A look into the behaviour of BF Cygni after 2009

M. Tomova

Institute of Astronomy and NAO, Bulgarian Academy of Sciences

Introduction

BF Cyg is an eclipsing binary with an orbital period of 757.2 days (Fekel et al. 2001), whose eclipses (orbital minima) are observed well in both quiescence and outbursts (Skopal et al. 2015). The last active phase of BF Cygni began in 2006 and continues up to now. During this period its light is modulated by the orbital motion and shows photometric minima with a variable depth and shape (see Fig. 1). The residual of the depth of the first five minima is examined in a number of articles of Tomov, Tomova & Bisikalo (2015, 2017, 2018, 2019) and is interpreted in the framework of the model of the collimated stellar wind for Z And (Tomov et al. 2014). In 2009 a collimated bipolar ejection of material from the system was observed for the first time (Skopal, Tomov & Tomova 2013). The profile of the Balmer lines transformed – satellite emission components, located approximately symmetrically to the central emission, appeared. From that moment on, these satellite components are present in the spectrum, sometimes both emission components are present, and at other times only the red one. This can be seen in Fig. 2, where our observations up to and including 2016 are presented. In 2015 and 2017 during the development of a new activity were observed 1-mag bursts with gradual fading to the pre-outburst level lasting for about 1 year (Shchurova et al. 2019). Skopal et al. (2017) noted that around mid-February 2017 BF Cyg is around its peak brightness of the burst and the line spectrum was dominated by hydrogen lines with a sharp absorption at ~ −70 km/s, and before the maximum the Balmer lines were accompanied by satellite emissions at ~ − 400 and +200 km/s.

We observed the system with a high resolution at the end of 2016, during the burst in 2017 and in September 2018 after the orbital minimum as well. Aim of our investigation is to analyse the profiles of some visual lines in the spectrum, to trace their evolution and to consider the changes of the mechanism of loss of mass of the outbursting compact object. One additional task is to estimate its mass-loss rate using the energy fluxes of some emission components of the spectral lines during the period of our observation. Here we introduce preliminary results of our investigation.

