Galactic-Center Arc & Threads:

Current sheet model

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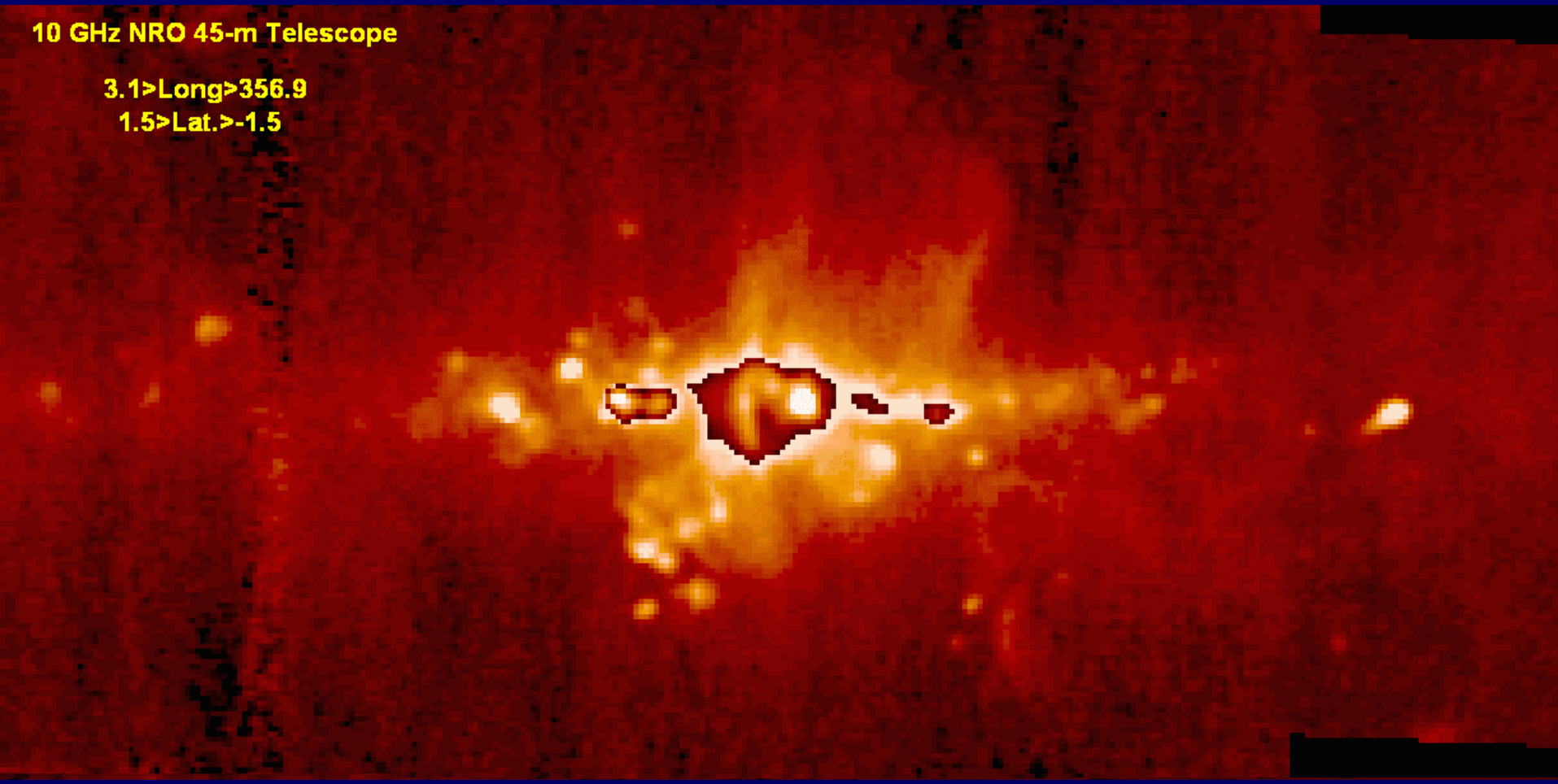
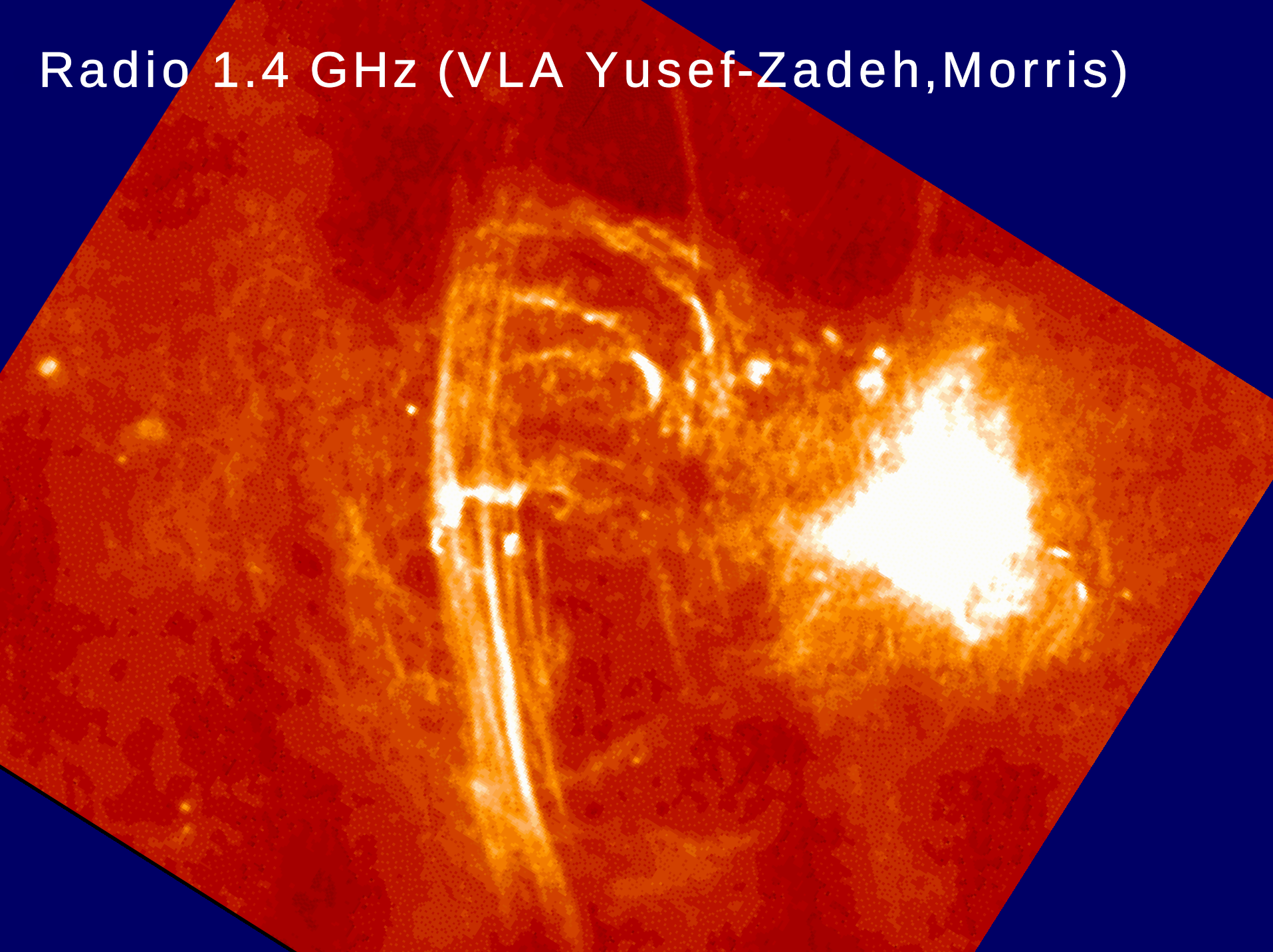
Radio 10 GHz (3cm) 6x3 deg, Nobeyama 45m

