Are jets rotating at the launching?

Yes, but much below claimed values

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Claims for rotating jets

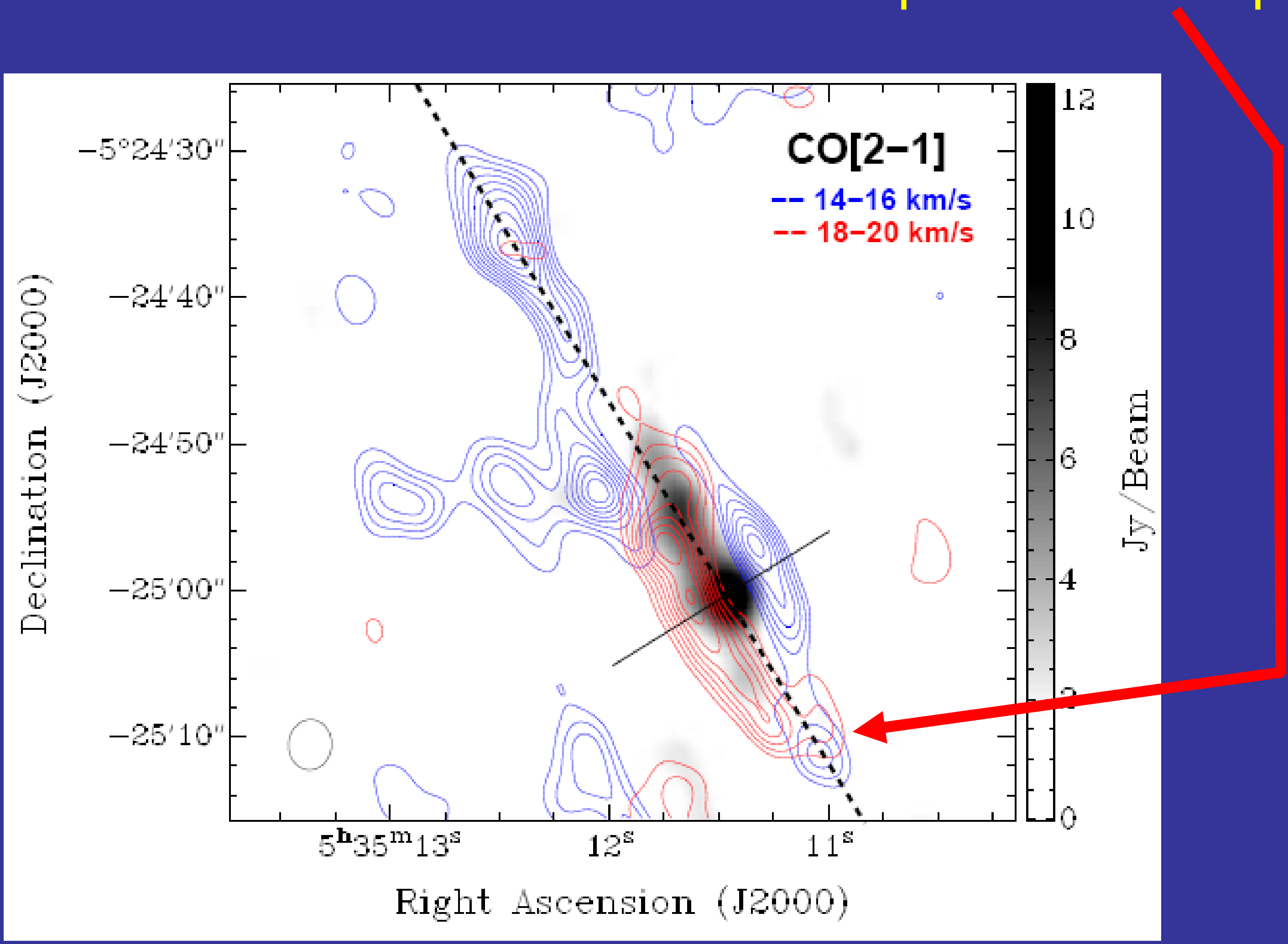
In previous papers (Soker, N. astro-ph/0703474 “Further Indications Against Jet Rotation in Young Stellar Objects”; Soker, N. 2005, A&A, 435, 125, “Interaction of young stellar object jets with their accretion disk”)

I proposed that the interaction of the jets with a twisted-tilted (wrapped) accretion disk can form the observed asymmetry in the jets' line of sight velocity profiles.

