FAR UV OBSERVATIONS OF MV LYRAE IN TWO DIFFERENT STATES

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1. INTRODUCTION

MV Lyrae (Refs. 1, 2) is an X-ray emitting (Refs.3-5) cataclysmic variable with a period of 0.133^d (Ref. 6). Two different states are observed spectroscopically (Refs. 7-9); one characterized by the presence of emission lines, the other by a continuum with absorption features not always visible.

Recently, attention was drawn to the fact that the object undergoes occasional drops in brightness of $\sim$5 mag (Refs. 10, 11). The X-ray flux probably varies in a correlated way (Ref.5). The presence of circular polarization reported by Vojkhanskaya et al (Ref.12) corresponding to a field 10^8 G was not confirmed by Tapia (Ref. 13).

IUE observations taken in 1980 Dec, at optical minimum (Ref.14) revealed a hot component $T \simeq 6\text{-}7\times10^4$ °K possibly contributed by the white dwarf surface. In this paper the ultraviolet continuum at minimum is compared with archival observations, taken when the source was in a brighter state.

2. OBSERVATIONS

The ultraviolet observations discussed here, have been reduced to absolute flux from the standard line-by-line extracted spectrum with the procedure developed at the European Southern Observatory and the calibration curves by Bohlin et al (Ref.15). A journal of observations is given in Table 1, together with integrated fluxes.

In Fig.1 the 1200-3200 A spectrum obtained combining the short wavelength and the long wavelength exposures of 1980, when the source was in low state ($m_B \simeq 18$; Ref.16) is compared with that taken in 1979 when the source was in a brighter state. Optical photometry by Romano and Rosino (Ref.16) twelve days before the 1979 ultraviolet observations, gives $m_B \simeq 15$, intermediate between the minimum and the maximum magnitude recorded so far.

Conspicuous variations in both the intensity and spectral index in the ultraviolet appear to have occurred between the two epochs. The short wavelength flux in 1979 was a factor of $\sim$5 higher than in 1980, while, in the long wavelength range, the factor is $\sim$10.

A power law fit to the spectrum observed in 1979 yields $F_\lambda \simeq 2.7\times10^{-10}\ \lambda^{-1.1\pm0.1}$ and, in 1980, $F_\lambda = 2.4\times10^{-3}\ \lambda^{-3.4\pm0.4}$ erg cm^{-2} s^{-1} A^{-1}. Another important difference between the two epochs is the presence of strong emission lines in the more intense spectrum, which are listed in Table 2.

3. DISCUSSION

The ultraviolet continuum in the high state can be fitted by a standard model of accretion disk (Ref. 17) with T=64000 and $R_{out}/R_{in}=25$. However if the interpretation of the UV continuum at minimum as due to thermal emission the white dwarf surface is correct, a disk model should be fitted to the difference between the high and low spectra. This yields slightly different parameters for the disk T=52000, $R_{out}/R_{in} = 15$ (see Fig.2). In both cases the predicted optical flux is higher than measured by Romano and Rosino 12 days in advance. Since at that epoch the magnitude was rapidly growing the discrepancy might not be critical.

Production of X rays should occur in the region of interaction of the accretion disk with the white dwarf as described by Pringle and Savonje (Ref.18). However the X-ray observations by Becker (Ref.5), at two different epochs, indicate a hardening of the X-ray spectrum for higher fluxes, which is not expected in the above mentioned model.

Harder X rays with higher flux are predicted in models like that proposed by Fabbiano et al (Ref.19) for SS Cyg and AM Her, where the ultraviolet and X-ray emissions are due to a shock in an accretion funnel, whose temperature increases with the accretion rate. If this is the case also for MV Lyrae, one should invoke the presence of a magnetic field of $\sim 10^6$G.

We note that a mild magneticity would be compatible with the observed line spectrum which resembles that of SS Cyg at minimum (Ref.19) and that of highly magnetized system lake AM Her and 2A 0311-227 (Refs. 20-22) although in the latter case the line to continuum ratio is higher by a factor of 10.