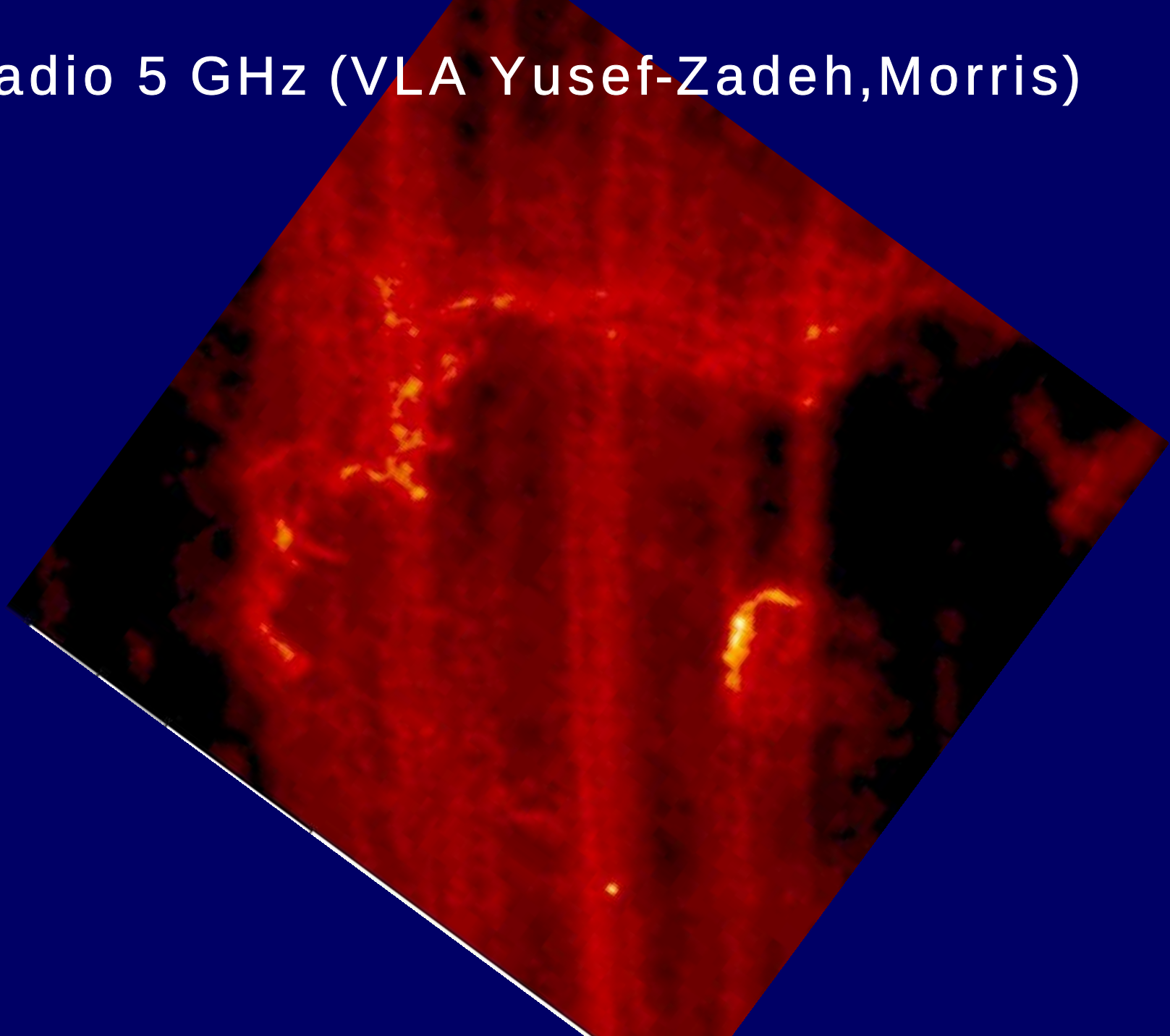
Sofue et al. 1985



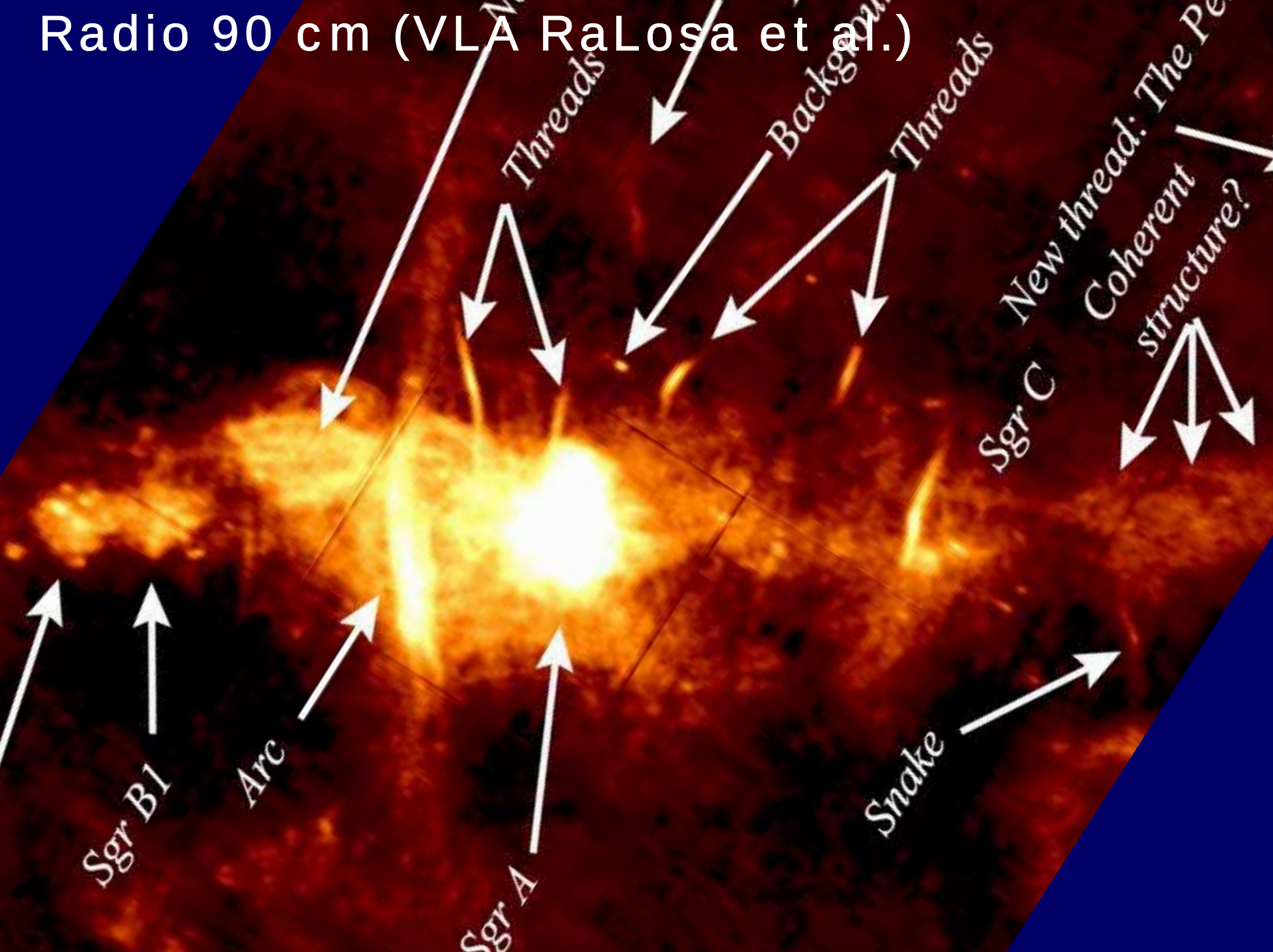
Vertical Magnetic Field in GC

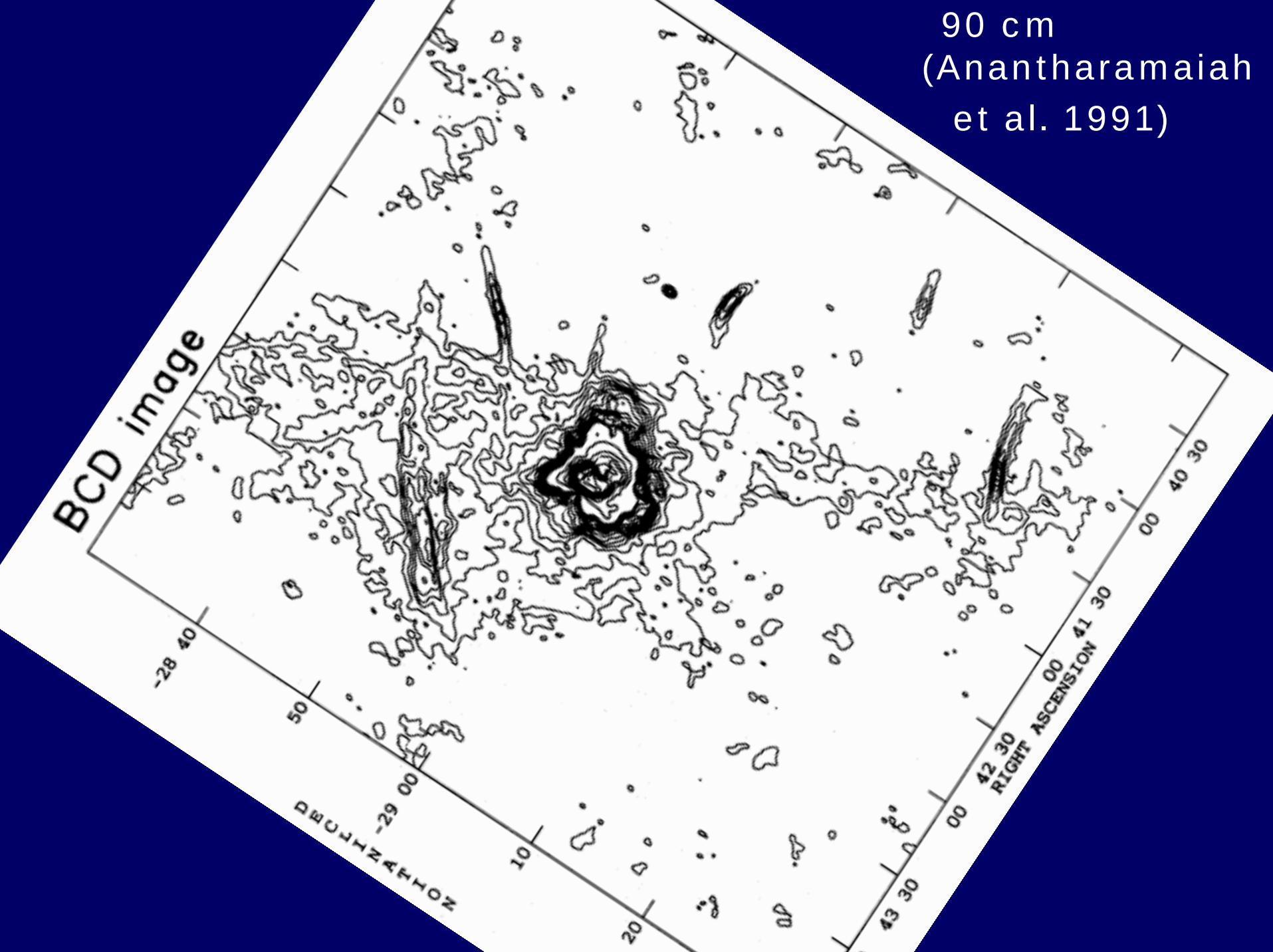

Radio 1.4 GHz (VLA Yusef-Zadeh,Morris)

Radio 5 GHz (VLA Yusef-Zadeh,Morris)



Radio Threads


Radio 90 cm (VLA RaLosa et al.)
Threads
Threads
New thread: The Pe
Coherent
structure?
Sgr C
Sgr B1
Arc
Sgr A
Snake


BCD image
90 cm
(Anantharamaiah
et al. 1991)
-28 40
50
-29 00
10
20
DECLINATION
43 30
00
42 30
00
41 30
00
40 30
RIGHT ASCENSION

Past models for the radio arc

Sofue, Fujimoto 1987; Benford 1988 : B⊥ x Bϕ (V)

Dahlburg et al. 2002: B x Cloud instability

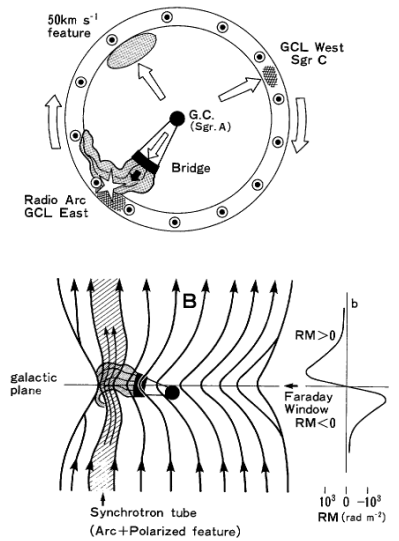


FIG. 4.—Schematic sketch of the shocked-jet model of the radio bridge (a jet from the Galactic center, Sgr A West) and the arc (an interaction surface of the jet with the ambient poloidal field in rotation). The observed rotation measure (rm) variation along the radio arc and its extensions is also sketched.

the jet energy has been converted to the turbulent, thermal, and magnetic energies.

What mechanism produces such a one-s
