SESSION 3. PHYSICS OF INDIVIDUAL OBJECTS

"Nature is malicious"

Pier Luigi Selvelli

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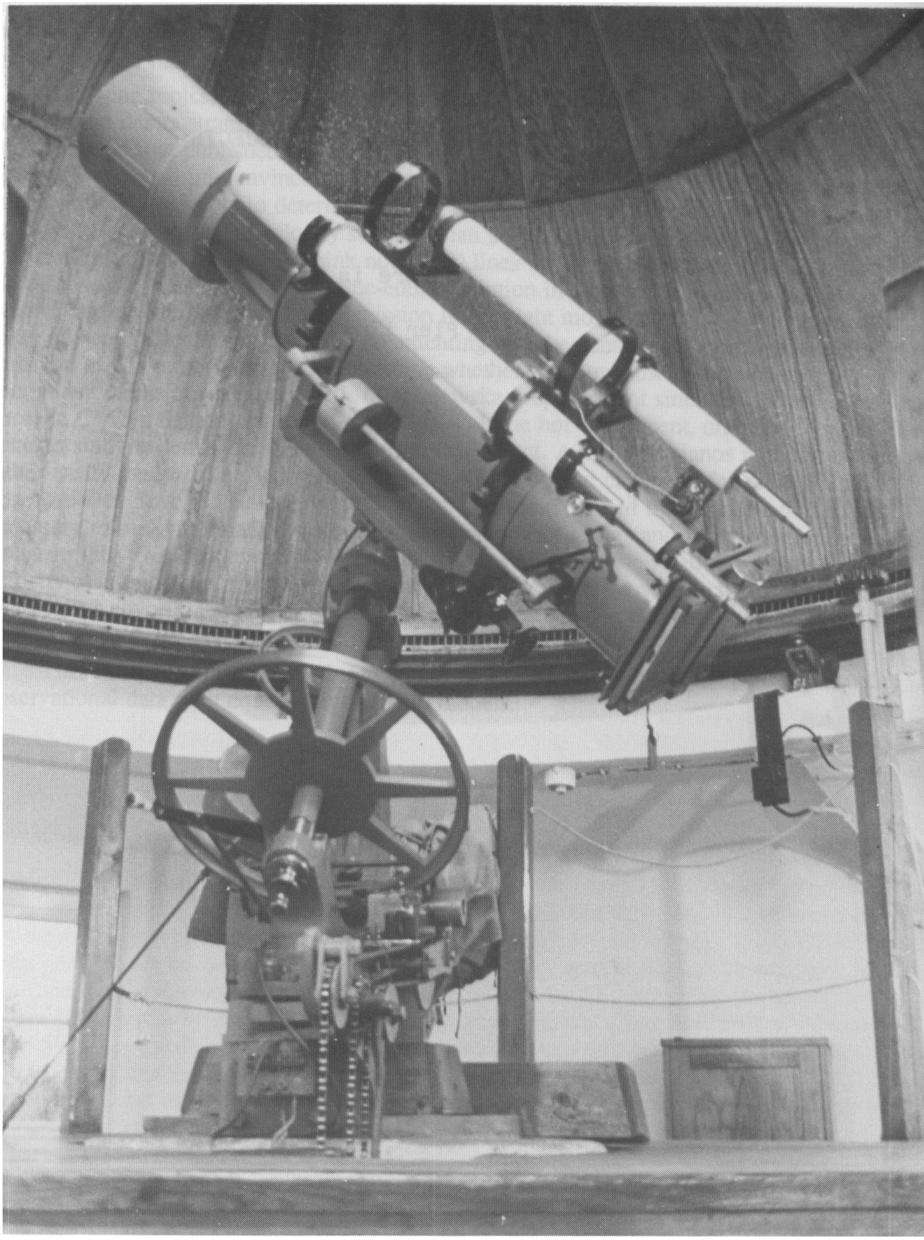

The famous H. Draper astrograph, since 1947 at the Torun Observatory. The first symbiotics were discovered by A. Cannon with this telescope during her work on the HD catalogue.

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Z ANDROMEDAE: QUIESCENCE AND ACTIVITY

A. Cassatella
IUE Observatory, ESA,
P.O. Box 54065, 28080 Madrid, Spain

T. Fernandez-Castro
Planetario de Madrid, Parque Tierno Galvan
28045 Madrid, Spain

N. Oliversen
Astronomy Programs, Computer Sciences Corporation
NASA Goddard Space Flight Center, Greenbelt,
Maryland 20771, U.S.A.

