The source of anomalously hard x-rays in M17's central O4-O4 binary

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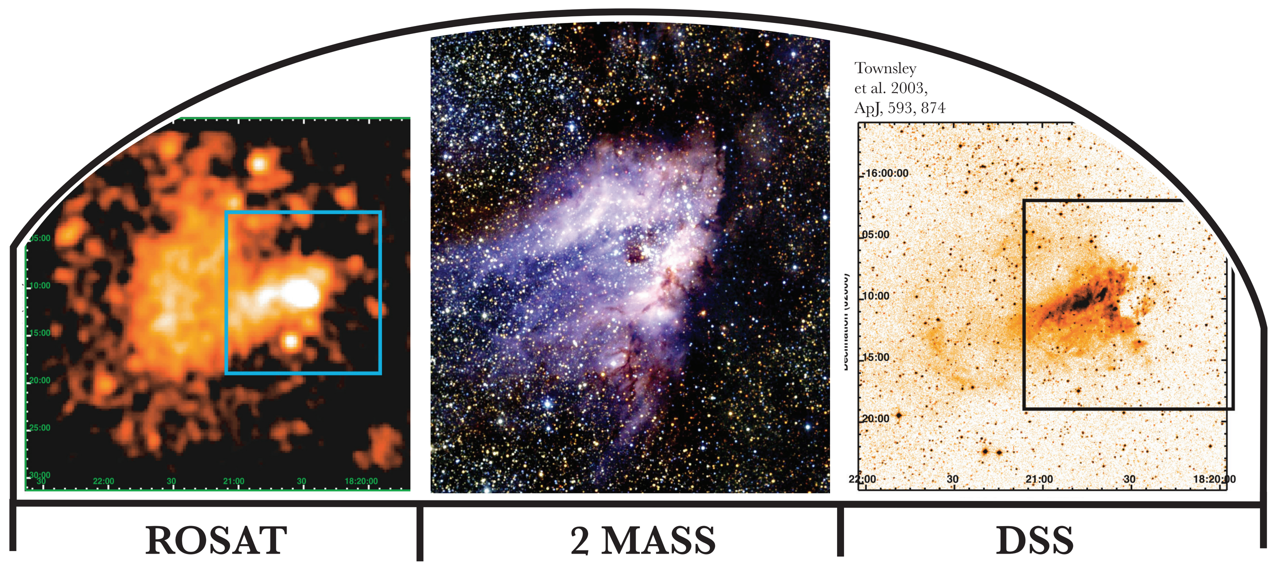
Background

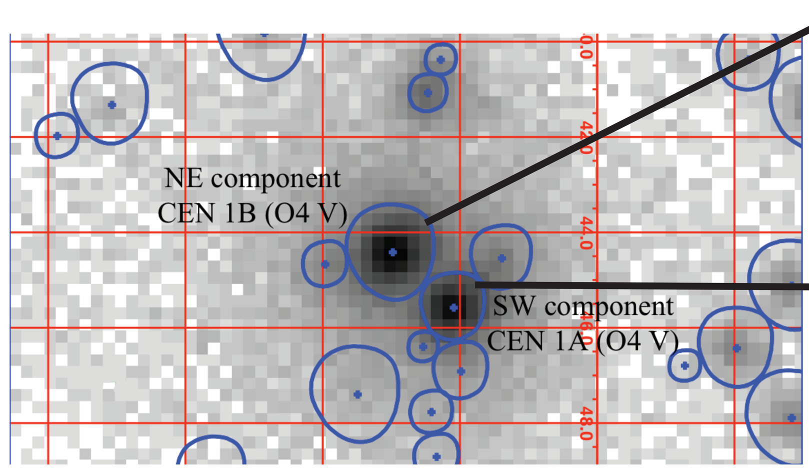
» Name: CEN 1 or Kleinmann's Anonymous Star
» Location: O4+O4 binary at the center of M17
» Separation: 1.8" (2900 AU at 1.6 kpc)
» Extinction: $A_V \approx 10$ (component A), 13 (component B)