tilted from the Galactic rotation axis? It has
a sporadic accretion of slightly off-plane ga
central massive object with a poloidal magn
highly-tilted, one-sided sporadic ejections of
dom directions (Fujimoto and Sofue 1987).
gas flow in the bridge, which has a large angl
axis of the Galaxy, may be just one case of s
jet from the nucleus. Another ejection which
in the past in a roughly opposite direction to
have excited the VLA filament in Sgr C at

1984) and is located at the root of the western side of the Galactic center lobe (Sofue and Handa 1984; Sofue 1985). A

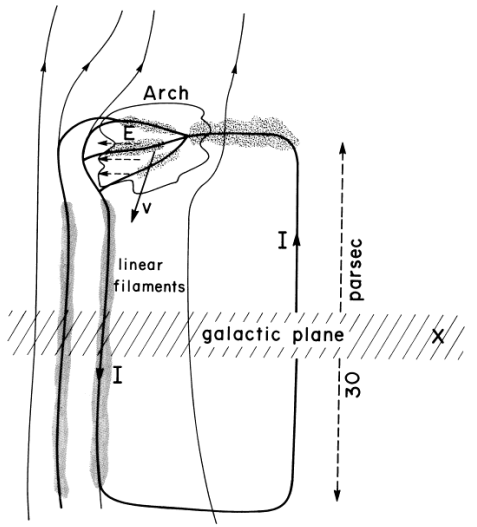
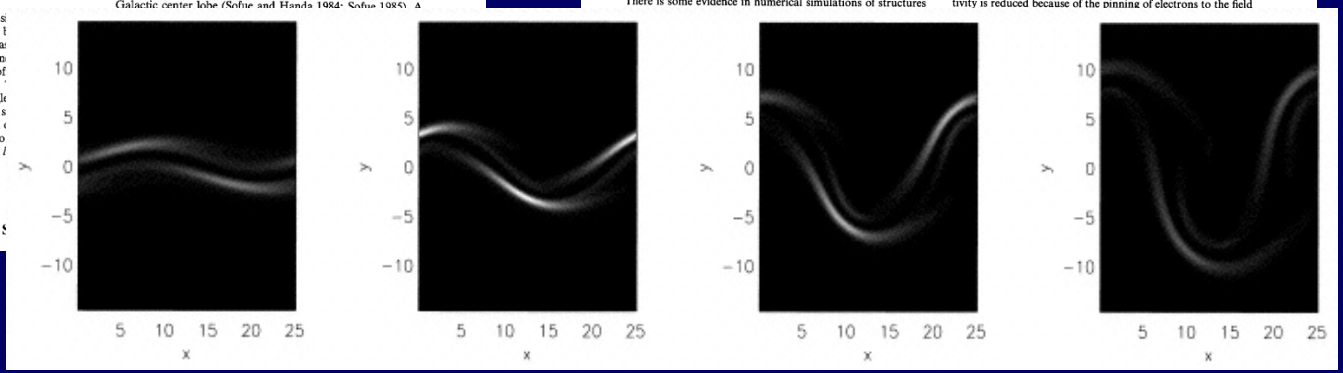


FIG. 1.—Schematic of a circuit with currents driven along ordered magnetic field lines by induction from a partially ionized molecular cloud. Lightly shaded irregular clouds are thermal radio emitters. Synchrotron-emitting linear filaments are ~ 1 lt-yr wide. A molecular cloud with velocity v drives the circuit current I with inductive field E. Local ordered magnetic field lines are deformed by the cloud. Galactic center is at position X. We presume all features are roughly in the plane of the paper.

