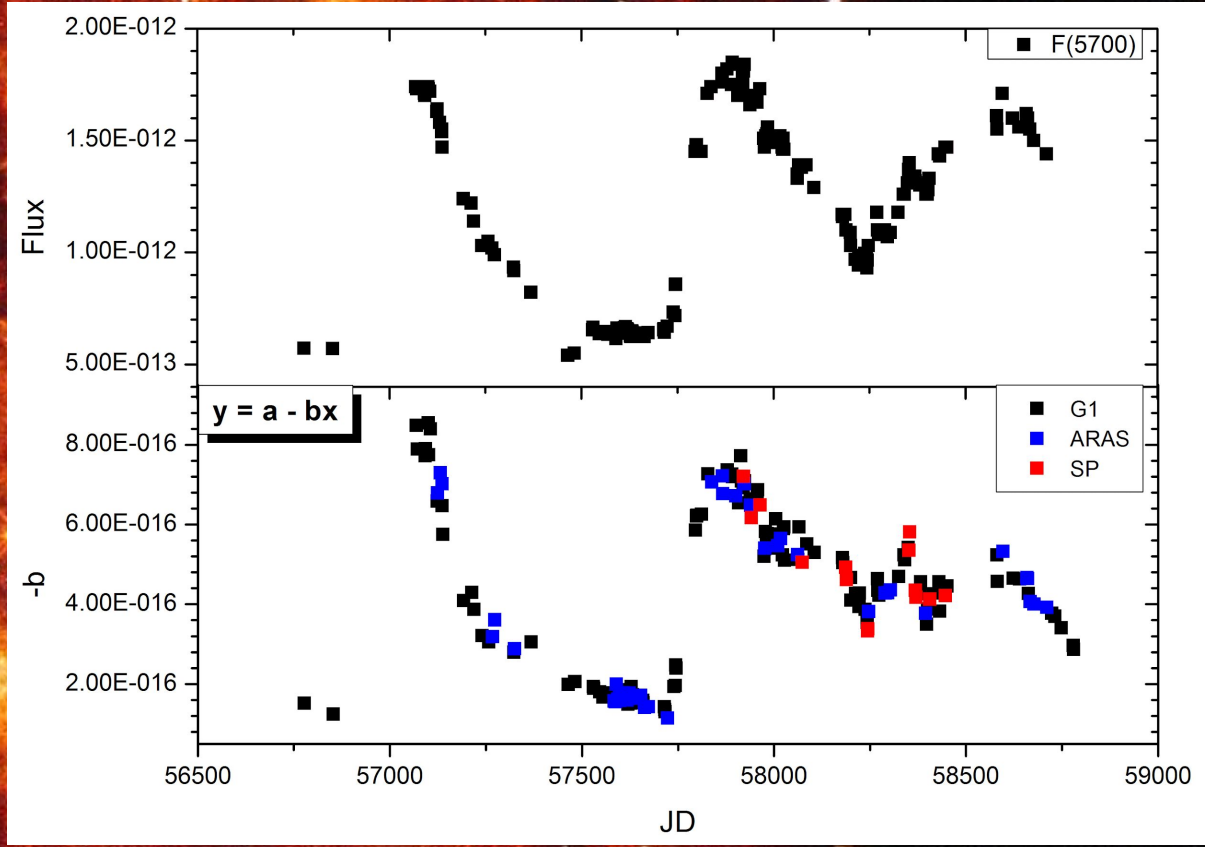


Data processing: Corrections for lines Δm

What is the reason for such changes of Δm?



