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VARIATIONS IN THE ULTRAVIOLET SPECTRUM OF THE SYMBIOTIC STAR Z ANDROMEDAE

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RESUMEN

Se describen variaciones de intensidad en líneas del espectro ultravioleta de Z Andromedae detectadas en espectros *IUE* de baja resolución tomados en enero y julio de 1979. Todas las líneas presentes aparecen en emisión y son clasificadas en 5 grupos. Se propone un modelo tentativo que será reexaminado más adelante.

ABSTRACT

Variations in line intensity detected on low-resolution *IUE* spectra of Z Andromedae, taken in January and in July, 1979, are reported. The lines, all of which appear in emission, are classified in 5 groups and a very tentative model of the envelope, that will be re-examined later, is proposed.

Key words: ULTRAVIOLET-SPECTRA – STARS-COMBINATION SPECTRA

I. OBSERVATIONS

Within a program of ultraviolet observations of 20 ymbiotic stars carried by one of us (J.S.) from the *IUE* atellite observatory in January and July, 1979, images of 10 of them were secured at the two epochs with the aim of detecting spectral changes, if any.

A coarse examination of the material disclosed that he Mg II doublet at 2800 A, that appears in emission, as vell as all discernible features in the spectrum, had ndeed changed drastically in Z Andromedae between January and July. As a consequence, the material available on the star, which is listed in Table 1, was scrutinized in detail.

All the material was taken in the low dispersion mode from the NASA *IUE* ground observatory at the Goddard Space Flight Center, Greenbelt, Maryland. The spacecraft and instrumentation as well as the in-flight performance have been described by Boggess *et al.* (1978*a*, *b*). The exposure times were normally chosen in such a way so as not to saturate the emission features, and, therefore, the continua are rather under underexposed.

The absolute photometric calibration of the SWP images was done by means of Bohlin and Snijder's (1978) calibration with the revision suggested by Bohlin *et al.* (1980). On the other hand, the LWR images used were not absolutely calibrated because one of them was exposed through the small aperture; consequently, the flux values that are listed in Table 2 for the LWR images are on an arbitrary scale.

II. SPECTRAL VARIABILITY

The study of the spectra disclosed variations in line strengths not only in Mg II but also in other lines. Table 2 lists the features that have been identified in the spectrum of Z And, the fluxes at the two epochs of observation and the percentages of variation. The variation in Mg II is described as 100%, and the other elements that vary, O I, Si IV, N V, N IV, O IV and perhaps O V, did vary in the same sense but not as drastically as Mg II. We have considered as real the variations that are larger than 25%, a limit which appears to be safe enough. Figures 1 and 2 illustrate the variations.

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TABLE 1

UV MATERIAL ON Z ANDROMEDAE

Image[a]	Aperture	Starting exposure time (UT)[b] day	hour	min	Exposure time (min)	Comments
LWR 3377	large	4	03	13	60	overexposed
LWR 3377	small	4	04	20	30	–
SWP 3797	large	4	04	57	40	–
SWP 5808	large	196	19	18	30	–
LWR 5057	large	196	19	54	20	–
SWP 5809	large	196	20	25	15	–

a. LWR: long wavelength redundant camera; range: 1845-3230 A. SWP: short wavelength prime camera; range: 1165-2126 A.
b. All plates were taken during 1979.

TABLE 2

GROUPS OF EMISSION FEATURES IN THE SPECTRUM OF Z ANDROMEDAE[a]

