OPTICAL AND ULTRAVIOLET[1] OBSERVATIONS OF HZ HER

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ABSTRACT

Results of five nights of photoelectric UBV photometry of HZ Her and of simultaneous ultraviolet spectroscopy with IUE are presented.

1 INTRODUCTION

In a recent paper, Kippenhahn and Thomas (1979) have discussed a model according to which energy is transported by circulation from the area of HZ Her which is illuminated by Her X-1 to the area in the shadow. Although there exists already a wealth of observational data about HZ Her (see e.g. Gerend and Boynton, 1976; Czerny-Schwarzenberg, 1978; Kilyachkov and Shevchenko, 1978), these data are not well suited for studying the observational consequences of the Kippenhahn-Thomas model. The authors found it therefore worthwhile to start their own observations which in particular address the phase of the X-ray eclipse. Results of the first of these observations, on the one hand photoelectric UBV photometry and on the other hand simultaneous ultraviolet spectroscopy with the IUE are reported here. A detailed presentation of these data will be given elsewhere (Kippenhahn et al. 1979).

2 THE OPTICAL OBSERVATIONS

Photoelectric observations in the UBV system have been made with the 123 cm reflector of the Calar Alto observatory near Almeria, Spain, on five successive nights, starting on May 20th, 1979. The journal of these observations is listed in Table 1. The orbital phases $\varphi_{1.7}$ are based on data of Giacconi et al. (1973), neglecting period changes, whereas for the X-ray phase φ_{35} the zero point has been taken from Giacconi et al.

1) Based on observations by the International Ultraviolet Explorer at the Villafranca Satellite Tracking Station of the European Space Agency.

M. J. Plavec, D. M. Popper and R. K. Ulrich (eds.), Close Binary Stars: Observations and Interpretation, 349–353.

Table 1: Journal of the UBV observations.

Night No.	Start of observations JD 2440000+	$\varphi_{1.7}$	φ_{35}	End of observations JD 2440000+	$\varphi_{1.7}$	φ_{35}
1	4014.396	0.153	0.932	4014.655	0.306	0.939
2	4015.375	0.729	0.960	4015.648	0.890	0.967
3	4016.369	0.314	0.988	4016.483	0.381	0.991
4	4017.383	0.910	0.017	4017.645	0.064	0.024
5	4018.360	0.485	0.045	4018.563	0.604	0.051

(1973) and the average period of $34\overset{d}{.}95$ from Davison and Fabian (1977). Accordingly, turn on of cycle No. 77 should have occurred on May 23rd, just before the observations of night No. 4. However the prediction of turn on can only be made with an uncertainty of about ±2 days.

The transformation from the instrumental to the standard UBV system has been done in the usual way, for details see Kippenhahn et al. (1979). The resulting light curves are shown in Fig. 1. Each data point corresponds to one integration, the length of the vertical bar indicates the rms error of the observation. The eclipse of the X-ray source is assumed to occur between the phases $\varphi_{1.7} = 0.93$ and $\varphi_{1.7} = 0.07$ (dashed lines in Fig. 1), corresponding to a half angle of $25\overset{\circ}{.}2$. The overall shape of the light curves agrees rather well with previous observations (Gerend and Boynton, 1976). But the totality of the eclipse and the asymmetric shape near primary minimum are features which have not been identified by Gerend and Boynton (1976) in their data analysis and are not reproduced by their "tilted disk" model. Details of these observations will be discussed by Kippenhahn et al. (1979).

3 THE ULTRAVIOLET OBSERVATIONS

Simultaneously to the optical observations of the minimum of HZ Her on night No. 4 (see Table 1), two low resolution spectra in the long wavelength range have been taken with the IUE. The journal of these observations is given in Table 2.

Table 2: Journal of the IUE observations.