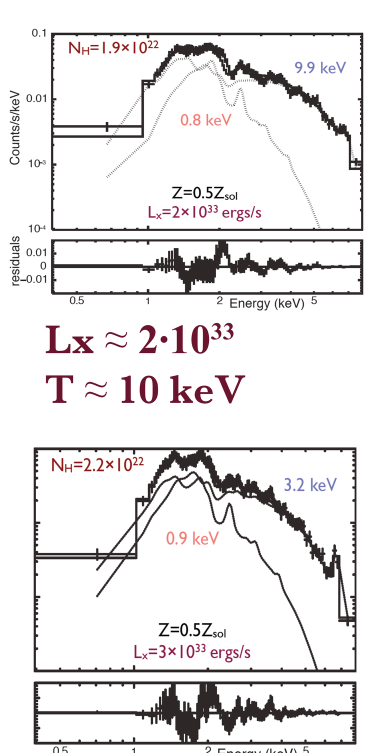


Motivation

CEN 1A and 1B have extremely hard x-ray spectra and high luminosities. Component A is time variable (see time variability section). We want to know:

What mechanism produces the extreme x-ray emission?





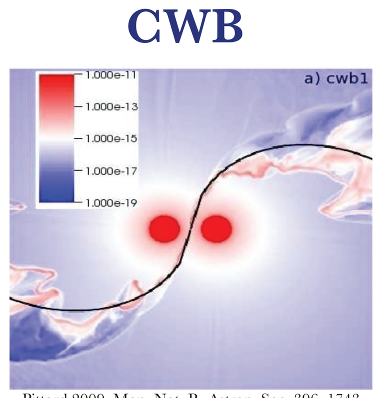
$L_x \approx 2{\cdot}10^{33}$
$T \approx 10$ keV

$L_x \approx 1\text{-}3{\cdot}10^{33}$
$T \approx 3$ keV

Hard x-ray emission

Strong x-rays from O-stars come from colliding wind binaries (CWB), or magnetically channeled wind shock (MCWS) systems.

CWB



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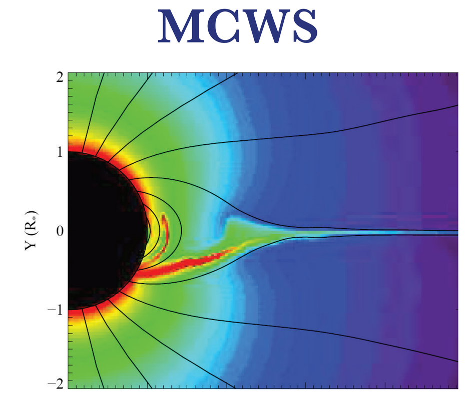
» stellar winds collide at high speed → Doppler broadened emission lines
» emission relatively far from the stars → high forbidden to intercombination (f/i) ratios
» implies binarity (4 stars)