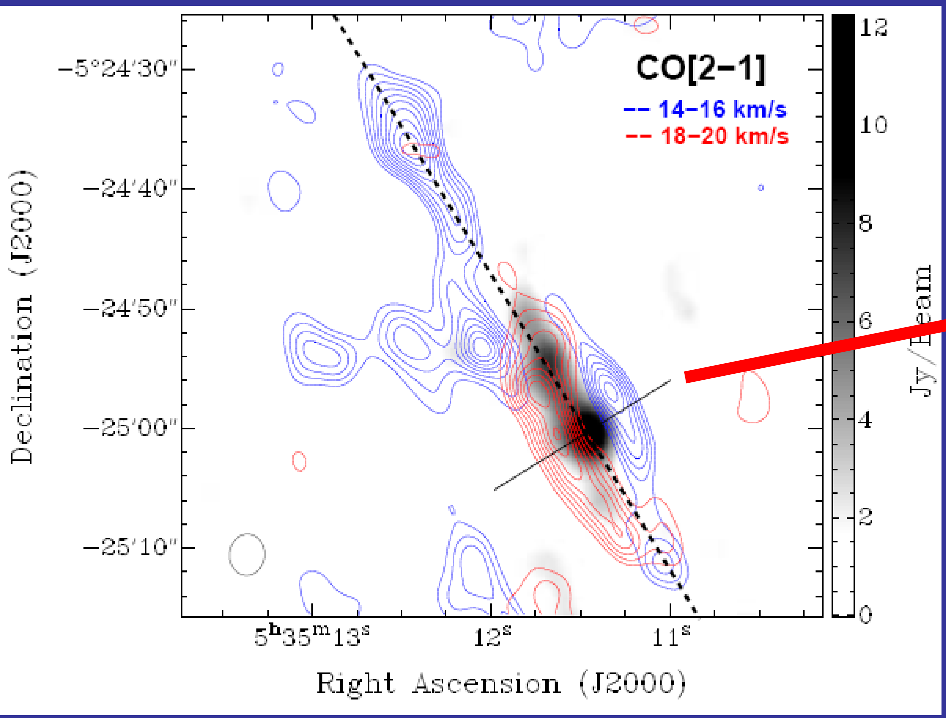
A more recent example that demonstrates the problematic interpretation of jet rotation is the paper by Zapata, L. A. et al. (2009) “A rotating molecular jet in Orion” (Ori-S6).

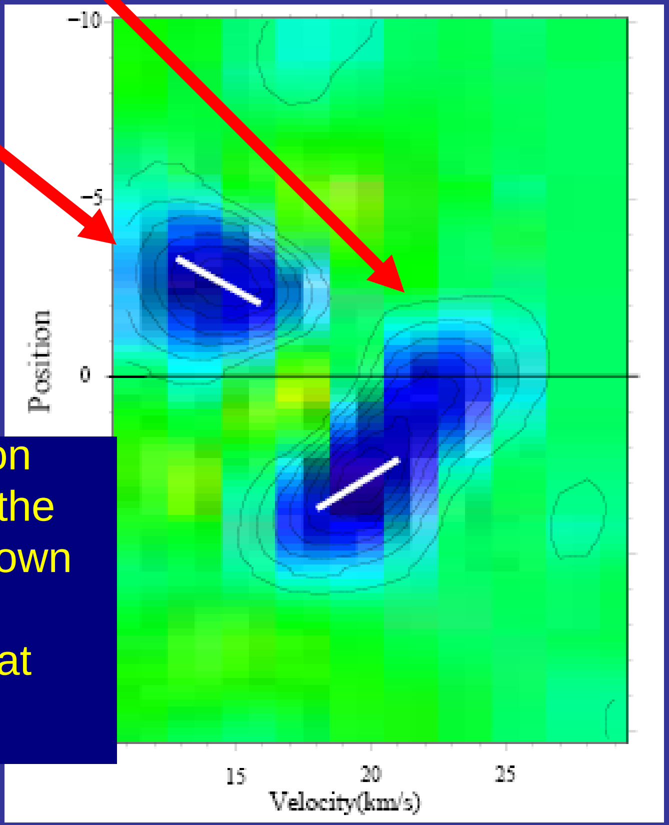
I will mention 4 problems:

Problem 1: Red and blue shifted component overlap.



Problem 2: The blue and the red-shifted components are disconnected.



