Low resolution spectroscopy of SS Cygni

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The spectra and their relation to a previous study

Spectra of SS Cygni were taken between 26 July and 24 August this year using using an Alpy600 spectrograph mounted on a Celestron C11 OTA (with 0.63 focal reducer). V-filter magnitudes for SS Cygni at the time of each spectrum were estimated from the AAVSO lightcurve generator for this period. All spectra were flat fielded and corrected for instrument response. The results, with no further processing are shown in the top panel of Fig (1).

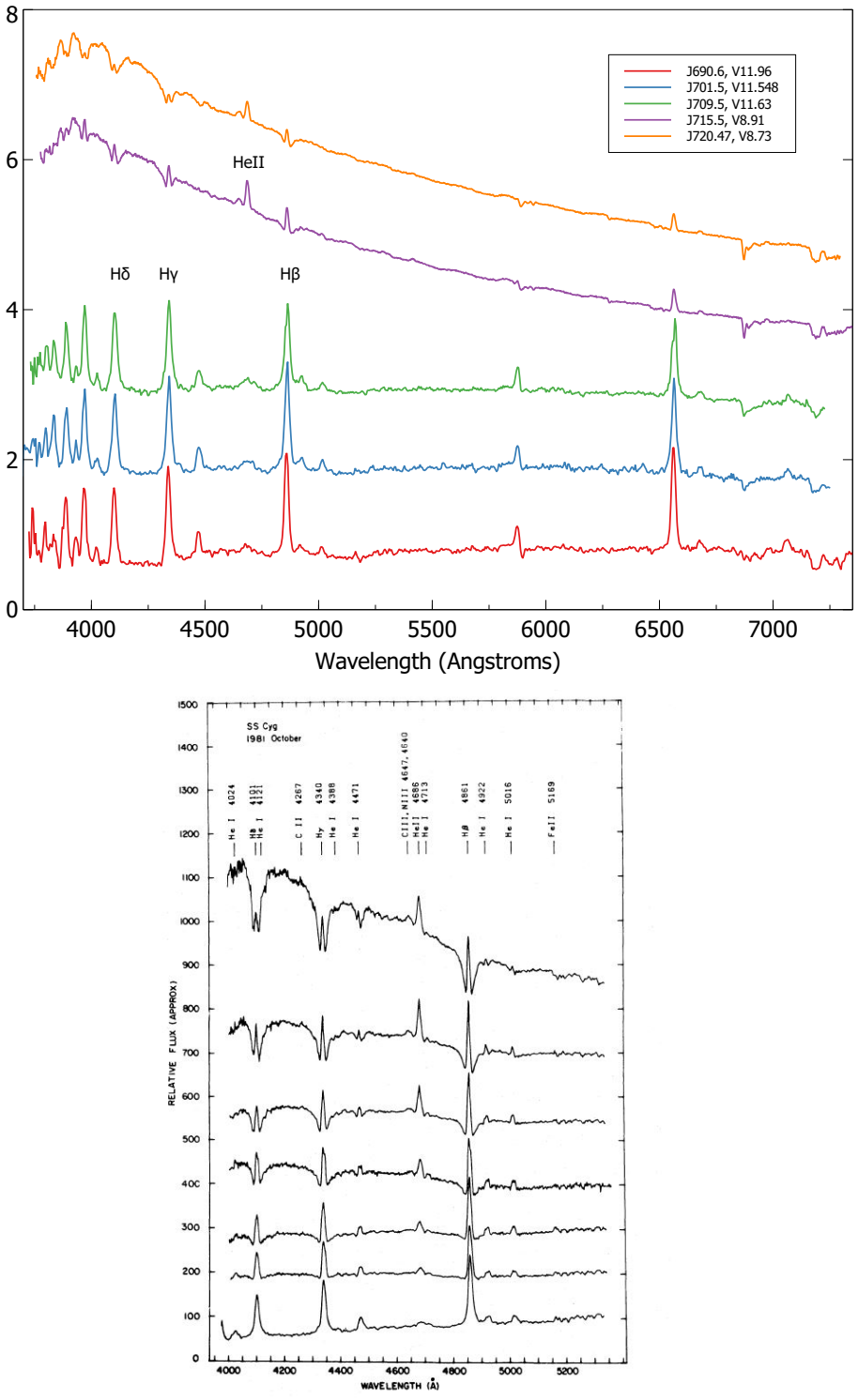

Figure 1: *Top*: Spectra of SS Cygni taken over 30 days (starting on 26 July 2019). The legend refers to the Julian date offset from 2458000, and the V-filter magnitude. Plots are offset vertically and stacked in temporal sequence with the earliest (J = 690.6, in red) at the bottom. This sequence also reflects a brightening transition from magnitudes 12 to 8.7. Some Balmer lines and an HeII emission line feature are identified. *Bottom* Representative spectra of SS Cygni from Fig 5 of Hessman et al [1]

The spectra are comparable with those obtained by Hessman et al [1] - see bottom panel of Fig (1). Both sets show similar trends in the continuum and feature shape dynamics as the brightening occurs.

Continuum analysis

