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Long-term spectroscopic monitoring of P Cygni-type stars. II. Spectroscopic variations of P Cygni during 1990-1992*

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Abstract. — We have monitored P Cygni from 1990 to 1992 with a fiber-linked echelle spectrograph and a CCD detector. The spectra cover the wavelength range 4050 Å $< \lambda <$ 6750 Å with a spectral resolution of $\lambda/\Delta\lambda \approx$ 12,000. The S/N-ratio of the spectra depends on wavelength and weather conditions, but typically it is better than 100. Due to the linear detector, we cannot only study radial velocities, but also the line strengths with good precision. We found variations in radial velocity of about 30 to 50 km s^{-1} and line strength variations of the order of 30%. The typical timescales of the variations are months. Clear line splittings have not been found in our data.

Key words: stars: P Cygni, activity, mass loss, supergiants

1. Introduction

P Cygni is, with a visual magnitude of $V = 4.8$, the brightest Luminous Blue Variable (*LBV*) in the sky. It had a large outburst in 1600, large variations (3 mag) for a period of about 200 years, and has been relatively stable – with a small secular brightness increase (de Groot & Lamers 1992) – for the last 200 years. Since the first spectroscopic observations in the last century, it has always exhibited a peculiar spectrum with almost all lines showing P Cygni profiles (undisplaced emission and blueshifted absorption). At present, P Cygni is photometrically slightly variable ($\approx 0\overset{\mathrm{m}}{.}2$), see e.g. Percy et al. (1988). The photometric history and an extensive discussion of the older literature has been presented by de Groot(1969). For a good summary see also de Groot & Lamers (1983).

Spectroscopic variations of P Cygni have been reported as early as 1913, (Merrill 1913), but these early reports are suspect, since other authors could not conform these variations (Frost 1912; Lockyer 1924; Elvey 1928). Adams & Merrill (1957) remarked that "no major changes in the general character of the spectrum have been reported since the first spectrogram was obtained in Harvard in 1887", but "the stronger dark lines are subject to interesting variations in intensity and structure".

Adams and Merrill also reported occasional line-splitting of the absorption components of several stronger spectral lines (see also the discussion by de Groot 1969). Lamers et al. (1985) have found variable absorption components in ultraviolet lines of FeII and FeIII as well. The splitting of absorption components of optical lines has been studied more recently extensively by several authors, e.g. Markova (1986), Markova & Kolka (1988, 1989).

de Groot (1969) first discussed in detail the line splitting observed especially in the higher Balmer lines and suggested a periodic variation with a period of about 110 days. Later, a number of different periods have been proposed, mainly in radial velocities and in photometry. These periods have been re-analysed by van Gent & Lamers (1986) and most have been found to be not real. In many cases, especially for the spectroscopy, the period analysis is seriously hampered by the poor sampling of the data, especially for the most likely periods of the order of 50 to 100 days. Therefore we started a long-term monitoring program to study the spectroscpic variations of P Cyg systematically.

2. Observations

We have been monitoring P Cygni with high resolution in wavelength ($\lambda/\Delta\lambda \approx$ 12,000) and time from 1990 to 1992 with a fiber-linked echelle spectrograph with a large spectral range (4050 Å $< \lambda <$ 6750 Å). This is the first long-term spectroscopic monitoring campaign for this star with an electronic detector (CCD). Previous long-term spectro-

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*Partly based on observations collected at the Centro Astronomico Hispano-Aleman, Calar Alto, operated by the Max-Planck Institut für Astronomie Heidelberg, and on observations collected at the Landessternwarte Tautenburg scopic studies of this star have relied on photographic data (e.g. Markova 1986, 1990). Compared to these studies, we have much higher S/N-ratio and more reliable intensity measurements.

The average spectrum resulting from our campaign has been published by Stahl et al. (1993), henceforth called Paper I. Stahl et al. (1991) found from the same data for the first time forbidden lines in the spectrum of P Cygni. In the present paper we want to present the variability of the strongest lines of P Cygni from 1990 to 1992.

For details of the observations and the data reduction we refer to Paper I.

3. Variability of P Cygni

A detailed analysis of the line profile variations requires detailed modeling and is postponed to a later paper. In the present paper we present the data and give only a qualitative discussion of the variations.

Since we could not detect any clear splitting of lines, (see below), we discuss in the following only the radial velocity of the absorption components and the intensity of the emission lines. These two measurements characterize the variability of the stellar wind of P Cygni.

Below, we mainly discuss two measurements:

- The heliocentric radial velocity of the lines, as determined from a gaussian fit to the absorption component, $v_{\rm exp}$.
- The emission-line intensity, which we simply define as the flux maximum of the line, measured in units of the nearby continuum, $F_{\rm max}/F_{\rm C}$.

These two quantities are easily measured in a quantitative way and give some quantitative information on the variability of P Cygni. We prefer the emission-line intensity to the equivalent width, because the strong lines of P Cygni have very wide wings, which makes the measurement of the equivalent widths problematic. The gaussian fit to the absorption component is certainly not always the best way to measure the radial velocity, since the absorptions are not always gaussian shaped. However, this measurement can easily be compared with data from other instruments and thus makes our data useful for studies on longer timescales.

We found from our observations clear variations in the expansion velocity measured from the lines ($\approx$ 30 to 50 km s^{-1}) (see Figs. 1 and 2) and in the emission line strength ($\approx$ 30%), see Figs. 3 and 4. This is qualitatively in good agreement with Markova (1993).

