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The Structure of the Accretion Disk in the ADC Source 4U 1822-371

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Abstract. The low-mass X-ray binary (LMXB) 4U 1822-371 has an accretion disk corona (ADC) that scatters X-ray photons from the inner disk and neutron star out of the line of sight. It has a high orbital inclination and the secondary star eclipses the disk and ADC.

We have obtained new time-resolved UV spectrograms and V- and J-band photometry of 4U 1822-371. The large quadratic term in our new optical eclipse ephemeris confirms that the system has an extremely high rate of mass transfer and mass accretion. The C IV $\lambda\lambda = 1548-1550$ Å emission line has a half width of ~ 4400 km/s, indicating a strong, high velocity wind is being driven off the accretion disk. Near the disk the wind is optically thick in UV, V, and J and the eclipse analysis shows that in V and J the optically thick wind extends nearly to the outer edge of the disk. The ADC must also extend vertically to a height equal to approximately half the disk radius.

Keywords: X-ray Binaries
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INTRODUCTION

4U 1822-371 is a low-mass X-ray binary star (LMXB) with an orbital period of $P_{orb} =$ 5.57 hr [1]. The compact star in the system is an X-ray pulsar with spin period $P_{pulse} =$ 0.593 s [3]. 4U 1822-371 is one of the rare eclipsing LMXBs [1, 4]. The eclipse is a transit of the secondary star across the accretion disk and is very broad at all wavelengths with no sharp features. The accretion disk is large and the X-ray emission comes from a partially-eclipsed extended cloud around the neutron star - an accretion disk corona (ADC) [4, 2].

OBSERVATIONS AND ANALYSIS

The new UV data consists of 300 time resolved UV spectra obtained with the ACS/SBC [5] in prism mode on HST in 2006. The time resolved spectra were integrated over the wavelength range to produce a UV light curve. The optical observations of 4U 1822-371 were taken in V and J bands with the SMARTS 1.3-m telescope at CTIO. Combining our data with previous observations we derived an improved optical ephemeris of

$$T_{min} = 2445615.31166(74) + 0.232108641(80)E + 2.46(21)x10^{-11}E^2. \qquad (1)$$

The quadratic term in the ephemeris yields a time scale for a change in orbital period of $P/\dot{P} = 3.0 \pm 0.3 \times 10^6$ yr. The deduced rate of mass transfer is large, probably greater than $6 \times 10^{-8} M_\odot$ yr^{-1}. Mass cannot be accreting onto the neutron star at this rate without violating the Eddington limit, so much of the transferred mass must be lost from the system.

The fluxes in the majority of UV emission lines are neither reduced during eclipse nor enhanced at other orbital phases. The emission lines must, then, arise from optically-thin material far above and below the disk. The full width at zero intensity of the C IV emission line is ~ 45 Å in agreement with [7], corresponding to projected velocities up to ± 4400 km/s. We attribute the C IV emission to a strong disk wind.

The eclipse model requires a torus centered on the NS. This torus has a vertical height $\sim$ 1/2 the disk radius and is optically thick. The photosphere of the V and J torus extends out to nearly the disk edge, which is near the tidal truncation radius, and the UV torus is slightly smaller. This large structure has a brightness temperature of $\sim$ 26,000 K, much lower than coronal temperatures and too low to be pressure supported. We identify it as an optically thick disk wind. The full orbital model also requires a dark variable-height disk rim. This rim is not likely a rim at all, but the cooler base to the disk wind.

CONCLUSIONS

We have inferred a strong disk wind from the C IV emission lines in the UV spectrum. The wind is optically thin far above the disk, but closer to the disk the wind is optically thick and blocks all of the accretion disk and NS from view. Our models also require a variable-height, optically-thick wall located at the edge of the disk. All previous models for the orbital light curve have needed a similar wall, but we now suggest that the wall is a cooler, darker layer at the base of the disk wind just above the disk. A complete analysis will be presented in Astrophysical Journal (arXiv: 0911.4492).

REFERENCES

1. K. O. Mason, P. Seitzer, I. R. Tuohy, L. K. Hunt, J. Middleditch, J. E. Nelson, and N. E. White, *ApJL* **242**, L109–L113 (1980).
2. K. O. Mason & F. A. Cordova, *ApJ* **255**, 603 (1982)
3. P. G. Jonker, and M. van der Klis, *ApJL* **553**, L43–L46 (2001).
4. N. E. White, R. H. Becker, E. A. Boldt, S. S. Holt, P. J. Serlemitsos, and J. H. Swank, *ApJ* **247**, 994–1002 (1981).
5. C. Pavlovsky, et al., *Advanced Camera for Surveys Instrument Handbook for Cycle 16, Version 7.1*, Baltimore: STScI, (2006)
6. A. N. Parmar, T. Oosterbroek, S. Del Sordo, A. Segreto, A. Santangelo, D. Dal Fiume, and M. Orlandini, *A & A* **356**, 175–180 (2000).
7. E. M. Puchnarewicz, K. O. Mason, F. A. Cordova, *Adv. Space Res.* Vol. 16, No. 3, 65 (1995)
8. N. E. White, and S. S. Holt, *ApJ* **257**, 318–337 (1982).
9. C. Hellier, and K. O. Mason, *MNRAS* **239**, 715–732 (1989).