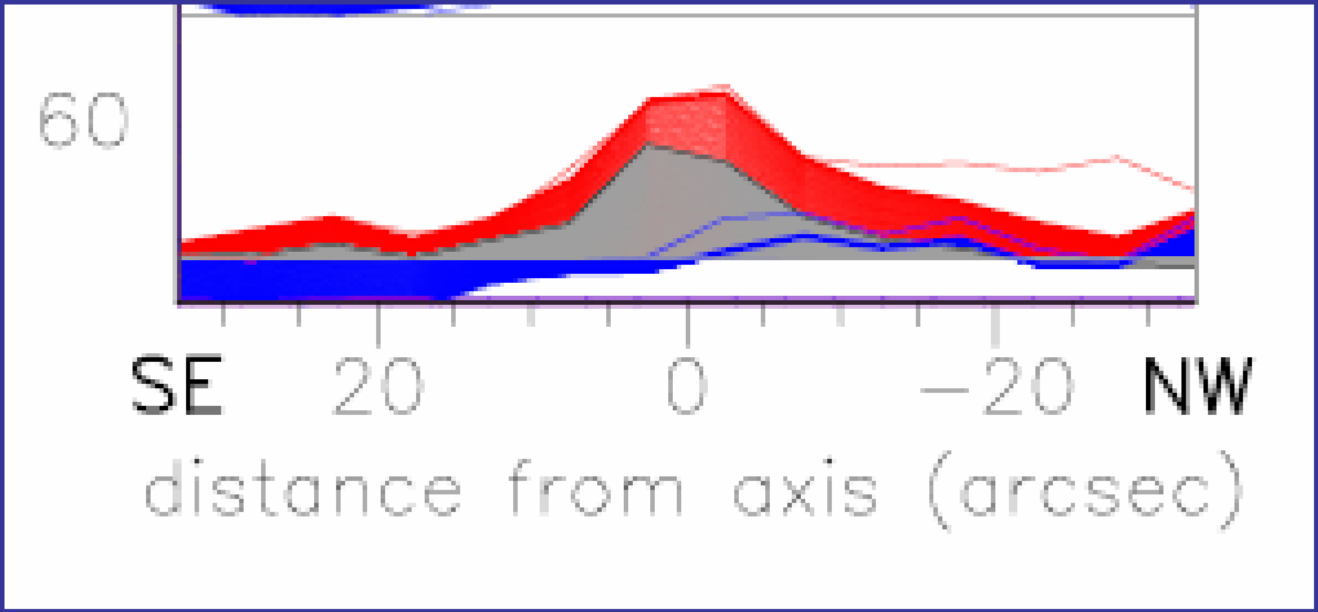


Position along the cut shown in the panel at left

15 20 25

Velocity (km/s)

Problem 3: Using the rotation interpretation at the edge of 30’’ across the disk gives a jet’s foot-point of 300AU. This is larger than the size of the disk given by the same authors.



Problem 4: Opposite rotation of ring and jet.

As Zapata et al. write:

"The sense of rotation of the circumbinary ring is nearly opposite to that of jet and outflow, and the jet leaves the system under an angle of 45° with the ring plane."

The tilted jet can lead to the asymmetric red-blue shift, as in the model I proposed in 2005

(Soker, N. 2005, A&A, 435, 125, "Interaction of young stellar object jets with their accretion disk").

Conclusion for this part

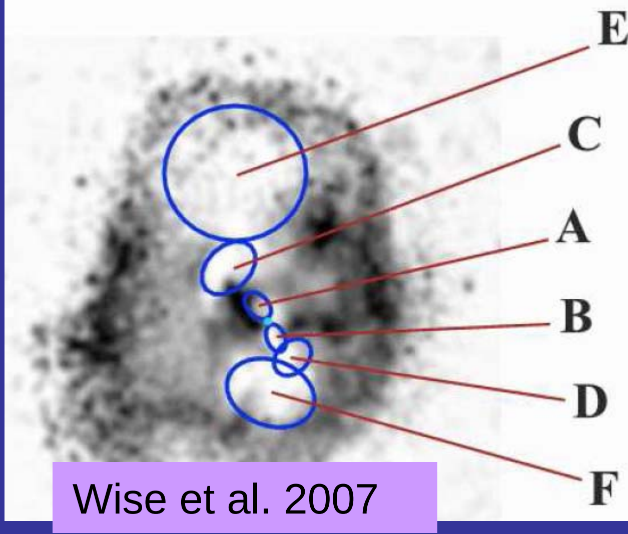
The transverse asymmetry in the Doppler shifts of YSO jets do not support the magneto-centrifugal acceleration model for jet launching

