<u>VV Cep up-to-date</u> (2019-02-22)

The hitherto unabated continued high observation density even before the actual eclipsing event, but also the spectral resolution of the used spectrographs, allows an analysis of the red and the blue components of the Hα emission.

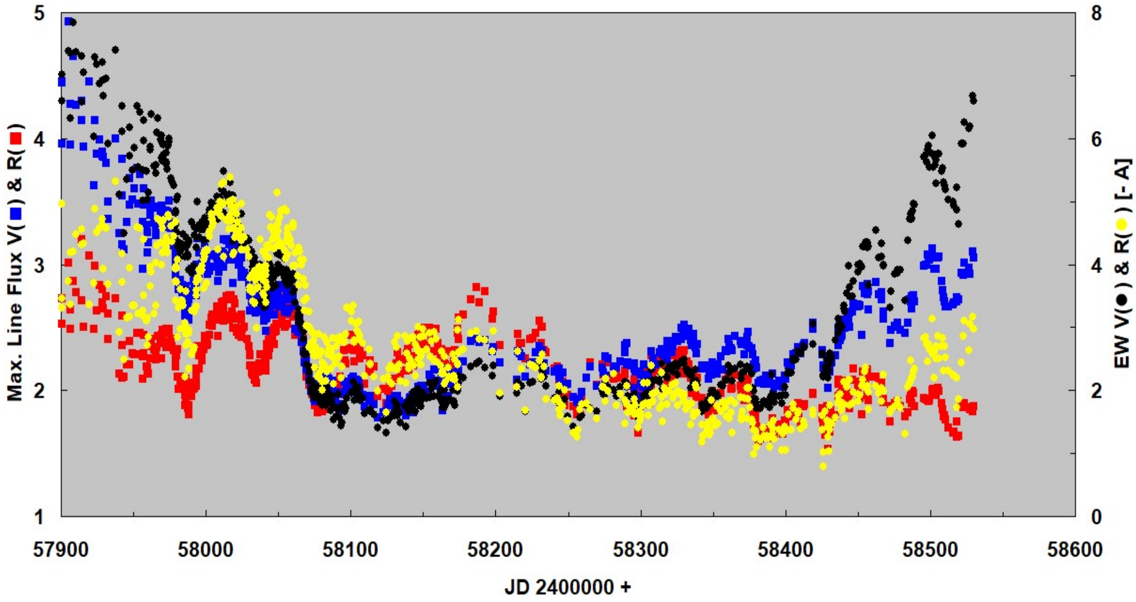

Fig. 1: Hα EW & Flux Monitoring of both emission components

Fig. 1 shows for both emission components during the entire eclipsing process the relative line flux on the left ordinate, and the EW on the right ordinate. The plot shows that even in the phase of total eclipse, where the direct view of the accretion disk is prevented, the quasi-periodic variations of both parameters can still be seen.

