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correct, $\dot{M} \sim \dot{M}_{GR}$ for the composite model, but $> \dot{M}_{GR}$ for the W.D. secondary solutions. If the bursts from X1916-053 are like those from other bursters, and the galactic center distance is close to 9 kpc, the results agree with the indications of flash theory that $\dot{M} \sim 5 \times 10^{-10}$ $M_\odot$ yr. The burst properties of X1916-053 thus argue for $\dot{M} \sim 2\text{-}5 \times 10^{-10}$ $M_\odot$ yr^{-1}. Table 2 compares this with $\dot{M}_{GR}$ for the solutions considered and notes other considerations relevant to the likelihood of the secondary being of that type.

Table 2. Comparison of M and M_{GR}

Type	M/M_{GR}	Comment
Equilibrium		
H burning	> 1-2	solution uncertain
He burning	<< 1	also inconsistent with optical id.
H W.D.(X=0.75)	> 3-6	
He W.D. (X=0.)	>> 100	inconsistent with τ_R
Non-Equilibrium		
H burning (X=0.2)	> 5-10	
composite	> 1-2	

The composite model comes within a factor of 2 of being a self-consistent solution for which $\dot{M} \sim \dot{M}_{GR}$. But discrepancies of 3-5 are of the same order. Other mechanisms for driving mass transfer are certainly expected to contribute but which is important for very low mass companions is not clear.

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References

Ayasli, S., and Joss, P.C.: 1982, Astrophys. J. 256, p. 637.
Faulkner, J., Flannery, B.P., and Warner, B.: 1972, Astrophys. J. 175, L79.
Inoue, M. et al.: 1981, Astrophys. J. 250, L71.
Joss, P.C.: 1978, Astrophys. J. Letters 225, L123.
Lewin, W.H.G.: 1982, in Accreting Neutron Stars, ed. W. Brinkman and J. Trumper, p. 77.
Paczynski, B., and Sienkiewicz, R.: 1981, Astrophys. J. 248, p. L27.
Rappaport, S., Joss, P.C., and Webbink, R.F.: 1982, Astrophys. J. 254, p. 616.
Swank, J.H., Taam, R.E., and White, N.E.: 1983, Astrophys. J., in press.
Taam, R.E.: 1981, Astrophys. J. 247, p. 257.
Taam, R.E.: 1982, Astrophys. J. 258, p. 761.
Walter, F.M., Bowyer, S., Mason, K.V., Clark, J.T., Henry, J.P., Halpern, T., and Grindlay, J.E.: 1982, Astrophys. J. Letters 253, L67.
White, N.E., and Swank, J.H.: 1982, Astrophys. J. 253, L61.
Whyte, C.A., and Eggleton, P.: 1980, Mon.Not.R.Astron.Soc. 190, p. 801.

COS-B X-RAY OBSERVATIONS OF CYGNUS X-3

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Abstract : The X-ray source Cygnus X-3 was further observed by the X-ray detector onboard the COS-B satellite from November 1981 to February 1982. This brings to 220 days the total duration of observation of this source by COS-B. Preliminary results from the last observations are presented which show that :

- the source intensity is not periodically modulated with periods from 1 to 60d.
- the measured mean time of X-ray minimum of the 4.8h modulation is in accordance with a long-term ephemeris with a non-zero period derivative.
- short term fluctuations of the time of X-ray minima inside the observation are present but probably not strictly modulated with the period of ~19d reported from previous observations (Bonnet-Bidaud and van der Klis 1981).

The last point does not allow to confirm the hypothesis of an apsidal motion as the cause of the short-term changes of the 4.8h period.

1. OBSERVATIONS

The COS-B satellite was pointed to Cygnus X-3 for more than three months from Nov. 5, 1981 to Feb. 18, 1982. The source was near the centre of the field of view at the near maximum sensitivity of the 80 cm^2 (2-12kev) proportional counter.
Data were recorded continuously during 25.4 s integration time every 102.4 s in the active part of the satellite orbit (24h out of every 36h). We used the exceptional length of this observation to test the different periods proposed for the source intensity changes (Holt et al. 1976, Molteni et al. 1980) and the phase changes of the X-ray minimum of the 4.8h modulation (Bonnet-Bidaud and van der Klis 1981).
Preliminary results are presented. Full discussion will be given elsewhere.

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2. RESULTS

2.a. Intensity changes

After background subtraction, heliocentric-corrected data in each satellite orbit were fitted to a sinusoidal curve of the form $A_0-A_1\cos(2\pi(t-T_0)/P)$. The quantities T_0 and P were computed from the quadratic ephemeris of van der Klis and Bonnet-Bidaud (1981). The results for A_0 and A_1 are presented in Figure 1.
The source mean counting rate varies from 10 to 35 c/s (1 COS-B c/s $\sim$ 2.3 to 2.7 10^{-10} erg.cm^{-2}.s^{-1} for the range of the source spectra), while the amplitude of the 4.8h modulation varies from 2 to 12 c/s.
Figure 1 shows that the source intensity is nearly constant in an interval of 60d from JD2444930. to JD2444990. which excludes all strict periodicities in the range 1 to 60d.
In particular the predicted times of X-ray maximum intensity with the period of 34.1d claimed by Molteni et al.(1980) (marked by arrows in Fig.1) do not correspond, at least in two cases, to any enhancement in the source mean level.