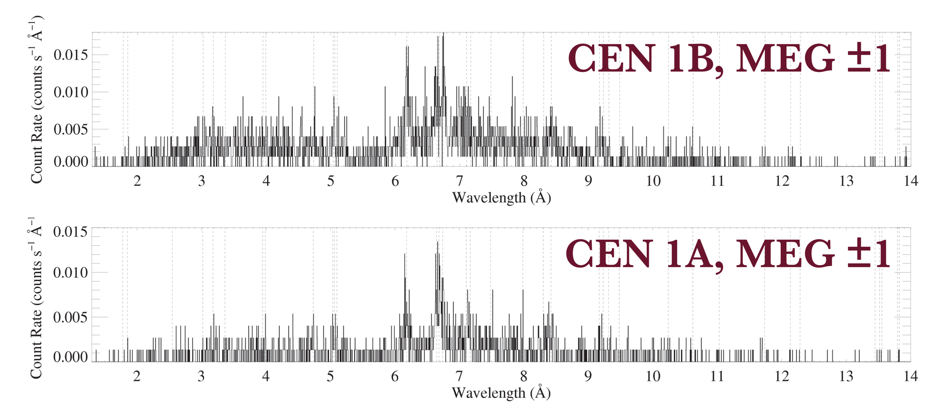
MCWS

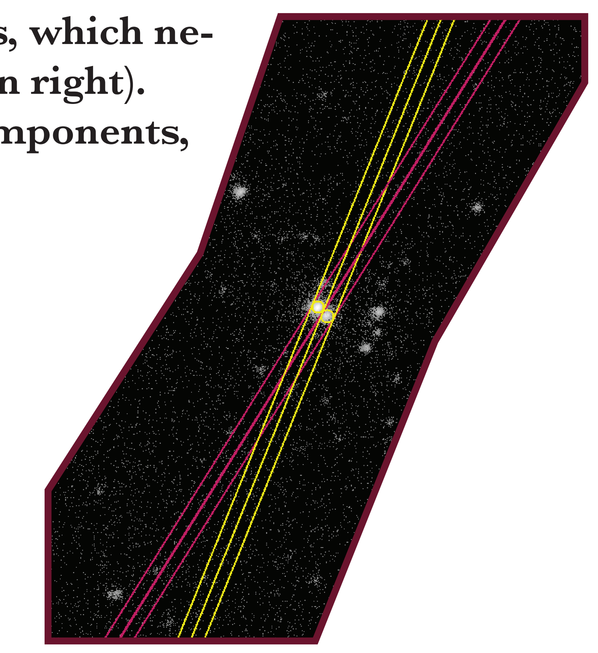


» static magnetically confined plasma → narrow emission lines
» strong stellar magnetic field channels wind near the photosphere → low f/i ratios
» implies stars are magnetic

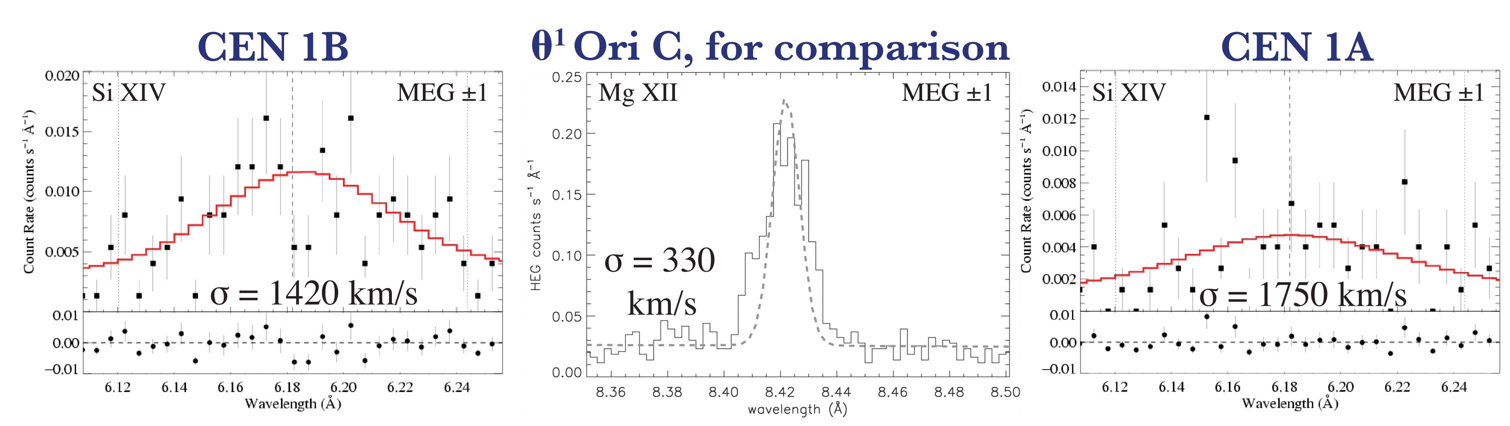
New *Chandra* grating data

The two sources are separated by only 3.5 pixels, which necessitates custom spectral extraction regions (on right). Spectra were successfully extracted for both components, shown below.



