Evolution of the accretion structure in the symbiotic binary BF Cygni during its last optical outburst began in 2006

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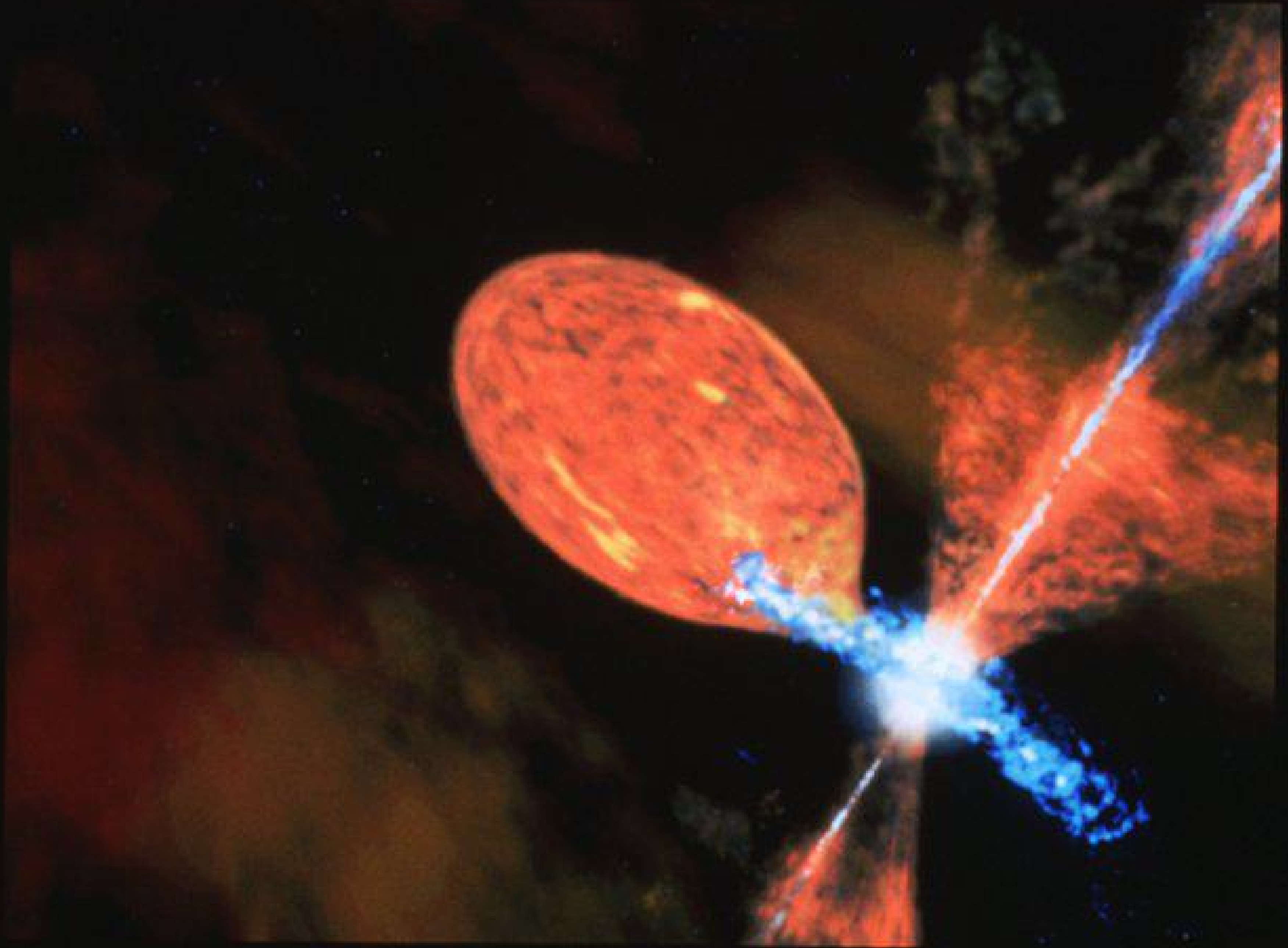


The system

Components:

- A normal M5 III giant (Murset & Schmid 1999,
  Kenyon & Fernandez-Castro 1987);
- A white dwarf with $T_{eff} \sim 10^5$ K (Skopal 2005);
- An extended surrounding nebula.

Orbital period: $P = 757.2^d$ (Fekel+ 2001)

