Intermediate Report December 2012
Campaign: Photometry and Spectroscopy of P Cyg

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Introduction

The international observing campaign, Photometry and Spectroscopy of P Cyg, begun in 2008, is a co-operative project of the American Association of Variable Star Observers (AAVSO), Active-Spectroscopy-in-Astronomy (ASPA) and Bundesdeutsche Arbeitsgemeinschaft Veränderliche Sterne (BAV). One goal of the campaign is the monitoring of the behaviour of the Hα-line equivalent width (EW) and the contemporaneous changes of the V-band magnitude of P Cyg. Another goal is to gather further information about the intrinsic flux of this spectral line.

Details

In our campaign is assumed that the variability of the EW is caused by variations of the continuum flux and not by variations of the line flux, which would indicate variations in the stellar wind density. Therefore, the variability of the continuum flux shall be our primary concern, when the properties of the stellar winds and rate of mass loss are studied. To find correlations of photometric to spectroscopic data, an AAVSO-call for observation was started at the beginning of the campaign, for measurements with photoelectric photometers (PEP) and DSLR measurements as well, based on the Johnson-V system. In the meantime 16 observers are involved worldwide.

Photometric measurements

Fig. 1 shows the comparison of PEP-measurements (123) and DSLR measurements (141) until 4.Nov. 2012. Exept for occasional outliers (which occurs in both) the observations on the 0.01mag accuracy level are rather alike on in the process.

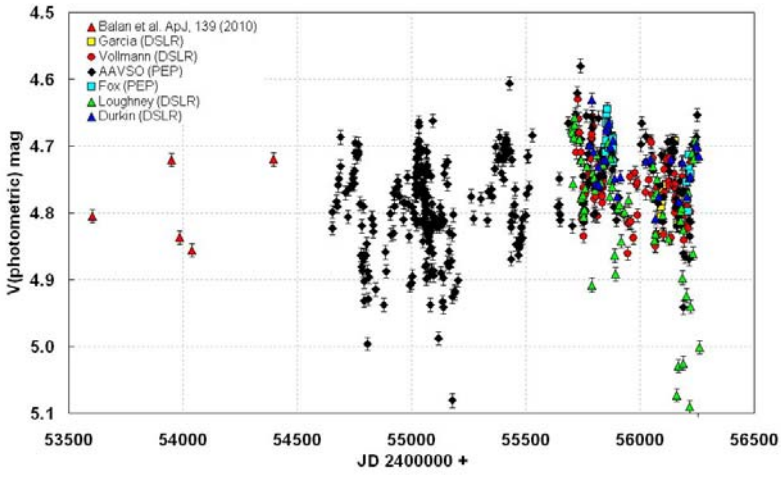

Fig. 1: Comparison of AAVSO-PEP observations with DSLR-observations

Photometric and spectroscopic changes in P Cygni are shown to be anti-correlated on short- and long-term scales. We observed a total change of 35 Å in the equivalent width (EW) of the Hα line and of ~ 0.25 magnitudes in the V-band brightness. Our observations extend from JD 2454671 (23 July 2008) through JD 2456244 (12 November 2012).

Results

Fig. 2 compares the time behavior of the V-brightness (upper) and the Hα EW (lower) in our campaign,