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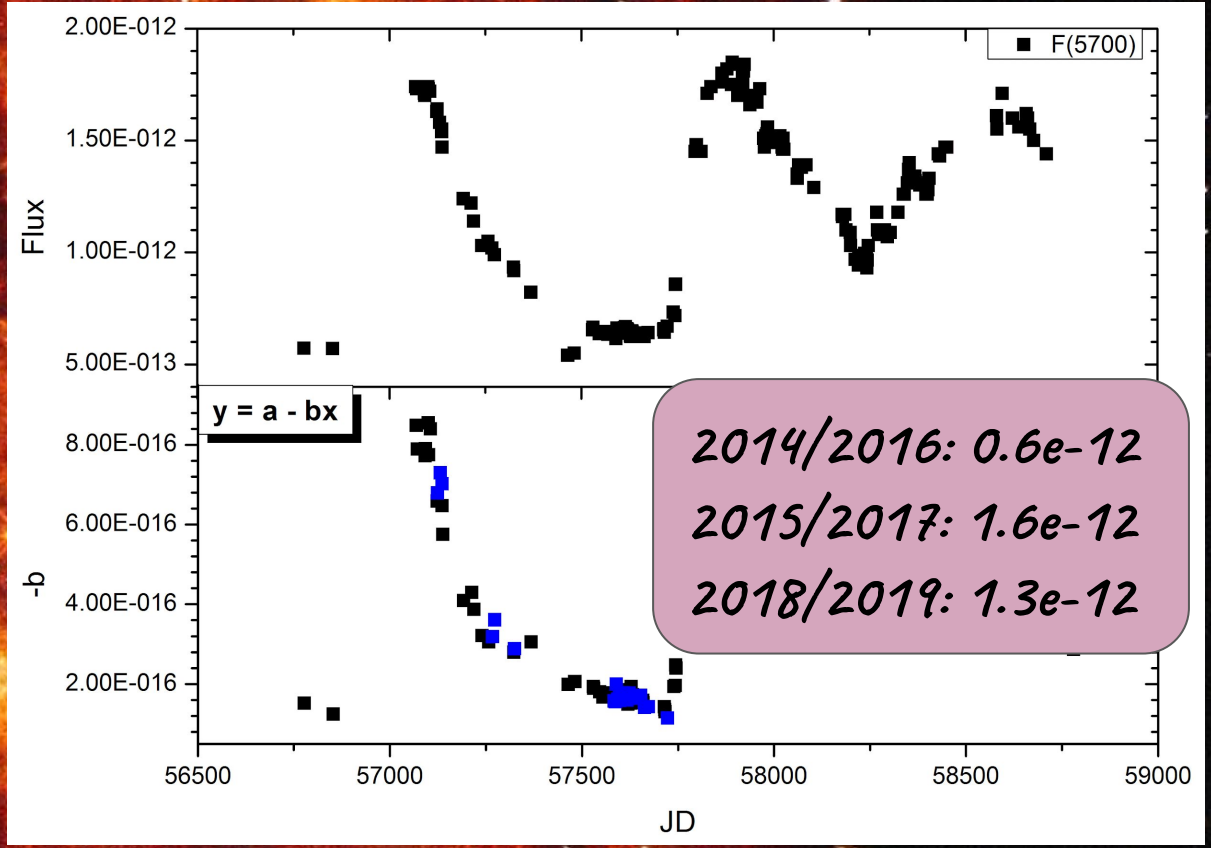

2014/2016: 0.6e-12
2015/2017: 1.6e-12
2018/2019: 1.3e-12

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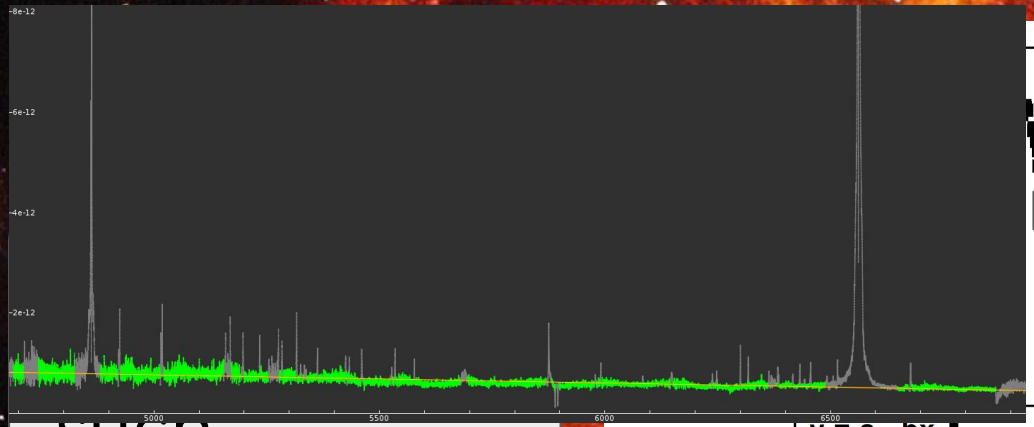

