Voyager Observations of Zeta Tau

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INTRODUCTION

Zeta Tau (HD 37202) is a well known Be/shell star of spectral type B1 IVe and vsin(i) = 220 km/sec (Slettebak 1982). Its visual and UV variability have been studied extensively (Heap 1975; Hubert-Delplace and van der Hucht 1978; Hubert-Delplace et al. 1983; Dawanas and Hirata 1984; Harmanec 1984). Zeta Tau has also been found to be a binary with an orbital period of 132.97 days (Harmanec 1984). Irregular light variations have been observed (Hoffleit 1982) and long term variations not associated with the 132.97 day period have also been seen (Hubert-Delplace et al. 1983).

OBSERVATIONS

Observations of Zeta Tau have been done with both Voyagers 1 and 2 since 1978. The Voyager spacecraft contain nearly identical objective grating instruments which cover the 500-1700 A spectral region. The effective wavelength resolution is about 15 A and their limiting flux is 2.0×10^{-13} ergs cm^{-2} sec^{-1} A^{-1} at 1000 A. Photometrically, the spacecraft are stable to <2%. Further discussions of the instruments and the method of data analysis can be found elsewhere (Polidan, Stalio and Peters 1986).

RESULTS

Figures 1 and 2 show two observations of Zeta Tau separated by 503 days. These observations show that in the spectral region shortward of Lyman α, the 950 - 1150 A flux has increased by about 40% while in the region longward of 1300 A the flux has increased by about 30%. Figure 3 shows the ratio of the 81/082 observation (JD 244 4687.4) to the 79/310 observation (JD 244 4184.3). Shortward of 1200 A, there seem to be changes in features at 975 A (C III] 977 A / Ly γ 973 A) and at 1020 A (Ly β / Si II 1012, 1016, 1021 A). The observed change in the continuum flux is probably associated with a change in the effective temperature of the underlying B star, though changes in the ubiquitous Fe III lines as the cause cannot be completely ruled out.

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Figure 1. Voyager observation of ζ Tau done on 79/310.

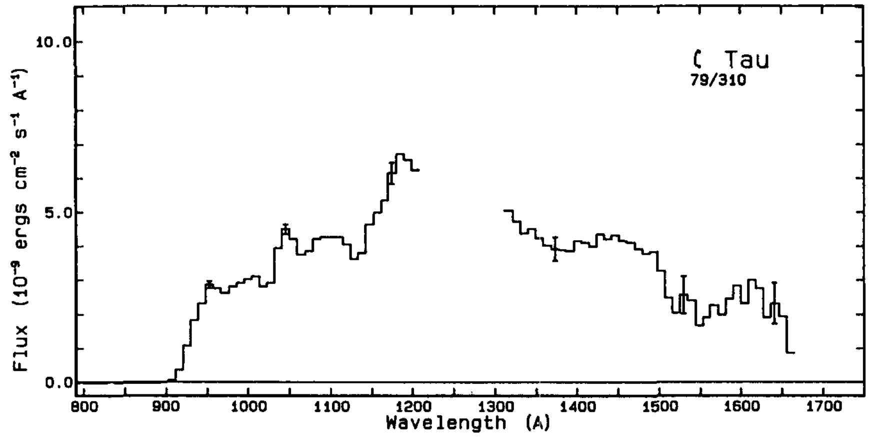


Figure 2. Voyager observation of ζ Tau done on 81/082.

