P CYGNI: A HYPERGIANT WELL WORTH WATCHING

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Abstract

The hypergiant P Cygni is discussed, and an invitation for the collaborative observation of this interesting star is issued.

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P Cygni is a hypergiant (an especially luminous supergiant) of spectral type B1Ia (Lamers et al. 1983). The star was discovered in the year 1600 when it had an outburst and reached third magnitude. After rather drastic brightness variations in the 17th century, P Cygni settled down at visual magnitude 4.9, showing only small variations of approximately 0.2 magnitude (Schneller 1957; De Groot 1969). See Figure 1. This star has long been considered the prototype object of the so-called P Cygni-type (PCT) stars, the characteristics of which were recently re-defined by Lamers (1986). With this definition, the PCT stars are located in the upper part of the Herzsprung-Russell diagram (HRD) close to the empirical upper luminosity limit (Humphreys and Davidson 1979), now called the Humphreys-Davidson limit (HDL) (Van Gent and Lamers 1986). PCT stars are believed to represent a relatively short-lived phase of the evolution of massive stars (Lamers 1986) whose close investigation can contribute greatly to our understanding of the physical processes which play a crucial role in this part of the HRD.

Figure 2 shows the upper part of the HRD with evolutionary tracks, including mass loss for stars with initial masses of 60 and 85 $M_{\odot}$ (Maeder 1983). The areas in the HRD where one finds red supergiants (RSG), late WN stars (WNL), and the so-called S Dor variables (center) are marked. The dot-dashed line indicates the HDL. Some other PCT and S Dor-type stars are also indicated: R71 and R81 are S Dor variables in the LMC, zeta1 Sco is a galactic PCT star, and eta Car is a unique object, however, with certain similarities to the other stars marked. Cyg OB2 No. 12 is a galactic supergiant hidden behind about 10 magnitudes of interstellar absorption.

It is thought that the region around the steeply rising part of the HDL represents physical conditions which cause stars to become unstable and lose mass at a greatly increased rate. This increased mass loss drives the star back to the left-hand side of the HRD. In fact, all stars in this area of the HRD vary in brightness and in mass-loss rate, the latter reflected in their changing spectra. The relation, if it exists, between the photometric and spectral variations is still unknown because suitable observations of these stars have hardly been made. This is illustrated by the case of P Cygni.

P Cygni's photometric variations have been studied by many authors from 1786 until today. Periods as long as 18 years and as short as 0.5 day have been derived. An appeal for photoelectric photometry has been made in the past (De Groot 1986). Recently, a compilation of photoelectric observations by many observers, amateurs, and professional astronomers (Percy et al. 1987) has shown that the star varies irregularly with a characteristic time-scale of about one month and a typical amplitude of 0.2 magnitude in V. See Figure 3. This time-scale and amplitude are consistent with those for other B-type supergiants. However, in order to make deductions about the cause of these seemingly irregular variations, it is necessary that they be made over an extended period and sufficiently frequently. Since the star is bright, it is often an awkward object for sensitive professional equipment. Amateur telescopes with their smaller apertures are eminently suited to this type of observation. One good observation every clear night by a number of observers around the globe should go a long way towards keeping close tabs on the photometric behavior of this peculiar star. After nearly four centuries of talking about how interesting P Cygni is, it is time that we should do something to unravel the cause of our curiosity!

Interestingly, the star R81 in the LMC, which is an almost identical twin to P Cygni (Wolf et al. 1981), was recently found to be an eclipsing binary with a period of approximately 75 days (Stahl et al. 1987). Stahl et al. remark that "Since the period of R81 has been found only after extensive monitoring with high precision...this finding may imply that irregular variations reported for P Cyg stars on the basis of less complete data sets may in fact be due to periodic variations." Harmanec (e.g. 1987) has argued on various occasions that both the Be and the P Cyg phenomenon may be due to gas streams in binary systems. Clearly, here is a very good reason for any observer to become serious about the regular photometry of P Cygni!