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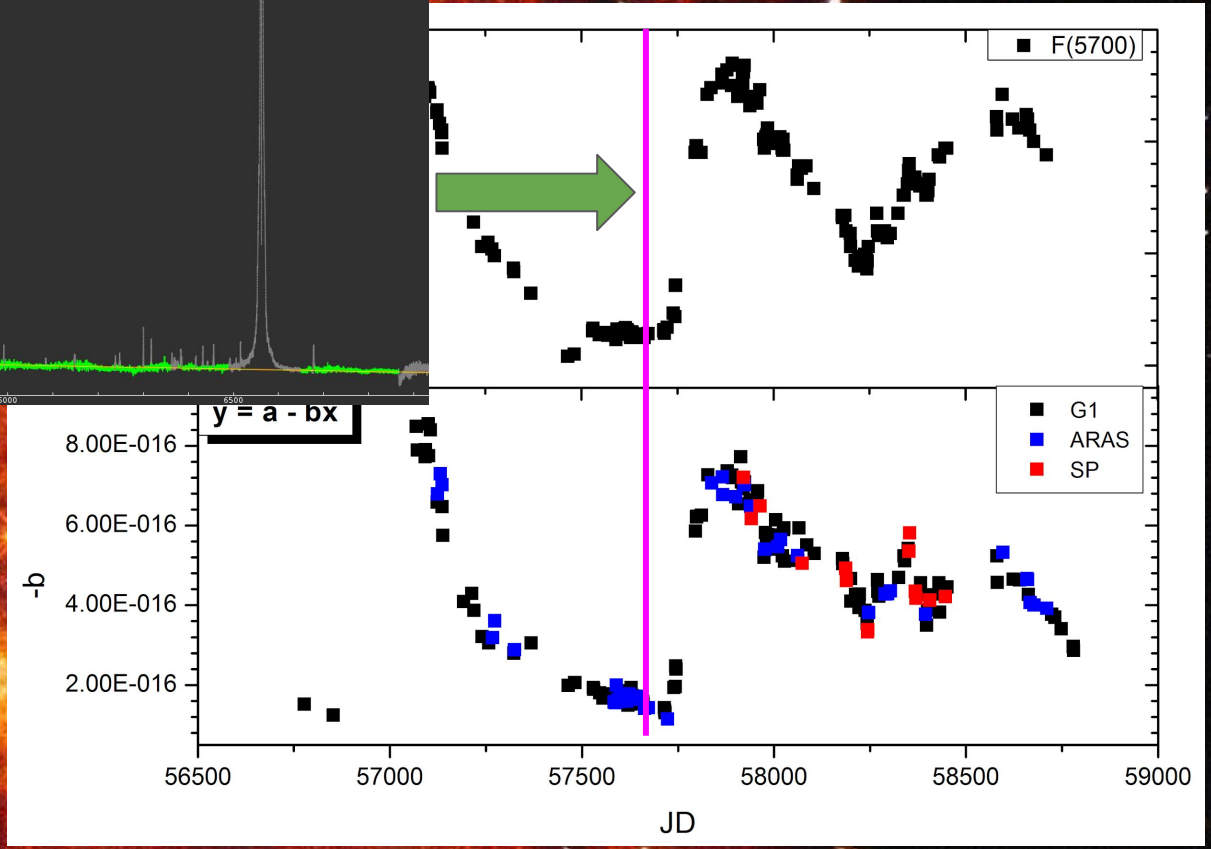