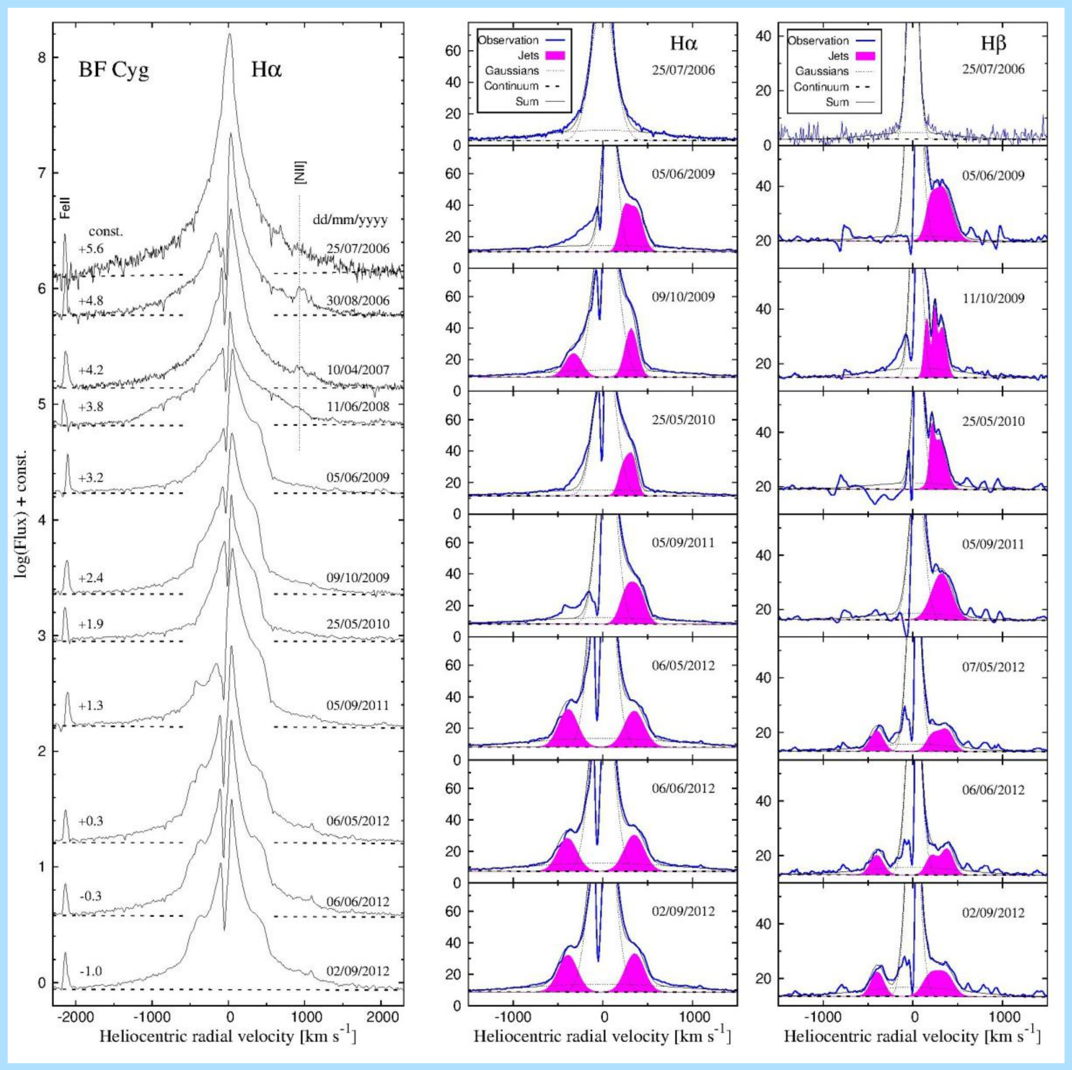
Eclipsing binary

Photometric orbital variations: in quiescent state

$\Delta U \geq 1.0^m$, $\Delta B \sim 1.0^m$, $\Delta V \sim 1.0^m$ (Skopal+ 2012)

Active phases: many active phases on different time scales.

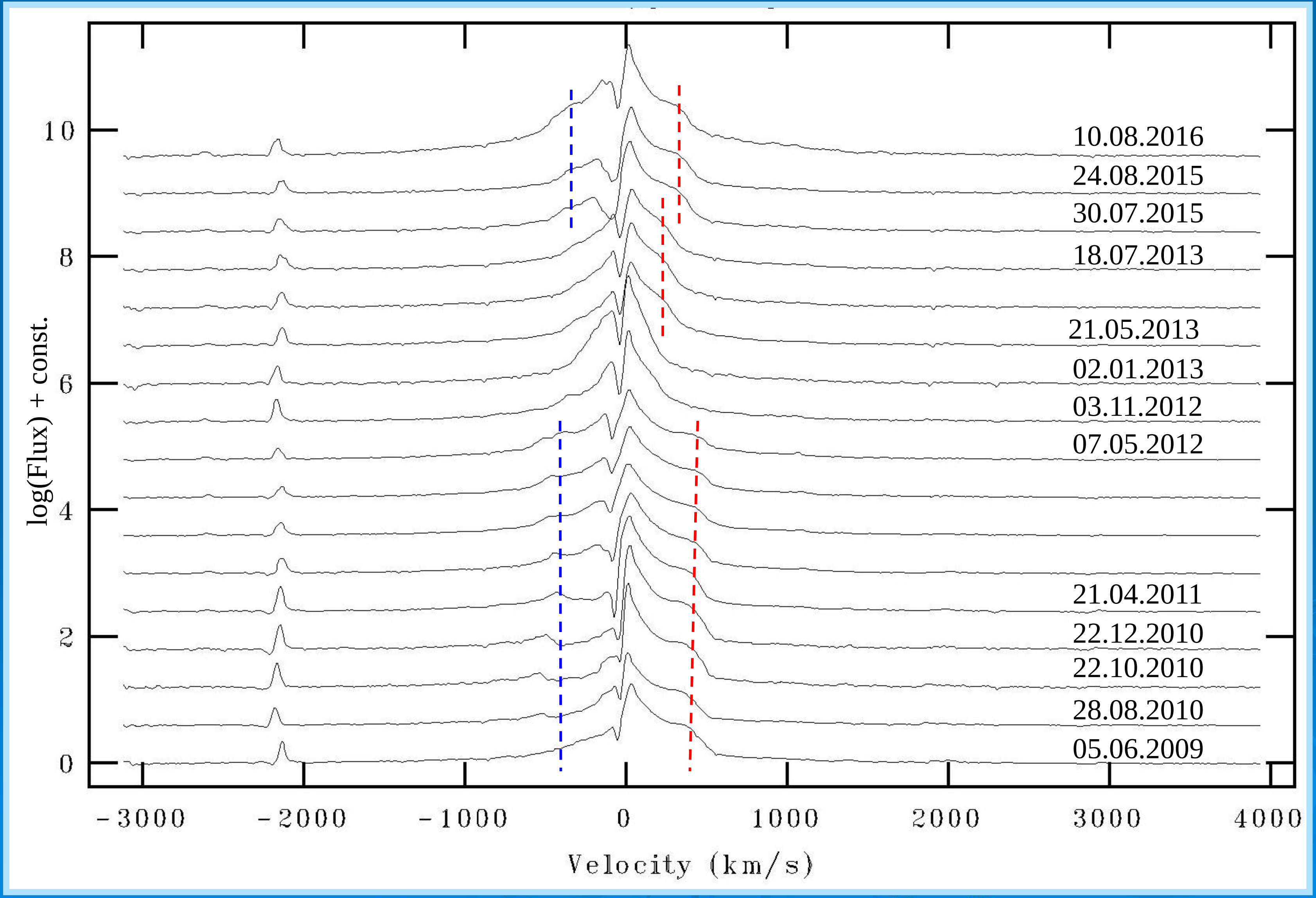
Evolution of the Hα and Hβ line profiles during the 2006 – 2015 outburst