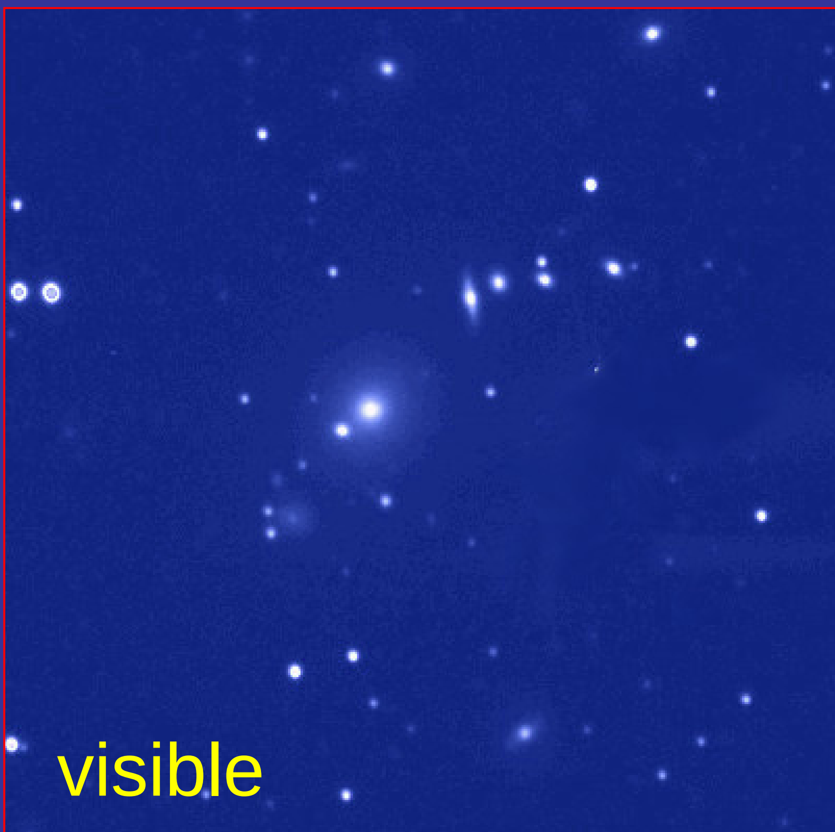
Some observations

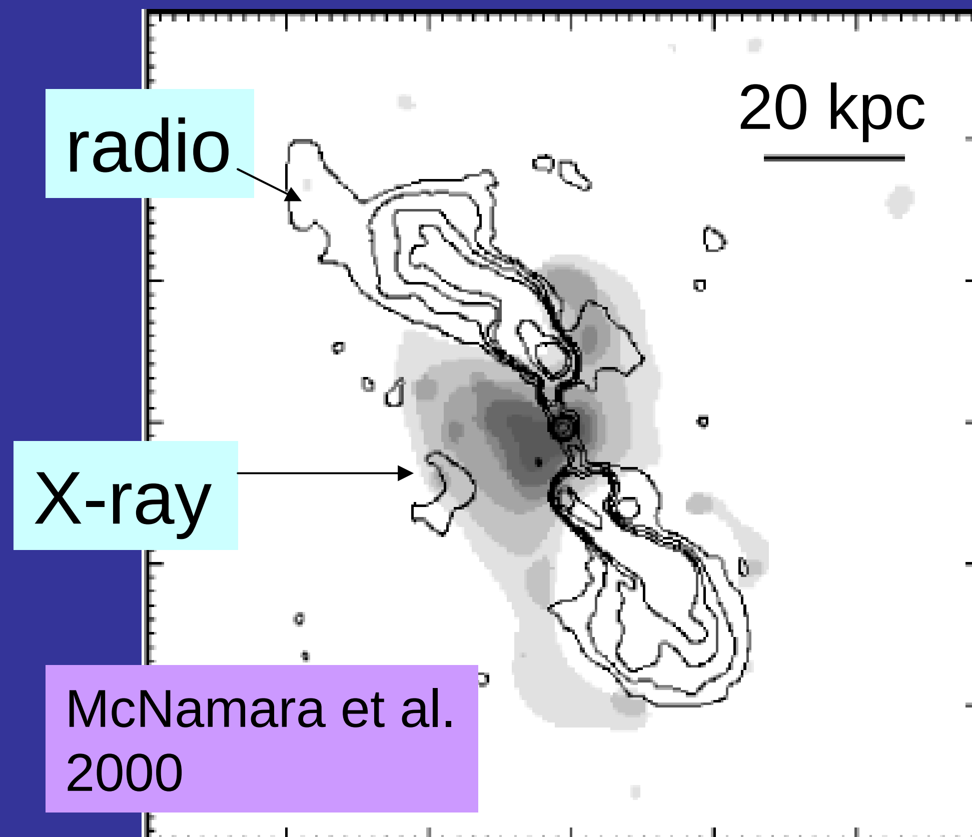
- Jets contain huge amount of energy. This implies ejection from the very inner region of the accretion disk.

Hydra A

A cluster of galaxies







Some observations

- Jets contain huge amount of energy. This implies ejection from the very inner region of the accretion disk.

- Jets launched in close binary systems, where it is unlikely that the inflowing gas builds a large scale magnetic field.

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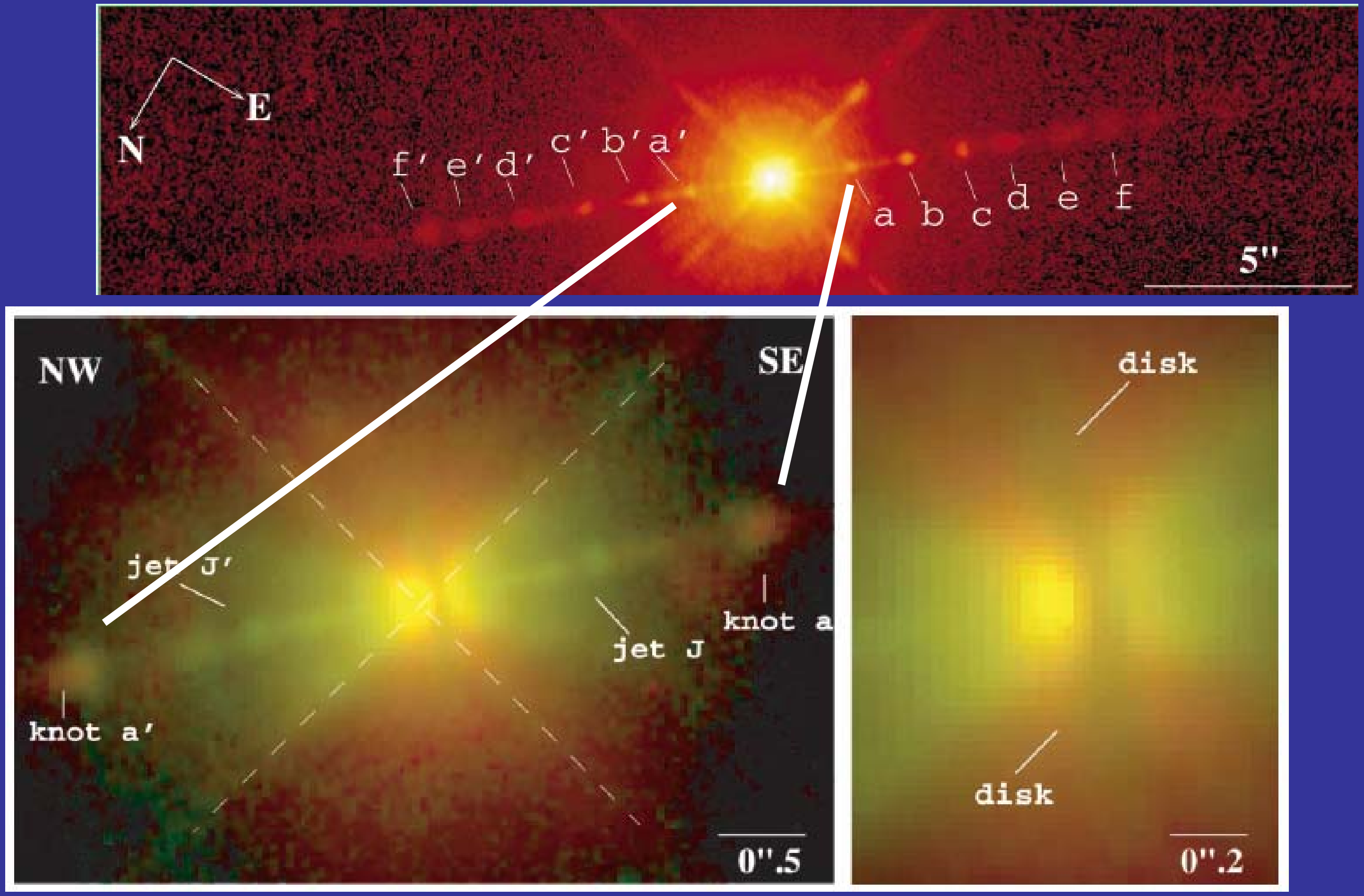
Speed: ~ 200 km/sec