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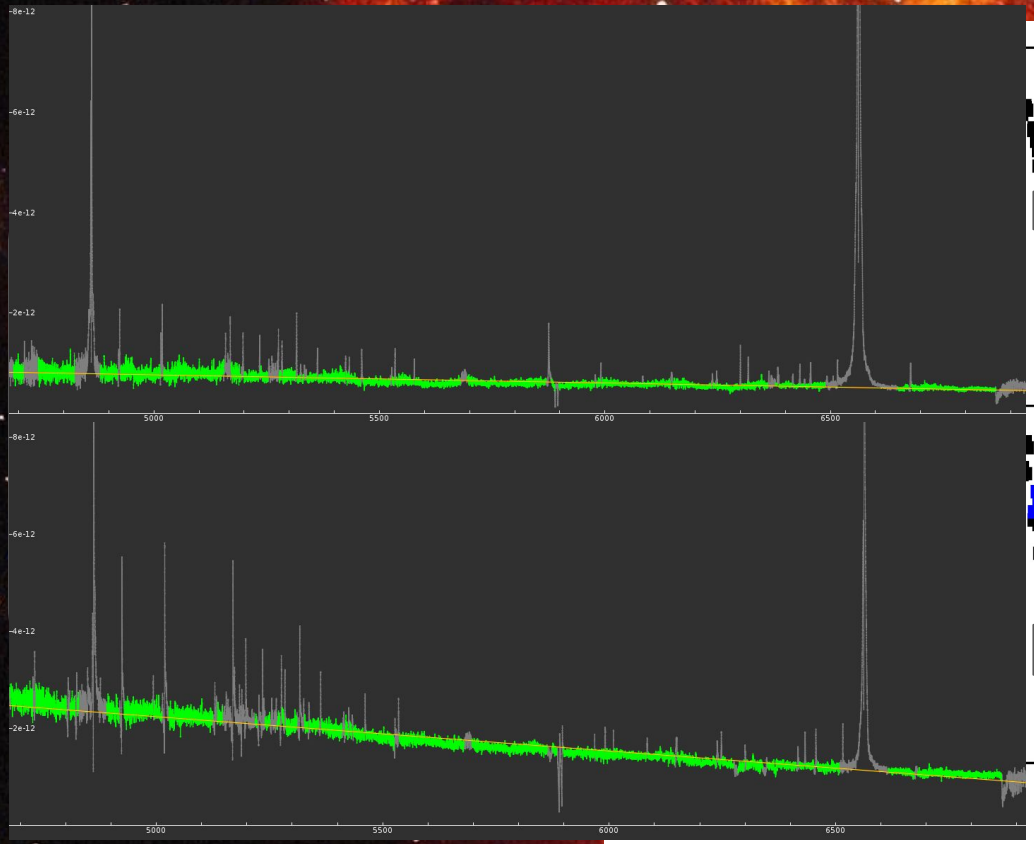

