Suzaku Observations of Massive Binary Systems

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Suzaku η Car, WR140, and WR25 teams,
X-ray Emission from Massive Binary Systems

- Evolved massive stars have strong winds
  - The winds eject CNO materials
  - $M_{\text{dot}} \sim 10^{-3} - 10^{-5} \, M_{\odot} \, \text{yr}^{-1}$
  - $v_{\text{wind}} \sim 500 - 3000 \, \text{km} \, \text{s}^{-1}$

- Collision of winds from a binary pair produces hot plasma
  - $kT \sim 2-4 \, \text{keV}$
  - $L_x$ up to $\sim 10^{35} \, \text{ergs} \, \text{s}^{-1}$
Simulation of the Wind-wind Collision

Assuming parameters of η Car (Okazaki et al.)
New Science w/Suzaku

- **XIS + HXD**
  - Good sensitivity between 5 – 40 keV (0.25-2 angstrom)
  - well constrains Fe K line/edge and hard slope profiles
  - Detection of hard components

- **Science on colliding wind plasma**
  - Plasma thermal equilibrium/non-equilibrium
  - particle acceleration at the wind colliding surface
# MBSs seen with Suzaku

<table>
<thead>
<tr>
<th>Spectrum</th>
<th>P (year)</th>
<th>e</th>
<th>i</th>
<th>$L_x$ $(10^{34} \text{ ergs s}^{-1})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>η Car</td>
<td>5.54</td>
<td>~0.9</td>
<td>45?</td>
<td>6-25</td>
</tr>
<tr>
<td>WR 25</td>
<td>0.57</td>
<td>0.56</td>
<td>37</td>
<td>~0.8</td>
</tr>
<tr>
<td>WR 140</td>
<td>7.94</td>
<td>0.88</td>
<td>32</td>
<td>0.5-2</td>
</tr>
</tbody>
</table>

X-ray luminosity variation of a wind-wind colliding system

$$L_x \propto n^2 v \propto \frac{\dot{M}^2}{D}$$
\eta\ Carinae

($P=5.54\text{yr}$)

XIS image on 2007-06-23

\begin{figure}
\begin{center}
\includegraphics[width=\textwidth]{plot.png}
\end{center}
\end{figure}

\textbf{Suzaku}

\textbf{RXTE}

(2-10 keV)

\textbf{Orbital Phase}

\begin{align*}
\text{RXTE count rates (cnts s}^{-1})
\end{align*}
Early Results on Very Hard X-rays

- Beppo-SAX measured fluxes above 15 keV (Viotti et al.)
- severe contamination by 1E1048.1-5937, IGR J10447-6027
- INTEGRAL resolved hard emission from η Car (Leyder et al.)
- another hard component above 22 keV
- It was interpreted as an inverse Compton component.
XIS+HXD spectra

- Excess component above 10 keV
  - No apparent flux variation between observations
  - Inverse Compton, additional thermal comp, or external hard source?

Sekiguchi, Hamaguchiet al. (PI: SWG, Hamaguchi)
WR140
(P=7.94yr)

XIS image on 2008-04-09

Suzaku

RXTE

2008-04-09
(20 ks)

Orbital Phase

RXTE count rates (cnts s\(^{-1}\))

1.4 1.6 1.8 2 2.2

2000/12~2003/03
2005/03~2008/09
XIS+HXD spectrum

Sugawara et al. (PI: Y Maeda)
WR25 ($P=0.57$yr)

- No detailed phase resolved spectra
- Some spectra show hot $kT \sim 4-5$ keV ($\text{XMM}: kT \sim 0.6, 2.8$ keV)

XIS image on 2007-06-23
Summary

- Suzaku observed evolved massive binary systems, η Car, WR140 and WR25.
- The XIS + HXD spectra of η Car showed excess from the thermal emission that dominates below ~10 keV.
- The HXD spectrum of WR140 was consistent with thermal emission with CXB background.
- X-ray spectra of WR25 showed very hot components.
- Big events are coming in early 2009. Stay tuned!