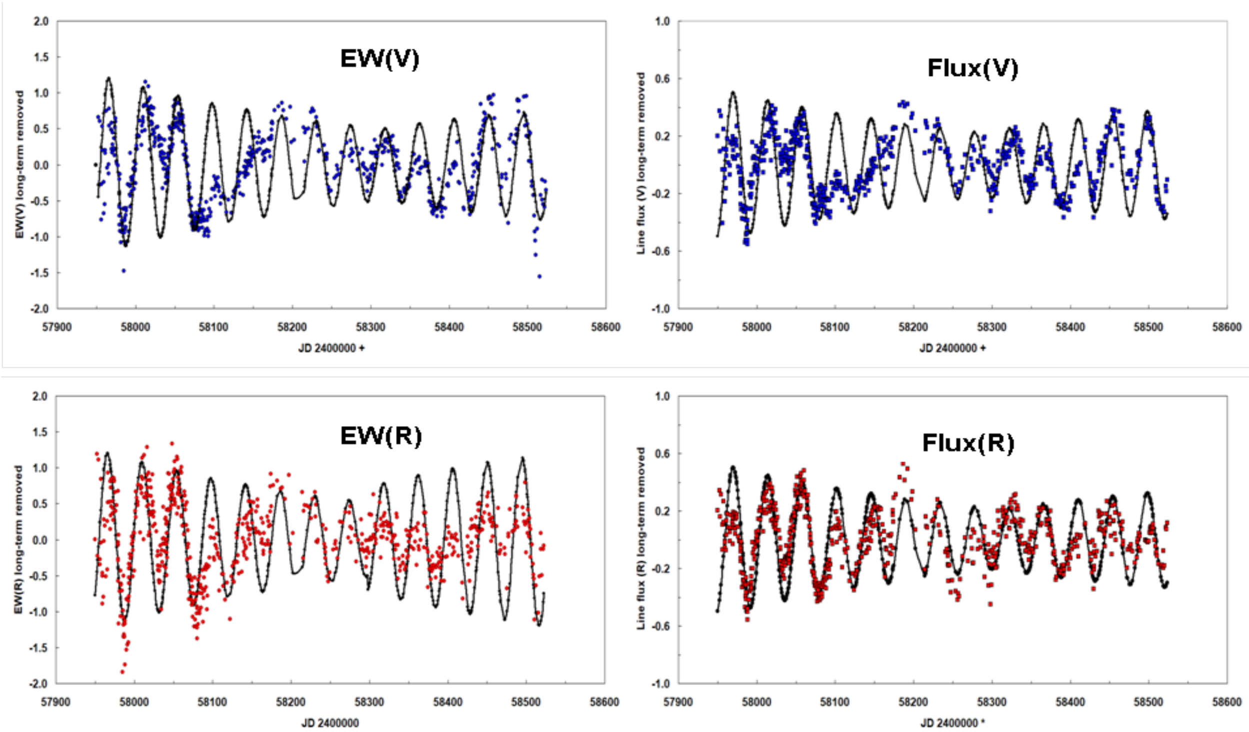

Fig. 2: Period Analysis of the Hα EW & Flux Monitoring of both emission components. 44d period of V & R emission. Amplitude decreases until mid eclipse / increases afterwards

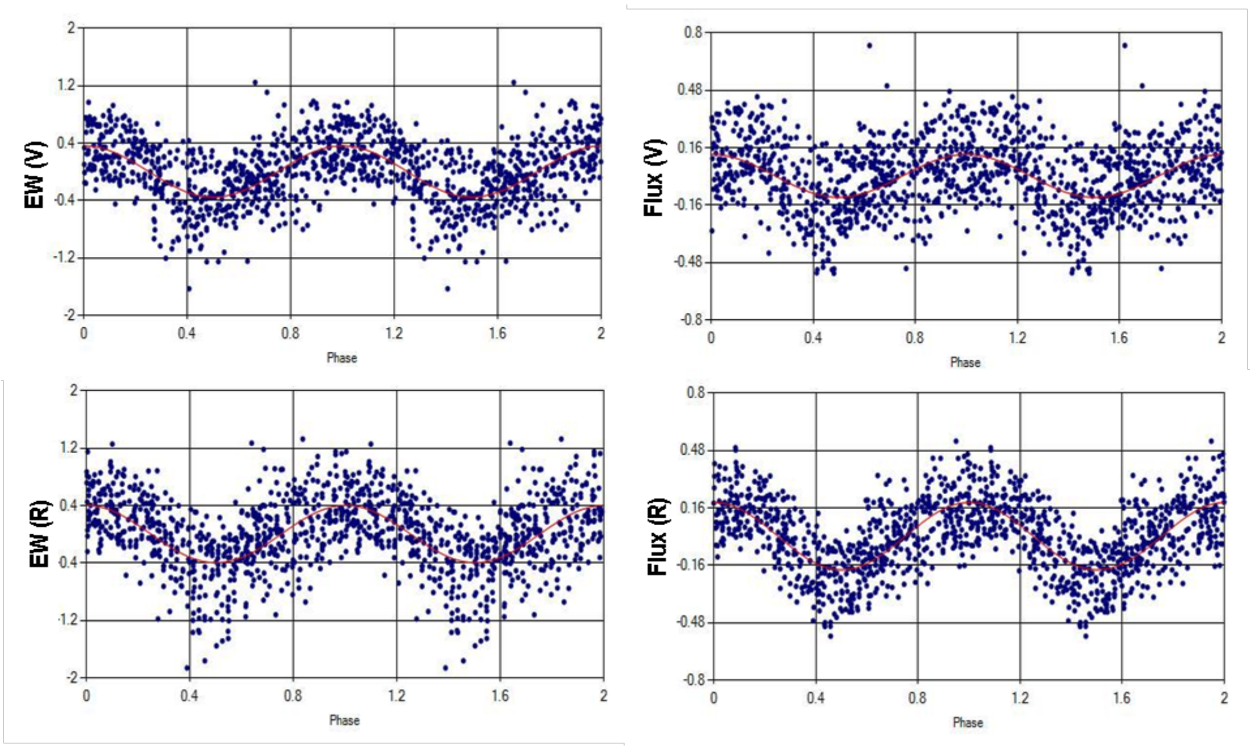

Fig. 3: Phase diagrams of the Hα EW & Flux Monitoring of both emission components shows in all parameters the 43-44 day period

The period analysis of the EW & the line flux in Fig. 2 of both components as well as the phase diagrams in Fig. 3 results for more than 800 spectra to a significant period of 43-44 days.