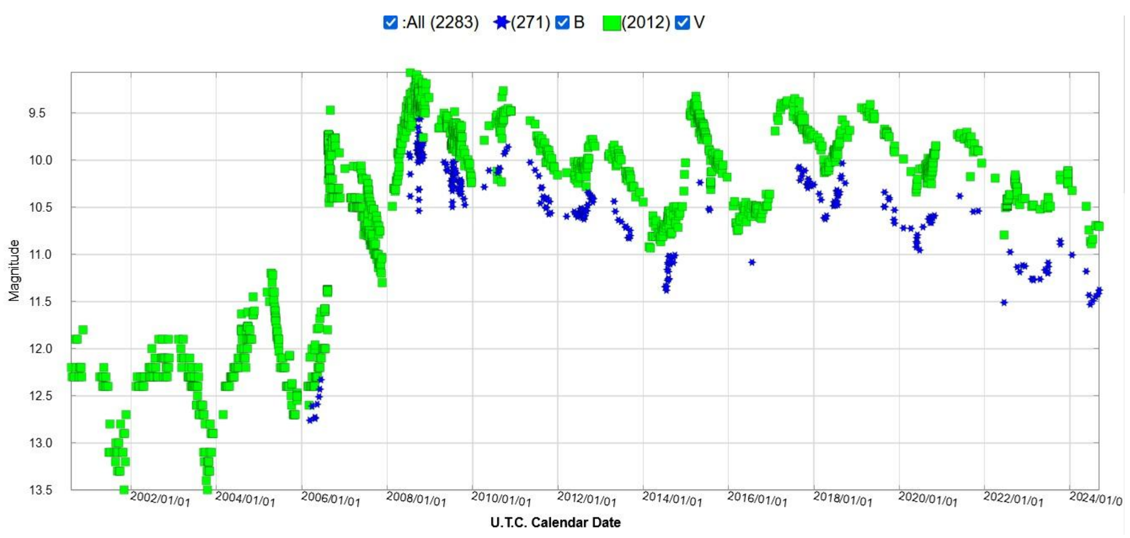

Fig. 1 The LC of BF Cyg from AAVSO

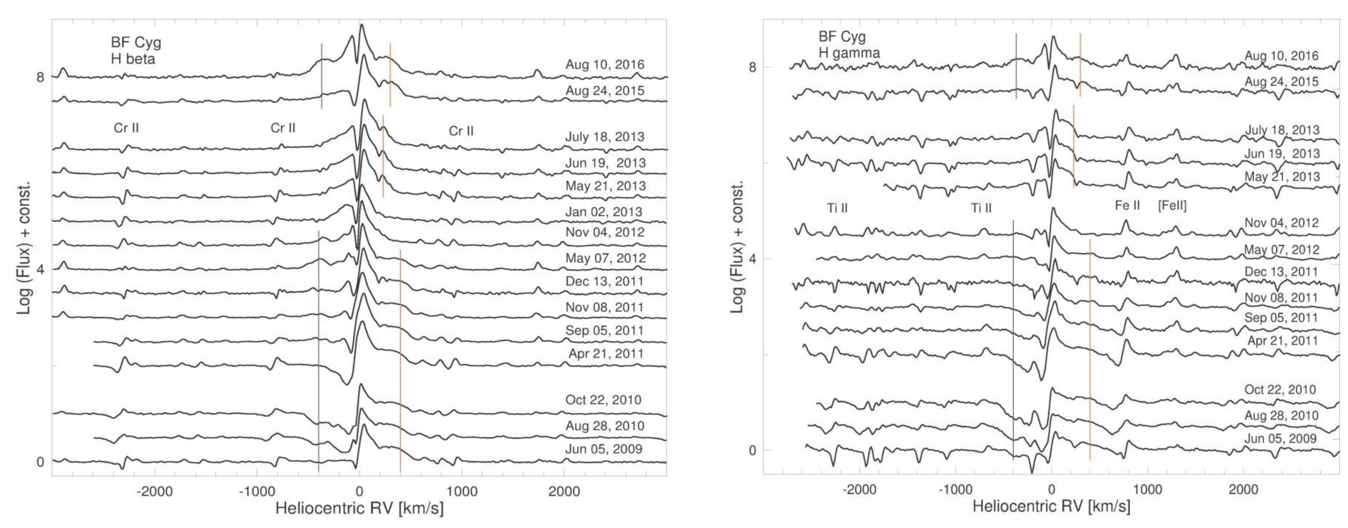

Fig. 2 The spectral evolution of Hβ and Hγ, June 2009 – August 2016

Observations

The system BF Cyg was observed with the ESpeRo Echelle spectrograph (Bonev et al. 2017BlgAJ, 26, 67) of the 2-m RCC telescope of the National Astronomical Observatory Rozhen, Bulgaria. The spectral resolution was ~30000. The spectra were reduced by means of IRAF (Tody 1993). In our study we considered only the lines in the ranges of Hβ, HeI 4922, HeI 5016, FeII 5169.

Spectral behaviour

1. The Hβ line

Our spectra from Dec. 11, 2016 and Sept. 02, 2018 showed a Hβ line consisting from two-peaks central emission component and a narrow absorption with RV = −10−15 km/s (see Fig. 3). Clearly visible emission components were present on both sides of the central component of the 2016 spectrum. These emission components were not visible in the 2017 spectra, which showed a rather broad emission component, diminished by broad blue absorption, in some cases up to about -500 km/s. It reached up to about −370 km/s in 2018. The presence of such components in the profile indicate a mass outflow from the outbursting compact object. We approximated the profile of the Hβ line with different number of Gauss functions. At first the central component was approximated and its contribution was subtracted from the emission in the area of the satellite components, in order to determine their parameters more precisely. Each satellite component of the Dec. 2016 profile was approximated with one Gaussian (see Fig. 3). We applied the same approach to the 2017 spectra but we were unable to find confident presence of the red satellite emission there. CrII and TiII lines are present over the red wing of the Hβ line, show strong P Cyg profile in this period and influence the red wing intensity. A red emission and a blue absorption satellite components have been fitted on the spectrum of Sept. 2, 2018, but these fits have large error and are not reliable. Therefore we can not conclude that the satellite components are present in the Hβ line in 2017, but rather a broad emission component of wind, whose blue part is diminished by P Cyg absorption.

2. The FeII 42 lines

The Hβ and FeII42 lines show the same characteristics − a narrow P Cyg absorption, broad red emission and broad blue absorption, but different velocities − lower for the lines of FeII42. This shows that the loss of mass which is observed in Hβ, is observed also in FeII42 lines.