As can be seen from the figures, the variations in different lines are correlated, but not all lines show exactly the same behaviour. A correlation between the radial velocity and the intensity variations is not obvious. These results are also in agreement with Markova (1993).

We searched for correlations of the spectroscopic variations with photometric observations kindly provided by Mart de Groot, but could not detect any clear correlation. This may partly be due to the absence of prominent features in the light curve during our spectroscopic campaign. The small photometric variations during our campaign also shows that the variations in line intensity (which are measured in units of the continuum) are real and do not reflect variations in the continuum level.

The typical timescale of the variability is from weeks to months, which is consistent with the dynamical timescale of the envelope. There is also a long-term component of the variations, which is especially clear from the observations of Hα. Variations with a much shorter timescale (less than a few days), cannot be well studied with our data, but appear unlikely because of the smooth variations observed on a time scale of weeks.

We cannot exclude that the observed variations of e.g. the HeIλ6678 line (see Figs. 5 and 6) are due to broad moving sub-components. However, our impression is, that the whole absorption component is shifting towards shorter wavelengths. This could be due to increasing optical depth as a result of increasing mass-loss. It is also possible that only the absorption at the higher expansion velocities is variable, or that the expansion velocity of the stellar wind is variable. Without a detailed wind model – making use of the information in all lines available – it is not possible to decide between these explanations.

No clear line-splitting has been observed by us at any time. Most lines have variable and sometimes also asymmetric absorption components, but clear splitting has not been observed by us. (A possible exception are the NaID lines. These lines are, however, on our spectra severely contaminated by terrestrial water vapour absorption, so that no clear conclusions can be drawn. The region around the NaID lines is also not free from blends. For possible blends in the NaID lines see e.g. the discussion in the Appendix of Bernat & Lambert (1982).) This is not only true for the lines discussed here, but for *all* lines in our spectra, i.e. also for weaker metal lines of SiIII, OII, etc. The metal lines typically show only variations of ±5% of the continuum level. As an example we show in Fig. 7 an overplot of all our spectra (117) in the region of the SiIIIλ4553 line. The absence of line-splitting is surprising since in other papers line-splitting is reported to be very common e.g. Markova & Kolka (1988). It should be mentioned that the spectral resolution of our data ($\lambda/\Delta\lambda \approx$ 12,000 for most spectra, but about 18,000 for some of them) is lower than the resolution of the coudé spectra of Markova & Kolka (1988). This is, however, at least partly compensated by the much higher S/N-ratio of our spectra. The line splittings found e.g. by Markova (1986, 1993) are typically larger than 40 km s^{-1} and thus should be detectable with the resolution of our spectra.

There is no doubt that at some phases line-splitting *is* present in P Cygni, at least in the higher Balmer lines, e.g. Adams & Merrill (1957), and possibly also in some

HeI lines (Astafiev 1969), although in these lines the splitting is not as clear. Unfortunately, the higher Balmer lines cannot be observed with our instrument.

Our result indicates, however, that the reported line-splitting is not as ubiquitous as sometimes reported in the literature. The photographic data appear to us to be of inadequate quality to detect the splitting of the metal lines, in other words, some of the reported line splittings appear to be over-interpretation of noisy photographic data (see the spectra published by e.g. Markova & Kolka 1989).

Strong variations on longer timescales than covered by our data have been checked by comparing with the spectra published by Hawkins & Jura (1987) and Bernat and Lambert (1982). By comparing our data for Hα, HeIλ6678 and HeIλ7065 with published data of Bernat and Lambert (1982) we found very good agreement in Hα. For the HeI-lines we find that our mean spectrum has stronger absorption in these HeI-lines. The emission-line strengths are very similar. Hawkins & Jura (1987) have observed only a very small wavelength range, containing a few faint lines (including one [FeII]-line). The agreement with our data is good. This comparison probably indicates that variations on timescales of weeks to months are dominant in the variability of P Cygni.

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Table 1. Variations of the hydrogen lines, 1990. The first column gives the Julian Date −2,448,000. Columns 2 to 4 give the heliocentric radial velocity of the absorption component and Cols. 5 to 7 give the emission line strength ($F_{\rm max}/F_{\rm C}$)