With reference to the continuum: while the binary system comprising SS Cygni is complex, there is a clear change in overall black body temperature associated with these spectra. This is obvious in the last two (J715.5, J720.47) compared to the first three, but, even within the latter, there is some indication of this effect. Thus, as temperature is increased, the roughly linear part of the spectrum between 4000Å and 6800Å has a slope which appears to become increasingly negative. To quantify this (short of fitting a full Planck curve!) I fitted a straight line in this wavelength range; the slopes are shown in Fig. 3. Also shown there are the V magnitudes estimated from the AAVSO light lightcurve

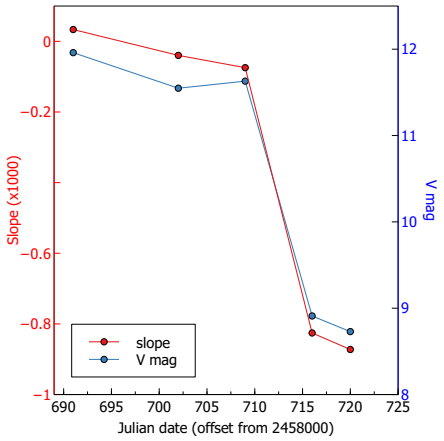

Figure 2: Slopes of best linear fit to the spectra between 4000Åand 6800Å, and V magnitudes for each spectrum

There is indeed a trend of increasingly negative slopes, but a firm rule is prevented by the relation between second and third spectra in the sequence.

Line feature analysis

The Balmer line features show a change from emission only, before the brightening, to a complex of emission and absorption afterwards. This is highlighted in Fig. (**??**) which shows the rectified (continuum removed) versions of the spectra for J690.6, J720 and J715.5 (magnitudes 11.96, 8.91 and 8.73, respectively). Even during the brightened phase, there is clearly some dynamic at work.