4. CONCLUSION

A consistent picture of MV Lyrae could be as follows. At minimum ($m_B \simeq 18$) mass transfer is absent (Refs. 14, 23). In the intermediate state ($m_B \simeq 15$), with moderate mass transfer, the system behaves similarly to SS Cyg at minimum. In the high state ($m_B \simeq 13$) the transition from a line emitting phase to a continuum

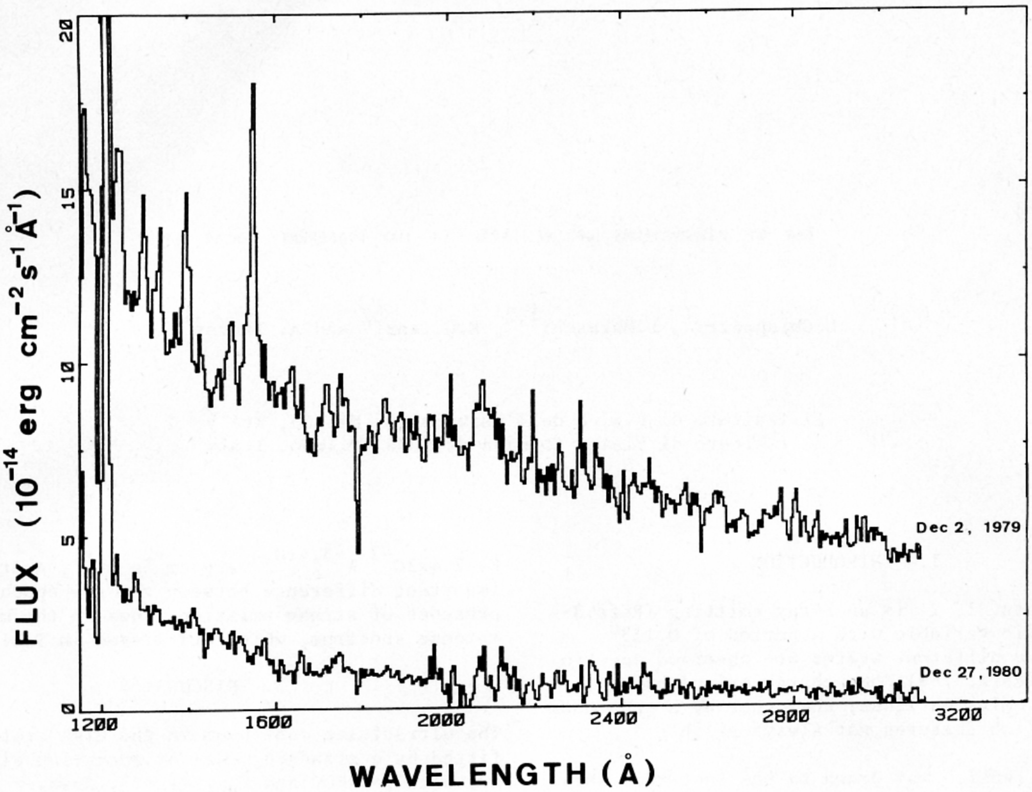

Fig. 1 : IUE spectrum of MV Lyrae in two different states

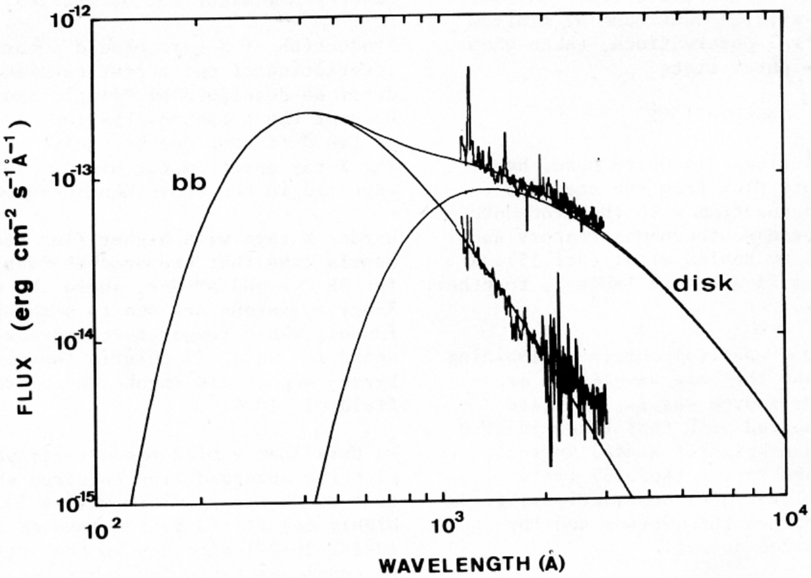

Fig. 2 : The IUE spectrum of MV Lyrae, taken on Dec 2, 1979, is fitted by superposition of two components: a) a black body distribution (labelled "bb") which represents a white dwarf of temperature $T = 7 \times 10^4$ K and radius-to-distance ratio = 3.3×10^{-13}; b) a standard disk model (labelled "disk") with $T = 5.2 \times 10^4$ K and $R_{out}/R_{in} = 15$. The spectrum taken in low state (1980 Dec) is accounted for the sole white dwarf continuum.

