Precessing thermal/non-thermal jets from SS 433

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Distance: 4.85 ±0.2 kpc
Jet velocity: 0.26 c
Orbital period: 13.0820 days
Precessing period: 162.4 days
Half-opening cone prec. angle: 19.85º
Opening angle of the jet: 5º
Axis inclination to the LoS: 78.83º

JETS PRECESSION
Period ~ 162 days

Equatorial emission: “ruff”
Re-heating (X-rays)

10^{12} cm  10^{15} cm  10^{17} cm
X-Rays  optical  Radio

East  West
Line of Sight

Blundell et al. 01
Simultaneous radio/X-rays

11 July 2003

60 ks of Chandra ACIS-S

40 ks of VLA @ 5 GHz

~10 arcsec
<table>
<thead>
<tr>
<th>ACIS-S</th>
<th>GRATING</th>
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<tbody>
<tr>
<td>2000</td>
<td><img src="Migliari_Fender_Mendez_02" alt="Image" /></td>
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<td>2003</td>
<td><img src="Migliari_Fender_Mendez_02" alt="Image" /></td>
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**NOT** a long-term and static structure
X-ray spatially resolved spectra

Vertical lines are @ 6.4 and 6.7 keV

This indicates HOT, MOVING plasma at large distances from the core (100s of days since launch)

Multiple X-ray lines with different energies East-West

High excitation lines (Fe XXV / XXVI ?)
X-ray and radio emitting regions are spatially close (if not coincident)

X-ray continuum is NOT consistent with being produced by synchrotron (c.f. XTE J1550-564)
- break in the synch. emission before soft X-ray band
- X-ray continuum is thermal

SIMULTANEOUS RADIO/X-RAY IMAGES

1550 from Corbel et al. 02
SIMULTANEOUS RADIO/X-RAY IMAGES: estimating the relative populations of a hybrid thermal/nonthermal plasma

- We can estimate the volume of the east-jet in the region analysed
  \[ V \approx f \times 7 \times 10^{49} \text{ cm}^3 \] (f is the `filling factor')

- From the volume and X-ray fluxes (Fe and bremsstrahlung continuum) we can estimate in two ways the baryonic mass that emits thermally:
  \[ M(\text{br}) \approx 7 \times 10^{-5} M_\odot \]
  \[ M(\text{Fe}) \approx 2 \times 10^{-5} M_\odot \]
  The corresponding kinetic power is \[ L_{\text{kin}} \approx 2 \times 10^{41} \text{ erg/s} \]

- From the volume and radio flux, from ‘minimum energy’ arguments and assuming that the particle distribution extends to Lorentz factors \( \sim 1 \) and one proton for each electron, the baryonic mass that emits synchrotron is:
  \[ M(\text{synch}) \sim 10^{-7} M_\odot \]
  IF \( f \sim 10^{-6} \) we obtain a ‘reasonable’ value for a stellar mass object accreting at Eddington of \[ L_{\text{kin}} \sim 2 \times 10^{38} \text{ erg/s} \]

IF we use the same filling factor for synchrotron population we obtain: \( M_x/M_r \sim 50 \)

THE MASS OF THE TAIL THAT PRODUCES SYNCH. IS \( \sim 1\% \)
“RUFF”
(Equatorial emission)

- X-ray equatorial emission
- Iron lines: it seems to be a massive baryonic outflow of matter perpendicular to jets
Summary

- X-ray arcsec scale jets are NOT static and long term

- X-ray jets spectra: multiple Doppler-shifted Fe lines: hot (∼keV) moving plasma at large distance from core

- Broadband radio/X-ray spectrum indicates hybrid thermal/non-thermal plasma with at most ∼1% of total mass in non-thermal component

- “Ruff” seems to be a massive outflow perpendicular to the axis of the jets