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Ci Cygni Since the 1980 Eclipse

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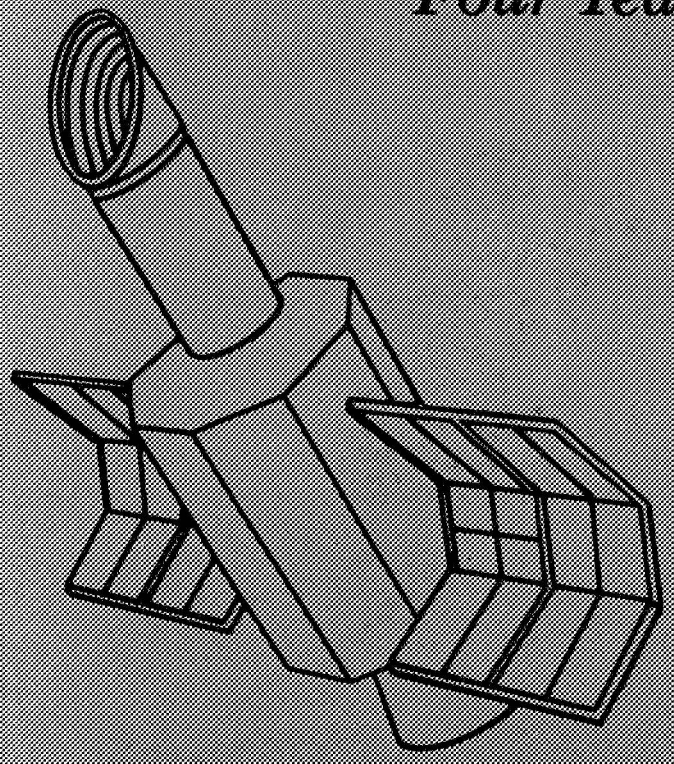

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CI CYGNI SINCE THE 1980 ECLIPSE

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ABSTRACT

Following the 1980 eclipse of the 855 day period symbiotic binary CI Cyg, we were confronted with a data set showing high excitation resonance lines which were largely uneclipsed but brightening on an orbital timescale, and intercombination lines exhibiting pronounced but nontotal eclipses and which were fading on an orbital timescale. Our model invoked a low density dissipating nebula surrounding the hot companion to explain the intercombination lines, and a shock between stellar winds to interpret the resonance lines. Subsequent synoptic observations have revealed continuing changes in the UV emission line fluxes, consistent with those described above, except for the brightening of Mg II and the emergence of strong, not previously seen [Mg V] emission. Post-outburst and phase dependent changes must be included in any interpretation of this system as the archetypal symbiotic binary. We anticipate that critical observations will be made during the 1982 October eclipse.

INTRODUCTION

CI Cygni (HV 3625) is relatively unique among symbiotic stars in that its complex but quasi-regular light variations are indicative of eclipses on an 855 day period (cf. Mattei 1978). Eclipsing symbiotics present not only an *a priori* argument for binarity, but can also be extremely useful in delimiting the physical interaction involved. Other eclipsing systems include AR Pav (Hutchings and Cowley 1982), possibly SY Mus (Michalitsianos and Kafatos 1982), and EG And (Stencel — this volume).

In the course of IUE programs ZACRS (1980) and ZADRS (1981) we have, with the addition of archival data from 1979, extended synoptic coverage of CI Cyg over more than one full orbital cycle, including the 1980 June eclipse. The results of the eclipse study are presented in detail elsewhere (Stencel *et al.* 1982). In this report we wish to detail striking recent changes in the UV spectrum of CI Cyg.

