LINE STRENGTH VARIATIONS IN β CEPHEI

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ABSTRACT

The line strength variations of the resonance line of C IV (1550Å, 2s ^2S - ^2P) observed by OAO-II have been confirmed by IUE observations. In addition, the NV resonance line (1204Å, 2s ^2S - ^2P), the Si III line (1206Å, 3p ^1P- ^1D, multiplet 11) and the Si IV resonance line (1395Å, 3s ^2S - ^2P) all vary in line strength essentially in phase with the C IV variation. The (preliminary) period of the variation is 6.02/12.04 days.

INTRODUCTION

Observations of β Cephei taken by OAO-II in 1971 revealed a mysterious variation in the C IV doublet at 1550Å (ref. 1). The doublet appeared to disappear totally, but this was an effect of the coarse resolution of OAO-2, since each line clearly appears in all of the IUE observations. IUE observations were taken October 10, 1978 (day 285) and February 24 to March 10, 1979 (days 55-71). The variations detected by OAO-II have been confirmed and other strong lines have been observed to emulate the C IV variation.

OBSERVATIONS

The October 10, 1978 spectra were exposed for 20 seconds. Since the 1550Å region is in a valley of low spectral sensitivity, the February - March exposures were incrementally increased to 50 seconds, and then decreased to 20 seconds. In this manner, the observations around February 26, 1979 provide the most reliable equivalent widths of C IV and, yet, the spectra could be searched for variations in other lines.

One scan on October 10, 1978 was lost due to confusion of the star tracker by the apparent visual companion located at 250°, 13.5 arsec distant with Δm = 4.7 mag. (references 2 and 3). Subsequent observations used an offset in the star tracker reference point to compensate for the apparent companion when it was in the field-of-view.

DATA REDUCTION

The data has been photometrically corrected with the new intensity transfer function. The relative net flux for order 89 (which contains 1550Å) was obtained by estimating the background flux at the edge of the order, subtracting it from the gross spectrum and applying the $(1+ax^2)\ \mathrm{sinc}^2\, x$ correction with a = 0.01. When each line of the doublet appeared clearly singular, each line's equivalent width was measured separately and added together. Since the lines blend together as their strength increases, such cases necessitated measuring a single equivalent width covering both lines.

Table I lists the IUE exposure number for the short wavelength prime camera (SWP), the observation midpoint time, and the total equivalent width. Figure 1 illustrates the variation of the C IV line strength over a 6.02 day period. (Zero time has been arbitrarily selected as day zero of 1978). If the data were plotted for a 12.04 day period, the crosses would appear between phases zero and 0.5, and the circles would appear between phases 0.5 and one. Visual inspection of the distribution of crosses and circles clearly shows the nearly perfect similarity. If this similarity did not exist, one would choose the 12.04 day period as the more likely period.

Figure 2 illustrates the variation observed in the C IV doublet. At minimum strength (ϕ = 0.94), the lines are clearly separable and their strengths are in the expected 2:1 ratio. As their strengths increase, the weaker (blue) component increases more rapidly than the red component, and extends its absorption further to the blue than the red component extends to the red. Furthermore, even at maximum strength (ϕ = 0.41), the region between the lines is never completely absorbed.

It is not yet clear whether this strong variation of the blue component is enhanced by the presence of other absorption lines varying in strength or not. Additionally, at some phases (e.g. ϕ = 0.23), the red wing of the blue component exhibits a very sharp rise. Figure 3 illustrates the same effects in the N V 1240Å doublet. This doublet does virtually disappear at minimum strength (ϕ = 0.94). Both components first appear to the blue side of their rest wavelengths. At maximum strength (ϕ = 0.41), both components are near their rest wavelengths, and then shift redward as the phase progresses. A similar effect occurs in the C IV lines, but it is much less obvious. Since the N V is a well separated doublet there is no blending between the components, and the effects are more dramatic than in C IV.

The Si III singlet at 1204Å and the SI IV doublet at 1395Å also show the same periodic line strength variation. Weaker lines do not exhibit any strong 6.02 day variation.

CONCLUSIONS

The OAO-II observations have been confirmed by the IUE observations which provide much better data for theoretical analysis. The 6.02 or 12.04 day variation appears in the strongest lines of C IV, N V, Si III, and Si IV and unusual line profiles are observed. Whatever mechanism causes these variations, it is most effective in the outermost layers of the stellar atmosphere. The previously hypothesized tidal distortion by an unseen binary companion for either $P = 12.04d$, $\varepsilon = 0$ or $P = 6.02$, $\varepsilon = 1/2$ does not explain the wavelength shifting. If a tidal distortion occurred, one would see both bulges, one contributing to the blue and one to the red wing. Pending further analysis which awaits receipt of the remainder of the processed data from the IUE observatory, we conclude that the mechanism must be pulsational with a 6.02 day period.