JD	Hα	Hβ	Hγ	Hα	Hβ	Hγ
43.6	-214.3	-206.2	-197.5	19.87	6.10	3.30
44.6	-212.9	-205.0	-193.4	18.51	5.95	3.20
59.6	-212.5	-203.8	-197.5	18.58	7.08	3.15
60.6	-210.2	-205.6	-194.8	18.48	5.67	3.11
62.6	-209.7	-203.2	-194.1	17.84	5.59	3.11
67.6	-210.6	-205.0	-189.9	17.92	5.27	2.96
84.6	-210.2	-205.0	-188.5	17.70	5.35	2.99
85.5	-210.2	-205.0	-193.4	17.61	5.34	2.97
86.4	-211.1	-205.0	-192.7	17.10	5.30	2.98
87.5	-208.8	-201.3	-191.3	17.57	5.35	2.96
88.4	-209.3	-203.8	-192.0	17.59	5.38	2.99
90.4	-209.7	-201.9	-192.7	17.40	5.45	3.05
92.4	-209.7	-202.5	-193.4	17.89	5.56	3.13
93.5	-211.1	-205.6	-183.7	18.22	5.62	3.13
94.4	-212.0	-206.2	-184.4	17.78	5.75	3.15
95.4	-211.6	-206.2	-194.1	18.22	5.73	3.20
96.4	-214.3	-201.9	-192.7	18.49	5.70	3.14
97.4	-209.7	-202.5	-193.4	18.26	5.68	3.18
98.4	-214.8	-201.9	-193.4	18.52	5.66	3.15
99.4	-209.3	-205.0	-194.1	18.26	5.64	3.15
100.4	-216.6	-206.2	-194.8	18.08	5.68	3.19
101.4	-216.6	-205.6	-192.0	17.72	5.62	3.06
102.4	-216.6	-205.6	-194.8	18.11	5.72	3.22
103.4	-216.1	-205.6	-194.1	18.32	5.78	3.22
104.4	-217.5	-206.9	-196.2	18.27	5.73	3.18
105.4	-216.6	-206.2	-193.4	18.20	5.75	3.18
106.4	-216.6	-206.2	-194.8	18.50	5.67	3.13
107.4	-216.6	-206.2	-194.8	18.33	5.65	3.12
108.4	-217.5	-207.5	-196.2	18.07	5.64	3.14
121.4	-219.3	-210.6	-201.7	17.86	5.25	2.94
126.4	-220.7	-210.6	-202.4	17.53	5.07	2.77
127.4	-220.7	-210.6	-202.4	17.50	4.94	2.73
128.4	-220.2	-213.0	-203.1	17.34	4.89	2.72
150.4	-219.3	-213.6	-203.8	13.90	4.18	2.41
151.4	-220.7	-218.6	-202.4	13.65	4.14	2.44
163.4	-221.6	-211.2	-201.7	13.72	4.37	2.48
166.4	-220.7	-208.7	-201.0	13.81	4.40	2.64
168.4	-217.0	-212.4	-204.5	13.77	4.55	2.59
175.4	-210.6	-209.9	-201.7	14.75	4.85	2.82
177.4	-216.4	-212.3	-195.7	14.59	4.98	2.88
180.4	-212.5	-208.7	-194.8	14.91	4.98	3.01
220.3	-216.6	-215.5	-197.5	15.88	5.23	2.94
223.4	-211.6	-203.8	-199.6	15.63	5.12	2.90
231.2	-217.9	-205.0	-197.5	15.57	5.10	2.90
232.2	-217.5	-205.0	-198.2	15.52	5.13	2.97
233.2	-215.2	-203.2	-194.1	15.66	5.13	2.97

Table 2. Same as Table 1, but for 1991

JD	Hα	Hβ	Hγ	Hα	Hβ	Hγ
347.5	-209.7	-205.6	-196.2	20.32	6.07	3.21
349.6	-211.1	-205.0	-196.2	20.56	6.04	3.25
399.6	-205.2	-198.2	-188.5	21.77	6.76	3.47
403.6	-205.2	-205.6	-184.4	21.71	6.96	3.46
412.5	-209.3	-205.0	-197.5	23.48	7.07	3.55
431.5	-207.9	-201.3	-194.1	22.89	6.73	3.33
439.5	-207.4	-197.6	-190.6	21.22	6.42	3.10
443.6	-208.3	-197.0	-188.5	22.09	6.31	3.69
449.4	-207.9	-195.7	-186.5	21.73	6.23	3.29
454.4	-203.3	-198.2	-189.2	21.20	6.00	3.17
457.4	-204.2	-198.8	-188.5	21.23	5.88	3.13
460.4	-206.1	-194.5	-182.3	21.06	5.95	3.16
461.4	-204.2	-200.7	-180.9	20.97	5.97	3.21
462.4	-205.2	-201.3	-182.3	20.92	6.16	3.23
465.4	-204.7	-200.7	-181.7	21.50	6.29	3.17
466.4	-202.9	-197.6	-189.9	21.76	6.03	3.23
467.4	-207.9	-196.4	-188.5	21.21	5.97	3.14
469.4	-205.2	-194.5	-183.0	20.87	5.92	3.11
471.4	-204.2	-200.1	-181.7	20.99	5.89	3.19
473.4	-203.8	-198.8	-186.5	20.13	5.84	2.99
474.4	-208.8	-198.8	-190.6	20.55	5.95	3.23
475.4	-207.0	-197.0	-189.2	21.19	6.05	3.25
478.4	-203.8	-201.9	-193.4	21.29	6.08	3.26
479.4	-207.4	-197.6	-185.1	20.79	6.09	3.21
482.4	-203.8	-201.9	-183.7	20.68	6.04	3.26
484.4	-202.9	-201.9	-183.0	21.34	6.10	3.30
490.3	-205.6	-198.8	-193.4	20.95	6.24	3.43
491.3	-204.9	-197.3	-192.0	20.83	6.25	3.44
492.3	-205.2	-199.4	-192.0	22.13	6.41	3.45
493.3	-204.7	-198.2	-191.3	22.19	6.41	3.46
494.3	-206.1	-200.1	-190.6	21.67	6.41	3.45
495.3	-204.2	-197.6	-190.6	21.92	6.34	3.38
496.3	-203.8	-197.0	-198.2	21.26	6.27	3.37
498.3	-202.9	-195.7	-189.9	21.22	6.28	3.38
499.4	-203.3	-203.2	-192.7	21.71	6.30	3.40
502.3	-204.2	-197.0	-199.6	21.63	6.26	3.32
509.3	-204.7	-200.1	-198.2	20.81	6.03	3.21
512.3	-207.9	-204.4	-191.3	20.96	6.07	3.30
514.3	-205.2	-200.1	-194.8	21.54	6.23	3.35
517.3	-207.9	-205.6	-191.3	22.40	6.45	3.51
518.3	-207.0	-204.4	-188.5	22.14	6.43	3.48
519.3	-206.5	-204.4	-191.3	21.88	6.31	3.43
520.3	-206.1	-203.8	-187.2	21.51	6.24	3.35
521.3	-205.2	-202.5	-191.3	20.64	6.19	3.35
539.3	-205.6	-206.9	-190.6	21.82	6.29	3.45
556.3	-210.6	-203.8	-192.0	23.06	6.65	3.52
561.3	-209.3	-204.4	-192.0	22.52	6.82	3.60
562.2	-208.8	-209.3	-190.6	23.33	6.77	3.40
587.2	-207.0	-205.6	-189.9	22.11	6.05	3.11
589.2	-204.2	-203.2	-189.2	21.10	6.01	3.13
591.2	-206.5	-206.2	-189.2	21.54	6.13	3.27
597.2	-207.4	-206.9	-190.6	21.71	5.91	3.10
602.2	-207.9	-206.9	-198.2	20.86	5.70	3.00