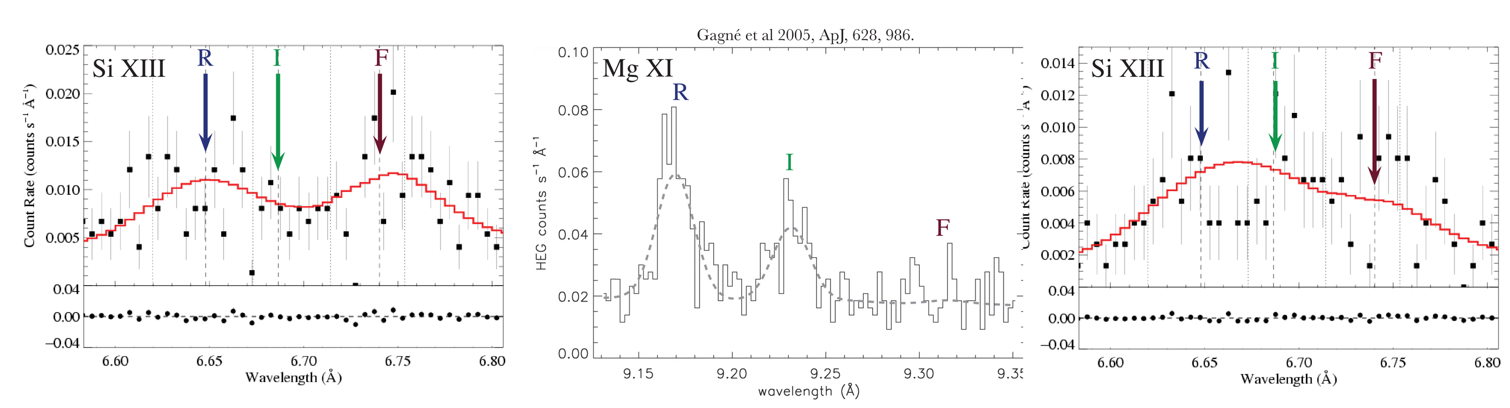


Line diagnostics



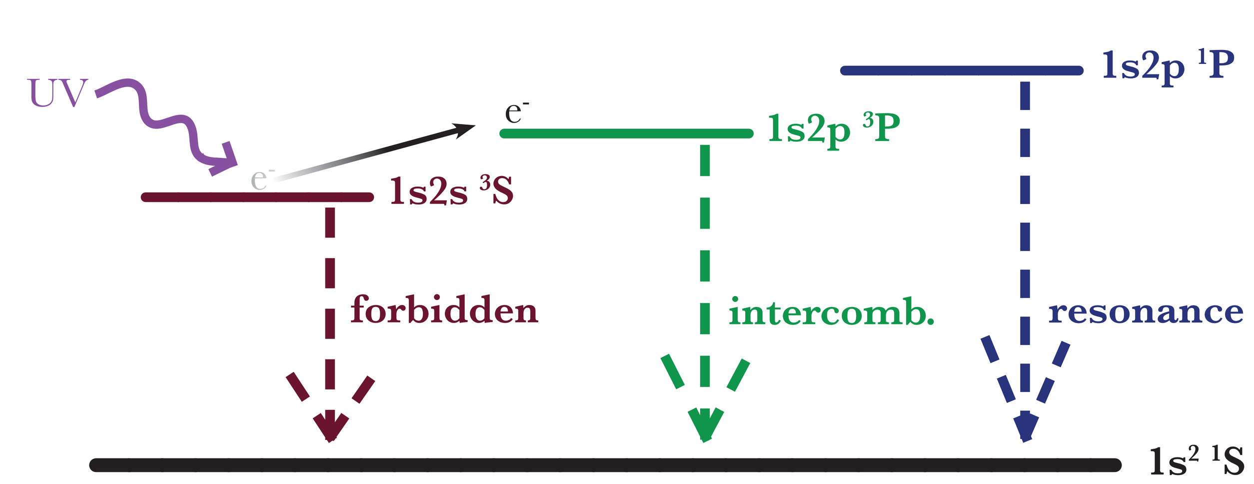
Line widths: The Ly-α lines of silicon (above) for both CEN 1B and 1A are drastically wider than the narrow line of the known MCWS star, θ^1 Ori C, suggesting emission does not occur in a stationary plasma.