A relation between the polarization of P Cygni and its brightness has also been noted (Percy et al. 1987). Although polarization measurements of P Cygni are still rather scarce, observations by Hayes in 1985 show that an increase in polarization coincided with a decrease in the star's brightness after a sharp maximum in the light curve. If polarization is taken as evidence for asymmetries in the star's envelope, then the increased polarization can be understood as the result of the asymmetric ejection of a shell which obscured the underlying photosphere and made the star look less bright. Further observations of P Cygni's polarization should give valuable information, but are outside the scope of most amateurs' equipment. These observations should, however, be done by astronomers with access to a polarimeter on a small- to medium-aperture telescope.

The relation between photometric and spectroscopic variations is not clear. Two H-alpha profiles obtained on 24 and 29 June, 1986, show that the strength of this emission line diminished rapidly between these two dates (Figure 4; from Baliunas et al. 1987). This can be explained as a reduction in mass-loss rate, leading to a more transparent envelope which allows us to observe the hotter underlying photosphere of the star. As Figure 3 (where these dates have been marked by vertical lines) shows, between those dates P Cygni's brightness increased significantly by about 0.05 magnitude. It is interesting to note that spectroscopic observations have also revealed some quasi-periodic variations in the radial velocities of the hydrogen absorption lines, indicating the ejection of shells on a time-scale of 60 days or shorter (Van Gent and Lamers 1986).

Besides the necessary photometry, there is now also an urgent need for more spectroscopic observations. Profiles of H-alpha at a resolution of at least 0.25 A will give valuable information about changes in absorption and emission line intensities. Correlation with photometric variations will help identify the cause of the brightness variations and of the mass loss. Similar observations of H-beta and H-gamma would be useful, too. This area is one which is now opening up to amateur observers. They can obtain very valuable data of this bright star which is of such crucial importance for a better understanding of the mechanisms of mass loss and, indeed, stellar evolution near the HDL.

Observers who are interested in collaborating on the investigation of this fascinating star are advised to use 22 Cyg (= HR 7613 = HD 188892; **V** = 4.949, **B-V** = -0.092, **U-B** = -0.523) as a comparison star and 36 Cyg (= HR 7769 = HD 193369; **V** = 5.594, **B-V** = +0.048, **U-B** = +0.028) as a check star. Measurements, preferably on the **UBV** system or a subset thereof, will be gladly received by the author of this article at the address indicated above; they will be acknowledged in the usual way in any subsequent publication. Please refer to the author, too, for any further information if necessary.

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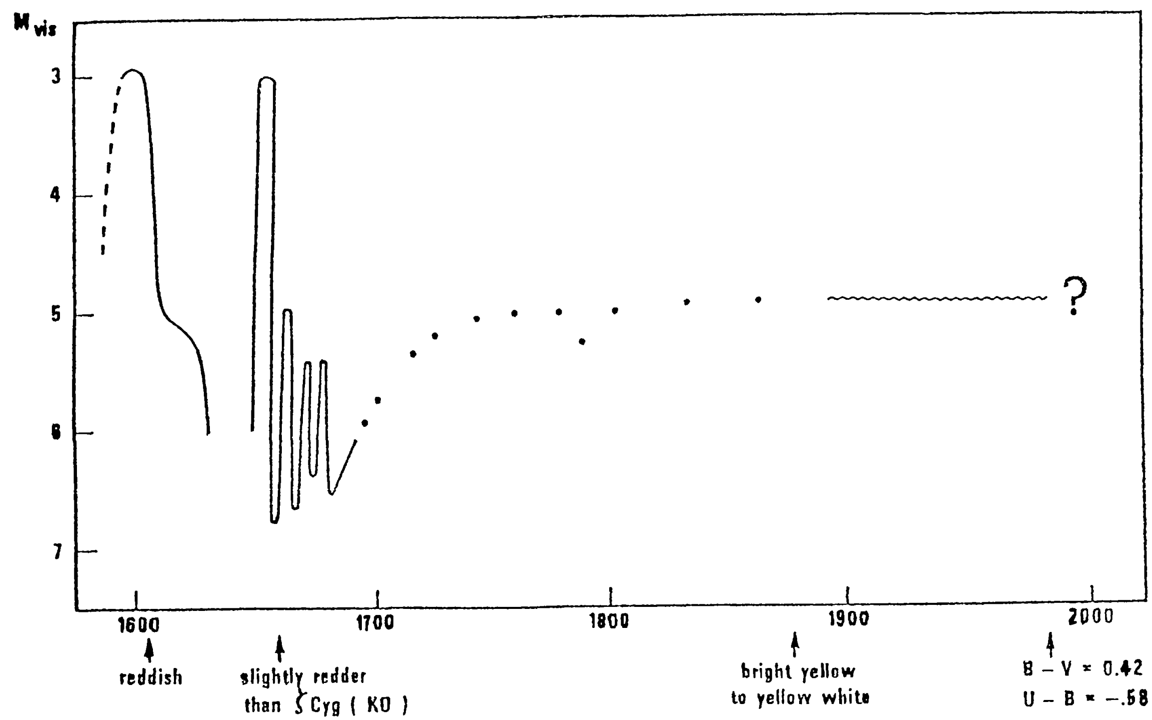

