THE VELOCITY LAW OF P CYGNI

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ABSTRACT. The multiple absorption components in the Balmer lines of P Cygni indicate that shells are ejected regularly with a period of about 200 days. The newly found multiple, flat-topped emission components are attributed to thin, spherical, expanding shells. Together with the absorptions they allow the derivation of a velocity law, illustrated in the following by a sequence of figures.

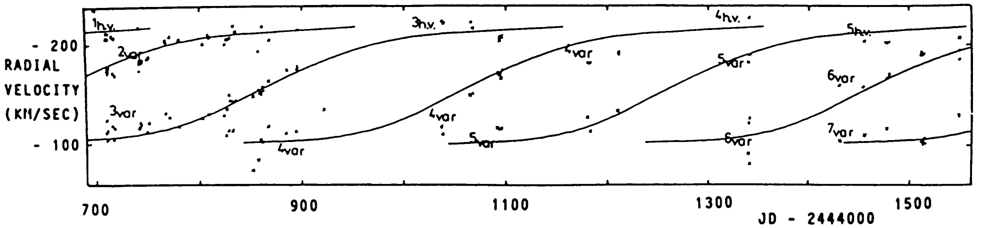

Figure 1. The radial velocities (averages of H9 to H14) of the absorption components (Markova, 1986) of 1981-83 are shown. The identifications of components at different epochs are based on the assumption that their velocities always increase up to the terminal velocity. The results are similar to those of Lamers et al. (1985) for UV-lines. The mean curve connecting the measurements (repeated every 200 days) shows that new components appear with this period and follow roughly the same velocity law.

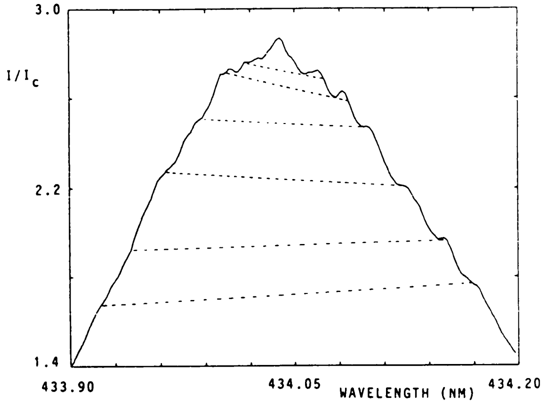

Figure 2. The representative Hγ emission profile was obtained from 13 spectra observed on Nov. 10 and 13, 1984. Averaging was necessary because (sometimes drastic, but largely chaotic) changes occur on time scales of hours or less. The flat-topped components, identified by dotted lines connecting related steps on both wings of the emission, are consistent with the profiles which Beals (1931) derived for thin, spherically expanding shells.

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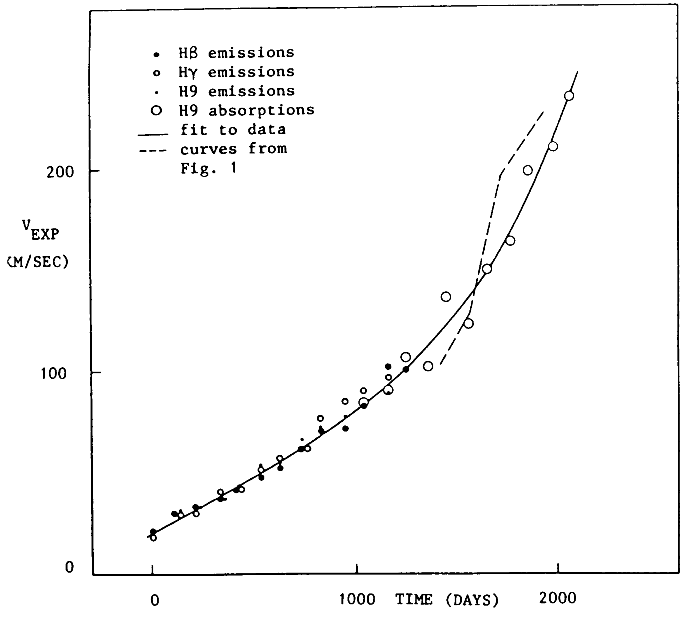

Figure 3. The expansion velocity of a shell can be determined from the width of the plateau. Velocities for the Hβ, Hγ and H9 mean profiles of Nov. 1984 and Sept. 1985, respectively, are shown. The velocities for different lines of the same shell agree well. The time interval between two subsequent shells is assumed to be 200 days. This period is used to shift the observations of 1985 relative to those of 1984, such that they form each second group of points. The excellent fit supports the 200-day period.

DISCUSSION. So far, we have studied in detail the emission structure of only three hydrogen lines. Comparable features are present in He I and N II lines. For a given spectrum their radial velocities agree with those of the hydrogen components. Furthermore, the velocities of some emission components in lower Balmer lines correspond to those of absorptions in higher Balmer lines and of other ions, such as O II, N II, Si III, up to hydrogen velocities of ~160 km/sec. The final increase in velocity of the heavier elements is noticeably slower (Markova, Kolka, 1987). The above results lead to the model of thin, spherical shells of accelerated expansion, ejected with a 200-day period. Integration of the full line in Fig.3 gives a preliminary velocity law for the hydrogen shells in the envelope of P Cygni. Following a steep rise near the stellar surface, an almost linear increase in velocity is observed between 50 and 350 R_* (V~60...240 km/sec). Assuming that the high velocity absorptions in Fig. 3 are not subject to systematic effects, the weakly indicated sudden increase in acceleration at ~200 R_* could be real.

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