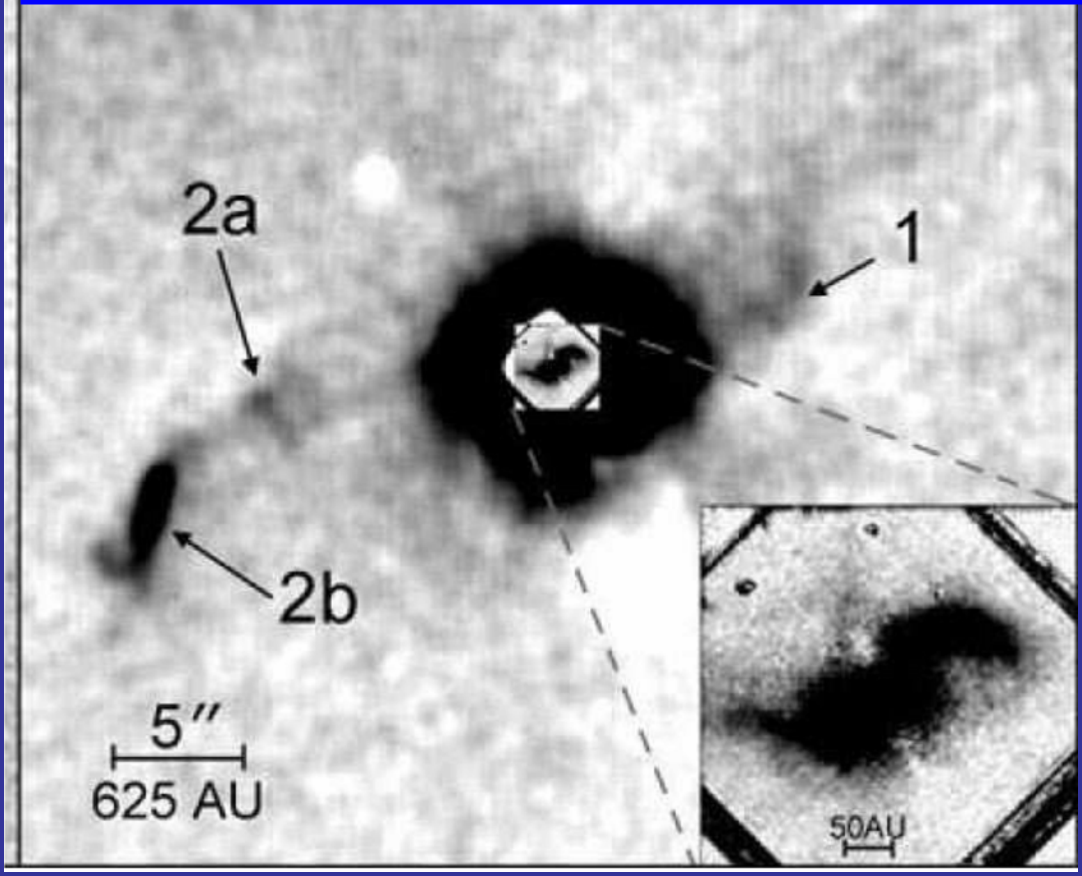
A pair of blobs is ejected every ~ 40 years



HENIZE 2-90: A planetary nebula (Sahai, R. et al.)