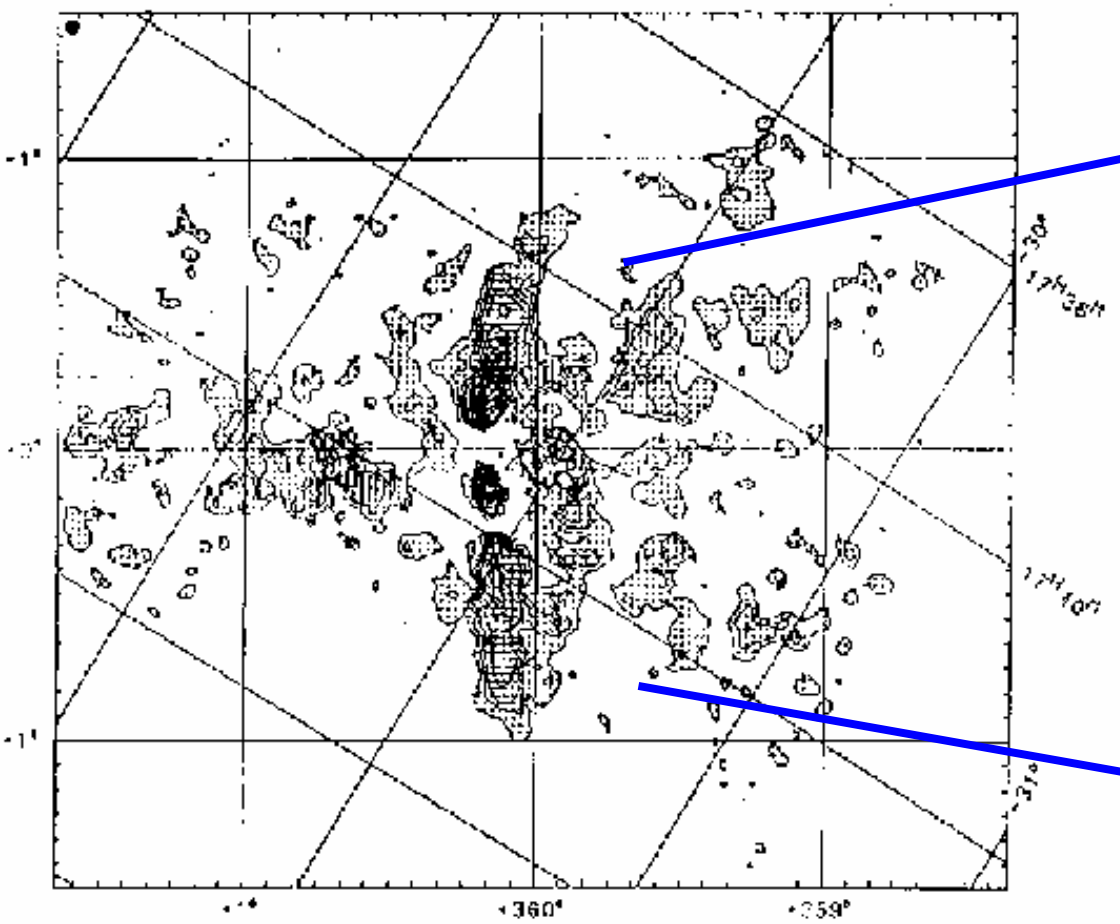
fields comparable to equation (6) occur, driving charge separation sheaths (Schmidt 1966). The plasma cloud slows very slightly as it breaks into separate regions of strong E fields. There is some evidence in numerical simulations of structures

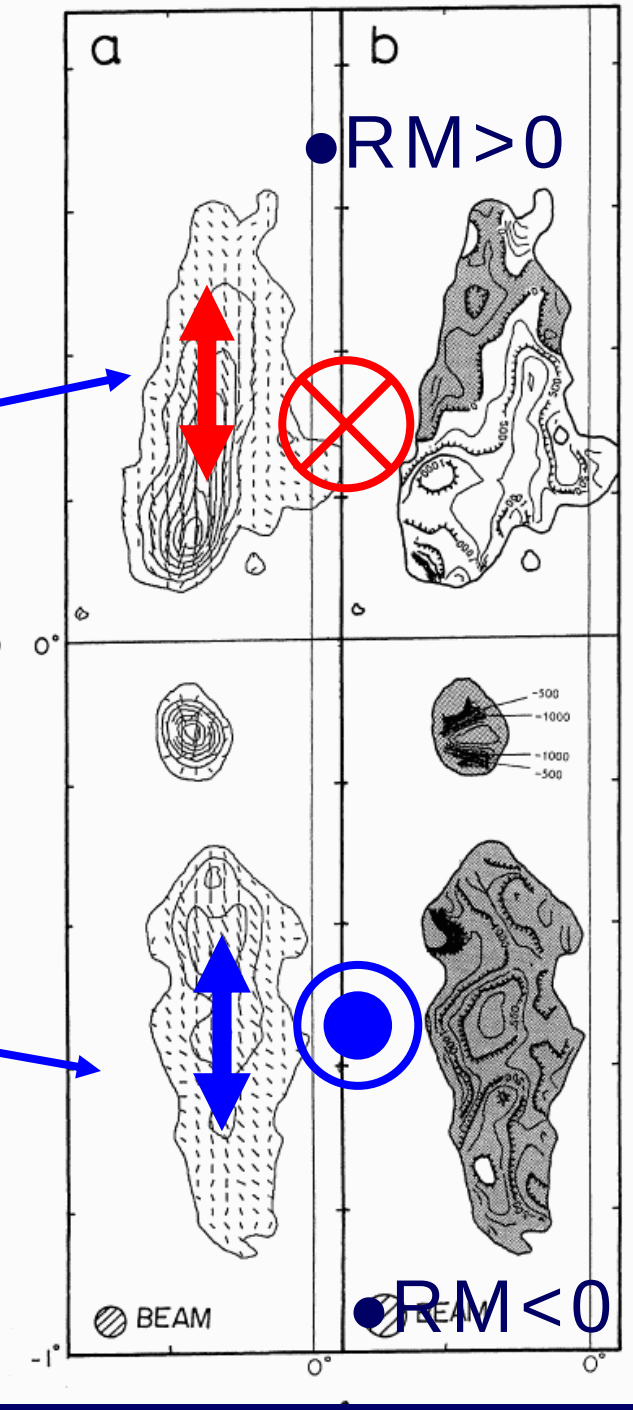
the molecular cloud. This process is usually very slow if only classical Coulomb scattering occurs, but there is an added effect from the strong magnetic field. The appropriate conductivity is reduced because of the pinning of electrons to the field



Interaction of VerticId Magnetic field and Rotating Gas

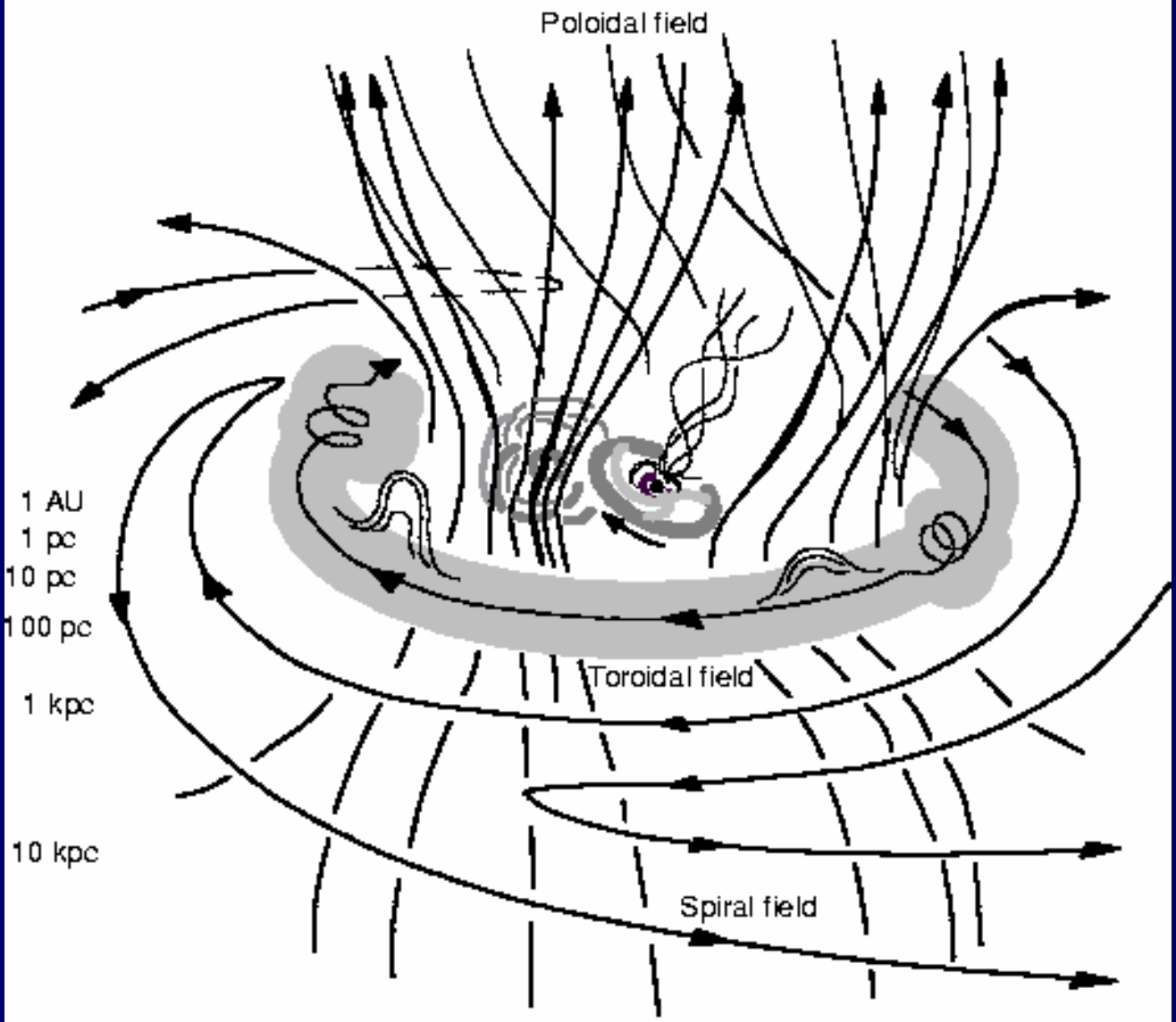
5 cm polarization (Sofue et al.)