REFERENCES

1. Fischel, D. and Sparks, W. M.: Ultraviolet Observations of β Canis Majoris and β Cephei in Scientific Results from the Orbiting Astronomical Observatory (OAO-2), NASA SP-310, 1971, pp 475-478.

2. Burnham, S. W.: A General Catalogue at Double Stars, part II, Carnegie Institution of Washington, 1908, pg 945.

3. Hoffleit, D.: Catalog of Bright Stars Yale University Observatory, 1964, pg 336.

TABLE I

SWP	Date GMT	W
2428	285:08:14:40	2.980
2929	285:08:49:50	3.290
2930	285:08:18:00	2.890
2931	285:09:45:36	3.059
2932	285:10:13:05	3.915
2933	285:10:40:10	3.451
2934	285:11:08:30	3.663
2935	285:11:36:08	3.626
2937	285:12:31:47	3.066
2938	285:13:00:12	3.292
4361	55:05:20:12	1.533
4362	55:05:48:35	1.315
4370	55:17:16:53	0.878
4384	56:23:07:32	0.951
4386	57:00:06:26	1.313
4387	57:00:35:02	1.802
4395	57:05:52:44	1.579
4405	58:04:22:35	2.631
4418	58:23:01:14	3.093
4452	61:02:56:22	1.636
4453	61:03:31:55	1.882
4458	62:02:32:44	1.678
4459	62:03:03:20	1.538
4460	62:03:33:05	1.479
4468	63:02:45:56	2.124
4481	63:20:46:40	2.570
4502	64:23:22:11	3.173
4511	65:22:36:10	2.505
4532	67:00:31:57	1.667
4533	67:01:57:30	1.542
4550	67:22:10:12	1.197
4551	67:22:38:28	1.387
4552	67:23:08:40	1.464
4554	68:01:57:02	0.879
4555	68:03:30:59	0.856
4576	69:20:20:25	2.055
4595	70:21:05:43	3.581
4596	70:22:00:44	3.439
4597	70:22:55:11	3.769
4598	70:23:49:55	3.382
4599	71:00:44:50	3.345

4600	71:01:34:06	3.392
4601	71:02:33:19	3.956
4602	71:03:27:30	3.913
4609	71:20:44:46	3.066