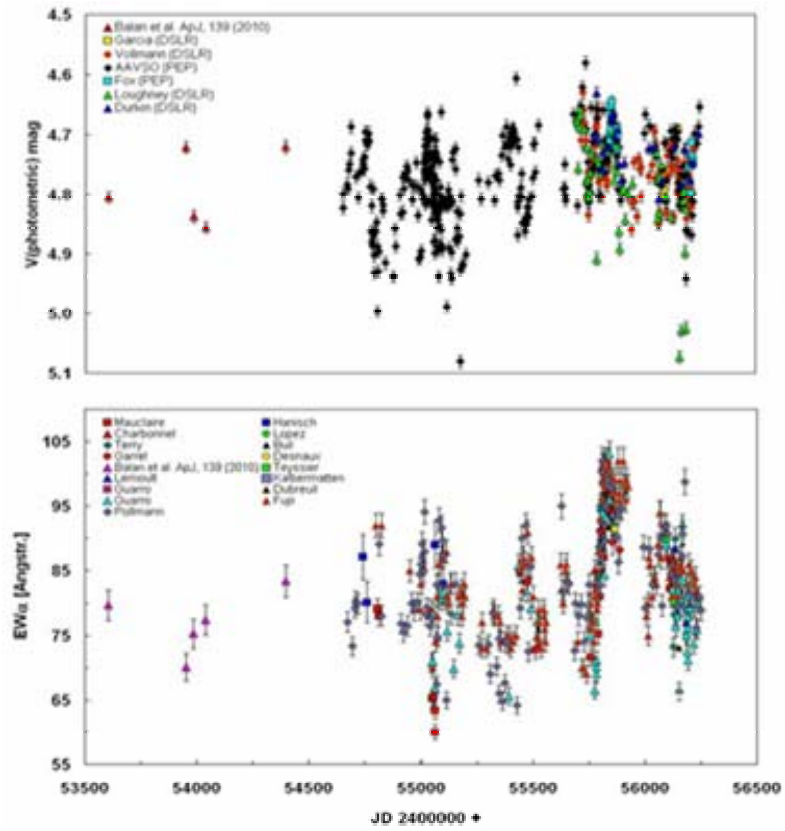

Fig. 2: Our photometric and spectroscopic observations of the V magnitude (upper) and the Hα-EW (lower) during the campaign [including data of Balan et al. [1]).

As can be seen in Fig. 2, when EW decreases, the contemporaneous stellar brightness increases and vice versa. Strict anti-correlation is expected if the variation of the continuum flux is independent from variations of the EW. If the Hα line flux is constant over time, an increase of the continuum brightness will yield a smaller line flux from the measured EW and vice versa.

To find out if and how the flux obtained from the spectral line profiles varies, the EW measurements is corrected [2]. It is important to consider the absolute flux of the line because its variations are caused by the effects of mass loss, stellar wind density and changes of the ionization state of chemical elements in it. In the current campaign we have already obtained 161 nearly simultaneous measurements of the EW and the flux in the V-band.

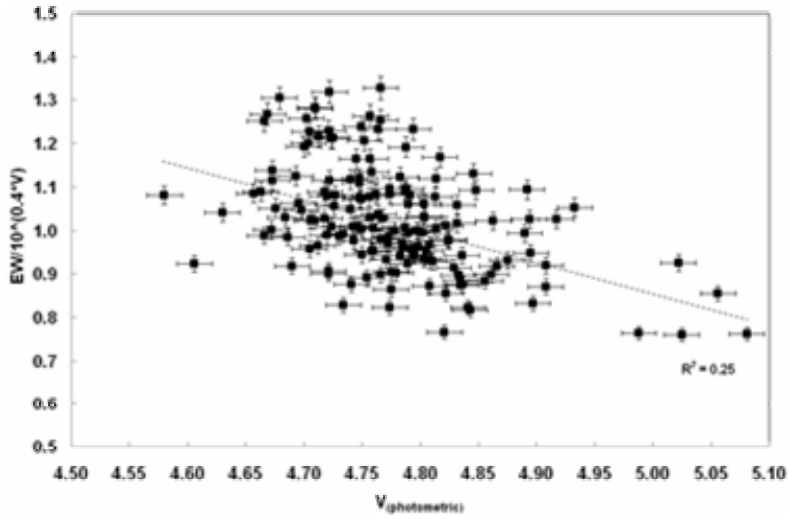

Fig. 3: Hα-line flux versus photometric V-brightness

Fig. 3 attempts to display if and to what extent the intrinsic line flux (as continuum-corrected EW) depends on V-magnitude. From a statistical point of view one can say that the low 0.25 correlation coefficient (which should be zero after the continuum correction), with consideration of the measurement uncertainties, suggests the conclusion that the Hα line flux is independent of V-magnitude.

With consideration of the standard deviation and possibly other kind of errors, the temporal variation of the line flux of Hα in the plot of Fig. 4 will represent the result of variations in the mass loss rate, stellar wind density and changes of the ionization from August 2005 until November 2012