The slow decay of Hα emission at the onset of the eclipse in Fig. 1as well as the fact that Hα emission persists during total eclipse implies that both emissions must come from an extended area beyond the accretion disk.

The significantly narrower profile shape of the Hα emission during total eclipse (see small inserted Figure bottom left in Fig. 4) implies a lower velocity source far from the accretion disc, confirming that not all the Hα emissions comes from the accretion disc.

The model that emerges from these considerations is that of two "emission lobes" rising above and below the orbital plane, with a narrow "waist" of emission in the orbital plane surrounding the immediate vicinity of the hot star and its associated accretion disk / region limited.

These two emission beams, which propagate above and below the orbital plane, must be regions of ionized hydrogen (HII regions), maintained by photo ionization of the far-ultraviolet (FUV) radiation emitted by the hot B-star, as well as by the equal hot accretion disk which surrounds the star.

This ionizing FUV radiation is directed in two "spotlight-like" beams into the circum stellar gas above and below the orbital plane, and adsorbs denser gas in the orbital plane.

The fact that the V and R curves differ significantly in time response (see Fig. 1) means that the emission areas responsible for the V & R emission comes from physically different regions.

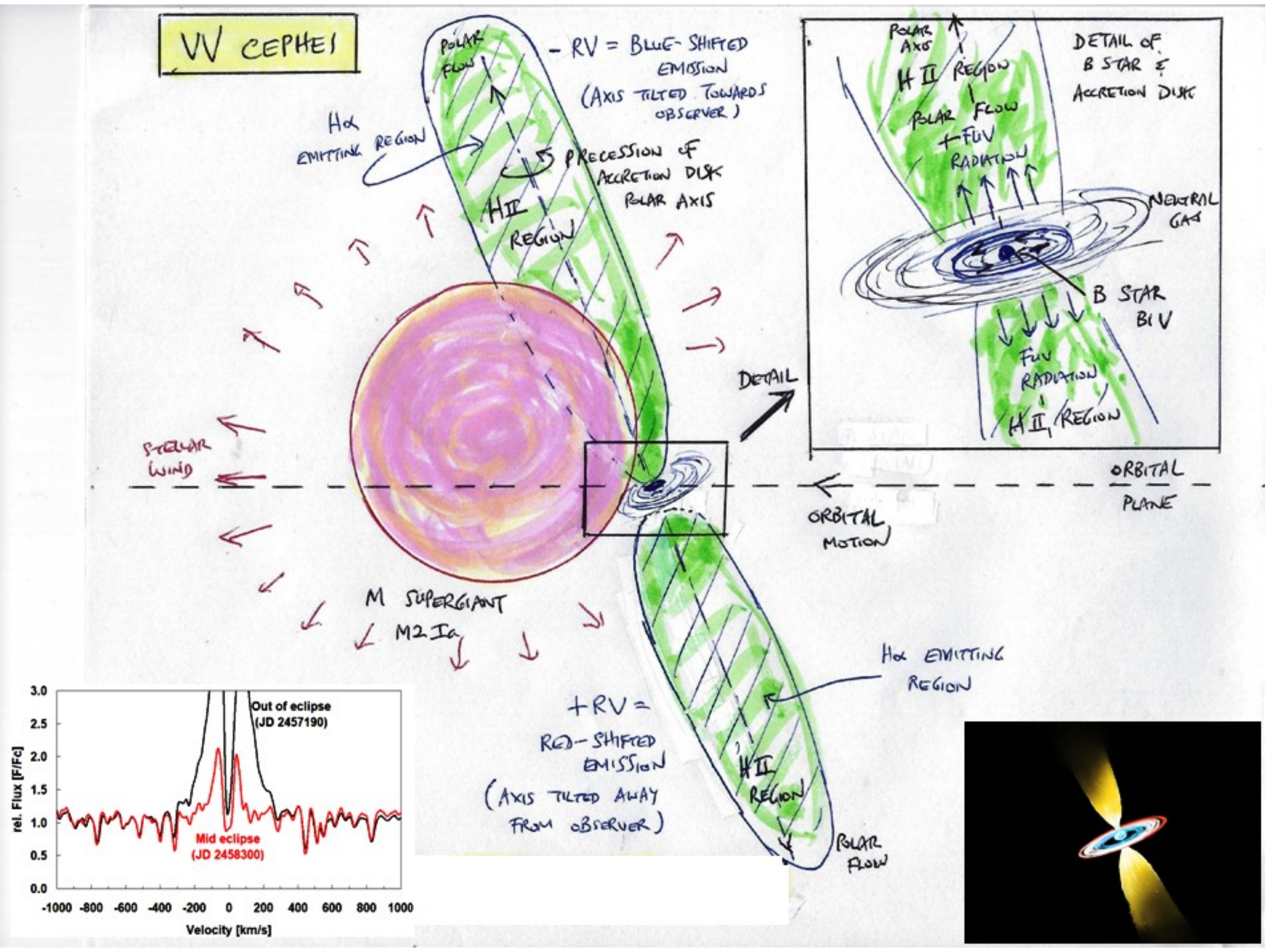

Fig. 4: Updated model (drawn by Phil Bennett) deduced from the current state of observation data and theoretical considerations from professional data in the past.

In this model, the V-emission comes from the lobe, which is slightly inclined to the direction of the observer line. The R emission comes from the other lobe, which is slightly removed from us.

In addition, the V-lobe must be tilted slightly closer to the M star at the start of the eclipse, whereas the R-lobe must be slightly more distant to account for the asymmetric nature of the V & R curves in Fig. 1.

