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ASYMMETRY IN ZETA AURIGAE CHROMOSPHERES

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ABSTRACT

The zeta Aurigae systems provide an opportunity to study the lowest levels of supergiant primaries. At phases very close to ingress and egress the radiation of the hot secondary passes through layers of the late supergiant primary dense enough to shield them from ionizing radiation, but not so dense as to absorb the background continuum seen in the SWP camera. The combined effects of continuum and line absorption is to reduce the total amount of radiation in the ultraviolet--i.e., an atmospheric eclipse. Parsons, Ake and Hopkins (Ref. 1; henceforth PAH) produced evidence that the atmospheric eclipse of the zeta Aur system 22 Vul is asymmetric. The eclipse of zeta Aur itself has long been known to exhibit asymmetry and variability in optical observations We look for IUE evidence of asymmetry in these two zeta Aur-type systems.

Keywords: Stellar chromospheres, Binaries, stellar rotation.

1 INTRODUCTION

Zeta Aurigae eclipsing binaries consist of a hot main sequence star orbiting a late-type supergiant primary. The dwarf companion makes a good probe of the primary's extended atmosphere. Optical observations to probe the lower chromosphere in this fashion have demonstrated that the lower chromosphere is asymmetric and the scene of considerable variability between orbits (Ref 2) The secondary's continuum, which dominates at ultraviolet wavelengths, is especially valuable as a probe of the primary's atmosphere in the case of observations made with IUE, where the continuum spectrum is completely dominated by the secondary.

Previous observations of the continuum of 22 Vulpeculae have demonstrated that the egress and ingress sides of the eclipse are not symmetric. PAH found that comparing the intensity of integrated radiation in 50 A bands in the far UV between comparable ingress and egress phases suggested a strong asymmetry in 22 Vul. This effect is particularly pronounced in the vicinity of 1650 A. Absorption in the ultraviolet is due not only to continuum absorption, but also to absorption from numerous lines, especially those due to Fe II (see Figure 1).

Given the strong asymmetry already reported in zeta Aur based on the optical observations, attention should be paid to the question of asymmetry in the UV as well. Although this task is complicated by the fact that zeta Aur has been only sparsely observed at egress, we here make a preliminary report on this question, as well as presenting new observations of 22 Vul supporting PAH's previous conclusions.

2. OBSERVATIONS

We have reported the discovery in IUE observations of the presence of narrow, strong low-temperature absorption lines due to Cl I, C I, N I, O I, and Ni II in 31 Cygni (Ref. 3), 22 Vul and zeta Aur (Ref. 4). These lines, observed approximately one week after egress and before ingress, respectively, of the blue dwarf component eclipse behind the cool supergiant, were attributed to the coolest part of the reversing layer. Such lines are produced by the shining of the hot dwarf companion's continuum through the edge of the supergiant's so-called "reversing layer" (near the temperature minimum), provided that the source region is sufficiently shielded from the ionizing radiation of the hot dwarf companion (Ref. 4). In the case of zeta Aurigae such lines have been well observed at ingress but not at egress

We here report two observations of zeta Aur which we obtained on Jan. 18, 1988 (SWP32744H and SWP 32745H) and compare them to nine IUE archived observations. The complete list of observations is given in Table 1a. High resolution observations are indicated by an 'H' suffix and low resolution by an 'L' suffix. In addition we report five new observations of 22 Vul which we discuss along with thirteen observations previously reported by PAH. A list of the 22 Vul observations is given in Table 1b. All observations were made with the large aperture. Data was reduced and analyzed at the IUE RDAF in Greenbelt on the IUE VAX.

In Figure 1 we have plotted the wavelength band around 1650 A for the two observations of zeta Aur corresponding to phases +0.44 and -0.42. The phases were determined using the period and mid-eclipse epoch taken from Wood (Ref. 5):