Line ratios: The He-like Si XIII complex for CEN 1B (below, left) has an f/i > 2, meaning emission occurs far from the star. The f/i ratio for CEN 1A is 0.8 ± 0.8, which suggests x-ray emission occurs close to A's photosphere.



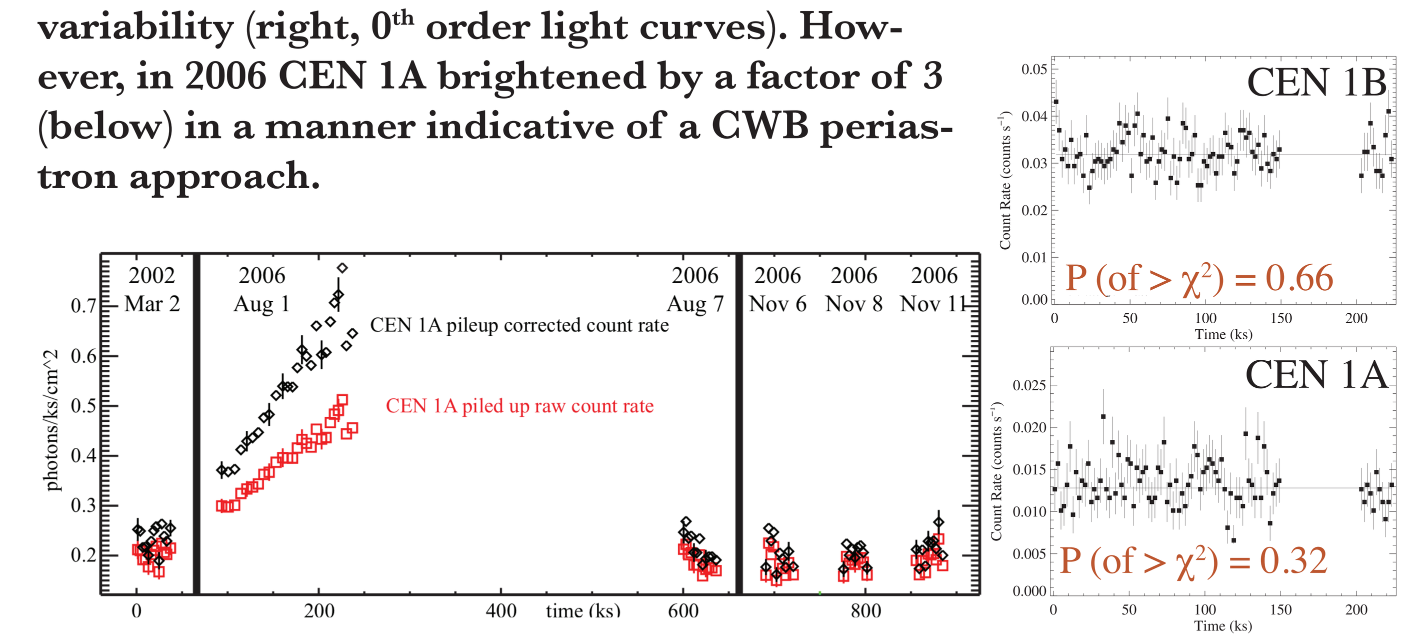
f/i ratio theory

Helium-like emission complexes (S XV, Si XIII, etc) are subject to alterations of their forbidden-to-intercombination line ratios due to UV photoexcitation of electrons out of the metastable upper level of the forbidden line. Low f/i ratios are thus diagnostic of close proximity to the UV-bright photospheres of O stars.