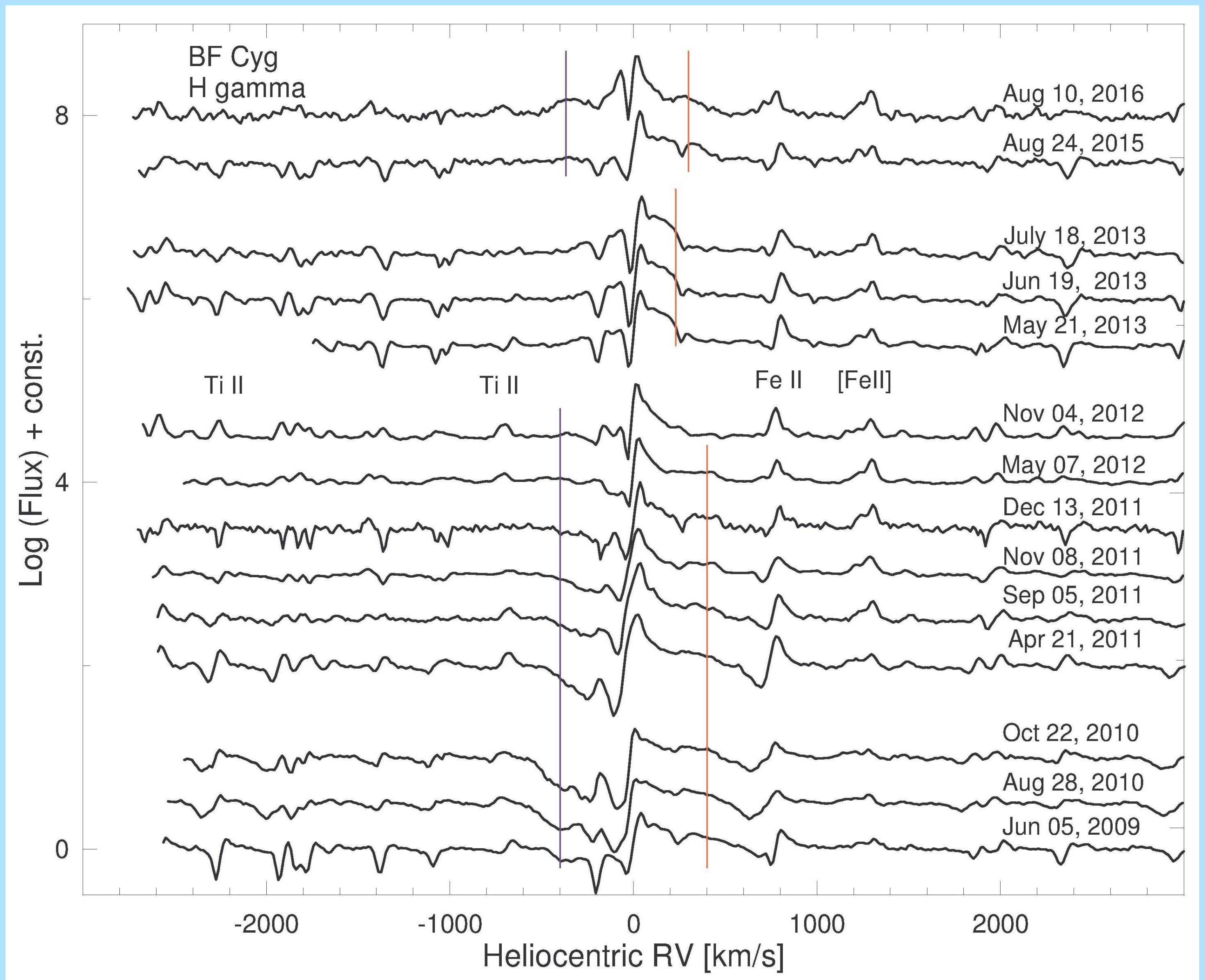
Since June 2009 satellite components indicating bipolar collimated outflow were observed.