H_2 Close-up Image of Elias 29 Late –Stage Protostar: Dynamical Age ~ 100 yr

(Ybarra et al. 2006, ApJ, 647, L159)



Large scale magnetic field cannot precess so fast

Some observations

- Jets contain huge amount of energy. This implies ejection from the very inner region of the accretion disk.
- Jets launched in close binary systems, where it is unlikely that the inflowing gas builds a large scale magnetic field.
- The presence of a strong stellar dipole field does not guarantee the presence of jets.
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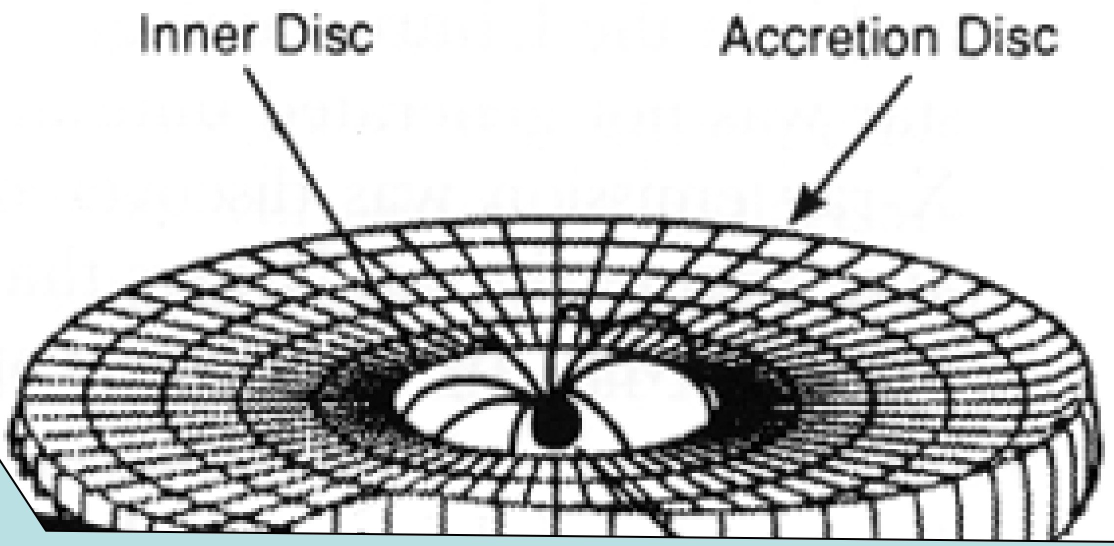
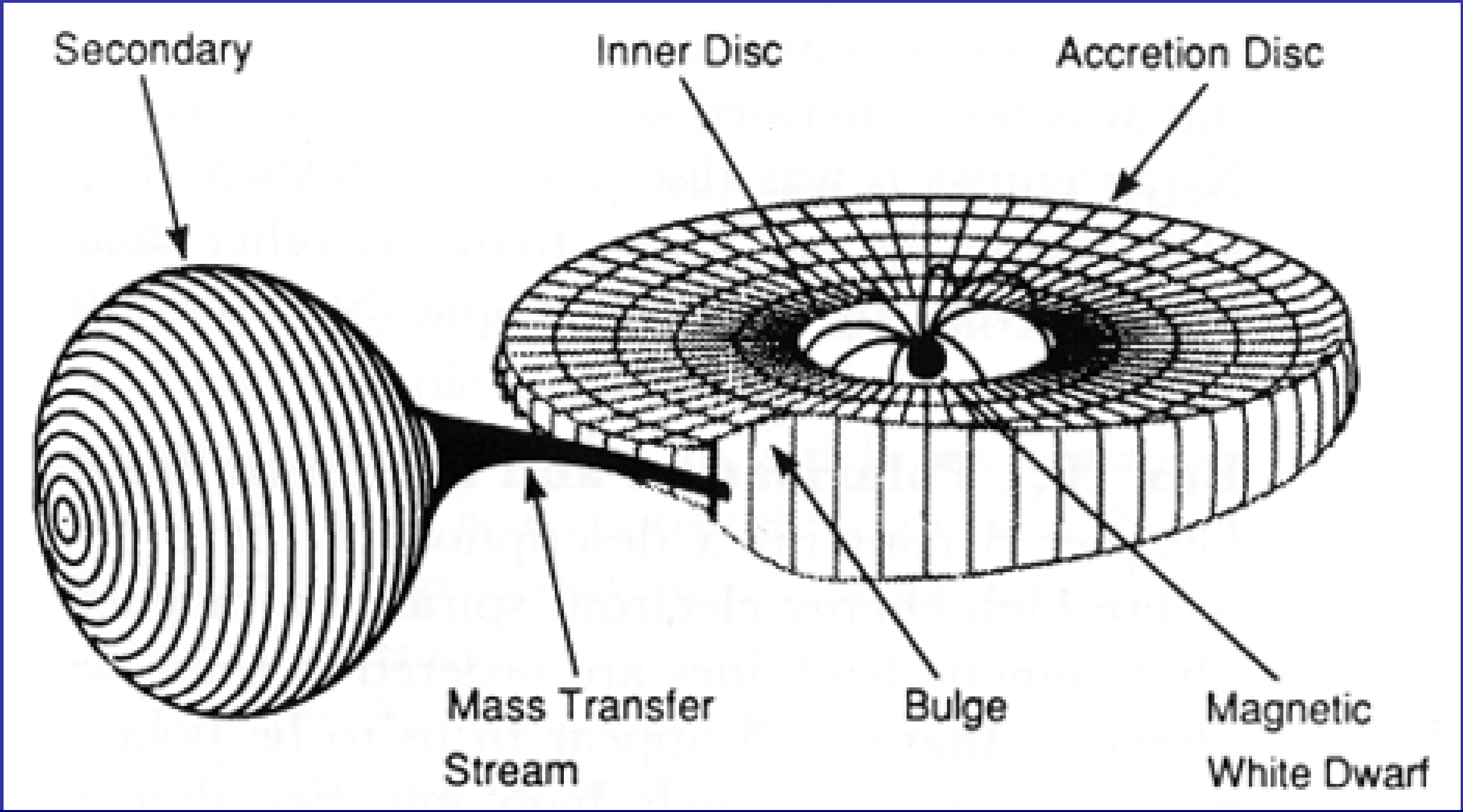