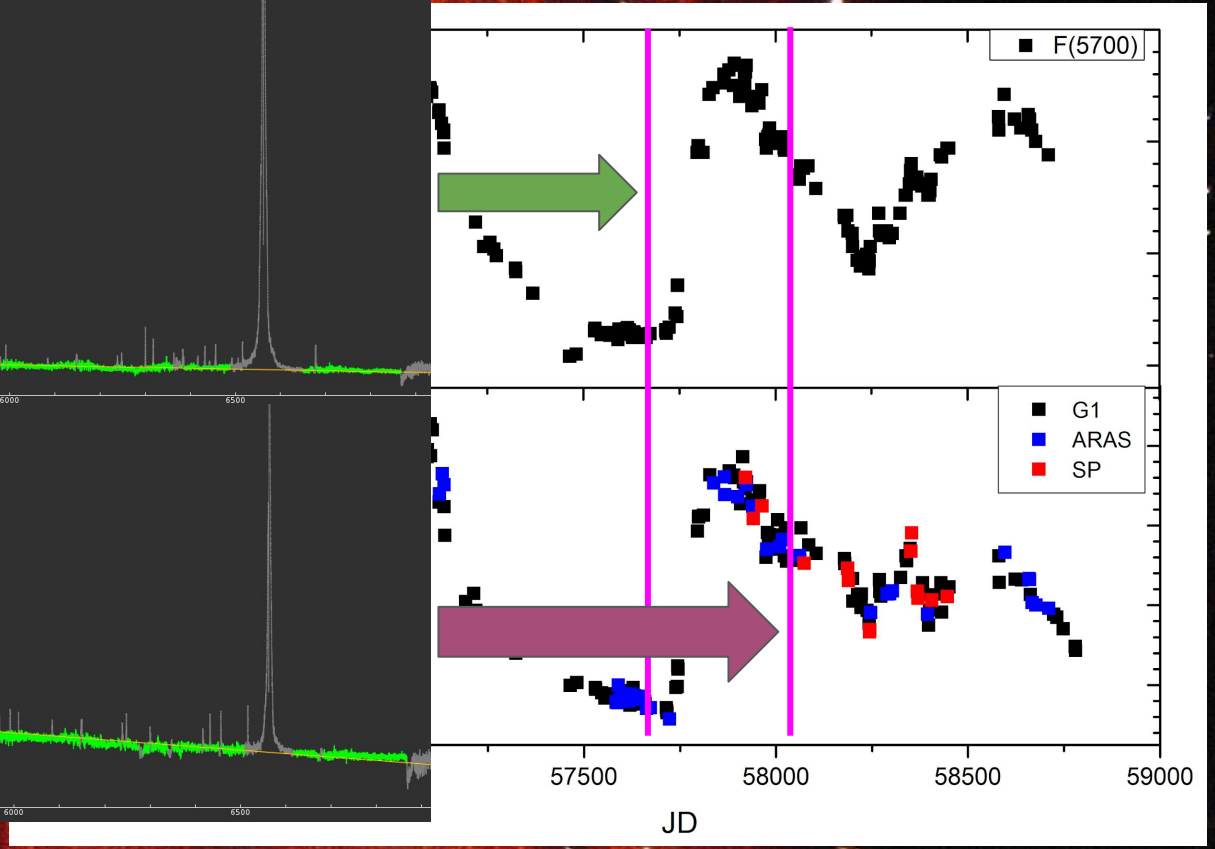

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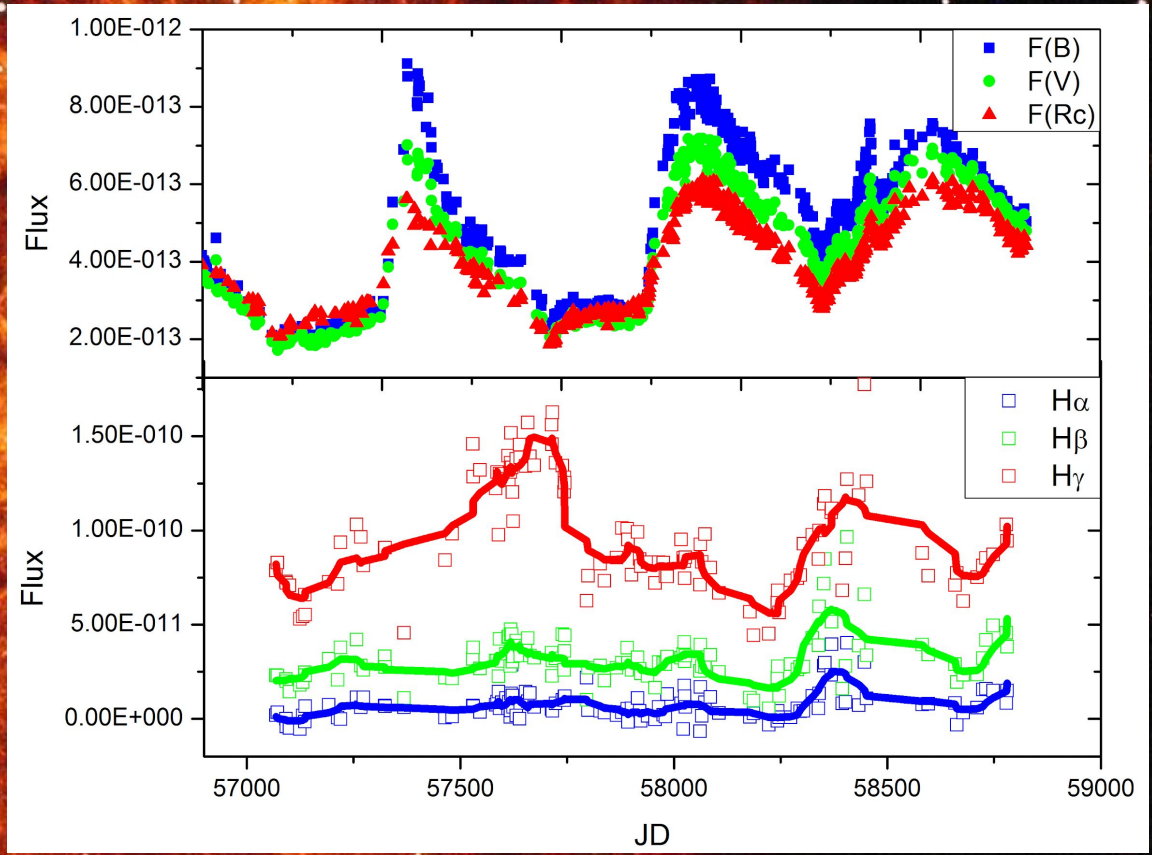