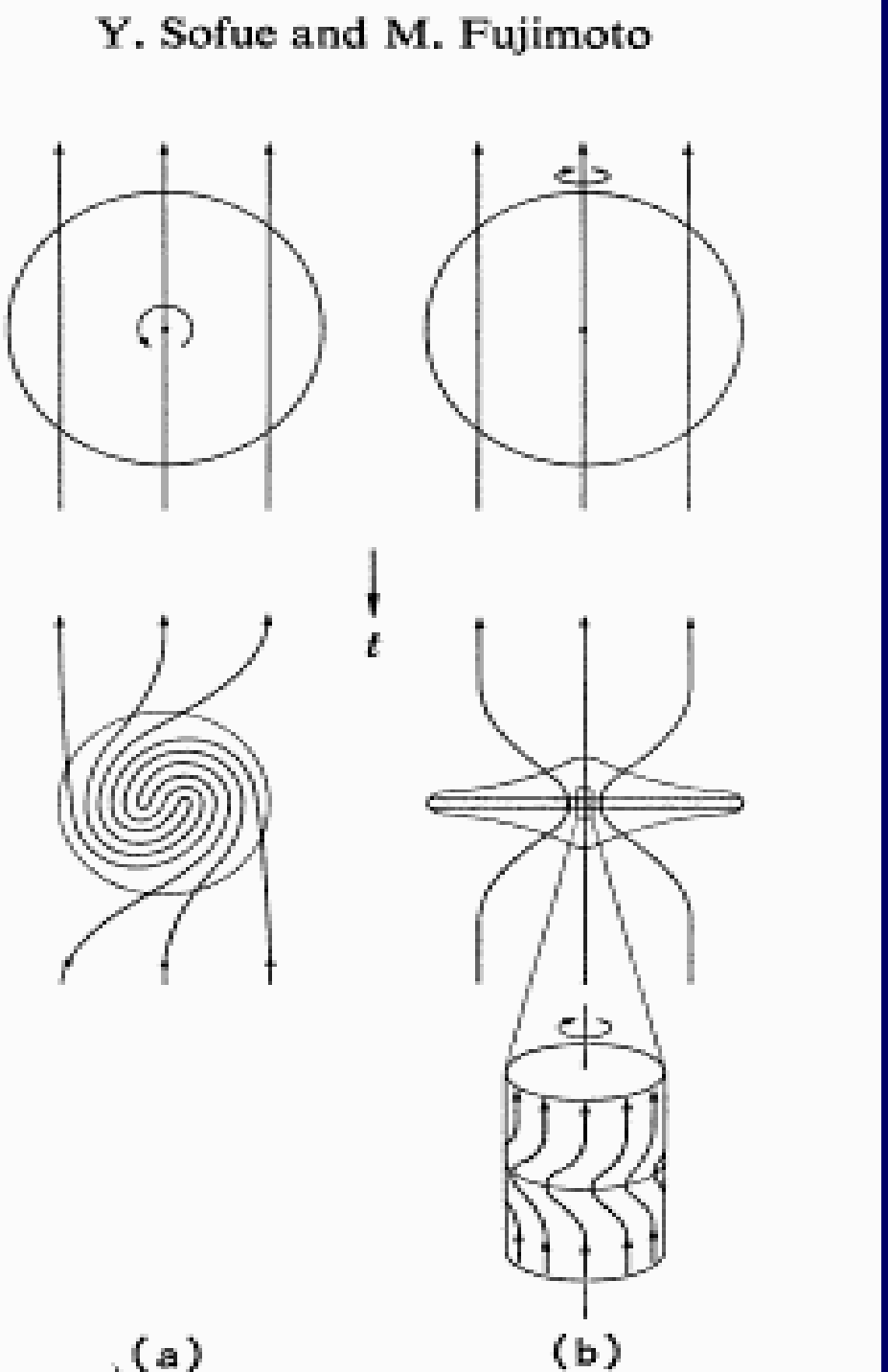
3 cm polarization (Tsuboi et al.)

Twisted vertical magnetic field in GC



Magnetic View of the Galactic Center

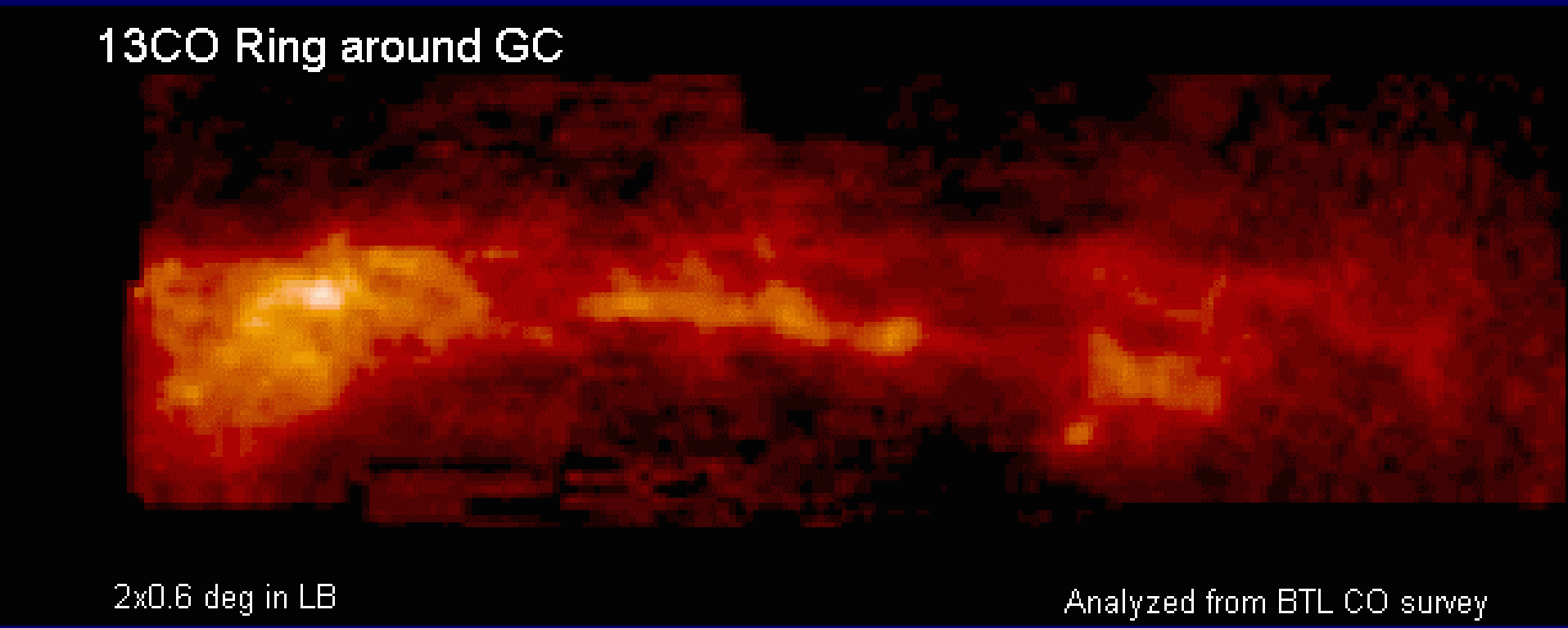
Origin of Vertical field in GC



High-velocity rotation and dispersion of Molecular Clouds

Molecular ring/clouds in GC

(CO Line BTL 7m Bally et al.)