Time variability

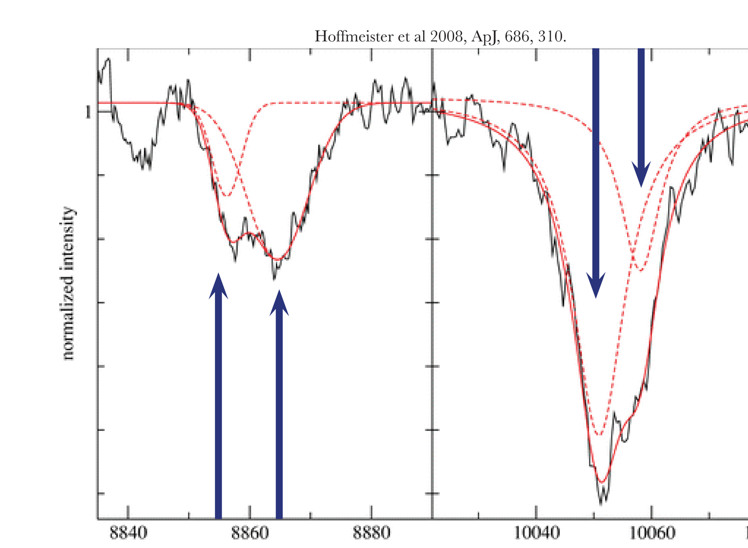
In this most recent *Chandra* observation, we see no significant time variability (right, 0^{th} order light curves). However, in 2006 CEN 1A brightened by a factor of 3 (below) in a manner indicative of a CWB periastron approach.



Results

CEN 1 completely dominates x-ray emission in M-17, though component B ($L_x \approx 2{\cdot}10^{33}$, $T \approx 10$ keV) is slightly harder and more luminous than A ($L_x \approx 10^{33}$, $T \approx 3$ keV, during its low state). Component A is found to increase in luminosity by a factor of three. The Si XIII f/i ratio is unaltered for B (>2) but reduced for A. Line widths are very large - larger than those seen in single O stars, and comparable to the wind terminal velocities.

Discussion



The very broad lines in CEN 1A and 1B are consistent with the CWB hypothesis; this system contains at least four stars. This interpretation is consistent with recent detection of Paschen line splitting in both components A (on right) and B, indicating that they are both spectroscopic binaries. The high f/i ratio for component B indicates emission far from the star, again consistent with the CWB hypothesis. Component A's low f/i ratio needs more detailed modeling, though it indicates emission only a few R_* out. This could suggest an asymmetry in wind momenta or a small binary separation during the observation.

Acknowledgments

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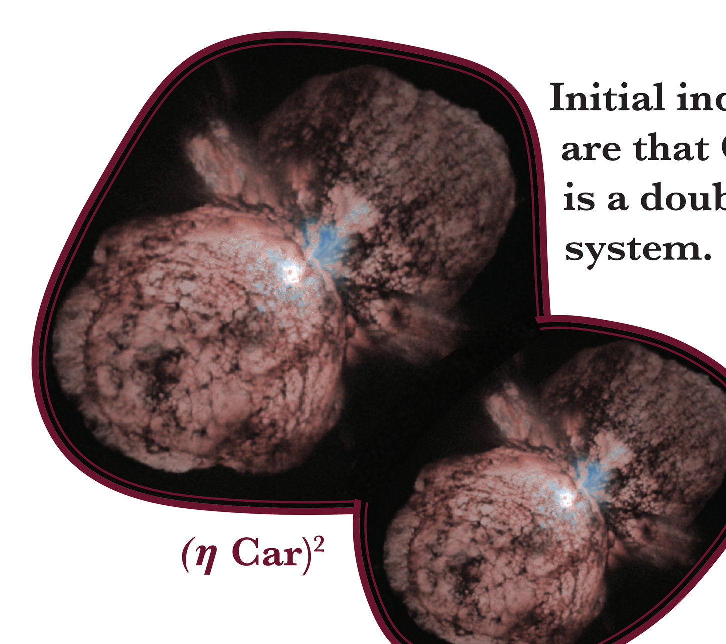

Initial indications are that CEN 1AB is a double CWB system.