If we assume that the rotation axis of the accretion disk precedes periodically, then varying surface portions of the upper emission lobe (V) and lower emission lobe (R) would produce the observed variability of EW and line flux in the observer line of sight.

If this model were correct, the precession of the disk rotation axis with a 44-day period that continues into both emission lobes, would be the same for both sources. However, this would mean that the EW and line flux amplitudes of both sources would necessarily be larger before the eclipse than during the eclipse. That this is the case is shown by the period analyzes in Fig 2.

A precessing disc rotation axis with a period of 44 days, however, would inevitably led to a simultaneous but counter-rotating variation of radial velocity and line flux of the emission components.

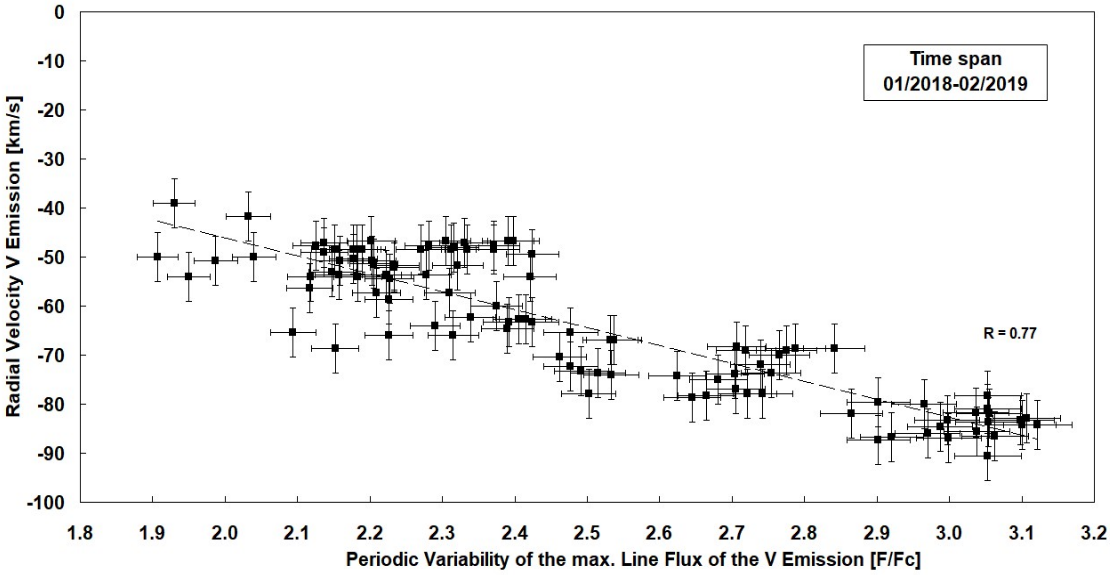

Fig. 5: Relationship of radial velocity to rel. line flux of the V emission component

This is exactly what we observe since the beginning of the eclipse. Fig. 5 shows the result of measurements at the V-emission component from more than 100 spectra from January 2018 to February 2019: with increasing (positive) radial velocity of the emission axis, it tilts away from the observer with contemporaneous decreases of the line flux (and vice versa).

In the model presented here a libration of the B star accretion disk as a consequence of the precession of its rotational axis is assumed as cause of the periodic EW & flux variability. Although the plane of the disk is perpendicular to the rotation axis, it is probably not aligned to the orbital plane of the companion. The gravitational force of the M supergiant now exerts a forced torque on the B star disc that triggers the 44-day precession period of the disc rotation axis.

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