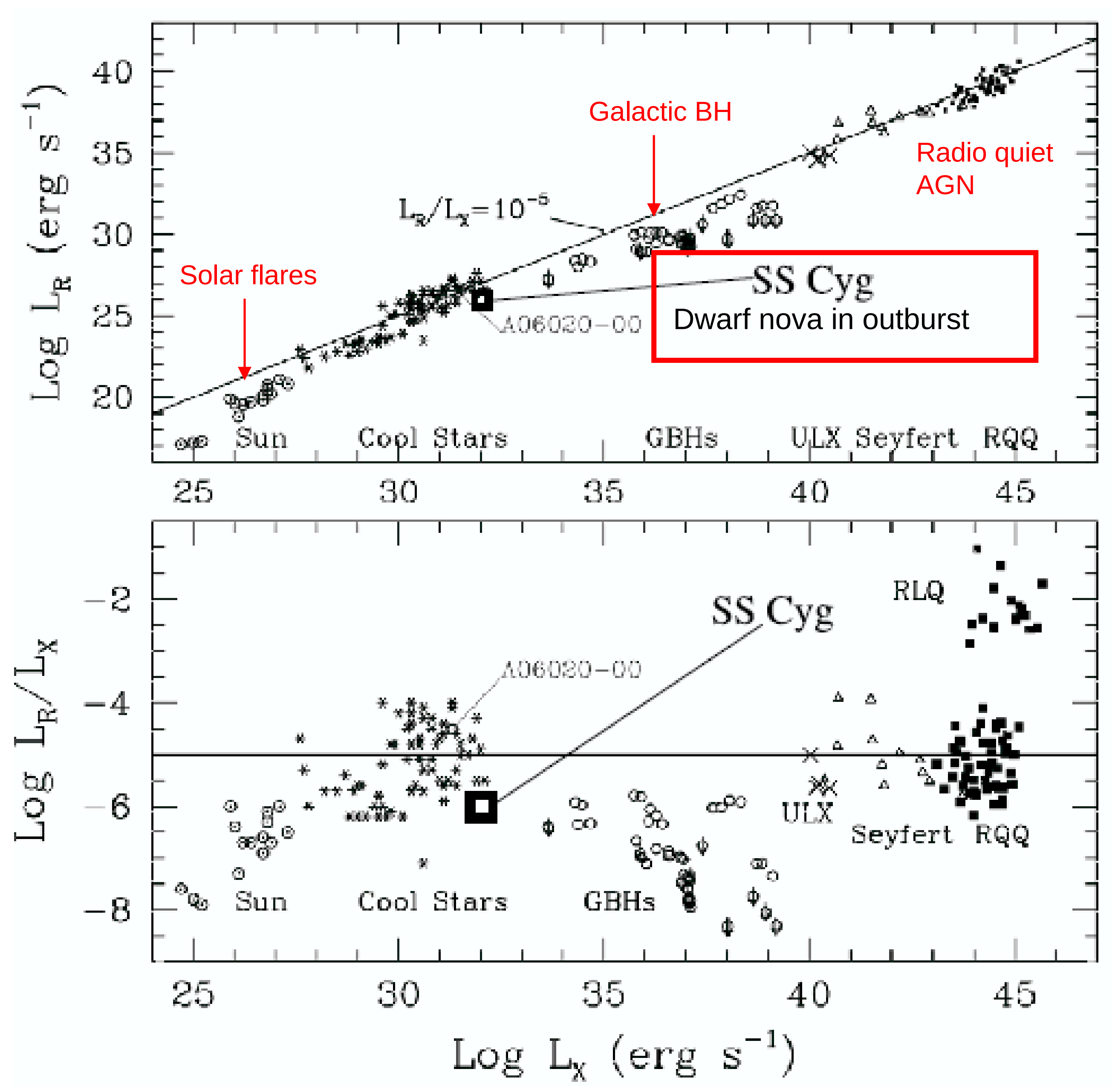
Disk truncated by stellar magnetic fields:



Cataclysmic variable systems:
Intermediate polar: NO JETS

Some observations

- Jets contain huge amount of energy. This implies ejection from the very inner region of the accretion disk.
- Jets launched in close binary systems, where it is unlikely that the inflowing gas builds a large scale magnetic field.
- The presence of a strong stellar dipole field does not guarantee the presence of jets.
- X-ray to radio emission correlation over 20 orders of magnitude in luminosity (Laor & Behar 2008).



Laor, A., & Behar, E. 2008, MNRAS, 390, 847

A POSSIBLE CONCLUSION

There is a very efficient dynamo in the inner part of the accretion disk, with a jets' launching mechanism that is similar to solar flares (coronal mass ejection).