Face-on View

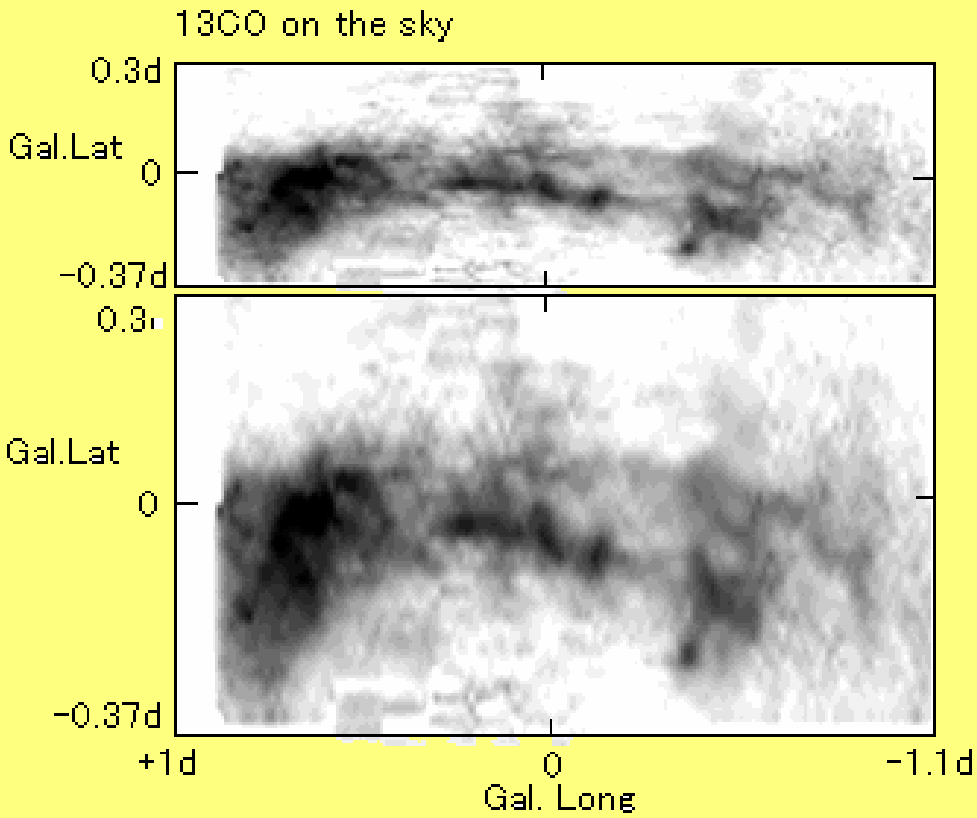


Fig.1. Tilted molecular ring on the sky (13CO)

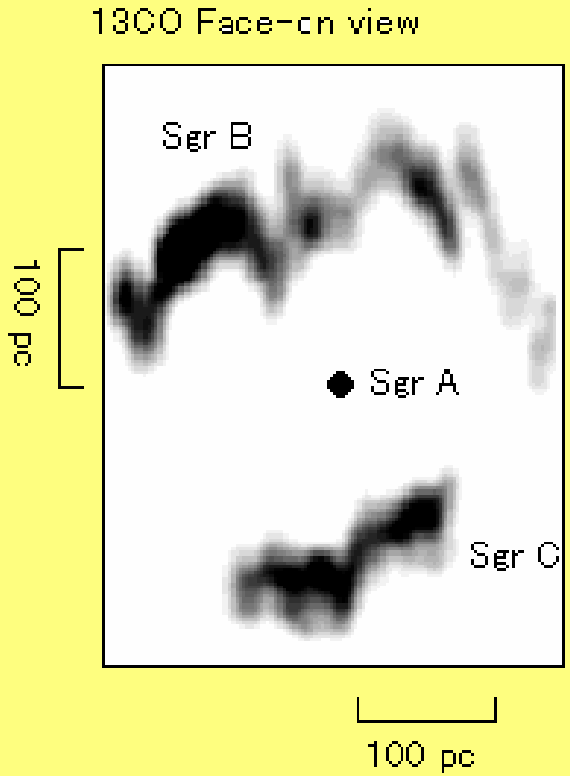
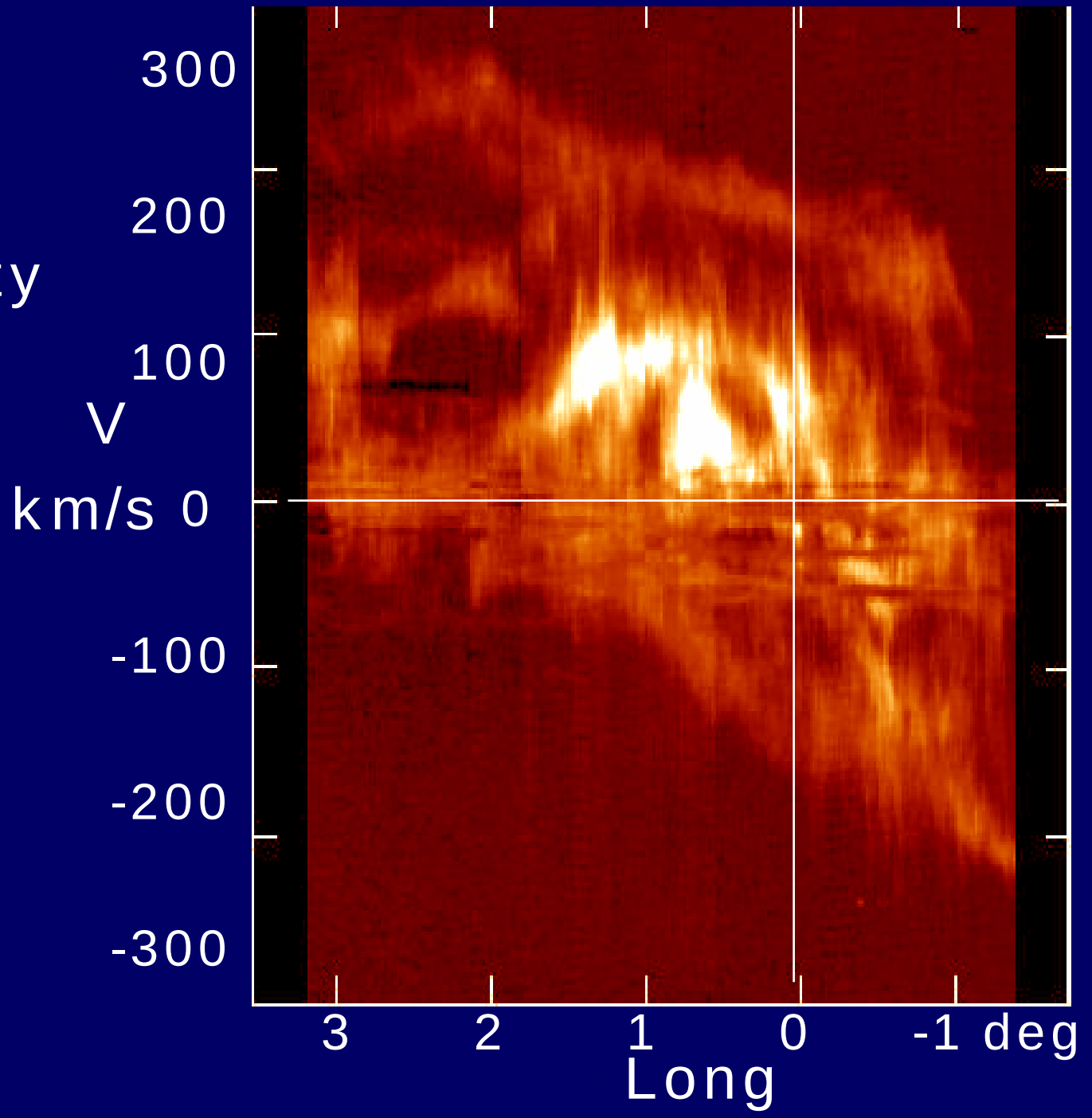