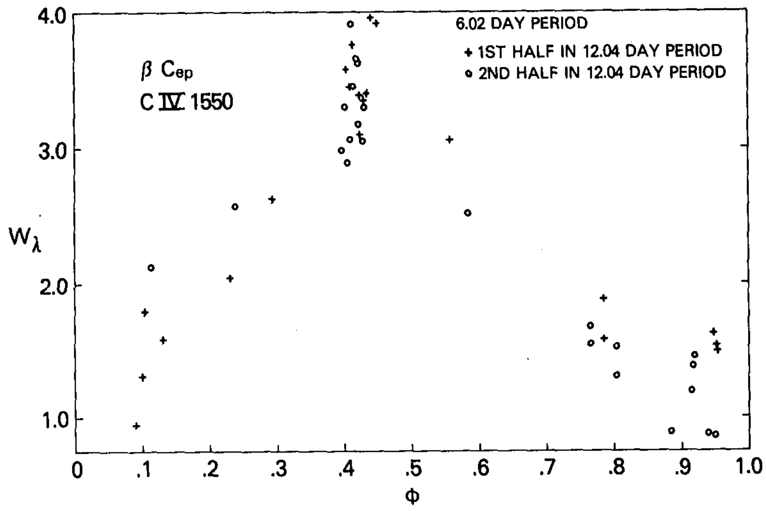

Figure 1

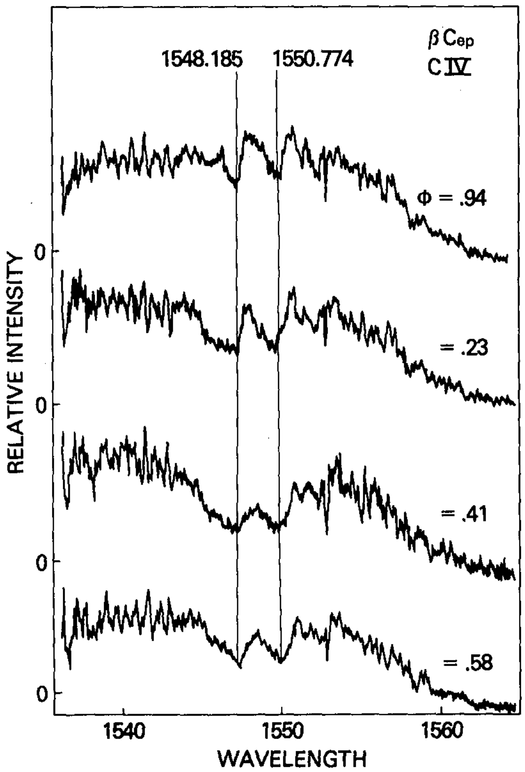

Figure 2

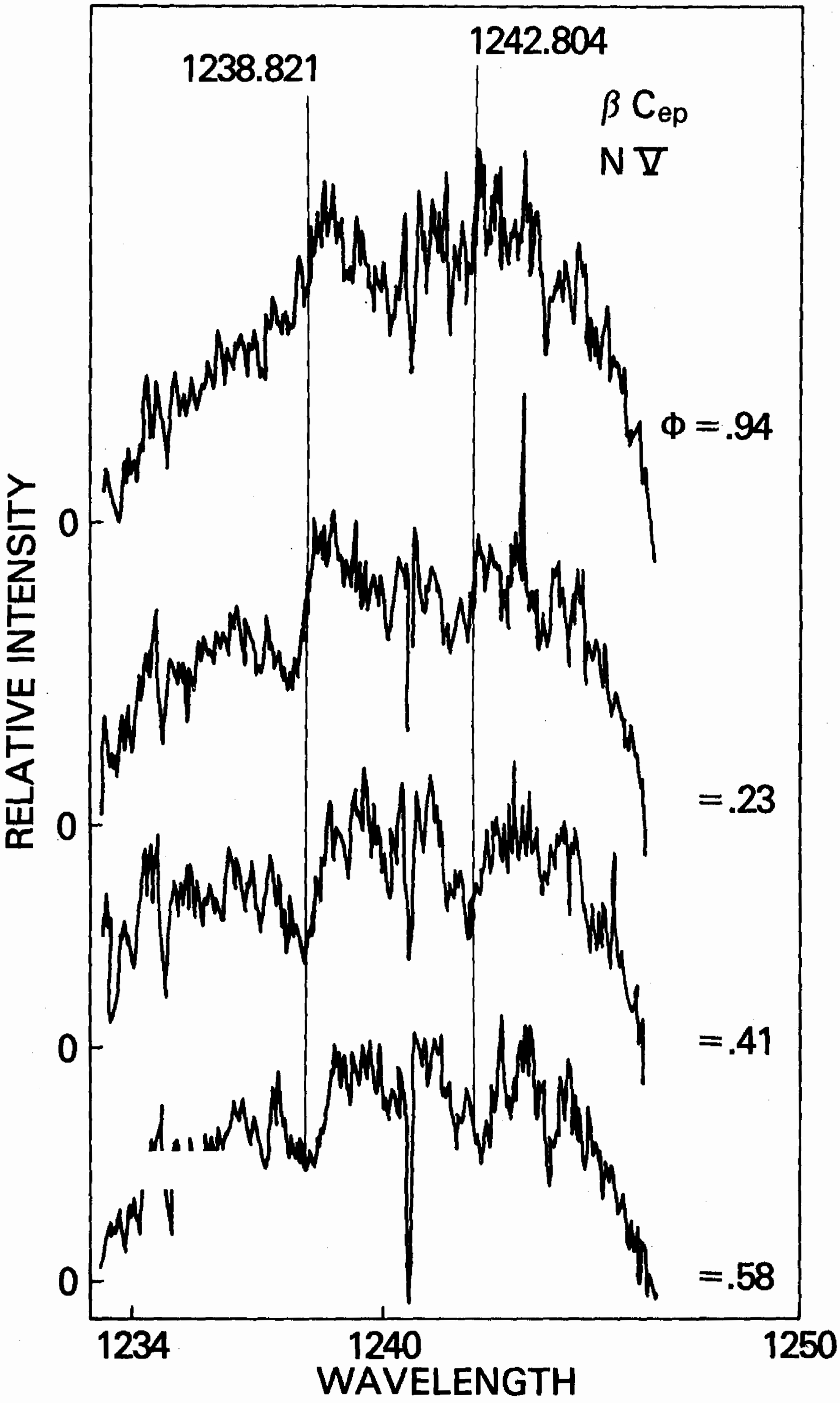
1238.821
1242.804
β Cep
N V
Φ = .94
= .23
= .41
= .58
RELATIVE INTENSITY
0
0
0
0
1234
1240
1250
WAVELENGTH

Figure 3