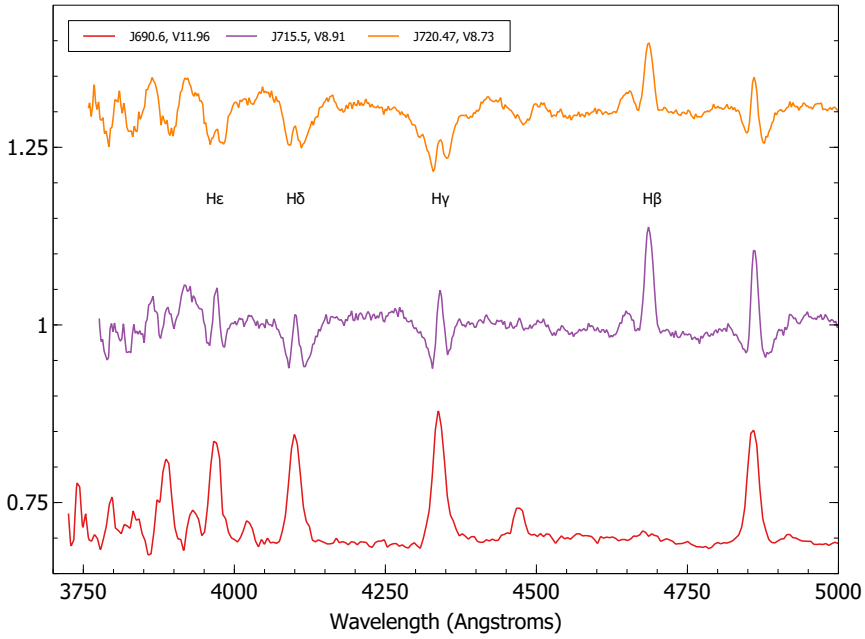

Figure 3: Rectified spectra for J690.6, J720 and J715.5. That for J690.6 has been scaled by 0.1 as its line features have much larger amplitudes than the others

A pseudo 'flux calibration'

The plots in Fig (1) are not flux calibrated; the spectrum amplitudes are relative values only. However, given the availability of concurrent estimates of V-magnitude, I thought it would be interesting to attempt some kind of 'rough and ready' flux calibration. To do this I multiplied each spectrum with a Johnson V-filter profile [2] and summed the result (convolution with the filter centre at correct place wavelength). This gave a notional 'relative magnitude'. I then scaled each spectrum so that these magnitudes were teh same as the measured counterparts. The result is shown in Fig. (4)

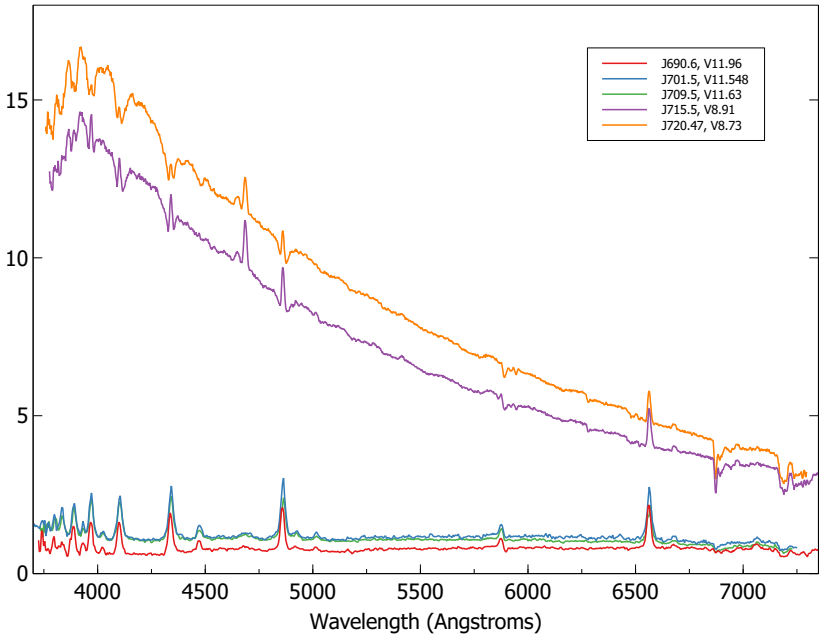

Figure 4: The spectra scaled to give observed V magnitudes.

References

[1] F. V. Hessman, E. L. Robinson, R. E. Nather, and E.-H. Zhang. Time-resolved spectroscopy of SS Cygni at minimum and maximum light. *The Astrophysical Journal*, 286:747–759, November 1984.

[2] Leibniz-Institut fur Astrophysik Potsdam. Johnson-cousins UBVRI filter curves. `https://www.aip.de/en/research/facilities/stella/instruments/data/johnson-ubvri-filter-curves/`.