The light curve of CI Cyg can be characterized by outbursts on a many-orbit timescale, with a decay period between bursts, all punctuated by rapid, deep eclipses every 855 days (Bath 1981). Placing the IUE observations in this context indicates that the data were obtained during the later asymptotic decay phase following the 1975 outburst. To our surprise, we discovered that while the intermediate temperature intercombination lines (N III, Si III, O III) were becoming fainter, He II 1640Å, and other high temperature (100,000 K) resonance lines (N V, Si IV, C IV) were actually brightening. At the same time the intercombination lines showed substantial eclipse effects, while the resonance lines were largely unaffected. The Balmer continuum, measured at 3000Å showed a total eclipse but comparatively little secular change. He II also showed a deep eclipse.

THE MODEL

We suggested that the Balmer continuum originates in the exterior of a thick but aging accretion disk. From the integrated light and reddening, we can estimate a total disk luminosity of about 200 $L_\odot$. Scaling laws for accretion disks suggest that a 1 $M_\odot$ white dwarf and a mass transfer rate of 10^{-7} $M_\odot$ yr^{-1} would satisfy the observed luminosity. Using a model for the continuum distribution, Kenyon (1982) argued for a main sequence companion to the red giant in CI Cyg, and our results suggest that if such an object is present (inclination and reddening factors may allow this) a transfer of 10^{-5} $M_\odot$ yr^{-1} would be needed. This latter rate may lead to super-Eddington flows and these may be involved in the outbursts.

To explain the secular behavior, we also postulated a low density dissipating nebula surrounding the hot companion. This may help to understand the changes in the intercombination lines and the He II feature (assuming photoionization-recombination). To explain the behavior of the hot resonance lines requires substantial emissivity at distances large compared to the dimensions of the occulting red giant star. A shock between stellar winds might accomplish this, and may also represent the "steady state" configuration of the system between outbursts.

RECENT SPECTRA

Mg II 2800Å emission presented a puzzlement because throughout 1980 it was observed to decline essentially irrespective of the eclipse phenomena seen in other lines. However, in early 1981 the trend sudddenly reversed and Mg II emission has been steadily strengthening in CI Cyg (see Fig. 1a). One could interpret this behavior in terms of a phase dependent modulation by the binary: bright between phases 0.5-0.75; faint between phases 0.75-0.5. Perhaps this represents a bright spot on the disk where the stream of accreting matter arrives, or a bright quadrant on the red giant star. Either way, the asymmetry is puzzling. Critical observations in spring 1982 will reveal the degree to which the Mg II behavior is modulated in phase.

Contemporaneous with the increasing Mg II emission in the appearance of [Mg V] emission at 2783 Å. This high excitation forbidden feature has not

been detected in any of the UV spectra of CI Cyg preceding 1981, and it has brightened throughout the past year (see Fig. 1b). Although the change in low dispersion sampling procedure has helped to augment the visibility of the 2783Å feature, comparing photowrites leads us to believe that the pre-1982 upper limits are valid. A high dispersion observation in 1981 August showed the feature to be diffuse, with a base width of about 150 km s^{-1}. The Mg II emission in that same high dispersion image showed redshifts with respect to lab wavelengths, much as though only the emission portion of a P Cygni profile was detected. This is reminiscent of P Cyg Mg II features seen in other interacting binaries containing late type stars (Stencel 1981). The emergence of [Mg V] must hail a new density threshold for the expanding nebula, and suggests that other forbidden lines may strengthen prior to a new outburst. Again, continued observations are critical.

OUTLOOK

The next eclipse of CI Cyg is fast approaching (October 1982), with ingress in the UV lines likely to begin before July. In addition to the secular changes in Mg II and [Mg V], their eclipse variations are worthy of close study. Also the odd behavior of the Si IV 1393/O IV] 1402 ratio which decreases dramatically during eclipse, deserves reobservation, as does the peculiar mid-eclipse flare-like brightening which is present in the optical data and suggested in the UV line variations. Deeply exposed high dispersion observations will also prove of value.