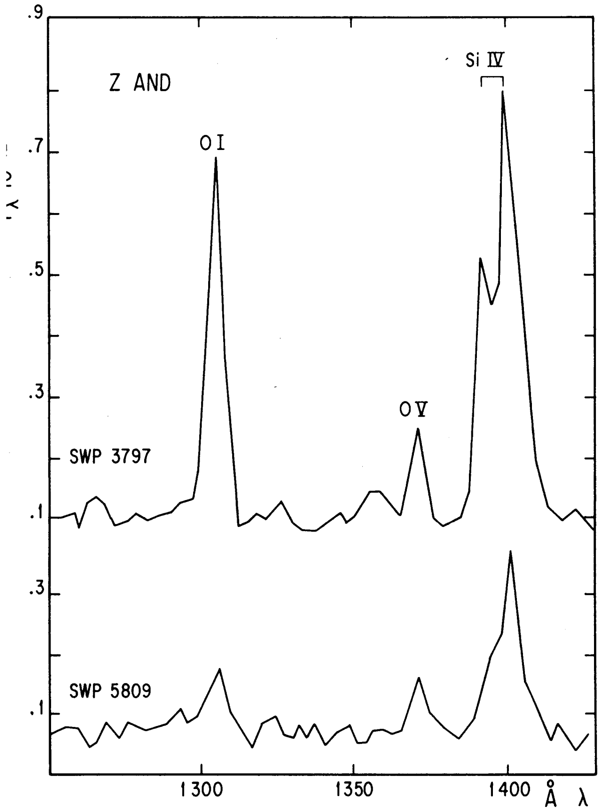
Group	λ	Element	Line fluxes January 79	July 79	Variation with respect to the mean (%)
a	2783	[Mg V]	71	60	–
	2929	[Mg V]	23	28	–
b	1240	N V*	1.40(–12)	0.45(–12)	–51
	1394	Si IV*	0.43(–12)	0.10(–12)	–63
	1403	Si IV*	0.70(–12)	0.20(–12)	–56
	1550	C IV*	2.54(–12)	1.57(–12)	–30
c	1371	O V	0.15(–12)	0.09(–12)	–26
	1640	He II	2.47(–12)	1.84(–12)	–
	2506	He II	49	35	–
	2732	He II	50	44	–
	2837	C II⁺	25	16	–
d	1486	N IV]*	0.48(–12)	0.18(–12)	–44
	1666	O III]*	0.39(–12)	0.17(–12)	–39
	1750	N III]*	0.12(–12)	0.09(–12)	–
	1892	Si III]*	0.27(–12)	0.18(–12)	–
	1909	C III]*	0.26(–12)	0.21(–12)	–
e	2795	Mg II*	56	0	–100
	2802	Mg II*	–	–	–
	1302	O I*	–	–	–
	1304	O I*	0.59(–12)	0.90(–13)	–72
	1306	O I*	–	–	–

a. The complete list of identifications will be included in a paper in which we will discuss all of our *IUE* data on symbiotic stars.
* Resonance line.

It is interesting to mention that on a high dispersion image of Z And secured on February 17, 1979 (Altamore *et al.* 1980), Mg II was not detected and O I 1303 was absent. This result is in agreement with what we have observed in July, 1979, when Mg II was absent and O I very much weaker than six months earlier.

a) *The Mg II doublet*

The Mg II-h and -k resonance doublet at 2795.5 and 2802.7 A is a most useful feature in the whole range of spectral types. As Stencel *et al.* (1980) have pointed out, the doublet "frequently displays emission cores in stars



'ig. 1. Time variation of the spectrum of Z And in the 200-1450 A range.

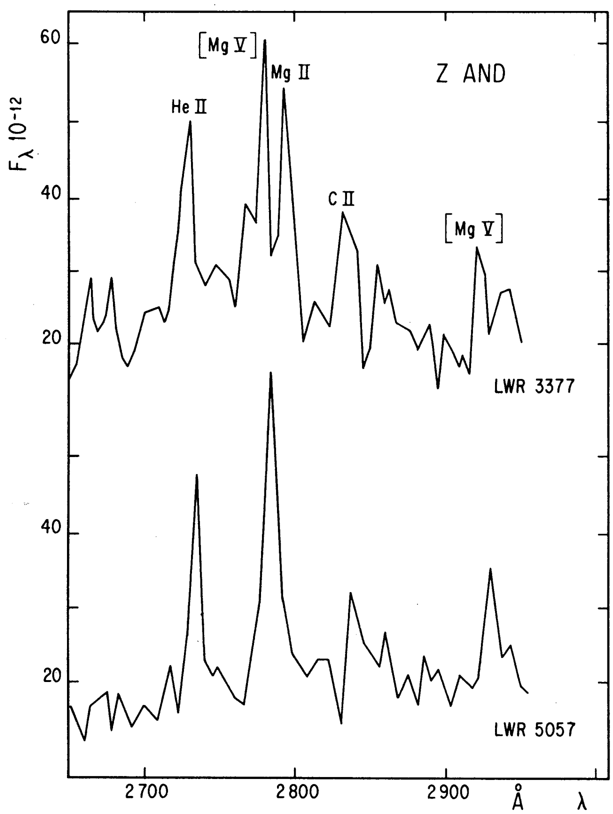


Fig. 2. Time variation of the spectral features of Z And in 2650-2950 A range.

ater than spectral type F". Actually, the feature is a tool or the diagnosis and the study of the properties of hromospheres in cool objects.