$$JD\ 2432553.666 + 972.162 \cdot E \qquad (1)$$

where E is the number of orbits since the eclipse

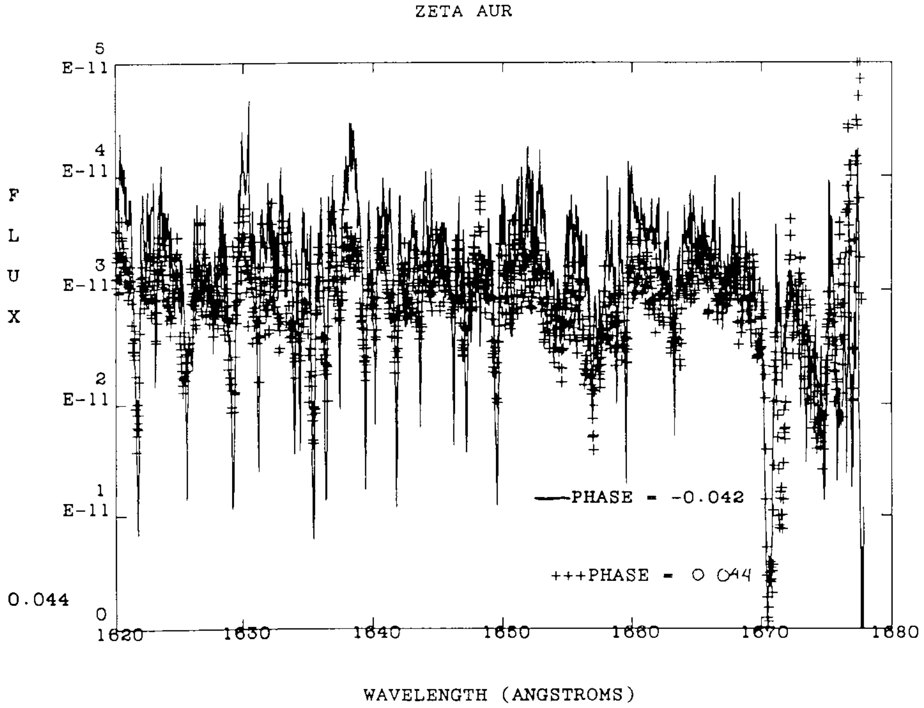

Figure 1. Flux in units of ergs/s/cm^2/A of Zeta Aurigae at the phases indicated. Solid line is from observation SWP7054H (Nov. 1, 1979); crosses from SWP32746H (Jan. 18, 1988).

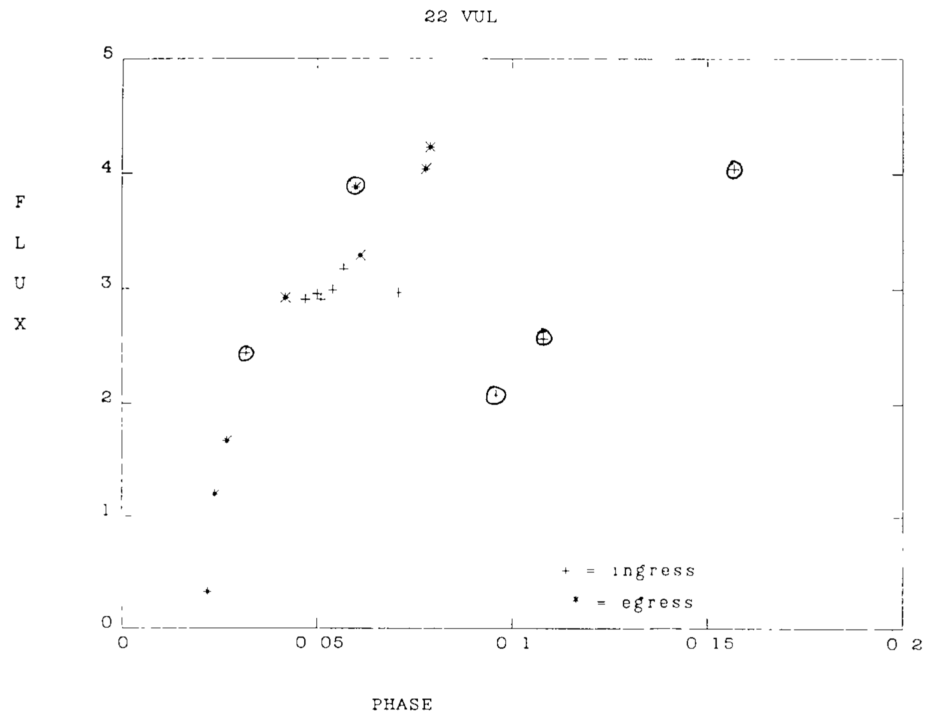

Figure 2. Integrated Zeta Aur flux in wavelength range 1625 A to 1675 A in units of 10**-12 ergs/s/cm^2 plotted against absolute phase.

Table 1

LIST OF OBSERVATIONS

Image	Date (year/day)	phase
	a. zeta Aurigae	
SWP 6545H	1979/260	-0.088
SWP 6562H	1979/261	-0.087
SWP 7141L	1979/318	-0.029
SWP 7157L	1979/320	-0.027
SWP 7195H	1979/324	-0.023
SWP 7805H	1980/029	+0.045
SWP 8090H	1980/091	0.069
SWP 8619H	1980/091	0.091
SWP25473H	1985/079	-0.023
SWP32744H	1988/018	+0.044
SWP32745H	1988/018	0.044
	b. 22 Vulpeculae	
SWP17794L	1982/240	+0 061
SWP19811L	1983/115	0 024
SWP23673L	1984/255	-0.071
SWP23690L	1984/228	-0.057
SWP23694L	1984/229	-0 054
SWP23705L	1984/230	-0.051
SWP23707L	1984/230	-0.050
SWP23715L	1984/231	-0.047
SWP23868L	1984/248	+0.022
SWP23879L	1984/249	0.027
SWP23915L	1984/253	0 042
SWP23991L	1984/262	0.078
SWP23993L	1984/262	0.079
SWP25678H	1985/103	-0.157
SWP25775H	1985/115	-0.108
SWP25800H	1985/118	-0.096
SWP25934H	1985/134	-0.032
SWP26106H	1985/157	-0.060