Fig.2. Molecular ring : Face-on View

CO line LV Diagram

High-velocity Rotation & Dispersion of Gas



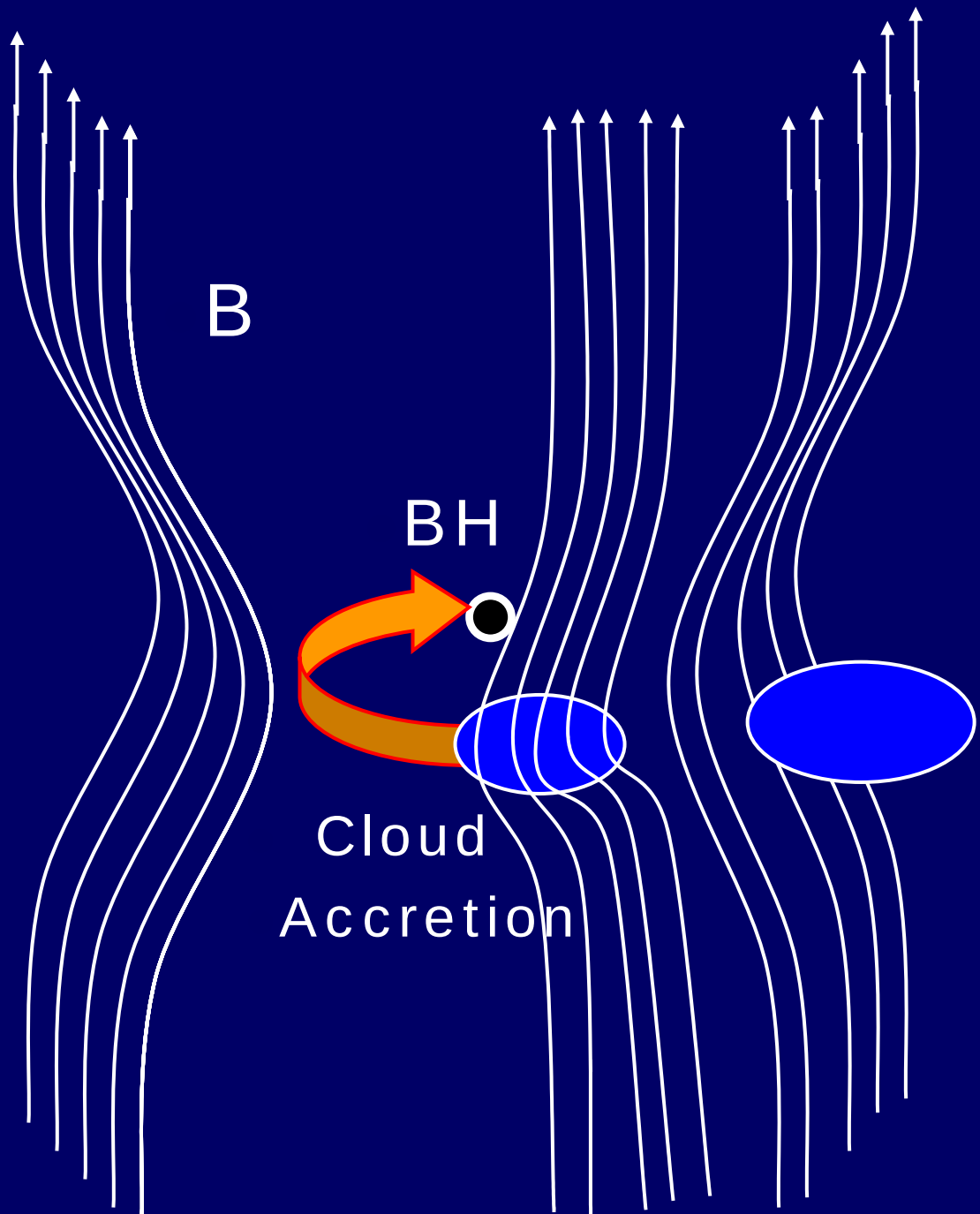
Magnetic reconnection and Current Sheet model

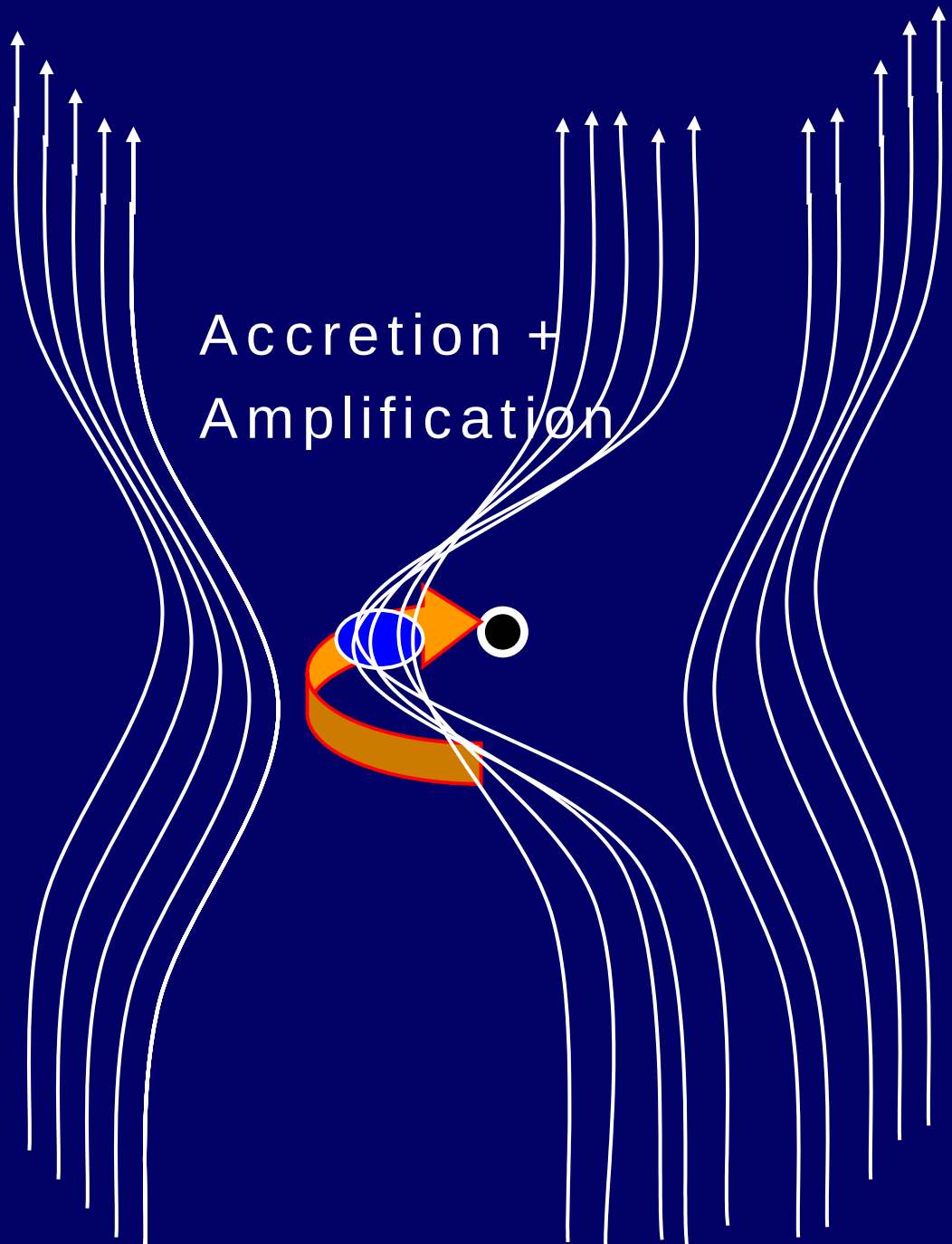
Thread properties

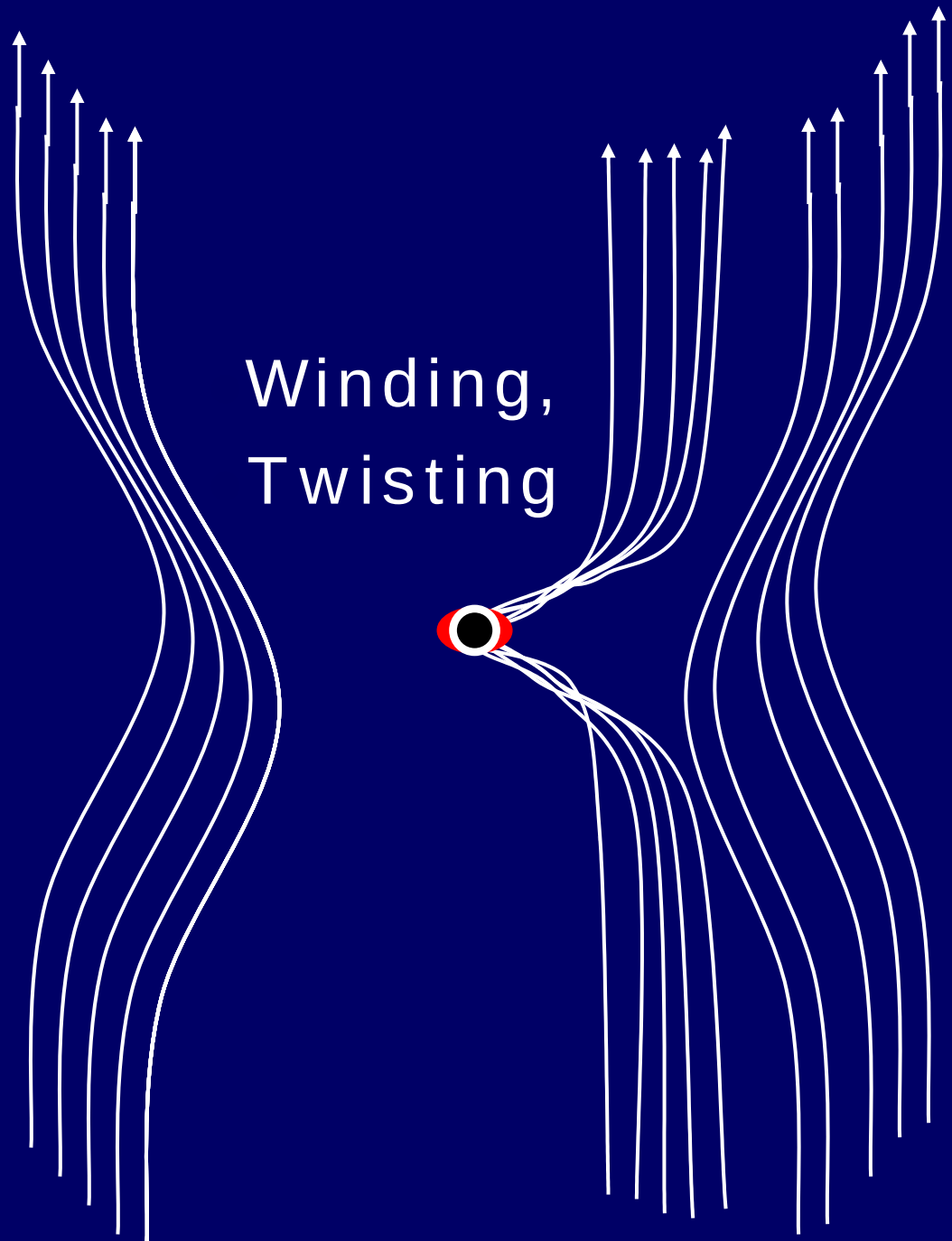
- Local, Isolated
- Thin/narrow
- Non-axisymmetric
- No energy injection (such as jets)
- High contrast against backgr.