Table 3. Same as Table 1, but for 1992

JD	Hα	Hβ	Hγ	Hα	Hβ	Hγ
683.6	-203.8	-199.4	-186.5	20.54	6.21	3.15
686.6	-206.5	-195.1	-190.6	20.26	6.38	3.37
689.6	-208.3	-205.0	-187.9	20.32	6.33	3.48
691.6	-205.2	-198.2	-191.3	20.69	6.30	3.52
757.6	-209.3	-200.7	-183.7	18.96	6.19	3.21
758.4	-210.2	-198.8	-184.4	19.43	6.25	3.25
760.4	-210.2	-200.7	-187.9	19.20	6.39	3.24
762.4	-207.9	-197.6	-187.2	19.87	6.56	3.33
763.4	-208.8	-198.2	-189.2	20.12	6.70	3.41

Table 4. Variations of the HeI lines, 1990. The first column gives the Julian Date −2,448,000. Columns 2 to 4 give the heliocentric radial velocity of the absorption component and Cols. 5 to 7 give the emission line strength ($F_{\rm max}/F_{\rm C}$)

JD	λ6678	λ5876	λ4471	λ6678	λ6678	λ4471
43.6	-175.6	-194.3	-176.9	2.76	4.66	2.22
44.6	-173.8	-191.3	-176.3	2.71	4.49	2.10
59.6	-173.8	-190.7	-178.3	2.68	4.07	2.29
60.6	-171.6	-191.8	-174.2	2.59	4.41	2.09
62.6	-170.7	-190.7	-173.6	2.62	4.30	2.09
67.6	-165.7	-188.7	-167.5	2.47	4.15	2.00
84.6	-158.1	-181.0	-158.1	2.62	4.43	2.07
85.5	-158.1	-180.5	-157.5	2.63	4.43	2.06
86.4	-159.0	-181.0	-157.5	2.64	4.42	2.06
87.5	-157.6	-180.0	-162.8	2.62	4.39	2.06
88.4	-159.0	-181.0	-157.5	2.65	4.40	2.08
90.4	-160.8	-182.1	-160.1	2.68	4.45	2.12
92.4	-162.6	-183.1	-163.5	2.73	4.58	2.17
93.5	-163.9	-184.1	-164.9	2.73	4.60	2.16
94.4	-165.3	-180.5	-165.5	2.76	4.57	2.19
95.4	-165.7	-187.2	-165.5	2.77	4.65	2.17
96.4	-168.9	-185.7	-171.5	2.79	4.65	2.17
97.4	-164.4	-186.2	-164.2	2.79	4.65	2.15
98.4	-164.4	-186.2	-170.9	2.74	4.61	2.13
99.4	-165.3	-186.7	-162.2	2.73	4.57	2.11
100.4	-172.9	-189.2	-172.2	2.74	4.61	2.15
101.4	-173.4	-189.2	-172.9	2.74	4.55	2.13
102.4	-173.4	-189.7	-170.9	2.75	4.63	2.13
103.4	-173.4	-189.7	-170.2	2.77	4.63	2.11
104.4	-175.2	-191.3	-171.5	2.72	4.60	2.09
105.4	-175.2	-191.3	-172.9	2.71	4.57	2.08
106.4	-175.6	-191.8	-172.9	2.67	4.54	2.06
107.4	-176.1	-192.3	-173.6	2.65	4.46	2.06
108.4	-177.9	-193.3	-174.2	2.61	4.42	2.08
121.4	-179.6	-198.4	-168.2	2.40	4.06	1.92
126.4	-179.2	-197.9	-176.3	2.39	4.02	1.91
127.4	-178.8	-197.4	-168.2	2.34	3.94	1.87
128.4	-179.6	-198.4	-169.5	2.31	3.90	1.87
150.4	-182.3	-206.1	-181.6	2.22	3.57	1.88
151.4	-182.8	-201.0	-176.3	2.22	3.56	1.86
163.4	-177.4	-195.9	-171.5	2.38	3.91	2.03
166.4	-178.3	-195.4	-173.6	2.42	3.97	1.96
168.4	-175.6	-198.9	-168.9	2.42	4.03	2.01
175.4	-172.5	-186.7	-169.5	2.58	4.25	2.06
177.4	-173.3	-187.2	-171.9	2.57	4.29	2.08
180.4	-169.3	-188.7	-168.2	2.61	4.29	2.10
220.3	-165.7	-187.2	-166.2	2.61	4.30	2.07
223.4	-163.0	-184.6	-158.1	2.51	4.10	2.03
231.2	-169.8	-188.7	-157.5	2.46	4.03	1.99
232.2	-168.0	-188.2	-158.8	2.49	3.99	1.99
233.2	-165.7	-185.7	-155.5	2.44	3.99	2.01