TABLE 1 - Journal of observations and integral fluxes of MV Lyr

Image No.	Exposure time	Epoch of Observations	Integral fluxes (erg $cm^{-2}s^{-1}$) 1230 - 1900	1900 - 2500	2500 - 3100
SWP 7296	90	Dec 2, 1979	$6.7x10^{-11}$		
LWR 6288	70	Dec 2, 1979		$4.3x10^{-11}$	$3.1x10^{-11}$
SWP 10905	40	Dec 27, 1980	$1.2x10^{-11}$		
LWR 9589	60	Dec 27, 1980		$3.8x10^{-12}$	$1.9x10^{-12}$
SWP 10906	150	Dec 27, 1980	$1.3x10^{-11}$		
LWR 9590	118	Dec 27, 1980		$4.0x10^{-12}$	$1.9x10^{-12}$

TABLE 2 - List of prominent lines in the spectrum of MV Lyr, taken on Dec 2, 1979

λ Obs (A)	e.w.(A)	Proposed identification
1238	4	N V (λλ1239, 1243)
1297		Si III (λ1296)
1337		C II (λ1334)
1396	9	Si IV (λλ1393, 1402)
1500		Si III (λλ1500 - 1506) ?
1551	15	C IV (λλ1548,1550)

with absorptions, should be due to the inner edge of the disk extending down to the white dwarf surface, as discussed in the case of SS Cyg and U Gem (Ref.19).

If this general picture is correct, the X-rays should soften considerably in the high state as predicted by Pringle and Savonje (Ref. 18).

Independently of the model, the X ray and UV observations indicate that the bulk of the luminosity is emitted shortward of the IUE range, in the EUV region. A study of the correlation between the X ray spectrum and the ultraviolet optical emission appears necessary in order to understand the object.

5. ACKNOWLEDGEMENT

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6. REFERENCES

1. MacRae D.A. (1951) Ap.J. vol.113, 432
2. MacRae D.A. (1952) Ap.J. vol.116, 592
3. Mason K.O., Kahn S.M., Bowyer G.S. (1979) Nature vol.280, 568
4. Cordova F.D., Jensen K.A. & Nugent J.J. (1981) M.N.R.A.S. voL.196, 1
5. Becker R.H. (1981) Ap.J. vol.25½, 626
6. Schneider D.P., Young P. & Shectman S.A.(1981) Ap.J. vol.245, 644
7. Greenstein J.L. (1952) PASP vol.64, 256
8. Greenstein J.L. (1954) PASP vol.66, 79
9. Vojkhanskaya N.F. (1980) Sov.Astr.vol.24, 300
10. Romano G. & Rosino L. (1980) Inf.Bull.Var.Stars 1776
11. Wenzel W. (1980) Inf.Bull.Var.Stars, 1810
12. Vojkhanskaya N.F., Gnedin Ya.N., Efimov Ya.S., Mitrofanov I.G., Shakhovskoi N.M. (1978) Sov. Astr.Lett. vol.4, 148
13. Tapia S. (1981) private communication
14. Chiappetti L., Maraschi L., Tanzi E.G., Treves A. (1982) Ap.J. (in press)
15. Bohlin R.C., Holm A.V., Savage B.D., Snijders M.A.J., Sparks M.M. (1980) Astr.Ap. vol.85, 1
16. Romano G. and Rosino L. (1981) private communication
17. Bath G.T., Pringle J.E. & Whelan J.A. (1980) M.N.R.A.S. vol.190, 195
18. Pringle J.E. & Savonje G.J. (1979) M.N.R.A.S. vol.187, 777
19. Fabbiano G., Hartmann L., Raymond J., Steiner J., Branduardi-Raymont G. & Matilsky T. (1981) Ap.J. vol.243, 911
20. Raymond J.C., Black J.H., Davis R.J., Dupree A.K., Gursky H., Hartmann L. & Matilsky T.A., (1979) Ap.J. vol.230, L95
21. Tanzi E.G., Tarenghi M., Treves A., Howarth D., Willis A.J. & Wilson R. (1980) Ast.Ap. vol.83, 270
22. Coe M.J., Wickramasinghe P.T. (1981) Nature vol.290, 119
23. Robinson E.L., Barker E.S., Cochran A. & Nather R.E. (1981) Ap.J. vol.251, 611