from Skopal, Tomov& Tomova (2013)

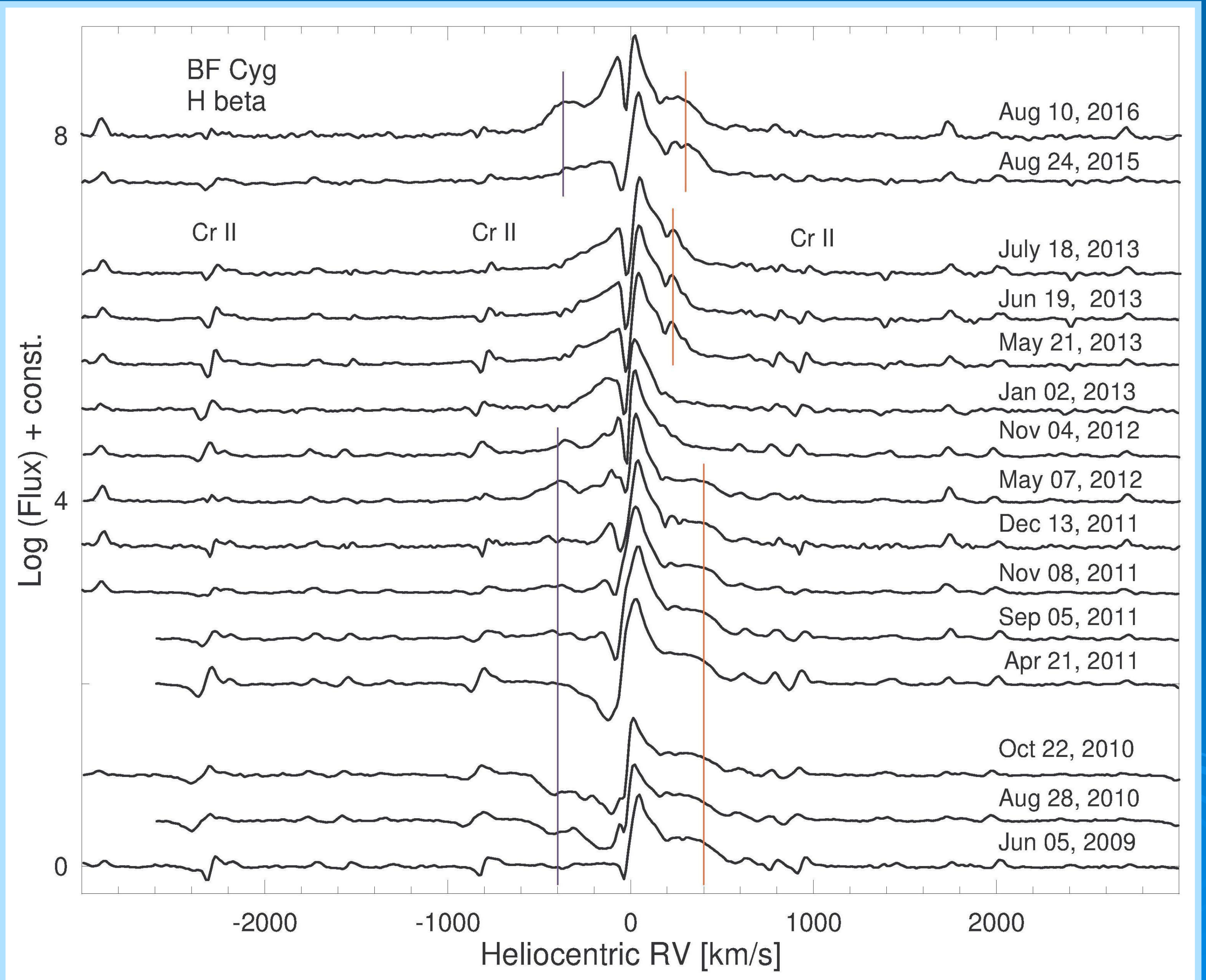
Evolution of the Hα profile



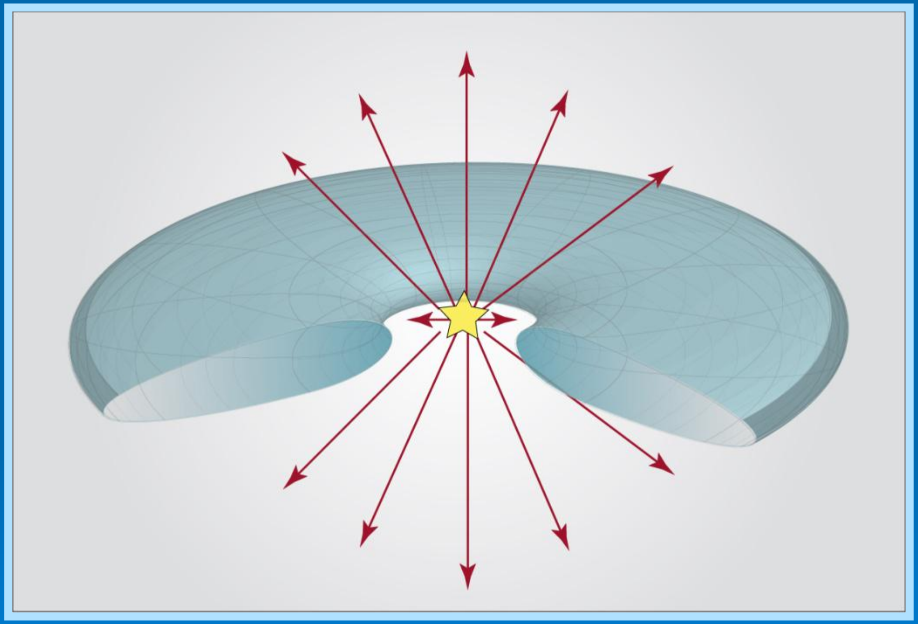
Evolution of the Hγ profile