Table 6. Same as Table 4, but for 1992

JD	λ6678	λ5876	λ4471	λ6678	λ6678	λ4471
683.6	-151.4	-173.4	-155.5	2.53	4.39	2.08
686.6	-153.6	-175.9	-156.1	2.61	4.45	2.06
689.6	-157.6	-172.9	-161.5	2.63	4.54	2.11
691.6	-156.3	-177.5	-160.1	2.62	4.53	2.14
757.6	-150.9	-169.8	-156.1	2.61	4.39	2.33
758.4	-151.4	-170.3	-156.1	2.63	4.50	2.19
760.4	-151.4	-164.7	-147.4	2.63	4.51	2.21
762.4	-149.6	-166.2	-156.1	2.68	4.71	2.23
763.4	-150.5	-167.3	-156.1	2.70	4.80	2.21

Table 5. Same as Table 4, but for 1991

JD	λ6678	λ5876	λ4471	λ6678	λ6678	λ4471
347.5	-158.5	-180.5	-161.5	2.54	4.24	2.08
349.6	-155.8	-178.0	-160.1	2.48	4.24	2.08
399.6	-149.6	-167.8	-158.8	2.70	4.60	2.17
403.6	-151.8	-169.3	-162.2	2.70	4.59	2.13
412.5	-168.0	-181.0	-166.9	2.72	4.69	2.15
431.5	-160.3	-175.4	-156.1	2.61	4.43	2.04
439.5	-155.4	-176.5	-156.1	2.63	4.21	2.02
443.6	-156.7	-169.3	-159.5	2.63	4.33	2.11
449.4	-154.5	-168.8	-156.1	2.55	4.23	2.07
454.4	-148.7	-169.3	-152.1	2.45	4.13	2.00
457.4	-150.9	-170.3	-153.4	2.45	4.13	1.98
460.4	-154.0	-168.3	-158.8	2.50	4.15	2.05
461.4	-152.7	-167.3	-155.5	2.50	4.19	2.08
462.4	-153.1	-167.8	-156.1	2.53	4.24	2.08
465.4	-151.4	-173.9	-154.8	2.56	4.28	2.09
466.4	-148.2	-171.3	-152.1	2.54	4.30	2.03
467.4	-153.1	-167.8	-151.4	2.49	4.22	2.01
469.4	-150.5	-168.8	-157.5	2.44	4.20	1.98
471.4	-151.8	-173.9	-156.8	2.46	4.17	1.96
473.4	-151.8	-173.9	-154.8	2.50	4.13	1.96
474.4	-157.2	-174.4	-154.1	2.51	4.21	2.02
475.4	-156.3	-170.3	-162.2	2.55	4.30	2.07
478.4	-155.8	-177.5	-160.8	2.56	4.26	2.05
479.4	-158.1	-171.3	-164.2	2.52	4.29	2.07
482.4	-157.2	-178.5	-161.5	2.55	4.29	2.03
484.4	-157.2	-178.5	-161.5	2.55	4.32	2.04
490.3	-159.9	-175.9	-159.5	2.63	4.44	2.14
491.3	-159.4	-174.9	-164.2	2.66	4.49	2.15
492.3	-160.8	-176.5	-160.8	2.69	4.59	2.16
493.3	-159.9	-175.4	-165.5	2.71	4.60	2.17
494.3	-161.2	-176.5	-160.8	2.69	4.57	2.15
495.3	-159.9	-174.9	-164.9	2.64	4.48	2.09
496.3	-159.4	-174.9	-164.9	2.58	4.40	2.09
498.3	-158.5	-180.0	-163.5	2.60	4.42	2.08
499.4	-159.4	-180.5	-163.5	2.61	4.43	2.09
502.3	-160.8	-182.6	-164.9	2.60	4.43	2.06
509.3	-164.4	-181.0	-161.5	2.55	4.26	2.07
512.3	-169.3	-184.6	-168.2	2.59	4.34	2.12
514.3	-166.6	-182.6	-164.2	2.69	4.50	2.18
517.3	-170.2	-185.7	-170.2	2.74	4.62	2.20
518.3	-169.8	-185.1	-168.9	2.73	4.64	2.18
519.3	-169.3	-184.6	-168.2	2.67	4.52	2.14
520.3	-169.3	-184.6	-168.2	2.63	4.48	2.12
521.3	-168.4	-183.6	-167.5	2.59	4.41	2.09
539.3	-164.8	-182.1	-166.2	2.64	4.51	2.14
556.3	-168.9	-191.3	-164.9	2.59	4.79	2.19
561.3	-173.4	-192.6	-174.9	2.68	4.80	2.25
562.2	-171.1	-188.7	-171.5	2.65	4.72	2.20
587.2	-161.7	-180.0	-164.9	2.44	4.42	2.04
589.2	-167.5	-184.1	-164.2	2.48	4.30	2.04
591.2	-165.7	-182.1	-168.2	2.53	4.43	2.08
597.2	-168.9	-184.6	-170.9	2.42	4.39	2.06
602.2	-169.3	-184.6	-167.5	2.42	4.22	2.03