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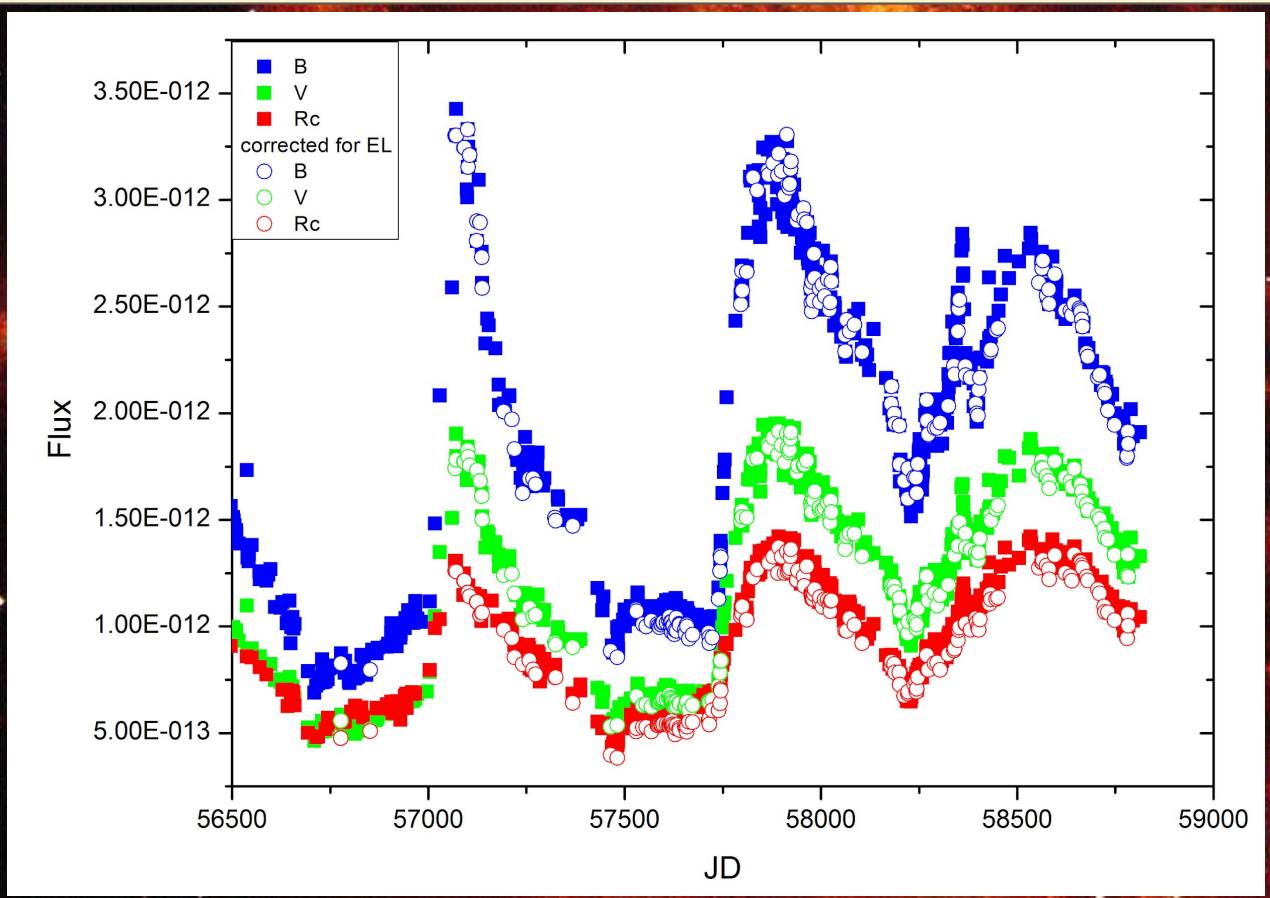

<ΔB> = -0.03
(0.01 .. -0.08)
<ΔV> = -0.03
(-0.01 .. -0.07)
<ΔRc> = -0.07
(-0.03 .. -0.19)

Conclusions:

1. We calculated ratio of fluxes with and without lines, transmitted through the given photometric filter, to obtain corrections ΔB, ΔV, ΔRc caused by emission lines.
2. The removal of emission lines makes the star's brightness fainter.
3. The significant effect in Rc passband is mainly due to a strong Hα emission and the high transmissivity of a given filter at λ6563 A.
4. Corrections are important for accurate calibration of spectra to absolute fluxes using simultaneous photometric observations.

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Thank you for your attention!