Evolution of the Hβ profile

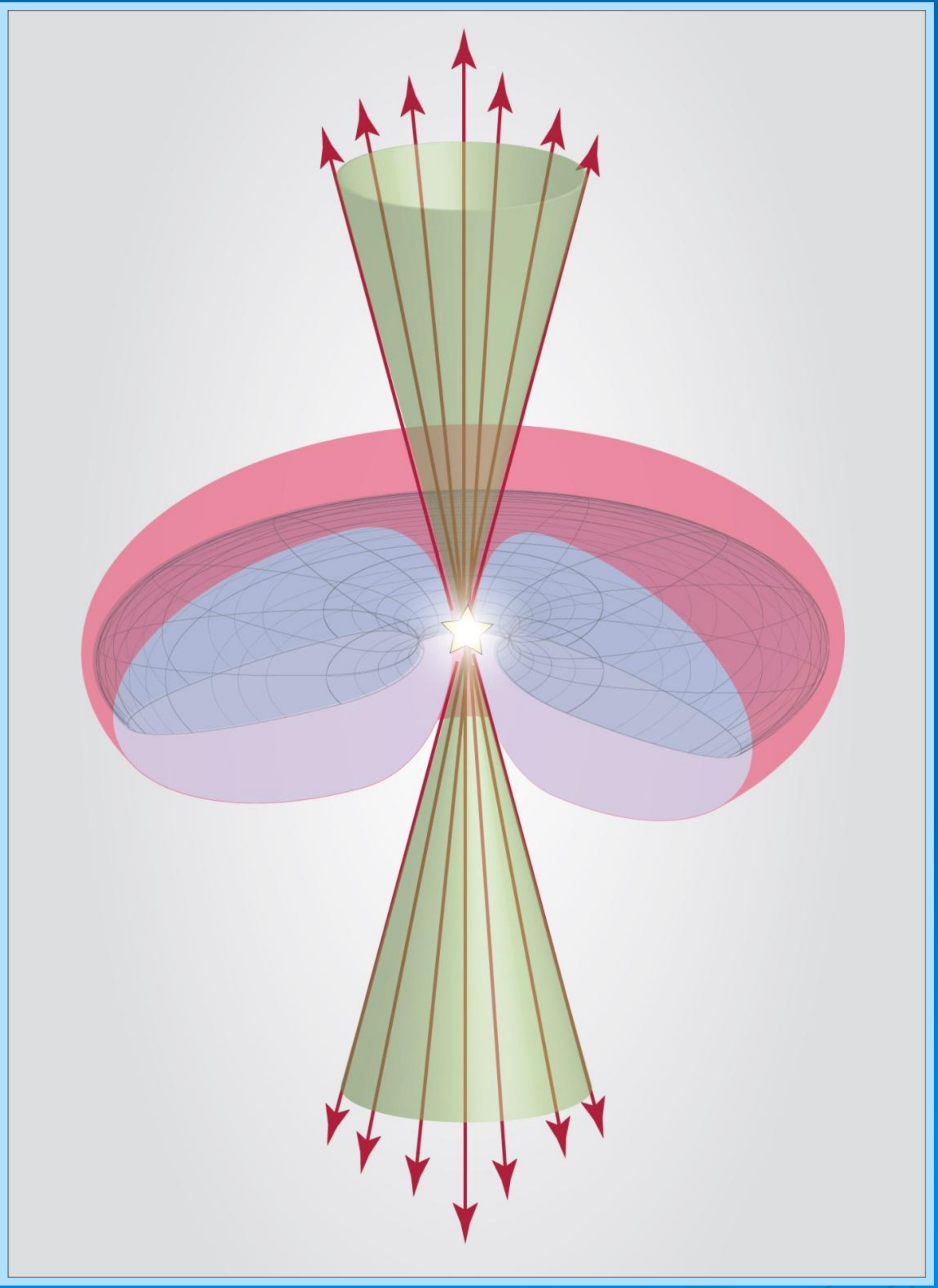


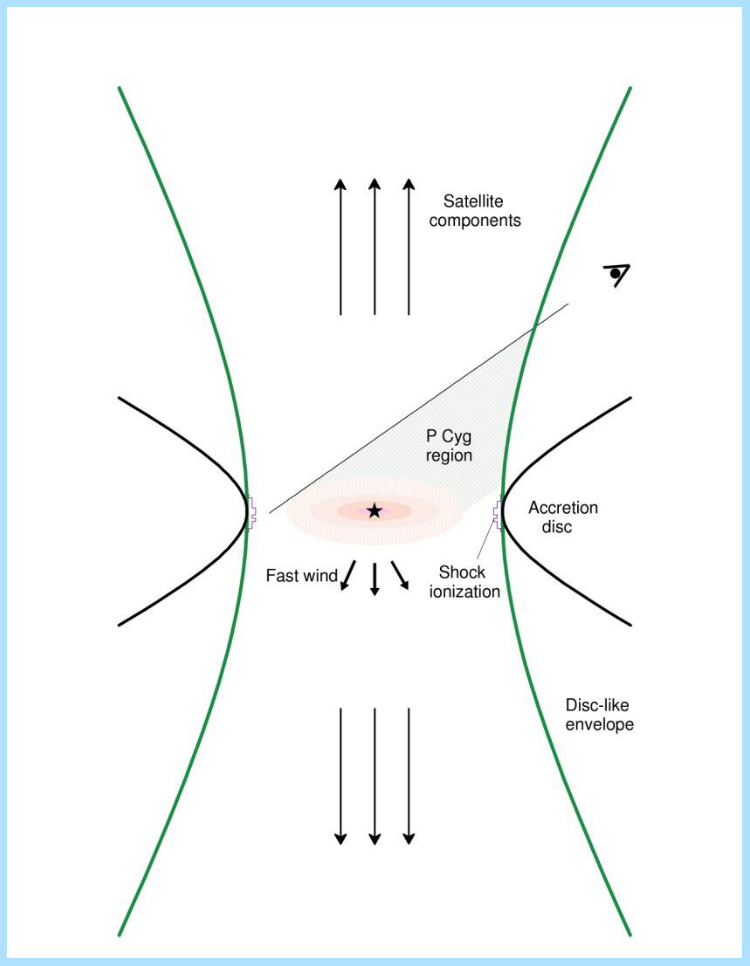
Schematic model of the region around the hot component during the first outburst