ACKNOWLEDGMENTS

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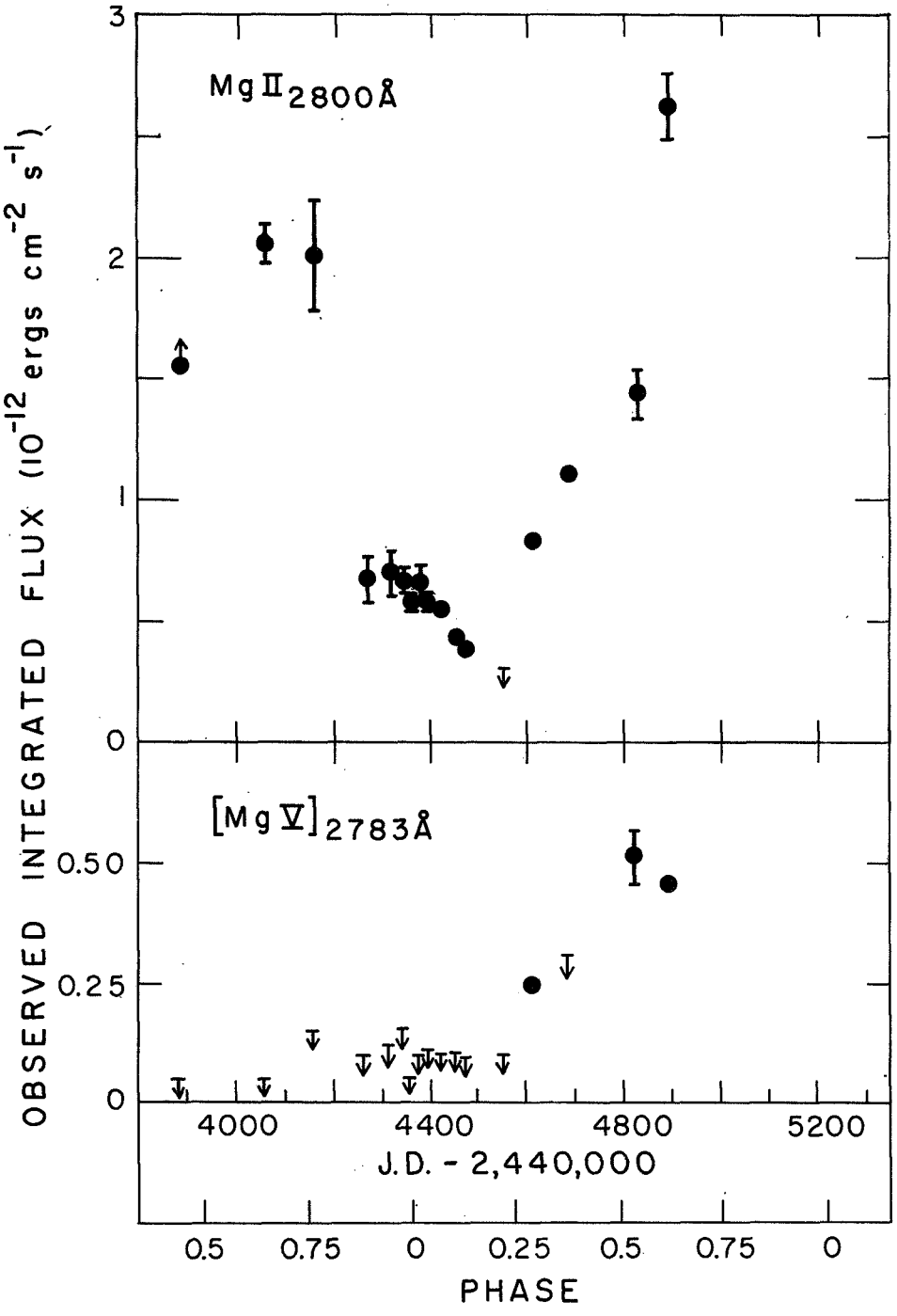

Figure 1. Temporal line variations in the spectrum of CI Cygni.