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Colliding Wind Shock X-rays in M17's Central Multiple O Star System

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ABSTRACT

We present high-resolution *Chandra* X-ray grating spectroscopy of the multiple O star system at the center of M17. This system is already known to be a strong source of hard X-rays, based on X-ray CCD observations. Here we present an anlysis of the X-ray emission line widths, line ratios, and global thermal spectral modeling, which, taken together, indicate that each of the two visual components of this system is itself an O+O binary with significant colliding wind shock X-ray emission.

Key words: stars: early-type – stars: winds, outflows – stars: individual: CEN1 – X-rays: stars

1 INTRODUCTION

X-ray emission from M17 is dominated by a single multiple O star system, "Kleinmann's Anonymous Star" or CEN1. The 1.8 $''$ separation of the two components is so large (2900 AU at 1.6 kpc) that the wind collision between these two components could not produce the strong ($L_X > 10^{33}$ ergs s^{-1}) X-ray observed from the system. In fact, initial *Chandra* imaging shows two distinct sources of X-rays, consistent with the positions of the two O4 stars (Broos et al. 2007). Howewver, both the high X-ray luminosities and the high plasma temperatures (Broos et al. 2007) observed in each of the two stars are difficult to reconcile with the standard embedded wind shock (EWS) picture of X-ray production in normal, single O stars (Owocki et al. 1988; Feldmeier et al. 1997). The X-ray luminosities are also too high to be explained by low-mass pre-main-sequence (PMS) companions. The two most viable explanations for the hard and strong observed X-ray emission are (1) that each component is itself a colliding wind binary (CWB), and (2) that each is a single magnetic O star, with the magnetically channeled wind shock (MCWS) mechanism (Babel & Montmerle 1997) operating. Of course, one scenario could apply to one component while the other scenario to the second component.

The primary X-ray spectral discriminant of these two models is the widths of the X-ray emission lines. CWB X-ray emission usually shows relatively broad emission lines, while MCWS X-rays shows narrower emission lines (Gagné et al. 2005). The *Chandra* grating data, presented here for the first time, will be able to differentiate these two scenarios via a precise measurement of the line widths. Additional constraints to the X-ray production models will be provided by helium-like forbidden-to-intercombination line ratios, which can constrain the distance of the X-ray emitting plasma from the stars' photospheres, and global thermal spectral modeling which can constrain the temperature distribution in the hot plasma.

In §2 we present the *Chandra* data. In §3 we present the analysis of the grating spectra and of the zeroth-order spectrum. And in §4 we discuss what the spectral analysis implies for the origin of the X-rays in this system. We summarize our conclusions in §5

2 OBSERVATIONS

Fig: (zeroth-order) image of field

Description of the two (GO, GTO) observations

Extraction of zeroth-order and grating spectra, coaddition of two observations; analysis of extent of contamination

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Dispersed spectra; zeroth-order spectra (**Figs showing each**)

Stars' properties (where? separate section?); (**Table**)

3 ANALYSIS

3.1 Line properties – widths but also limits on shifts (try *windprofile* fits?), fluxes (**Figs: strongest lines with Gaussian fits**; **Table: line properties**)

3.2 f/i modeling – **Fig: complexes with best-fit *hegauss* models; implied constraints on plasma location**

3.3 Global modeling – zeroth order spectra, and first-order, too – **Figs: zeroth order spectrum with best-fit model; portion of first-order, too**; **Table: 2T apec model parameters**

3.4 Time variability (?) – include ACIS-I light curve too? (Leisa and Pat's input); but even if not, **Fig: light curves for GO and GTO data** (see James's poster, upper right)

4 DISCUSSION

Lines far too broad to be MCWS in either A or B (given the spectral hardness, anyway, in analogy to θ^1 Ori C); in fact, these are the *broadest* X-ray lines seen in a CWB system

f/i ratios indicate that some of the X-ray plasma is moderately close to the photosphere of at least one of the stars; either the wind momenta do not balance and/or the binary separation is quite small

Temperatures are high, so CWB wind shocks at close to the terminal velocity (reconcile with *f/i*)?

$L_{\rm X}$ in context of other CWB systems

And generally, how do these binaries fit in with the diverse behavior seen in X-ray properties of CWBs? Similarity to HD 93259, HD 93403, HD 47129, QZ Car...

Double CWB system – Hoffmeister binary context and need for more RV data to determine the binary systems' properties; are there hints/clues about the probable binary orbit and stellar and wind properties given what we see in the X-rays? e.g. hard means P is not super short; *f/i* means likely not too long, either

5 CONCLUSIONS

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