Figure 1. P Cygni's historical light curve from various sources.

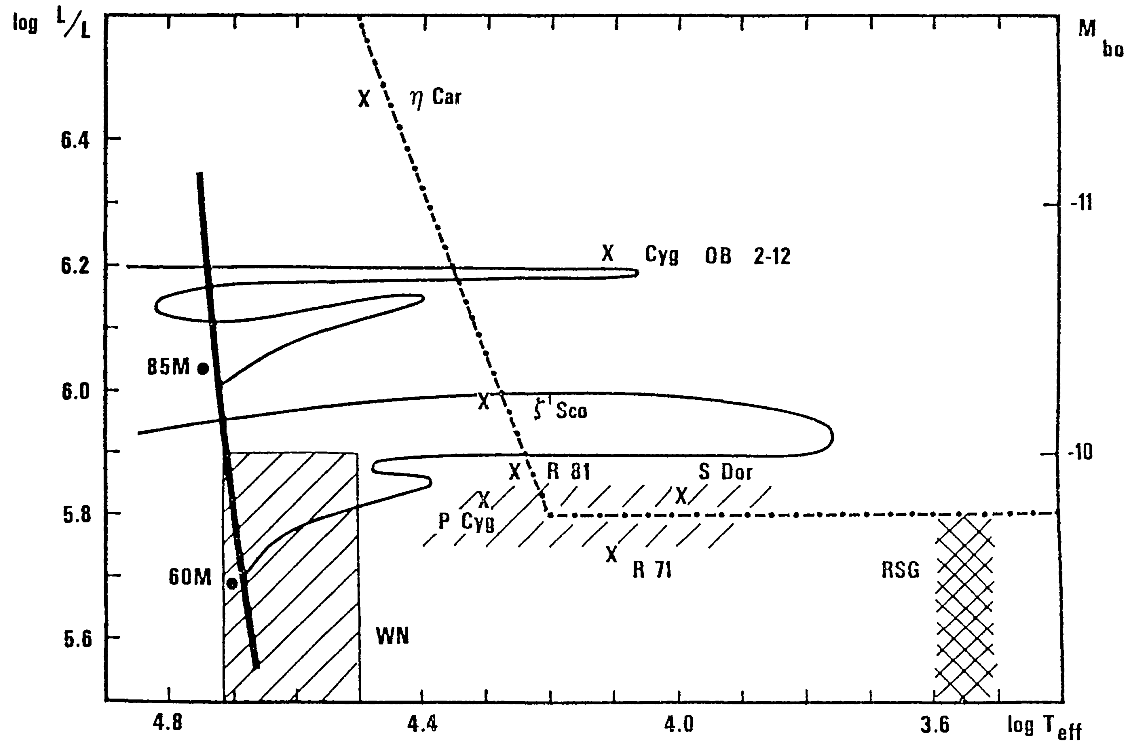

Figure 2. Upper part of the HRD. P Cygni and other similar stars are located in relation to the HDL.