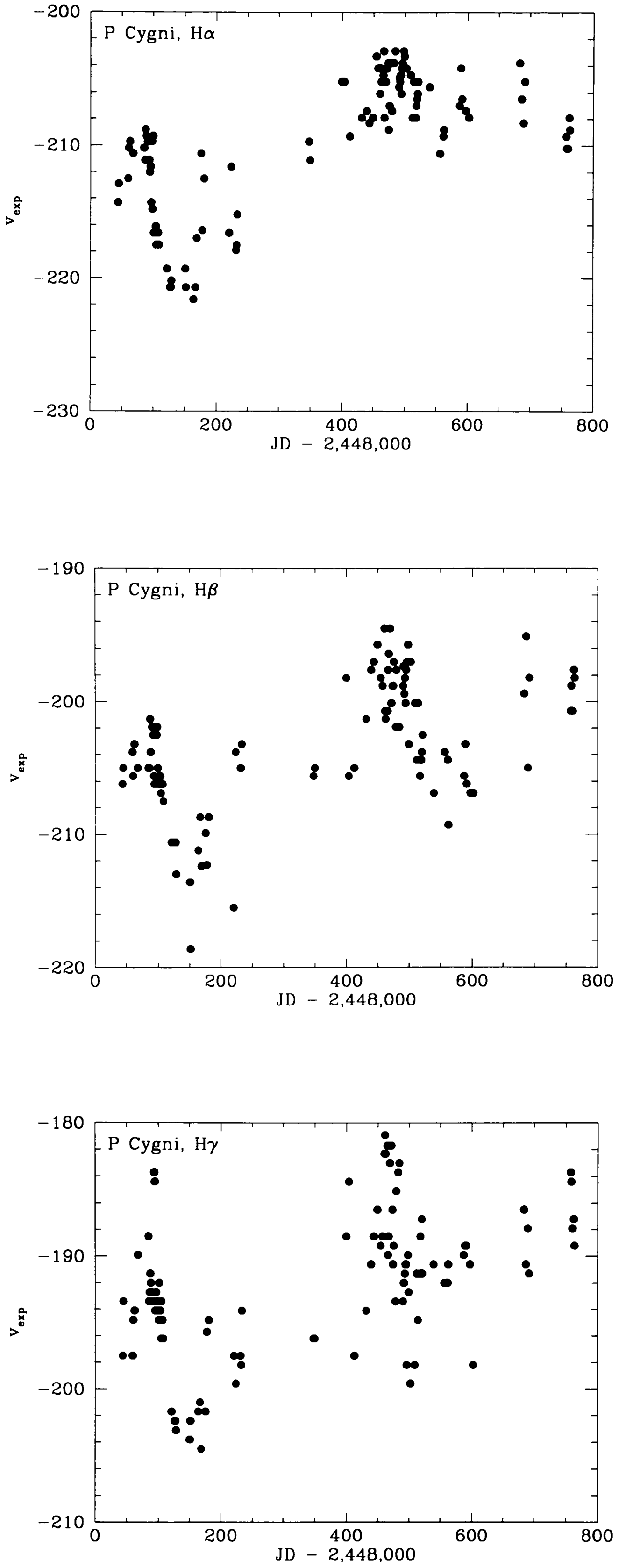

Fig. 1. The expansion velocity as measured from the blue-shifted absorption component of the Hα, Hβ and Hγ lines of P Cyg during our monitoring campaign

