UV OBSERVATIONS OF THE 1981 ECLIPSE OF 32 CYGNI

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ABSTRACT

Preliminary results of an extensive set of high dispersion UV spectra of the supergiant eclipsing system 32 Cyg are detailed and contrasted with spectroscopic studies of other ζ Aur systems.

INTRODUCTION

32 Cygni (K5 Ib+B6 V) is a member of the ζ Aur class of 'atmospheric' eclipsing binaries. This group includes ζ Aur, 31 Cyg, 32 Cyg, ζ Aur, ζ Aur, with orbital periods ranging from 972 to 9890 days (Wright 1970; Hack 1981). Historically, optical studies have used the B dwarf stars in such systems to probe the cool supergiant's outer atmosphere. Such data have formed a cornerstone in our knowledge of stellar chromospheres. We approached ultraviolet observations in this spirit and found that as a bonus, information concerning binary star interaction arises.

The archetype, ζ Aur, underwent eclipse in late 1979, and Chapman (1981) has reported that the mid-eclipse UV spectrum is dominated by numerous emission lines. Comparing line strengths at second contact and mid-eclipse allowed us to determine that the hot lines are formed in a shell/halo around the B star rather than in a cool star transition region (Stencel and Chapman 1981). Outside of eclipse, we also discovered pronounced redshifted absorption, in the resonance lines of Mg II and C IV, which occurs only near time of secondary minimum. Chapman (1981) has proposed an accretion shock structure to explain this. It was against this background of results that we examined the subsequent eclipse of 32 Cyg. Unlike the central eclipse of ζ Aur however, 32 Cyg experiences a grazing occultation.
OBSERVATIONS

As a result of our efforts in programs MF2YK, CBCRW and OD46B, we have achieved fair synoptic coverage of the 1147 day orbit of 32 Cyg since late 1978. As a fortunate consequence of time trades with T. R. Ayres who was monitoring Capella, we obtained 24 sets of LWR+SWP spectra during March and April 1981. These spectra very clearly show the gradual extinction of the B star continuum and the development of a rich emission line spectrum at mid-eclipse. We note good agreement between observed and predicted times of eclipse.

ANALYSIS

The large amount of data poses a challenge to efficient analysis strategies. Our efforts are focused along the following lines. First, we have selected the longwave end of the SWP images (1600-2000 Å) as a region optimized for absorption line curve-of-growth studies. We have measured equivalent widths for a thousand lines of Fe I and Fe II to examine the height dependence of excitation and density in the K supergiant's outer atmosphere. The results are shown in Figure 1, and argue for the existence of a chromosphere, much as did the optical work of Wright (1959), with two important distinctions: we can probe to much greater distances in the UV and we have evidence for a geometrically extended chromosphere. This latter point is of interest in current cool star research (cf. Stencel 1982).

Second, we have measured emission line and continuum fluxes and velocity shifts in an effort to correlate these with tidal distortions observed photometrically by E. Guinan (private communication). Although substantial flux variations occur in many emission lines, they appear uncorrelated with the optical variations. Monitoring the velocity shifts in the multiple absorption components in the Mg II lines reveals no substantive shifts during the 1981 eclipse interval. In fact, repeated observations during 8 hour intervals near first and fourth contacts place stringent limits on the scale size and filling factor of "prominence-like" structures in the K star atmosphere, because little profile variation was noted.

Third, our observations spanning the interval near secondary minimum show pronounced changes in Mg II absorption and Fe III emission features, suggesting accretion shock structure with a scale size comparable to the orbital separation (cf. Chapman 1981). With secondary minimum approaching in March 1983, it would be prudent to monitor this system during the fifth year of IUE operations.

Finally, progress is being made in realistic models for calculation of the emergent radiation from these systems. Hempe (1982) has developed a generalized Sobolev method for three-dimensional flows with local nonradiative coupling. With this escape probability approach, he has qualitatively reproduced the phase variations of line profile shapes in ζ Aur. It is hoped that this approach will lead to accurate supergiant mass loss rate determinations.
OUTLOOK

1. Our experience in monitoring the ζ Aur systems suggests to us that understanding the nature of the binary interaction will require careful observation of secondary minimum passage, particularly in the UV. This should reveal details of the proposed accretion shock structure. One immediate application may be in the case of ε Aur (eclipse 1982-84) where the "mysterious secondary" may be an extended shock structure around a B dwarf. This hypothesis suggests strong changes may be seen in UV and the Balmer lines (cf. Chapman et al. -- this volume).

2. The ζ Aur system interpretation may prove useful in application to related types of binaries, particularly the symbiotics and Ba II binaries. In each instance, similarities of spectral details (P Cyg features, line velocities) support the suggestion that comparable interaction processes are involved.

3. The ζ Aur systems will continue to play an important role in cool star outer atmosphere research. Three ways in which this will occur include: (a) exploration of extended chromospheres; (b) discovery of new fluorescence mechanisms with a known source of excitation (viz. Fe II UV 191), and (c) improvements in stellar wind and mass loss rate data.

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REFERENCES

Stencel, R. 1982, in Second Cambridge Workshop on Cool Stars, ed. M. S.
Fig. 1. Excitation temperature with height variation in the chromosphere of the K supergiant in 32 Cyg.