1. INTRODUCTION

Z Andromedae, often considered as the prototype of symbiotic stars, experimented, after several years of quiescence, a small outburst in March-April 1984, followed by a larger one in September-October 1985. The imminence of a new activity phase was predicted by Viotti et al. (1982). Z And is, together with AG Draconis, the only symbiotic star observed both during quiescence and activity with the IUE satellite. The early photometric and spectroscopic history of Z And has been recently reviewed by Kenyon (1986).

2. Z And during quiescence

The behaviour of Z And in the ultraviolet during quiescence has been studied by Fernández-Castro et al. (1988), on the basis of data obtained by the International Ultraviolet Explorer from 1978 to 1982. In that period of time, the UV continuum and the emission line fluxes varied quasiperidically with a period of about two years, in phase with the Hα variability found by Altamore et al. (1979), with the UBV photometry by Belyakina (1985) and also in

1) Based on observations by the International Ultraviolet Explorer; (2) Affiliated with the Astrophysics Division, Space Sciences Department

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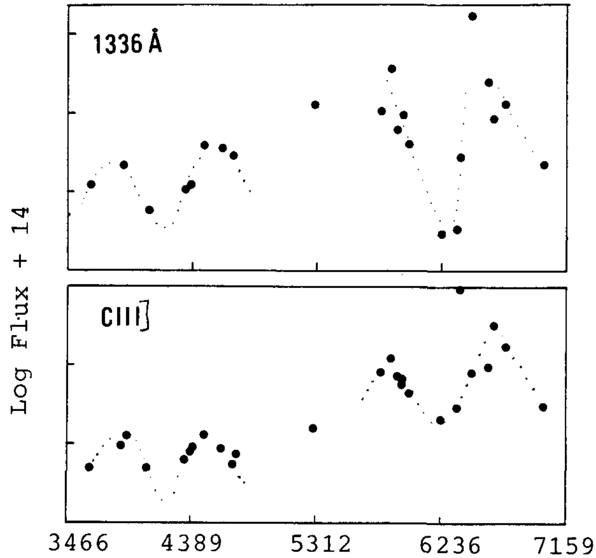

Figure 1: Time evolution (JD-2440000) of the continuum flux at 1336 A and of the emission line flux in C III] 1909 A.

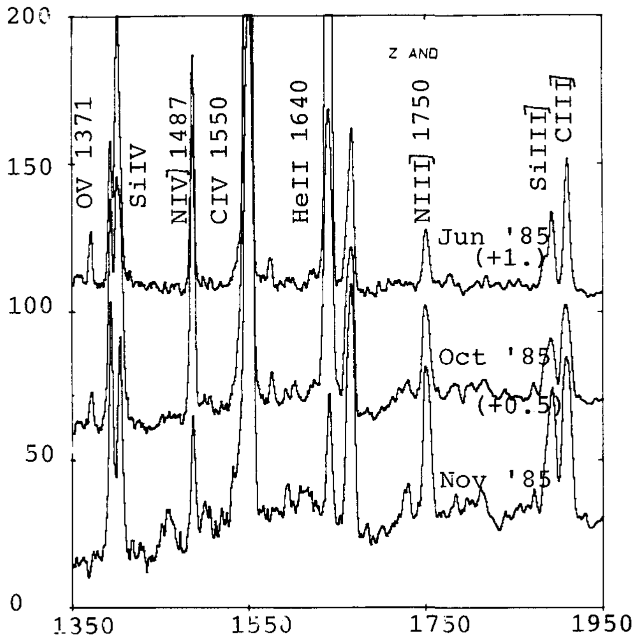

Figure 2: Spectral variability of Z And in the far UV shortly before (June 1985) and during the outburst (October and November 1985). Ordinates are observed fluxes in units of 10^{-14} erg cm^{-2} s^{-1} A^{-1}.

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agreement with the ephemeris given by Kenyon and Webbink (1984). The electron density derived from Si III]/C III] flux ratio, also varied in phase with the UV flux. In particular, a correlation was found between the electron density variations, and the UV continuum flux at 2900 A. This fact, together with the presence of a Balmer jump in emission, indicates that the principal contributor at those wavelengths is nebular emission, mainly free-bound transitions.

The temperature of the hot source ($T_h \geq 10^5$ K), estimated with the Zanstra method using the He II 1640 A emission line and the continuum flux at ~ 1400 A, remained roughly constant, suggesting that no significant changes of the ionization temperature occurred during quiescence.

