Probing the jet structure: highlights of the observing campaign of the XTE J1550-564 large-scale jets

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The nice Chandra images’ talk

XTE J1550-564 western jet’s 2002-2003 Chandra gallery

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Large scale jets

- **Compact, persistent radio jets (~10 AU)**
- **Transient, relativistic radio jets (~100s AU)**
- **Large scale jets (up to ~10s pc)**
- **Radio lobes/cavities**

**Accretion & ejection relation**

**Interaction with the ISM, & radio duty cycle**
XTE J1550-564 large scale jets

Low Mass X-ray Binary:
- September 1998: X-ray outburst + the detection of relativistic compact jets ($v_{\text{app}} \sim 1.7c$, Hannikainen+09);
- June 2000: discovery of large-scale (~0.5pc) radio & X-ray jets (Corbel+’02)
  
  \[ <v_{\text{app, east jet}} > = 1.0c \text{ to } 0.1c; \]
  \[ <v_{\text{app, west jet}} > = 0.55c \text{ to } 0.4c. \]

Dynamical Model:
the jets propagate unseen in an under-dense ISM cavity and become visible when they impact the cavity’s boundaries (Wang ’03; Hao&Zhang ’09, Steiner+’12).

Follow-up of the western jet:

✓ X-rays: 8 Chandra observations;
★ Radio: 24 ATCA observations (1.4 GHz, 2.5 GHz, 4.8 GHz, 8.6 GHz).
XTE J1550-564 jets: dynamics

- Western jet first detection in 2001
- Beginning of the deceleration phase

**Flux:**
- Rising phase
- Radio plateau
- Decay phase

**Projected Angular Separation (arcsec):**
- Cavity's eastern boundary
- Cavity's western boundary

**Days from Flare (MJD):**
- Chandra East Jet
- ATCA East Jet
- Chandra West Jet
- ATCA West Jet
- Cavity west wall (Steiner+’12)
- Cavity east wall (Steiner+’12)
Jet structure

Spatially resolved X-ray jet:

Evolution in ~1.5 yrs of the X-ray morphology:

- deceleration of the main peak ($v_{app} \sim 0.07c$);
- formation of an apparently receding tail ($v_{app} \sim -0.10c$);
X-ray tail: reverse shock

Forward shock $\rightarrow$ ISM
Reverse shock $\rightarrow$ jet plasma

☑ Steep decay ($F \propto t^{-2}$): synchrotron radio & X-ray emission from the reverse shock (Wang '03; Hao&Zhang '09, Steiner+'12)

Chromatic decay: faster in radio than in X-rays?
X-ray tail: colliding shells

emission from internal shocks formed by colliding shells (models for compact jets of microquasars, prompt emission of GRBs, blazars, Kaiser+’00, Jamil +’10, Malzac+’14, Sari&Piran’97, Spada+’01)

A second X-ray & radio outburst in 2000 (Corbel+’01):

- assuming same jet velocities, the new ejecta reached the large scale jet location in ~2002;
- @8.6 GHz: flux re-brightening + spectral flattening in September 2002.
Polarized radio emission

- up to 9% linearly polarized flux @4.8 GHz and 8.6 GHz;
- $E$ vector parallel to the jet axis;
- polarization angle changes on < month timescales.

probe of the $B$ field configuration in the ejecta:

shock-compressed $B$ field +

evolution of the jet internal structure

Radio & X-ray high resolution observations allowed to probe the structure of large scale jets in XTEJ1550-564. More jets are needed!
Large-scale radio & X-ray jets in H1743-322 (Corbel + '05)

Outburst in 2008: radio and X-ray observations of the decay phase (Jonker et al. 2008):

radio & X-ray flares
+ optically thin radio emission in low-hard state ($\alpha_r = -0.5 \pm 0.15$)
+ outlier in the radio-X-ray lumin. relation (Coriat + '11)

Colour scale : spectral index

Radio monochromatic luminosity (erg/s/Hz)

X-ray luminosity (erg/s)
Observations: H 1743-322

Analysis of the archival Chandra observations (March 8-24 2008):

Evidences for ejection events in the 2007/2008 outburst: H1743-322 is an “X-ray jet repeater”?
Observations: H 1743-322

Weak extended source at larger scales:
- $F(0.5-7) \sim 9 \times 10^{-15}$ erg/cm$^2$/s;

- Trajectory & flux are consistent with the western jet in 2004;
- from Corbel + ’05:
  - decelerating jet: the estimated prop. motion is $6.7 \pm 1$ mas/day, $\sim 15''$ ($\sim 0.6$ pc @8kpc) from H1743 => in good agreement with the observed position!
Conclusions

Chandra images are nice...but also necessary to understand jets at large and small scales in μQS and AGN