Schematic model of the region around the hot component during a recurrent strong outburst

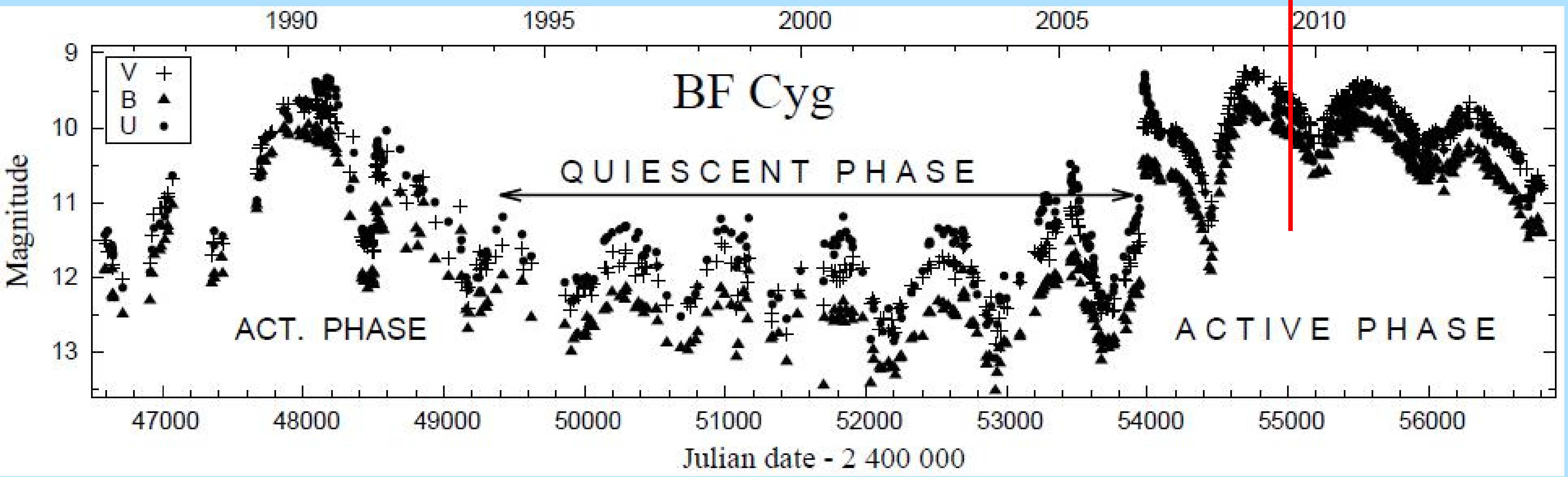
Schematic model in the plane perpendicular to the orbital plane