of January, 1948

3 CHROMOSPHERIC ASYMMETRY

Our objective is to determine whether the amount of chromospheric material between us and the B star differs between ingress and egress. A plot of the integrated flux of Zeta Aurigae from 1625 A to 1675 A as a function of absolute phase shown in Figure 2 shows no significant difference between the ingress and egress phases. This seems puzzling in view of the asymmetries reported in the optical spectra. A direct comparison of this part of the spectrum shown in Fig. 1 from two small aperture observations suggests that there are differences between phases -0.042 and +0.044 in terms of the strengths of various absorption lines--some stronger at ingress and others at egress. Unfortunately, small aperture spectra cannot be used to compare the continua because sensitivity to pointing accuracy.

In Figure 3 we have plotted the integrated flux from 1625 A to 1675 A for 22 Vul as a function of absolute phase for both ingress and egress. The new points not taken from PAH have been circled. It is clear that the addition of these new points strongly confirms PAH's conclusion that the atmospheric eclipse is asymmetric in 22 Vul.

Comparing Figures 2 and 3 it is clear that the eclipse in 22 Vul begins symmetrically but departs from symmetry at a phase greater than about 0 05. Further, the pronounced dip at ingress is suggestive of some sort of feature in the chromosphere. PAH suggested a gas stream to the hot component or clumps in the atmosphere (perhaps related to magnetic fields). The asymmetries observed in the optical observations of zeta Aur were, by contrast, attributed to the effects of the

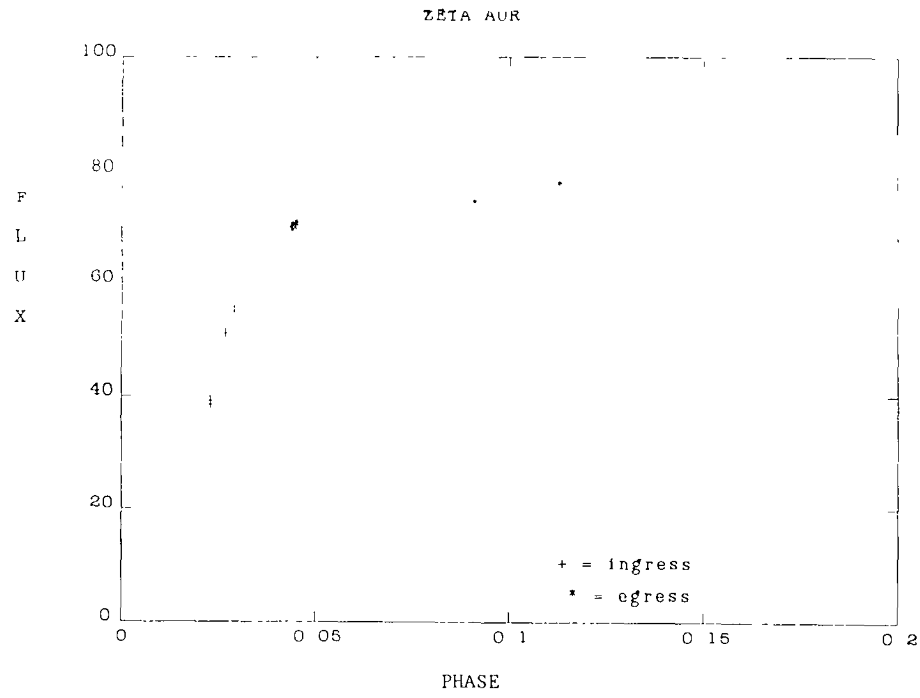

Figure 3. Integrated 22 Vul flux in wavelength range 1625 A to 1675 A in units of 10**-12 ergs/s/cm^2 plotted against absolute phase Circled points are from present research, other points from PAH.

ionization front due to the B star on the rotating chromosphere of the supergiant (Ref. 6).

It is of interest that the feature first reported visible during the August, 1984 ingress of 22 Vul is still visible during the April, 1985 ingress Unless the system is co-rotating, this fact renders suspect the hypothesis that a single stationary clump in the chromosphere accounts for the absorption in both cycles. Co-rotation (requiring a rotational velocity of the primary of order 10 km/s) would seem inconsistent with the rotational velocity which we have previously derived for the primary, viz. 2.4 $\pm$2.5 km/s (Ref. 5).

All our statements are preliminary. 22 Vul should be examined thoroughly during a single eclipse in order to ascertain whether the asymmetry is really a permanent feature. In the case of zeta Aur the coverage at ingress should be extended further from eclipse.

4. ACKNOWLEDGEMENTS

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