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# SPECTRAL CHANGES IN V 1057 CYGNI

Since the discovery by G. Welin (1) that the object V 1057 Cygni in late 1969 underwent remarkable changes in brightness and spectral appearence, this object has been followed with great interest. Prior to the outburst, V 1057 (LkHα 190) was known as an advanced T Tauri type star (Herbig (2)) showing only moderate light variations (see summary by G. Welin (3)). Since September 1970 the star has changed both in brightness and spectral type.

During 1970 the brightness of the star remained fairly constant (Meinunger and Wenzel (4)) but declined monotonically during 1971. Various estimates of spectral type indicate that the star may have changed from approximately B3 (Sept. 70) to early F (mid-1972) and the luminosity class has been estimated to III or III-IV over the period; see G.Haro (5) for a summary. Spectral peculiarities and anomalous line shifts have been reported by G.H. Herbig and E.A. Harlan (6).

In view of the extraordinary changes that are taking place on this star it is important to observe the star continuously and to present all information that may be important for describing and understanding the rapid evolutionary change of V 1057 Cyg. The following is a preliminary report on the spectral properties of the star as derived from a number of spectrograms taken in 1971 and 1972 at the Stockholm and McDonald Observatories.

Table 1

| No. | Date | | Instr. | Image-tube | Disp. Å/mm | Spectral region | Spectral type | Lum. class |
|---|---|---|---|---|---|---|---|---|
| 1 | 23/4 | 1971 | S | yes | 33 | Hβ to Hγ | A5 - A7 | ~ IV |
| 2 | 24/4 | 1971 | S | yes | 33 | Hβ to Hγ | A5 - A7 | ~ IV |
| 3 | 20/8 | 1971 | McD | yes | 100 | blue | ~ A7 | |
| 4 | 22/8 | 1971 | McD | yes | 100 | blue | ~ A7 | |
| 5 | 24,25/4 | 1972 | S | no | 59 | blue | | |
| 6 | 7,8,10/5 | 1972 | S | no | 59 | blue | F0 and F5 | III |
| 7 | 11,12,15/5 | 1972 | S | no | 59 | blue | F0 and F5 | III |
| 8 | 5/10 | 1972 | S | yes | 39 | blue | | |
| 9 | 16/10 | 1972 | S | yes | 39 | blue | ~ F1 | |
| 10 | 16/10 | 1972 | S | yes | 39 | blue | ~ F1 | |
| 11 | 17/10 | 1972 | S | yes | 59 | red | | |

Table 1 gives date of observation and instrumentation and dispersion used (S refers to the 1 m reflector of the Stockholm Observatory, McD to the 82-inch reflector of the McDonald Observatory). A few spectrograms were exposed for several nights. No displacement of the iron comparison spectrum was noted over these nights. The resolution for the spectrograms taken with image tube is lower than for those taken without.

The spectrograms were classified on the MK system. Spectral types and luminosity classes are given in Table 1. The spectrum of V 1057 Cyg is rather peculiar and as a consequence the spectral class will be dependent on which criteria are chosen. The lower Balmer lines are broad and shallow and apparently variable in structure (see below) and the K line of Ca II is relatively narrow. As is demonstrated below both the Balmer lines and the K line are in general displaced to the violet.These lines are obviously related to an expanding shell, the metallic lines may be more representative for the stellar object. In our material a spectral classification based on the appearance of the Balmer lines and the K line give an earlier spectral type than what is obtained from the metallic lines. The following is a short description of each spectrogram.

Nos. 1 and 2: Hβ and Hγ broad, no outstanding emission lines present. The metallic line spectrum is well developed indicating a later spectral type than found by others for April - May 1971. The ratio of λ4481 to λ4417 indicates a luminosity fainter than class III.

Nos. 3 and 4: Only a rough estimate of spectral type can be made on this low dispersion spectrogram.

No. 5: Unwidened spectrogram. The spectrum is not conspicuously different from Nos. 6 and 7.