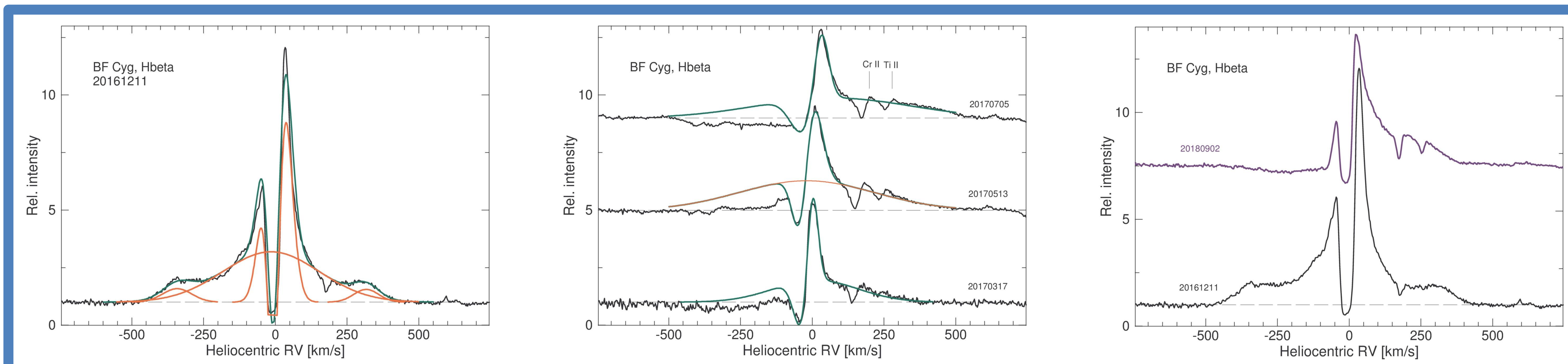

Fig. 3 *Left and middle:* Approximation of Hβ line. Observed spectra are in black. Gaussians of components are in orange. Resulting curves approximating the observed spectra are in green. The satellite components are seen on the left panel. *Right:* Comparison of the profiles before and after the burst.

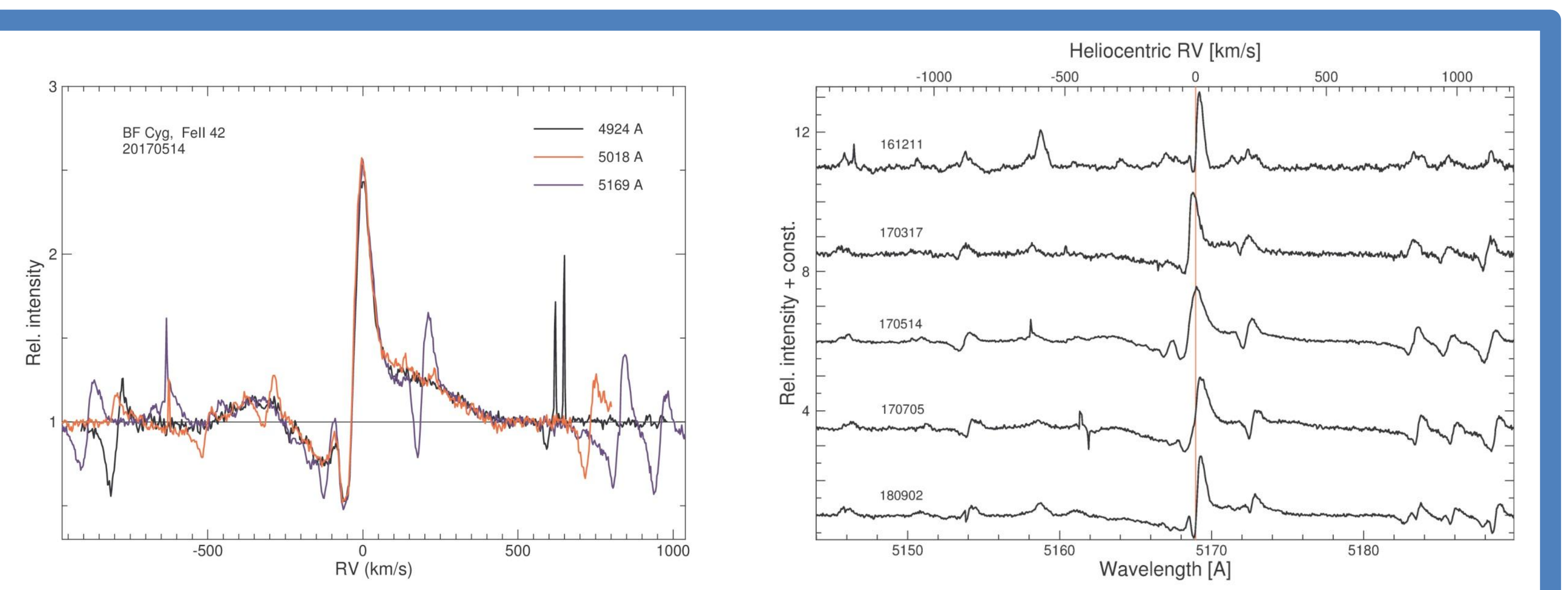

Fig. 4 *Left:* Example of FeII42 line profiles. A broad red emission and a broad blue absorption components are visible. The narrow P Cyg absorption is also present. *Right:* Evolution of the FeII42 5169 A line in our spectra during Dec. 2016 – Sept. 2018.

Conclusion

We present preliminary results from our study of the Hβ and FeII line profiles during the burst in 2017. These lines contained clearly visible components indicating mass-outflow from the system. Based on approximation of the Hβ line profile we can not conclude that the satellite components are present in the 2017 observations, but rather a broad emission component of wind, whose blue part is diminished by P Cyg absorption.

Acknowledgements

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