No large magnetic fields are required.

$\alpha\omega$ dynamo

ω: The ω effect is diffenretial rotation. This is strong in disks.

α: In galactic dynamos the α effect is due to heating by supernovae and OB stars, or from dynamical effects of $\vec{B}$ itself. Here the local heating is done by small shocks (Soker & Regev 2003), and $\vec{B}$ itself.

This α-effect equires that radiative cooling is inefficient:

long radiative diffusion time, or

long radiative cooling of optically thin medium.

$\alpha\omega$ dynamo

The accelerated gas moves at a fraction of the Keplerian velocity

$$v_t = \beta v_{Kep}$$

For the $\vec{\mathrm{B}}$ coherence length we take the disk hight $H = \varepsilon r.$

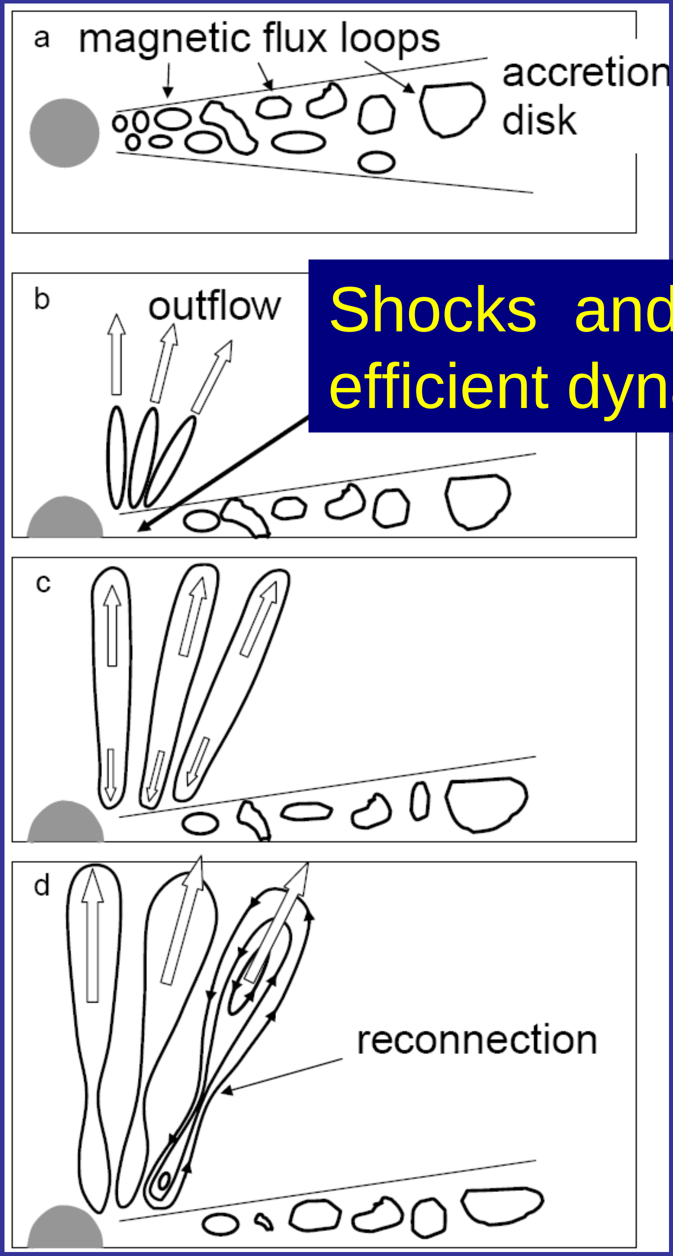
The growth time of $\vec{\mathrm{B}}$ (Beck et al. 1996) for $\varepsilon \approx \beta \approx 0.1$

$$\tau_B \approx \left(\frac{H}{v_t \Omega}\right)^{1/2} \approx \frac{1}{\Omega} = \frac{P_{Kep}}{2\pi}$$

Conclusion: $\vec{\mathrm{B}}$ amplification time is short

(Soker & Vrtilek 2009).

It is possible to have a double-stage acceleration process.



Shocks and/or an efficient dynamo

SUMMARY

There is a very efficient dynamo in the inner part of the accretion disk, with a jets' launching mechanism that is similar to solar flares (coronal mass ejection).

Single Stage Acceleration

- Kinetic energy of rotating disk's material
- ↓ Stochastic Shock waves
- Internal (e.g., thermal) energy
- ↓ Pressure gradient
- High velocity outflow (jets)

Double Stage Acceleration

- Kinetic energy of rotating disk's material
- ↓ Stochastic Shock waves
- Internal (e.g., thermal) energy
- ↓ Pressure gradient
- Outflow
- ↓ Stretching magnetic flux loops
- Magnetic energy in loops
- ↓ Magnetic field reconnection
- High velocity outflow (jets)

Solar Flares

- Kinetic energy of solar rotation and convection
- ↓ $\alpha\omega$ Dynamo
- Magnetic fields in the outer envelope
- ↓ Buoyancy of magnetic tubes
- Outflow
- ↓ Stretching magnetic flux loops
- Magnetic energy in loops
- ↓ Magnetic field reconnection
- High velocity ejection