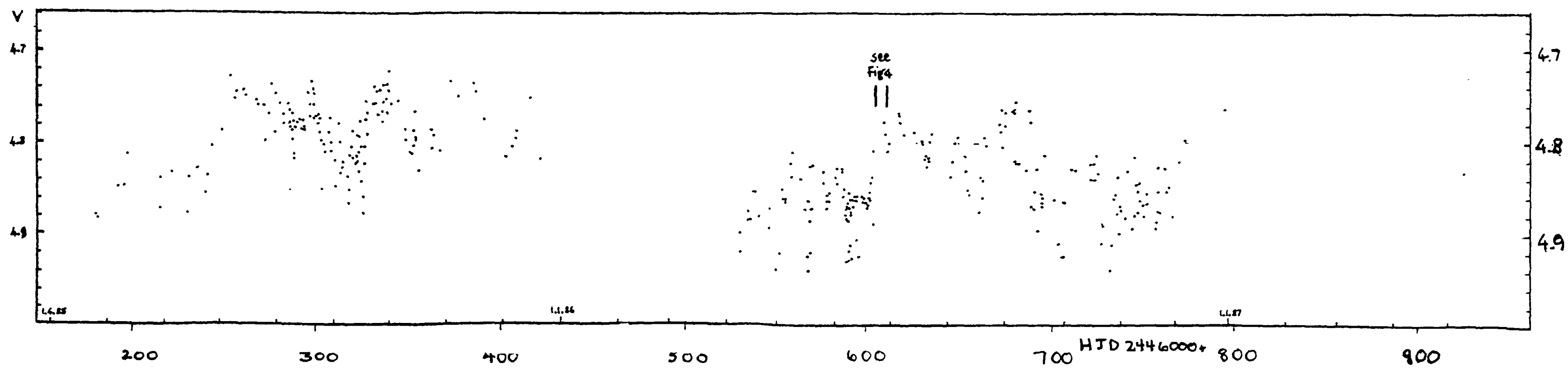

Figure 3. Modern photoelectric V-band light curve of P Cygnicompiled from observations by many amateur and professional astronomers.

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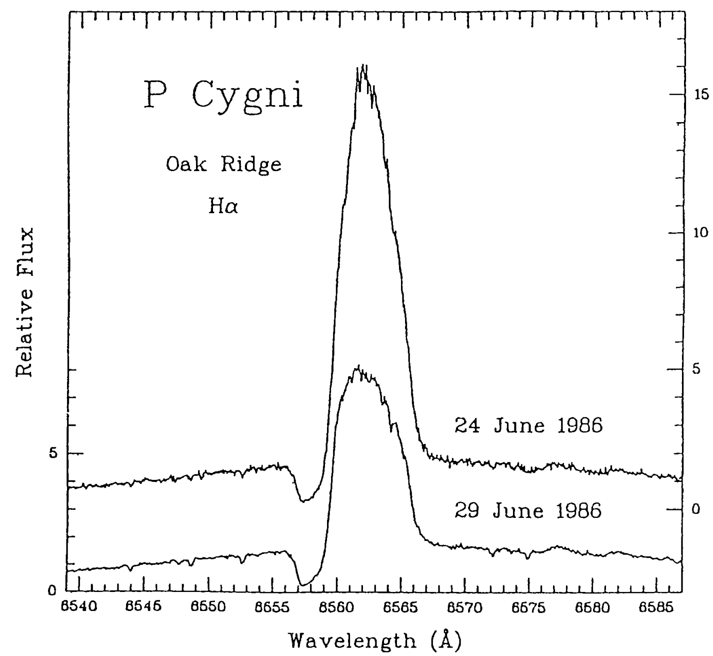

Figure 4. H-alpha profiles of P Cygni from Oak Ridge Observatory.