In early type stars the lines appear normally in bsorption and the interstellar components are supermposed upon them. Among B stars, the doublet appears elatively weaker in emission-line stars (Lamers and nijders 1975; Ringuelet 1978) and, therefore, the trength of the ultraviolet absorption lines of Mg II may onceivably be inversely correlated with the strength of he H emission in the visual spectral region.

Dr. R. Viotti kindly made available to us a plot of the ariations of the intensity of Hα in Z And from late 977 through late 1980, which corresponded to a range etween −0.45 and −1.8 magnitudes relative to the ontinuum. Our image of early January 1979 correponded to a time when the intensity of Hα was escribed as of magnitude ∿1.4, while our July 1979 nd Altamore *et al.*'s. February 1979 images corresponded o magnitudes ∿ − 1.1. and ∿ − 0.9, respectively. On oth these images Mg II was not detectable. From the hree images it would appear as though there is some ind of a direct correlation between the intensity of the 1g II and Hα emission lines, which would actually be oherent with the correlation between Mg II absorption and Hα emission in Be stars. But more observations are certainly needed to ascertain that these apparent correlations are generally valid in Z And.

b) *Emission Lines present in Z And*

The emission lines that have been identified on our images of Z And can be separated in 5 groups, *a through e*, as indicated in Table 2.

The characteristics of each group are: (a) forbidden lines; (b) resonance lines of N V, Si IV and C IV; (c) high excitation lines of O V, He II and C II; (d) resonance intercombination lines of N IV, O III, N III, Si III and C III, and (e) resonance lines of Mg II, O I, Si II and Fe II. It is tempting to try to locate, at least in a schematic way, the regions where each group of lines form, in spite of the fact that we do not have as yet enough information to propose a model for the envelope, particularly if the object is a binary system.

Tentatively, we would place the forbidden lines (group a) in the outermost layers since the densities that are required are low, around 10^6 cm^{-3}. Farther in, we would locate first the zero or very low excitation lines of group *e*, then the region responsible for the resonance lines of highly ionized atoms (group *b*), after that, the layers where the resonance intercombination lines (group *d*) originate, and, finally, the higher excitation lines of group *c*. In this sequence the excitation temperature, T_e, would be increasing and reach a maximum at the region where the lines of group *b* are formed; afterwards, T_e would be decreasing outwards. As yet, we cannot say anaything about the excitation temperature profile in the stellar envelope. The identification of the line at 1371 A as a high excitation transition of O V requires knowledge of the excitation temperature profile in the envelope, and suggests that a more thorough analysis of the ultraviolet spectrum of the star is needed. If we are dealing with a binary system it may be that the hot companion has a chromosphere-corona formation with a maximum T_e close to its surface that would account for O V 1371. This maximum T_e may imply shock-wave dissipation, and then the situation would agree with Ilovaisky and Wallerstein's (1968) conclusion that in Z And the energy for the high excitation emission lines probably results from shock-wave dissipation. We may have again shock-wave dissipation at the maximum T_e that would account for the lines of group b, that is, at a certain distance from the M star, much in the same way as in γ_2 Velorum (Sahade and Zorec 1980), although this is a completely different kind of object.

Another possibility of locating the regions where the different groups of lines originate could be thought of in terms of the lines of group *e* forming in the chromosphere of the M star, but then the Fe II resonance lines at about 2598 A would be strong (Stencel *et al.* 1980) and this is not the case in Z And.

We expect to come back to a more elaborate model once we have worked out the rest of our *IUE* material on symbiotic stars.

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DISCUSSION

Wing: In your list of line identifications, there does not seem to be much evidence of C II. Since lines of C III and C IV are strong, would not the absence of C II λ1335 or the C II multiplet near 2325 A cast doubt on your identification of the λ1278 line as C I?

Sahade: You may be right. In regard to C I, I would say that the line is at the limit of detectability and it may be better not to include it in the list. As for the absence of the resonance lines of C II and the possible identification of other lines with higher excitation transitions of C II, I do not think that this should pose any worry because we are dealing with an envelope characterized by a certain excitation temperature profile.

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