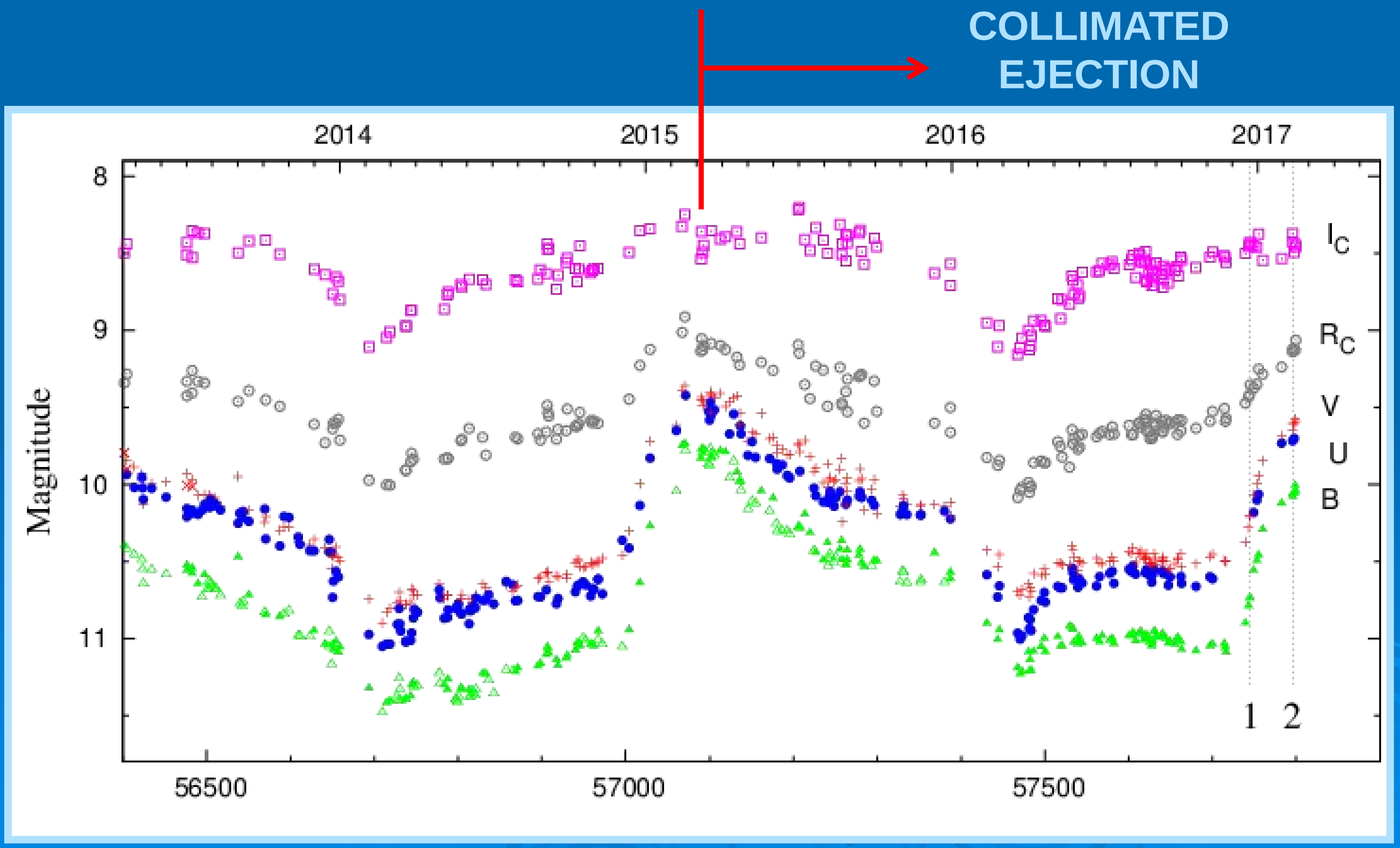
Light curves in quiescent and active phases