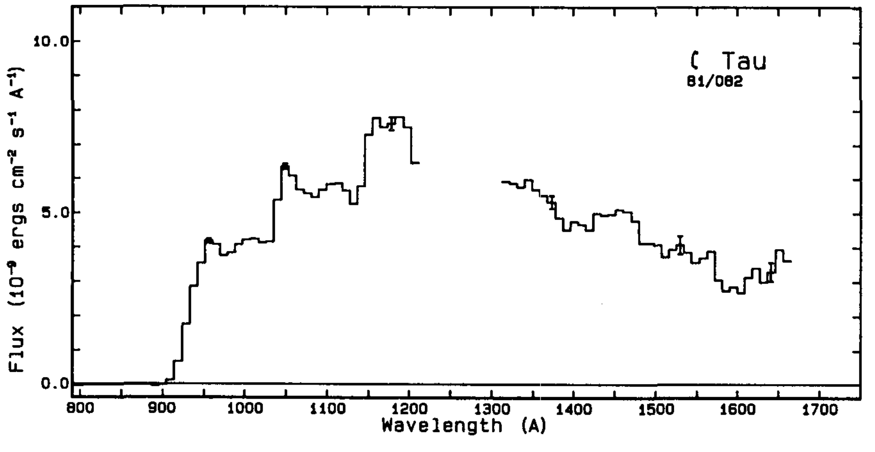
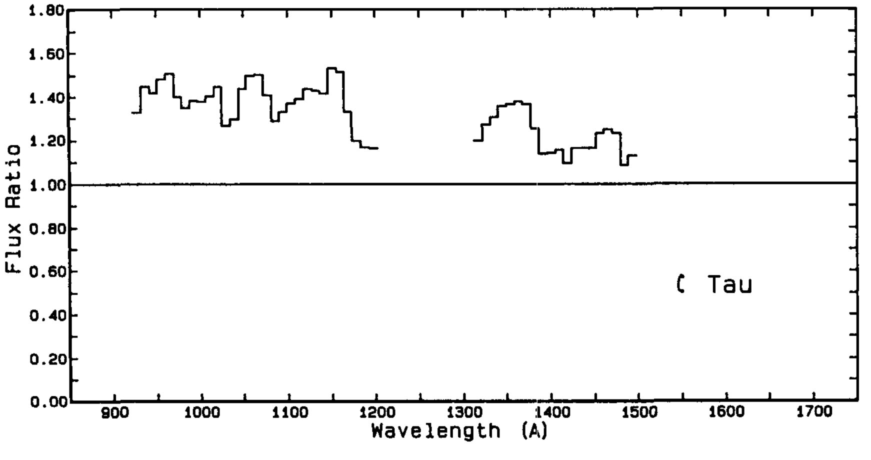


Figure 3. The ratio of two Voyager observations separated by 503 days.



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Support for this latter case comes from observed variations in the Fe III resonance line region near 1120 A. The line variation occurring in the Voyager spectral region is consistent with IUE spectra of Zeta Tau taken during this same time period. In the IUE spectral region, there are clear changes in the low ionization shell lines but the Fe III lines, however, show no change.

As is stated in the paper of Peters and Polidan in this volume, 30 to 70% of the total flux of the Be star emerges shortward of 1700 A, i.e., the flux sampled by Voyager is dominated from emission by the photosphere and not the surrounding gas and dust. Thus changes in the photospheric effective temperature will be expected to cause ionization changes in the envelope. This seems supported by the IUE observations. These results coupled with the results of Peters and Polidan clearly show the need to include the changing level of photospheric flux in future models of Be stars. A detailed investigation of the relationship between the line flux variability seen in IUE and the photospheric variability seen in Voyager for Zeta Tau is currently under way.

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DISCUSSION FOLLOWING CARONE

Snow:

Were there any simultaneous or contemporaneous observations in other wavelengths, particularly the infrared?

Carone:

The *Voyager* ζ Tau observations were obtained as part of two calibration programs, we suspect without knowledge of its Be characteristics, and so any simultaneous observations at other wavelengths would be coincidental. We are searching for these. For recent and future observations, coordinated observations have been obtained or are planned.

Snow:

I think it is impossible to properly interpret changes seen in the far-UV without knowing what happened at the same time elsewhere in the flux distribution. I implore you to try to get optical and IR data in conjunction with your upcoming *Voyager* observations.

Carone:

The Voyager spacecraft directly sample the photosphere of the underlying star. Something like 60% of the total flux of the star is emitted in the spectral region covered by the *Voyager* spacecraft (912-1700 Å). A much smaller amount is emitted in the optical/IR. Observations in these spectral regions are mainly sampling the surrounding gas. Therefore, observations in the far UV and those in the optical/IR are looking at two different components in the Be star system. If we are to understand what changes are induced in the surrounding gas by 40% variations in the underlying B star then we must, as you have stated, have simultaneous far UV, UV, optical and IR observations.