An alternative model for X-rays from jets

Hans Moritz Günther
MIT

Zhi-Yun Li (University of Virginia),
Christian Schneider (ESA)


https://github.com/hamogu/RecollimationXrayCTTS
There is a stationary component in the jet.

Blue contours: 1999
Green contours: 2011


HST/STIS: DG Tau
In IR and X-rays, too.

Chandra 450 ks
Güdel, …,
Günther et al.
(in prep)

NIFS: [Fe II]
White et al. (2014)

Schneider, Günther et al., in prep.
Mass flux through inner X-ray shock

\[ T = 4 \text{ MK} \left( \frac{v_{\text{shock}}}{500 \text{ km s}^{-1}} \right)^2 \]

\[ \dot{M} = A_{\text{jet}} \rho v_0 \]

\[ d_{\text{cool}} = 20.9 \text{ AU} \left( \frac{10^5 \text{ cm}^{-3}}{n_0} \right) \left( \frac{v_{\text{shock}}}{500 \text{ km s}^{-1}} \right)^{4.5} \]

Unlikely, given how constant the inner component appears.
Explanation I: Diamond shock

- Sophisticated model (MHD, conduction, ...)
- Assume nozzale at base
- Numbers tuned to HH 154, but might work in DG Tau, too.
- This is a good model. But it might not be the only one.

Bonito et al. (2010)
Explanation II: Stellar wind meets disk wind / disk field.

- Disk wind or stellar wind?
- Disk wind probably has higher mass flux, but lower velocity

Model
- Assume contact discontinuity between disk wind and stellar wind
- Collimation shock will form in stellar wind

\[
\frac{d\omega}{dz} = \tan\left[\arctan\left(\frac{\omega}{z}\right) - \arcsin\left(\frac{\sqrt{z^2 + \omega^2}}{R_0}\right)\right]
\]
How would such a shock look like?

- Stellar wind region thin and long
- Shock not resolved in optical obs
- High stellar mass loss
- $10^{-3}$ of jet mass sufficient to power X-rays
Shock properties and spectral fit

Fiducial model

- $5 \times 10^{-10} \; M_{\odot}/yr$
- 800 km/s

Fiducial model

- High $v_\infty$
- Low $\dot{M}$, low $P$
- Shallow $P$
DG Tau: X-ray and FUV emission

- Stationary inner component: Needs to be reheated continuously → Jet collimation
- At least two scenarios possible
  - A new blob emerges
  - Diamond shock
  - Stellar wind – disk wind shock
- Need to explore more options, not just the first!


https://github.com/hamogu/RecollimationXrayCTTS
C IV luminosity too large to be explained only by cooled X-rays

HST/STIS: DG Tau