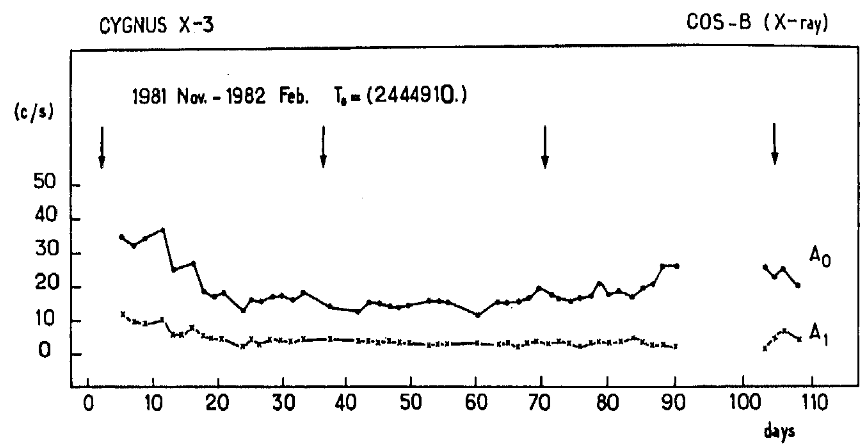

Figure 1. The mean level A_0 and the amplitude A_1 of the 4.8h modulation against time. Each A_0 and A_1 point is determined from a sine fit to about 5 cycles of the source. Continuous coverage is more than 60%. Vertical units are in c/s after background subtraction. Statistical error bars are smaller than the points. There is no evidence of a 34.1d periodic intensity variations as proposed by Molteni et al.(1980) (the arrows indicate the predicted times of maximum intensity with this period).

2.b. X-ray minimum phase changes

The flux in each satellite orbit was first normalized by subtracting the mean and dividing by the amplitude as derived in 2.a. A function of the form $a-b\cos(2\pi(t-T_{min})/P)$ with P computed from the quadratic ephemeris of van der Klis and Bonnet-Bidaud(1981), was then fitted between JD2444912.5 and JD2445017.5. The best fitting value for T_{min} was T_{min} = JD2444965.9688±0.00014 (one-sigma single parameter error bar). This new determination is shown in Figure 2 and compared to the previous quadratic ephemeris. A new determination of the period derivative using this last point gives $\dot{P}$ = (1.09±0.08) 10^{-9} s/s with χ_ν^2=1.36 for ν =58, while a constant period hypothesis yields χ_ν^2=4.35 at ν=59. According to the F-test the probability for $\dot{P}$ to be zero is now less than 6 10^{-10}. This result confirms with a higher degree of confidence the existence of a continuous change of the 4.8h modulation period though with a rate of change slightly less than previously quoted (Manzo et al. 1978, Lamb et al. 1979, Elsner et al. 1980, van der Klis and Bonnet-Bidaud 1981).

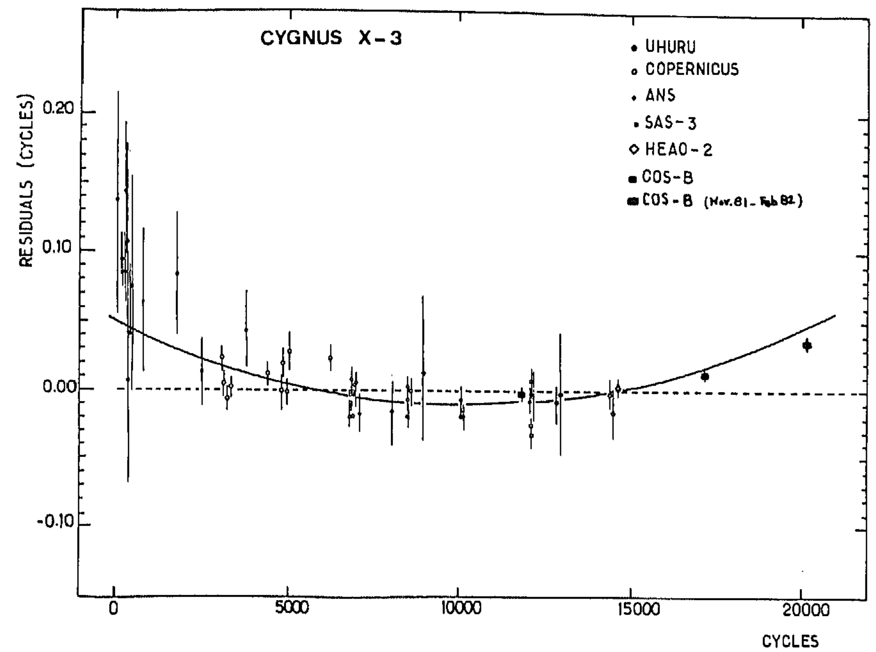

Figure 2. The mean heliocentric time of X-ray minimum in the (Nov.81-Feb.82) COS-B observations compared to the nine years ephemeris of van der Klis and Bonnet-Bidaud (1981) (drawn parabola corresponds to their best value of $\dot{P}$ = 1.2 10^{-9} s/s).
Introduction of the last point gives a more accurate value of $\dot{P}$ = (1.09±0.08) 10^{-9} s/s, with an improved level of confidence for the $\dot{P}$ = 0 hypothesis (formal chance for a constant P is less than 6 10^{-10}).