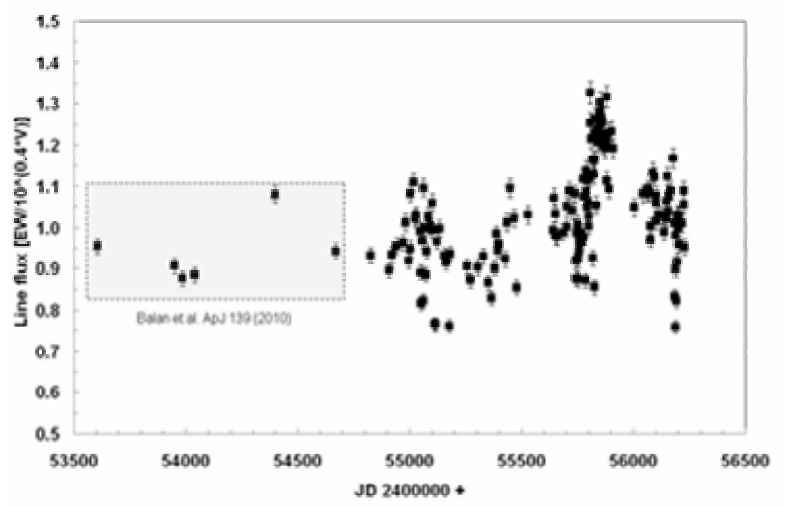

Fig. 4: The intrinsic Hα-line flux from
JD 2453605 (2005/08/22) to JD 2455911 (2012/11/12)

Variations of the mass loss rate manifest themselves in P Cyg generally also in a varying absorption depth and proportionally to it in a varying emission strength of the HeI line at 6678 Å, which is developed in the helium-forming zones near the "surface" of the central star.

Fig. 5 shows HeI6678-spectra from April 2003 to Nov. 2012 for illustration of the variability of the absorption depth and the emission strength as a consequence of a variable mass loss rate of the star (in units of the normalized continuum).

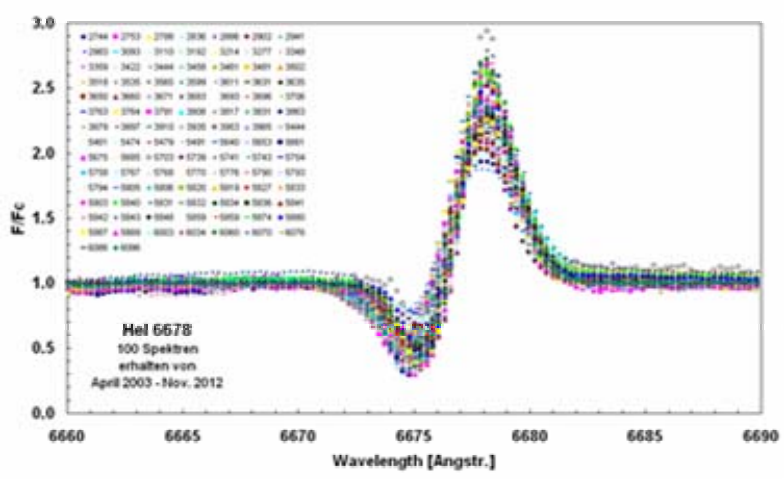

Fig. 5: Variability of absorption depth and emission strength
in the profile of the HeI6678 line of the period 2003/04 bis2012/11.

The plot of absorption depth versus emission strength in Fig. 6 shows, that both measured variables are related only with a correlation quality of ~ 0.44. Even if the emission comes by recombination, one would expect that a higher density (= higher mass loss) produces both, more absorption and more emission. The small coefficient of correlation could therefore be an expression for not implausible temperature variations in the stellar wind, whereby the absorption can increase also without change of mass loss, thereby without the emission increases.

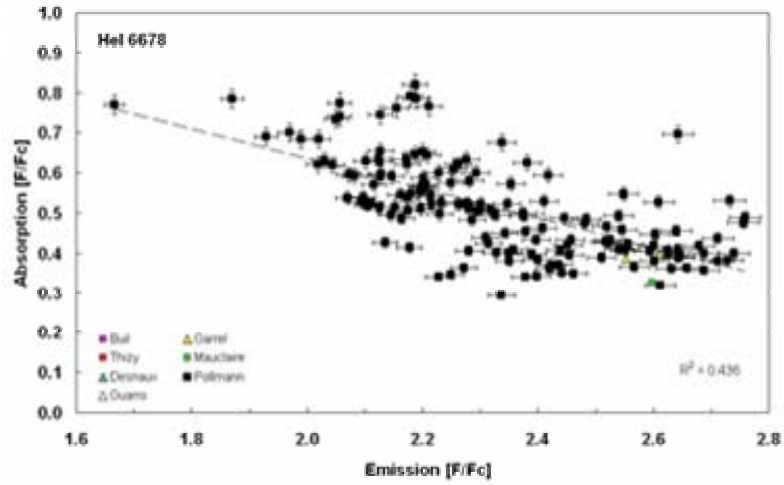

Fig. 6: Variability of the absorption depth versus emission strength
of the HeI6678 line for the period April 2003 until November 2012

References
[1] Balan, A., et al., ApJ, 139, 2269-2278 (2010)
[2] JAAVSO, volume 40, 2012

Acknowledgements
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