Camera Image	Dispersion	Exposure (min)	Exposure midpoint JD 2440000. +	Phase midpoint $\varphi_{1.7}$	φ_{35}
LWR 4583	Low	150	4017.610	0.0435	0.0235
LWR 4584	Low	207	4017.751	0.1268	0.0275

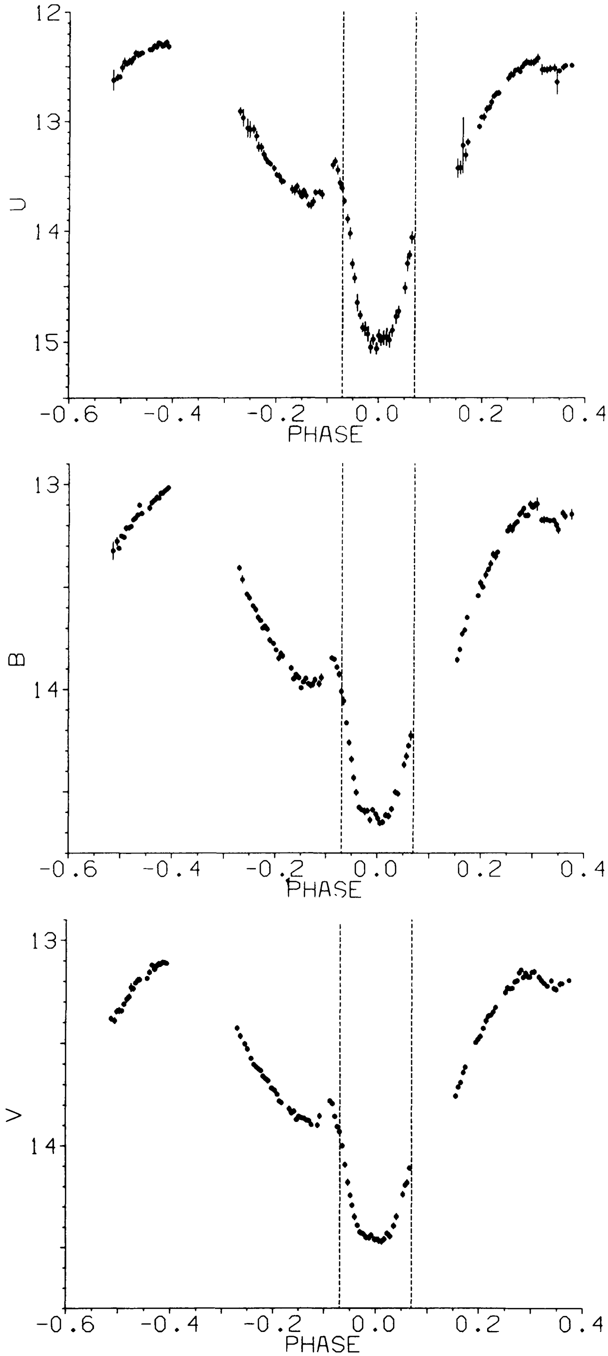

Fig. 1: The observed light curves of HZ Her in U, B and V (from top to bottom) versus the orbital phase. For details see text.

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In spite of the relative long exposure the spectrum which has been taken during the eclipse of the Her X-1 is underexposed by about a factor of two, resulting in a low signal to noise ratio. The mean UV flux in the usable wavelength range $\lambda\lambda$2400-3000 Å is found to be about $5\cdot10^{-15}$ erg cm^{-2} s^{-1} Å^{-1}. This is about half the estimated flux in the short wavelength range (Dupree et al., 1978). Due to the low signal to noise ratio, neither emission nor absorption lines could be identified. The shape of the continuum is consistent with black body temperatures in the range 7000-9000 K.

The second image, taken outside the X-ray eclipse, is well exposed in the ranges $\lambda\lambda$ 2000-2400 Å and $\lambda\lambda$ 2900-3100 Å, but saturated in between due to the long exposure. Again neither emission nor absorption lines could be identified with certainty. The UV fluxes at $\lambda\lambda$ 2000 Å and 3000 Å are about $4\cdot10^{-14}$ erg cm^{-2} s^{-1} Å^{-1} and $2.5\cdot10^{-14}$ erg cm^{-2} s^{-1} Å^{-1} respectively.

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DISCUSSION FOLLOWING KIPPENHAHN, RITTER, SCHMIDT AND THOMAS

Mazeh: Two Russian observers (Kilyachkov and Shevchenko) published recently UBV light curve of HZ Her near eclipse. Are their results similar to the light curves you have presented?

Ritter: I don't know because we have not been aware of the Russian observations.

Budding: How sensitive are the derived temperatures to what is assumed about interstellar reddening?

Ritter: The spectra that I have presented have not been corrected for interstellar reddening. This certainly must be done, and until it has been done I cannot say how sensitive the derived temperatures depend on the reddening. Thus these temperatures should be considered as a rough estimate.