In the near-infrared, Z And remained practically constant, even during activity phases. From IRAS data, there is no significant indication of infrared excess due to dust emission in the 12 μm and 25 μm bands (Kenyon, Fernández-Castro and Stencel 1987).

The IR reddening corrected (E(B-V) = 0.35; Viotti et al. 1982) energy distribution of Z And in quiescence can be fitted by a black body of 3200 K which corresponds to a spectral type M4 on the Ridgway et al. (1980) scale, in good agreement with the recent determination by Kenyon and Fernández-Castro (1987a), who derived a spectral type M3.5 from the analysis of molecular absorption bands in red spectra.

Although the assumption of a luminosity class is very crucial for the model, we can adopt with reasonable confidence that the cool component of Z And is a giant, as determined by Kenyon and Fernández-Castro (1987a).

The radio spectral index of Z And in quiescence, as observed by Seaquist, Taylor and Button (1984), is α = 0.62, close to the expected value for a completely photoionized wind. The corresponding mass loss rate, calculated from Wright and Barlow (1975) is 2.0 x 10^{-7} $M_\odot$/yr, while the accretion rate onto the compact object represents a small fraction of the total mass lost (2 %). Therefore, the accretion luminosity is at least ~ 40 times smaller than that provided by the recombination continuum, for any reasonable range of masses assumed, implying that accretion effects from the giant play a negligible role in the energetics of the system, as in the case of RW Hya discussed by Kenyon and Fernández-Castro (1987b).

The case of Mira Ceti is substantially different from that of Z And. In Mira Ceti the accretion luminosity is of the same order as that of the recombination continuum. Reimers and Cassatella (1985) and Cassatella et al. (1985) suggested that in Mira Ceti accretion from the wind of the

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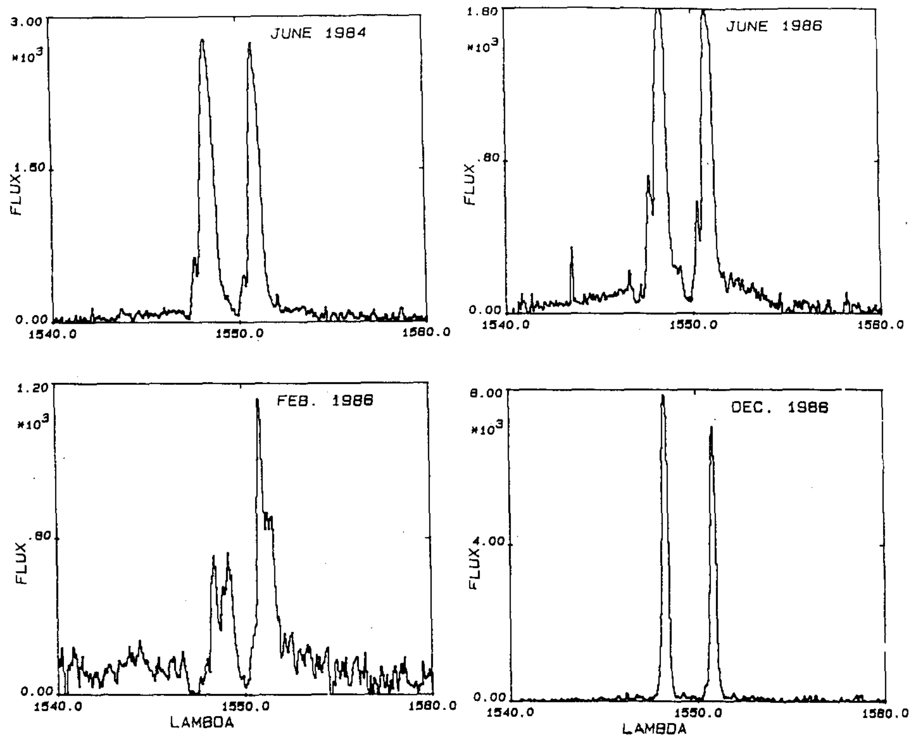

Figure 3: Evolution of the line profiles of the C IV 1550 A doublet at four different dates during the outburst of Z And. Note the complex structure of the profiles in February 1986.

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red giant forms a optically thin accretion disk around the white dwarf which gives raise to the broad emission lines and the Balmer continuum observed in the UV. Z And does not present in the UV, at least during quiescence, any feature that could be ascribed to line formation in an accretion disk.