COLLIMATED EJECTION

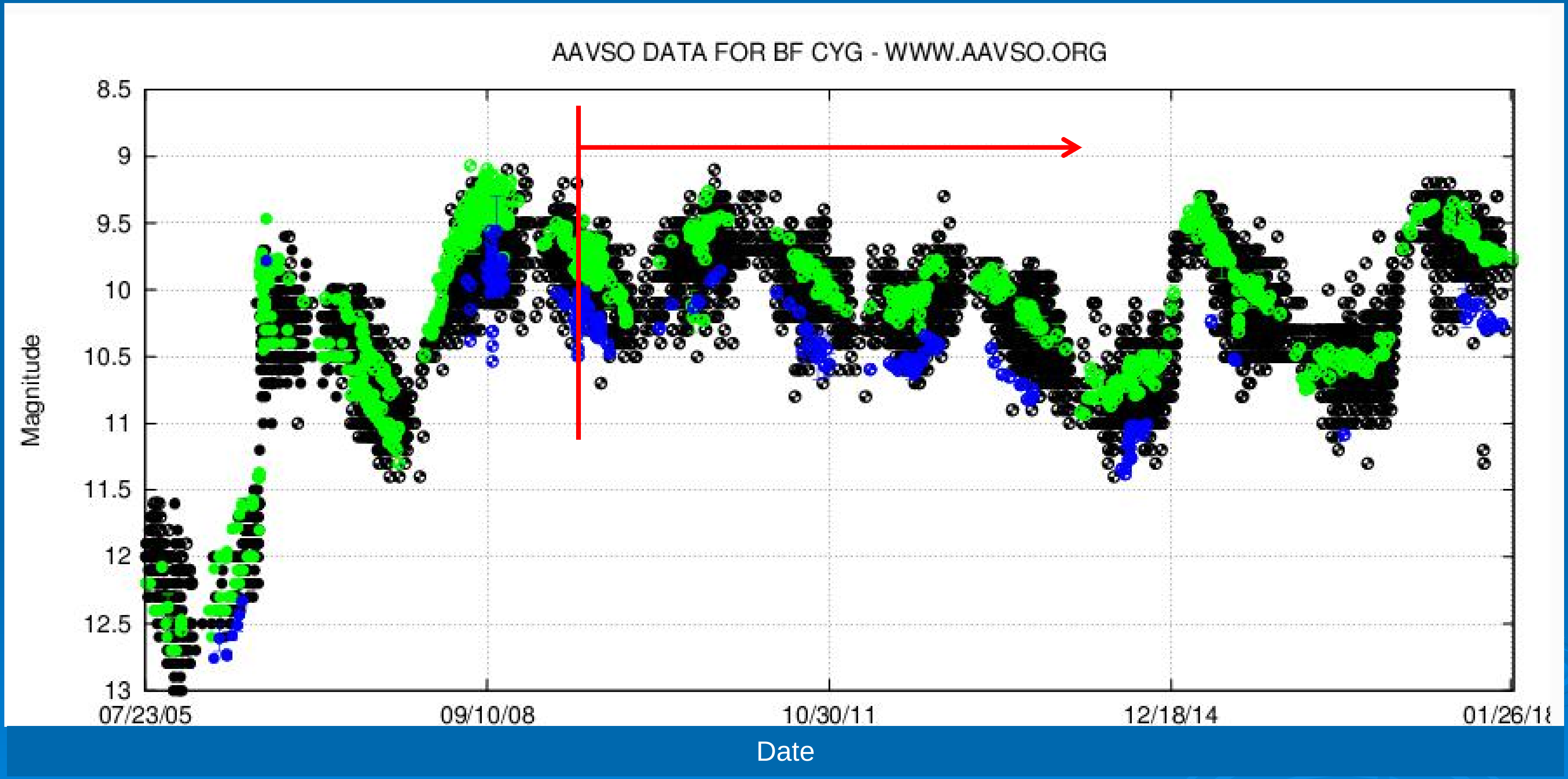


from Skopal, Sekeras, Tomov+ (2014)

Light curves during activity after 2014



from Skopal+ (2017)


AAVSO DATA FOR BF CYG - WWW.AAVSO.ORG
Magnitude
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
07/23/05
09/10/08
10/30/11
12/18/14
01/26/18
Date

Model
Interpretation of the light curves

Parameters of the system:

$$
\begin{array}{lcll}
A & = & 492\ \mathrm{R}_\odot & \text{(Fekel+ 2001)} \\
i & = & 75^\circ & \text{(Fekel+ 2001)} \\
R_g & \sim & 150\ \mathrm{R}_\odot & \text{for a distance of 3.8 kpc} \\
 & & & \text{(Skopal 2005)}
\end{array}
$$

Parameters of the disc-like envelope:

	Minimum 2 13/12/2009	Minimum 3 23/01/2012	Minimum 4 11/02/2014	Minimum 5 22/03/2016
R_{in} [$\mathrm{R}_\odot$]	25	25	...	18
R_{out} [$\mathrm{R}_\odot$]	150	150	...	$93 \div 78$
H [$\mathrm{R}_\odot$]	170	130	...	$90 \div 126$
m [$\mathrm{M}_\odot$]	3.5×10^{-7}	2.7×10^{-7}	...	0.8×10^{-7}
n_e [cm^{-3}]	7.5×10^{10}	7.5×10^{10}	...	7.5×10^{10}
n_e^2V [cm^{-3}]	2.21×10^{61}	1.70×10^{61}	(0.30×10^{61})	0.48×10^{61}

Emission of the different regions in the nebula

Table 2 $UBVR_CI_C$ continuum fluxes and emission measure of the different regions in the circumbinary nebula. The fluxes are in units of 10^{-12} erg cm^{-2} s^{-1} Å^{-1} and emission measure in 10^{61} cm^{-3}.

Min	Emitting region	F_U	F_B	F_V	F_{R_C}	F_{I_C}	n_e^2V
2[a]	Whole nebula	2.184	0.913	0.768	0.647	0.491	2.60[b]
	Disc-like envelope	1.856	0.776	0.653	0.550	0.417	2.21
	Uneclipsed part	0.928	0.388	0.327	0.275	0.208	1.10
	Residual of the depths	0.655±0.075	0.989±0.046	0.516±0.027	0.283±0.019	0.220±0.017	
	r[c]	42	−61	−37	−3	−5	
3	Whole nebula	1.680	0.702	0.591	0.498	0.377	2.00
	Disc-like envelope	1.428	0.596	0.502	0.424	0.320	1.70
	Uneclipsed part	0.714	0.298	0.251	0.212	0.160	0.85
	Residual of the depths	0.596±0.075	0.840±0.046	0.437±0.027	0.213±0.019	0.088±0.017	
	r	20	−64	−43	0	85	
4	Whole nebula	1.512	0.632	0.532	0.448	0.346	1.80
	Disc-like envelope	0.504	0.210	0.178	0.150	0.116	0.60
	Uneclipsed part	0.252	0.105	0.089	0.075	0.058	0.30
	Residual of the depths	0.110±0.075	0.221±0.046	0.189±0.027	0.082±0.019	0.055±0.017	
	r	129	−52	−53	−8	5	
5	Whole nebula	2.268	0.948	0.798	0.672	0.509	2.70
	Disc-like envelope	0.404	0.168	0.142	0.120	0.092	0.48
	Uneclipsed part	0.202	0.084	0.071	0.060	0.046	0.24
	Residual of the depths	0.110±0.075	0.374±0.046	0.189±0.027	0.046±0.019	0.039±0.017	
	r	84	−78	−62	30	18	

[a] The data for this minimum are from the work of Tomov et al. (2015) and are included in the Table for comparison.

[b] The data are for 2008 October 23 in the work of Skopal et al. (2015).

[c] $r = (\mathrm{U} - \mathrm{R})/\mathrm{R}$ in per cent; U – Uneclipsed part, R – Residual of the depths.

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Thank you
for your attention!