We further investigated changes in the time of X-ray minimum inside the observation. Data in each satellite orbit (~ 5 cycles of the 4.8h modulation) were folded using the above quadratic ephemeris and then cross-correlated to a template curve around minimum in order to minimize possible effects of the changes in the shape of the modulation around maximum (see Bonnet-Bidaud and van der Klis 1981). A set of 49 independent phase points were obtained which show fluctuations of $\sim \pm 2\ 10^{-3}$d. A period search through those points was performed by folding them with periods in the range 10 - 30d and comparing the resulting folded curve with a flat curve using a χ^2 test. No significant peak was observed around the period of 19d quoted from previous observations (Bonnet-Bidaud and van der Klis 1981). However a simulation of a pure 19d sinusoidal signal distributed according to the data points shows that the data window will prevent to detect a modulation of the order or less than $2\ 10^{-3}$d.

3. CONCLUSION

The source flux is not periodically modulated with periods from 1 to 60d. This probably excludes the massive binary model recently proposed by Molteni et al. (1980).
Periodic 19d changes in the time of X-ray minimum are not confirmed from the present observation possibly due to an unfavourable data coverage. The long term variation of the 4.8h modulation period is now clearly established. We compute that if the companion star is $0.4 \leqslant \dot{M} \leqslant 0.6\ M_\odot$, the long term 4.8h period changes will be explained by a mass loss of the system of $\dot{M} \sim 5\ 10^{-7}\ M_\odot.yr^{-1}$. We further note that if Cygnus X-3 belongs to the class of the low-mass binaries, the observed long-term increase of the orbital period means that Roche-lobe overflow by a red-dwarf companion cannot be powering the X-ray source as the expansion of the orbit will prevent this mecanism from operating.

4. REFERENCES

Bonnet-Bidaud,J.M.,and van der Klis,M.:1981,Astron.Astrophys.101,p.299.
Elsner,R.,Ghosh,P.,Darbro,W.,Weisskopf,M.,Sutherland,P.,and Grindlay,J.: 1980,Astrophys.J. 239,p.335.
Holt,S.,Boldt,E.,Serlemitsos,P.,and Kaluzienski,L.:1976,Nature 260,p.592.
Klis van der,M.,and Bonnet-Bidaud,J.M.:1981,Astron.Astrophys.95,L5
Lamb,R.C.,Dower,R.G.,and Fickle,R.K.:1979,Astrophys.J.229,L19.
Manzo,G.,Molteni,D.,and Robba,N.R.:1978,Astron.astrophys.70,p.317.
Molteni,D.,Rapisarda,M.,Robba,N.R.,and Scarsi,L.:1980,Astron.astrophys. 87,p.88.

THE AM HERCULIS MAGNETIC VARIABLES

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ABSTRACT

The observational properties of the ten known AM Her systems are reviewed. A multitude of components of continuum and line radiation from these objects are outlined. We discuss the important physical processes involved in the accretion flow and funnel shock, with emphasis on the properties of the emission line regions. Other topics include the properties of the white dwarf primaries and M dwarf secondaries, the maintenance of synchronous rotation, and the implications of "clumpings" in the known orbital periods (80-115 minutes) and magnetic field strengths (20-35 megagauss).

1. INTRODUCTION

AM Herculis objects are cataclysmic variable (CV) binary systems containing a strongly magnetic white dwarf primary. Their unique, defining observational property is strong circularly and linearly polarized radiation, at or near optical wavelengths. Since the primary star's magnetosphere apparently prevents formation of the usual CV accretion disk, material spilling over from the secondary star is funneled onto the white dwarf's surface near a magnetic pole. Most gravitational energy is released in a standing shock region in this polar accretion column, including much X-ray and polarized optical radiation. Thus the term "polars" -- first proposed by two Polish astronomers (Krzeminski and Serkowski 1977) -- has also been used to label these systems. The original polarization discoveries of AM Her and several other systems were made by Tapia -- cf. Tapia (1977).

Since AM Her was first identified as an exciting, unprecedented kind of CV, the literature on this new group has proliferated and many new systems have recently been discovered. In this review we concentrate on the observational properties of these objects, with limited attempts to point out which theoretical ideas are surviving the early tests. The previous reviews emphasizing early work on AM Her itself are those of Kruszewski (1978) and Chiappetti, Tanzi

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