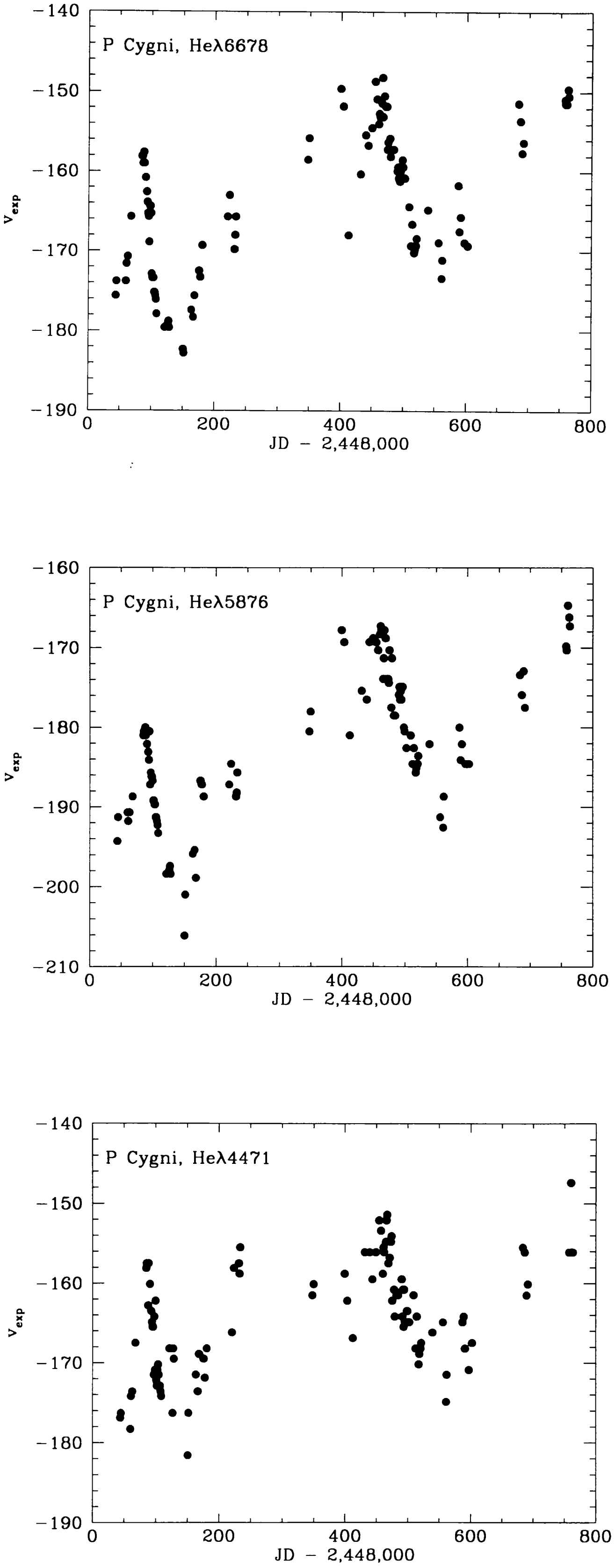

Fig. 2. Same as Fig. 1, but for HeIλλ6678, 5876, 4471

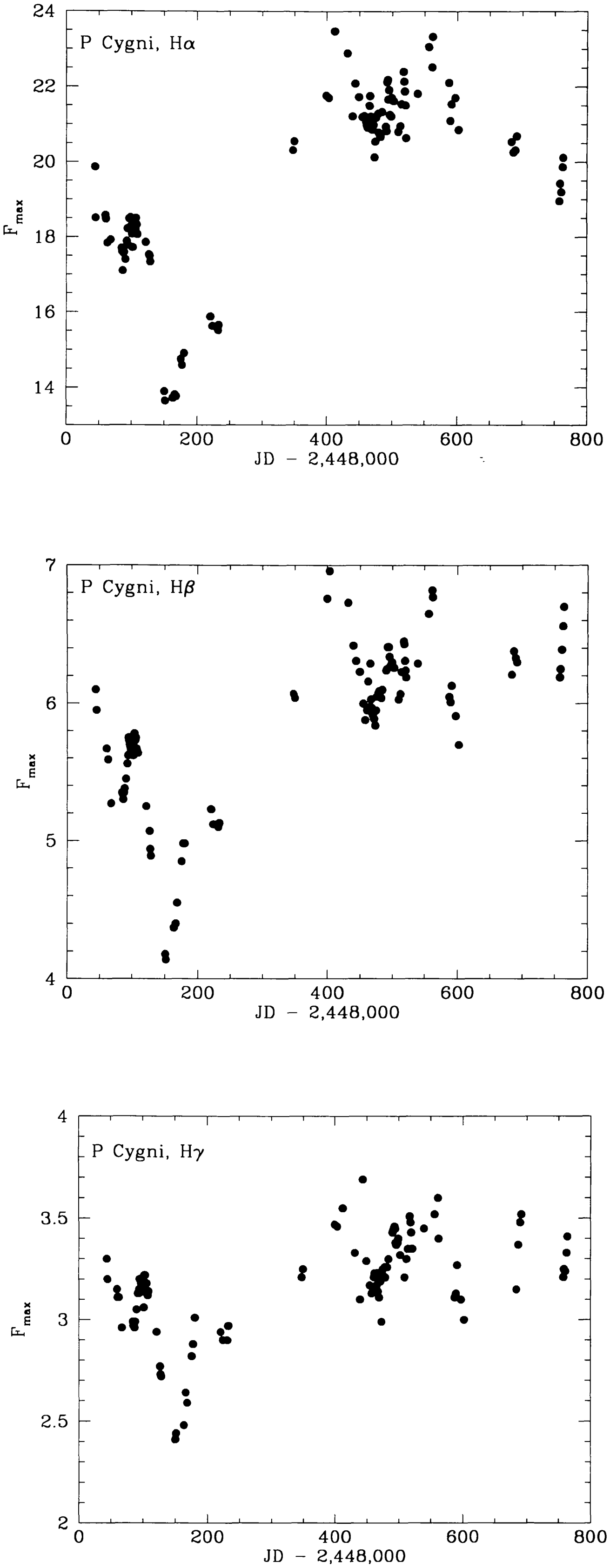

Fig. 3. The peak intensity of the Hα, Hβ and Hγ lines of P Cyg as observed during our monitoring campaign