3. THE OUTBURST OF Z AND

Z And, after a long period of quiescence, entered a new active phase undergoing a small outburst in March-April 1984, lasting less than 200 days, followed by a larger one in September-October 1985 with a duration of about 250 days.

The behaviour of Z And in the ultraviolet during the recent activity phases can be summarized as follows:

a) The regular variations of the UV continuum and of the emission line fluxes observed during quiescence continue during activity, but are superimposed to variations having the time scale of the V light curve (Mattei 1987).Examples of the time evolution of the UV continuum and of the emission lines in the period 1978-1987 are shown in Fig. 1.

b) The UV energy distribution of Z And in outburst differs strongly from that in quiescence: the hot stellar continuum almost disappeared during activity. The fainting of the hot continuum is accompanied by a decrease of the degree of ionization of the emission lines. An example of these changes for the period June-November 1985 is shown in Fig. 2.

c) A general broadening of the emission lines is seen in the high resolution IUE spectra obtained during the active phase in 1985-1986. The same behaviour was observed by Viotti et al. (1984) during the outburst of AG Draconis in 1981-1982. In February 1986, the profiles of the emission lines were broad and had a complex structure, as it can be realized from Fig. 3, showing the C IV 1548-1550 A doublet. Another interesting aspect is that the flux ratio CIV 1548/ CIV 1550 A changed dramatically during activity and, in February 1986, became lower than what expected in the optically thick case. This fact might be indicative of the development of a high velocity wind from the hot component during outburst.

4. THE MODEL OF Z ANDROMEDAE

The UV to near infrared energy distribution of Z And can be modeled, according to Fernandez-Castro et al. (1988), in terms of three components: a nonvariable cool giant (M3.5), a hot component with $T_h \geq 10^5$ K and $R_h = 0.07\ R_\odot$ which accretes only a small fraction

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of the mass lost by the red giant, and a nebula, photoionized by the hot source. This model is analogous to that proposed by Boyarchuk (1968). The nebula is bow-shaped, as also supported by radio data (Seaquist, Taylor and Button 1984), and is responsible for the observed gas continuum and for the emission lines. The regular variability during quiescence could be ascribed to partial occultation by the cool star or to eccentricity effects. A discussion on the possible models of Z And is given by Yudin (1986).

As for the active phases of Z And, the data recently obtained are being analyzed in order to gain insight on the outburst mechanism.

REFERENCES

Altamore, A., Baratta, G.B. and Viotti, R.: 1979, Inf. Bull. Var. Stars, No. 1636.

Belyakina, T.S.: 1985, Inf. Bull. Var. Stars, No. 1611.

Boyarchuk, A.A.: 1968, Soviet Astron. 11, 818

Cassatella, A., Holm, a., Reimers, D., Ake, T. and Stickland, D.J.: 1985, M.N.R.A.S. 217, 589.

Fernández-Castro, T., Cassatella, A., Giménez, A. and Viotti, R.: 1988, Astrophys. J., 324, in press

Kenyon, S.J.: 1986, The Symbiotic Stars, Cambridge Univ. Press

Kenyon, S.J. and Fernández-Castro, T.: 1987a, Astron. J. 93, 938.

Kenyon, S.J. and Fernández-Castro, T.: 1987b, Astrophys. J. 316, 427.

Kenyon, S.J., Fernández-Castro, T. and Stencel, R.E.: 1987, Astron. J., submitted.

Kenyon, S.J. and Webbink, R.F.: 1984, Astrophys. J., 279, 252.

Mattei, J.: 1987, these Proceedings

Reimers, D. and Cassatella, A.: 1985, Astrophys. J. 297, 275.

Ridgway, S.T., Joyce, R.R., White, N.M., Wing, R.F.: 1980, Ap. J. 235, 126

Seaquist, E.R., Taylor, A.R. and Button, S.: 1984, Astrophys. J. 284, 202.

Viotti, R., Altamore, A., Baratta, G.B., Cassatella, A. and Friedjung, M. 1984, Astrophys. J. 283, 226.

Viotti, R., Giangrande, A., Ricciardi, O. and Cassatella, A.: 1982, in IAU Coll. 70, The Nature of Symbiotic Stars, ed. M. Friedjung and R. Viotti (Dordrecht: Reidel), p. 125.

Yudin, B.F.: 1986, Sov. Astron. 30, 84

Wright, A.E. and Barlow, M.J.: 1975, M.N.R.A.S. 170, 41.

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