Nos. 6 and 7: The hydrogen lines are strong and broad indicating a spectral type of about F0. The G band is, however, well developed.This together with the appearance of the metallic lines yields spectral type F5, which we feel is more representative for the stellar object. The ratios of λ4172 to λ4226 and λ4417 to λ4481 indicate a luminosity class of III. The profiles of Hγ and Hδ are assymetrical,the red side being steeper than the violet. It is possible that red-displaced emission,which has been observed at Hα, produces such effects. On spectrogram No.6, Hδ is actually split in two components. On this spectrogram Hγ gives a large positive radial velocity (see below).

Nos. 8,9 and 10: The resolution does not permit a detailed study of the metallic line spectrum. Hγ and Hδ are assymmetrical but in the opposite sense as compared to Nos. 6 and 7. The spectral type F1 is derived from the Balmer lines and the K line.

No. 11: This spectrogram is of poor resolution. Weak Hα emission is present on the red side of the Hα absorption line.

These observations indicate, as suggested by Haro (5), that V 1057 Cyg is changing towards a later spectral type. Our estimates of spectral type place the star at later spectral types than found by other investigators. In a private communication to G Rieke et al. (7), G.H. Herbig reports a spectral type of A7 III for mid-1971, in close agreement with our estimates when based on the metallic line spectrum. As noted by G. Rieke et al., this spectral type would give a more congruent picture of the total visual absorption as derived from photometric and polarisation data of V 1057 Cyg.

For spectrograms Nos. 6 and 7 heliocentric radial velocities of various lines were determined. The result is summarized in Table 2 where the mean radial velocity in km/s of the Balmer lines and selected, relatively unblended metallic lines are given with mean errors. The number of lines measured is given in parenthesis. The last column gives the velocity of the Ca II K line.

Table 2

| Spectrogram | Balmer lines | Metallic lines | Ca II K |
|---|---|---|---|
| No. 6 | - | $-12 \pm 7$ (6) | -116 |
| No. 7 | $-57 \pm 8$ (6) | $-24 \pm 7$ (5) | -169 |
| mean of 6 and 7: | | -18 | -142.5 |

On spectrogram No. 6, Hγ and Hδ were the only Balmer lines measured. As mentioned above Hδ appears double on this plate. The violet absorption component measures -328 km/s, the central emission like feature -180 km/s and the red absorption component is centered at +4 km/s. The center of gravity of the Hγ line is displaced to the red by +48 km/s. In the computation of the mean velocity of the Balmer lines on spectrogram No. 7 the H 11 line was omitted. This line is found at +3 km/s and blends are suspected.

The mean velocity of the metallic lines is close to the velocity of -14 to -19 km/s found by G. Courtès et al.(8) and J.S. Miller (9) for the H II region NGC 7000. In April 1971, G.H. Herbig and E.A. Harlan (6) and private communication, observed several of the metallic lines together with the Balmer lines at a velocity of approximately -60 km/s. The K line, the Hα absorption line and a few other lines were found at much more negative velocities.

Hence one cannot avoid the feeling that the region where the metallic lines are formed and which apparently was expanding by some 40 km/s in April 1971 is now settling down to the same velocity as the star itself. This reasoning builds on the assumption that the velocity of the stellar object is close to the velocity of the North America nebula in which the star is supposed to be situated. The large negative shifts observed for the K line and the Balmer absorption lines indicate that material is still driven outwards at a high rate. If the large widths of the Balmer lines are due to a velocity field in an envelope surrounding the star, then the K line is formed over a different region of the envelope. The large changes observed in the structure of the lower Balmer lines show that considerable changes occur in the envelope with time. These variations may be connected to variable Balmer emission.

The hydrogen lines and the Ca II lines are not representative for the stellar object but rather the "chromospheric" or circumstellar regions. Therefore spectral classifications derived from low dispersion spectrograms and based mainly on the appearance of the hydrogen lines and the Ca II lines tell us very little about the temperature characteristics of the stellar object.

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