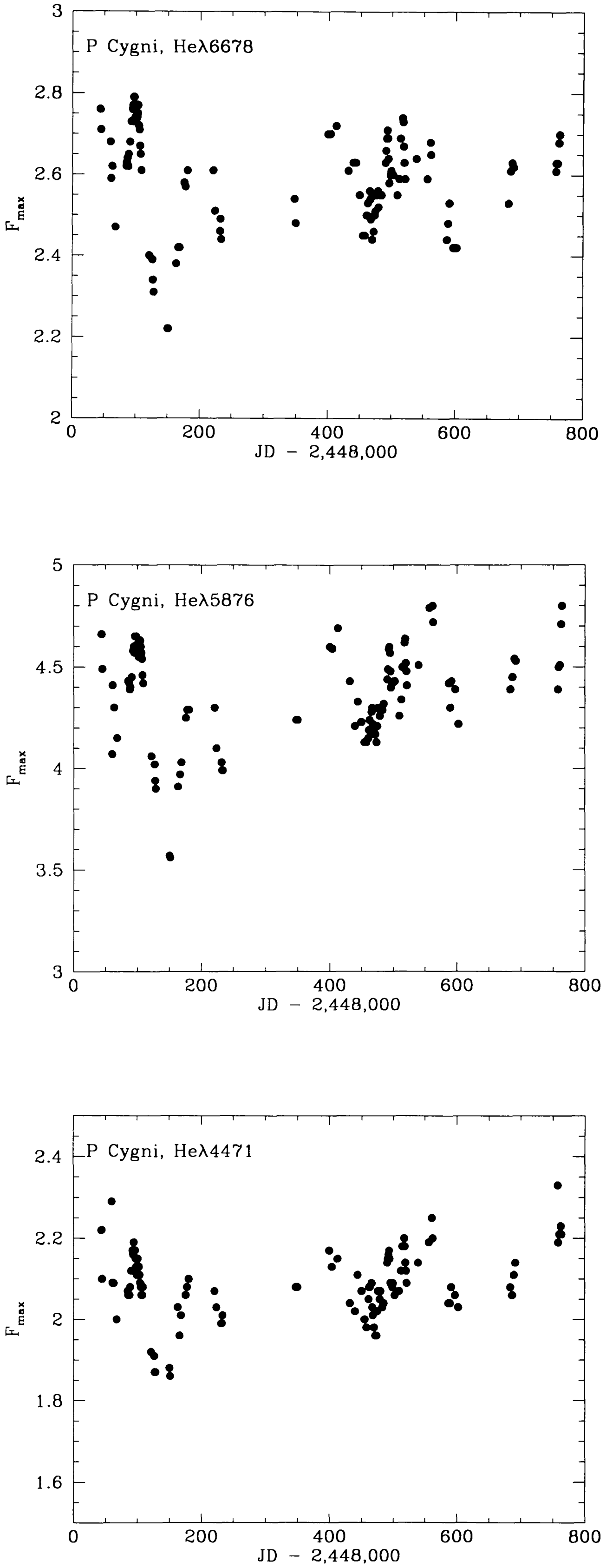

Fig. 4. Same as Fig. 3, but for HeIλλ6678, 5876, 4471

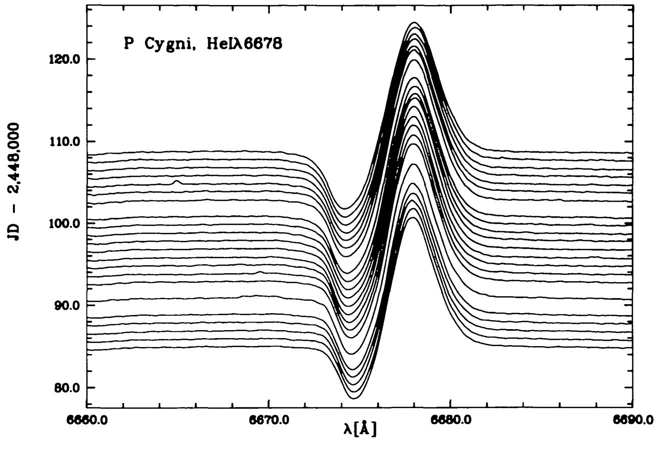

Fig. 5. A series of HeIλ6678 spectra obtained during the summer of 1990. Note the smoothly varying blue edge of the absorption component of this line

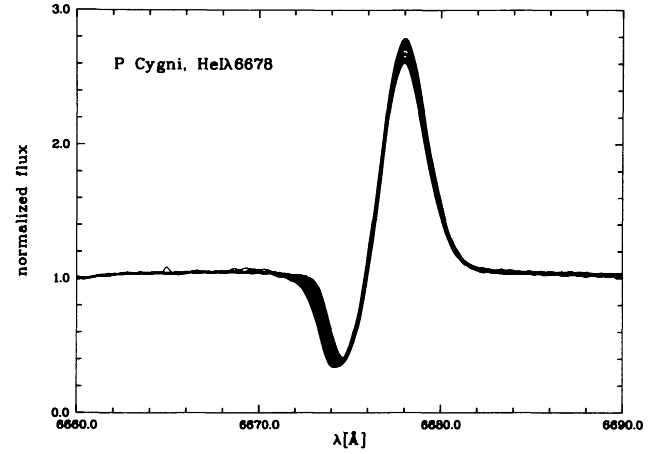

Fig. 6. Same as Fig. 5, but without offsets between the individual spectra. In this plot, it can be clearly seen, where in the line profile the variations are located

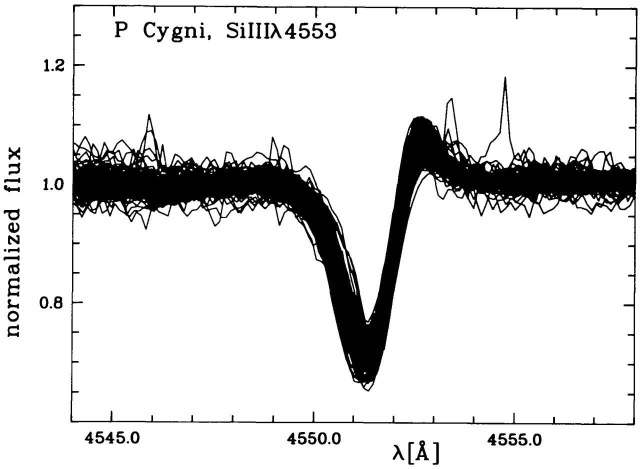

Fig. 7. Overplot of 117 spectra obtained with our instrument in the region around the SiIIIλ4553 line. Variations in radial velocity and intensity of the emission and absorption components are clearly detected. Line-splitting is not seen in any of these spectra