- GC MHD circumstance
  - Vertical magnetic field
  - Molecular clouds
    - High-rotation (deep grav.pot)
    - High-velocity dispersion

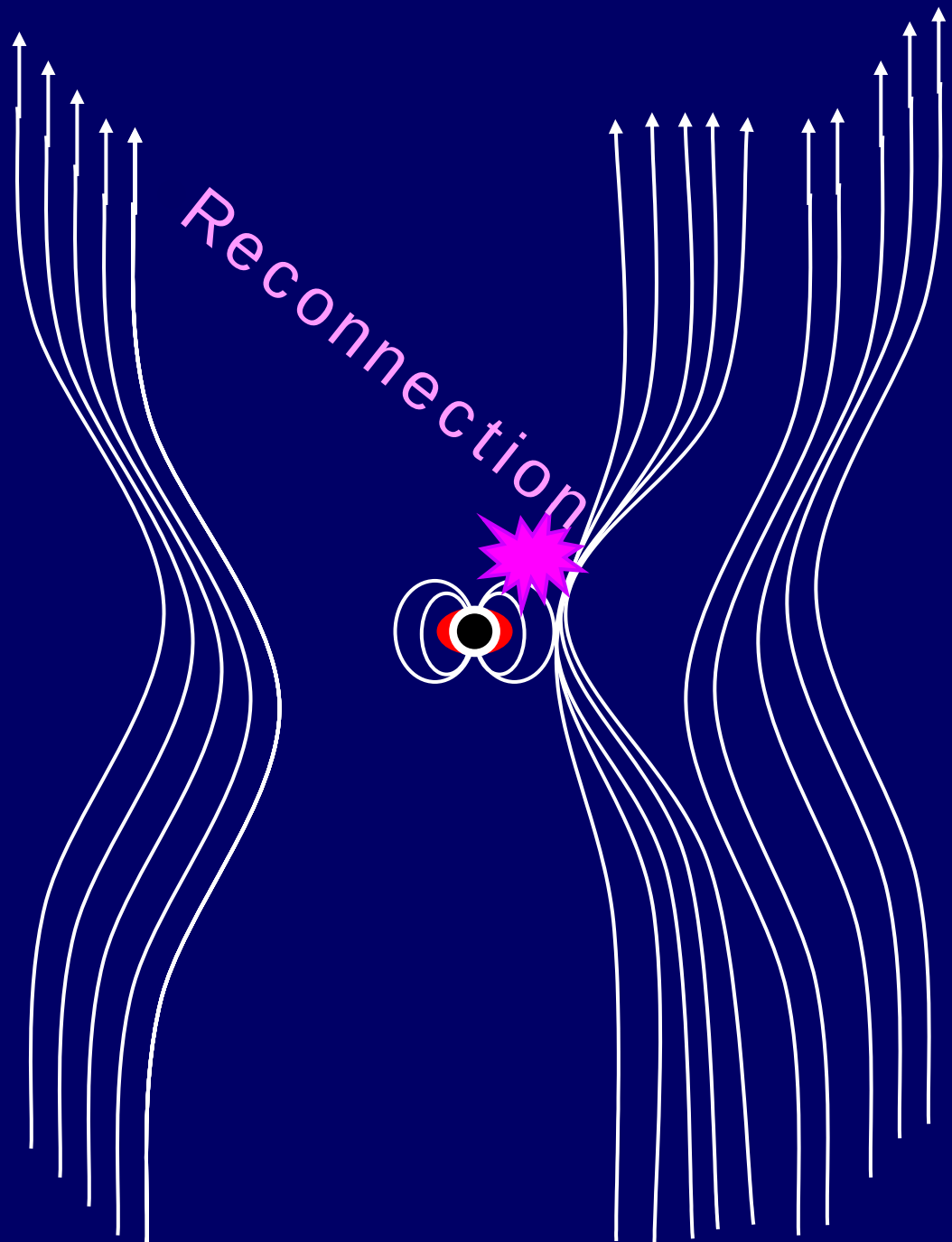
Origin of Threads

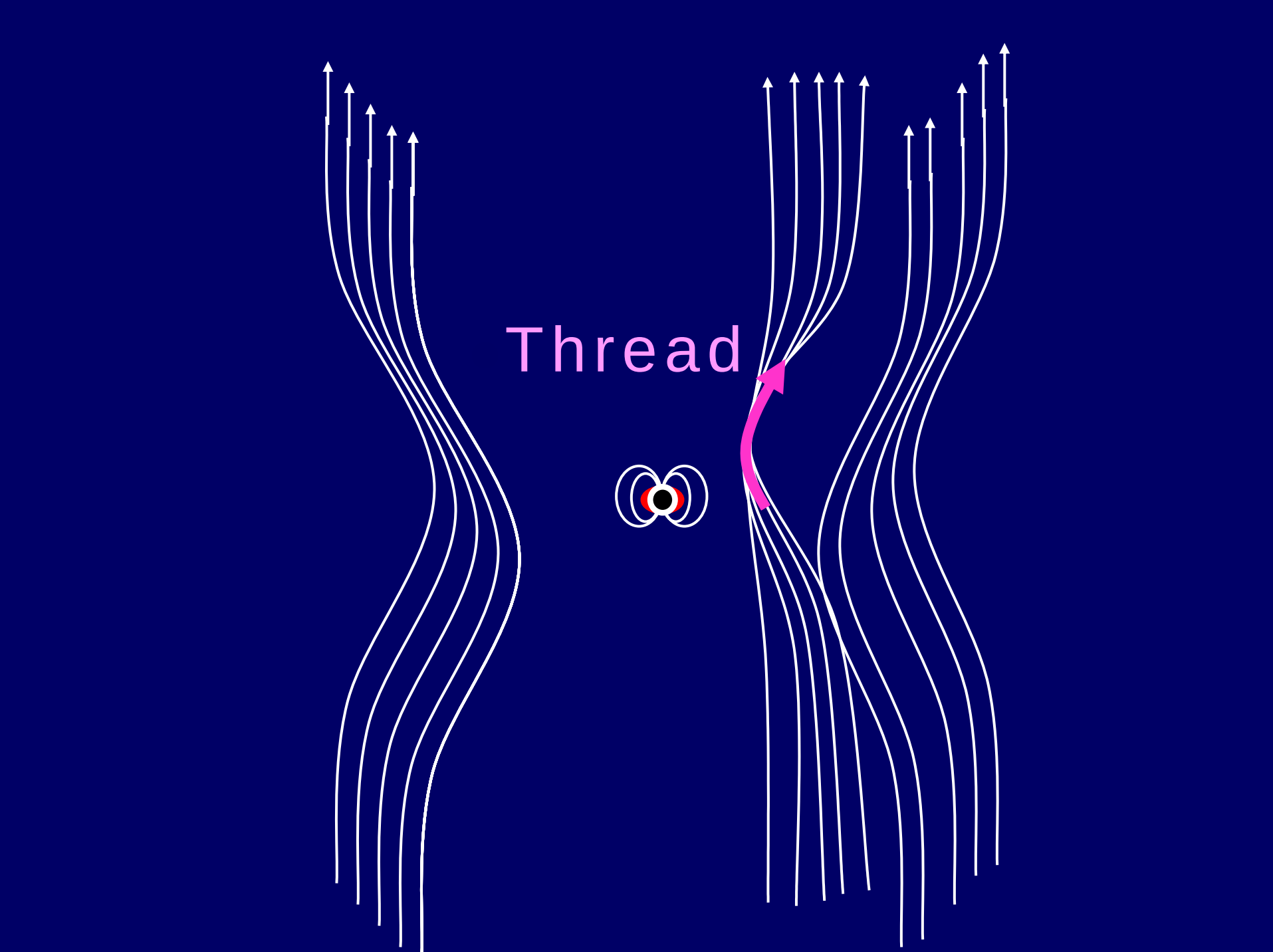


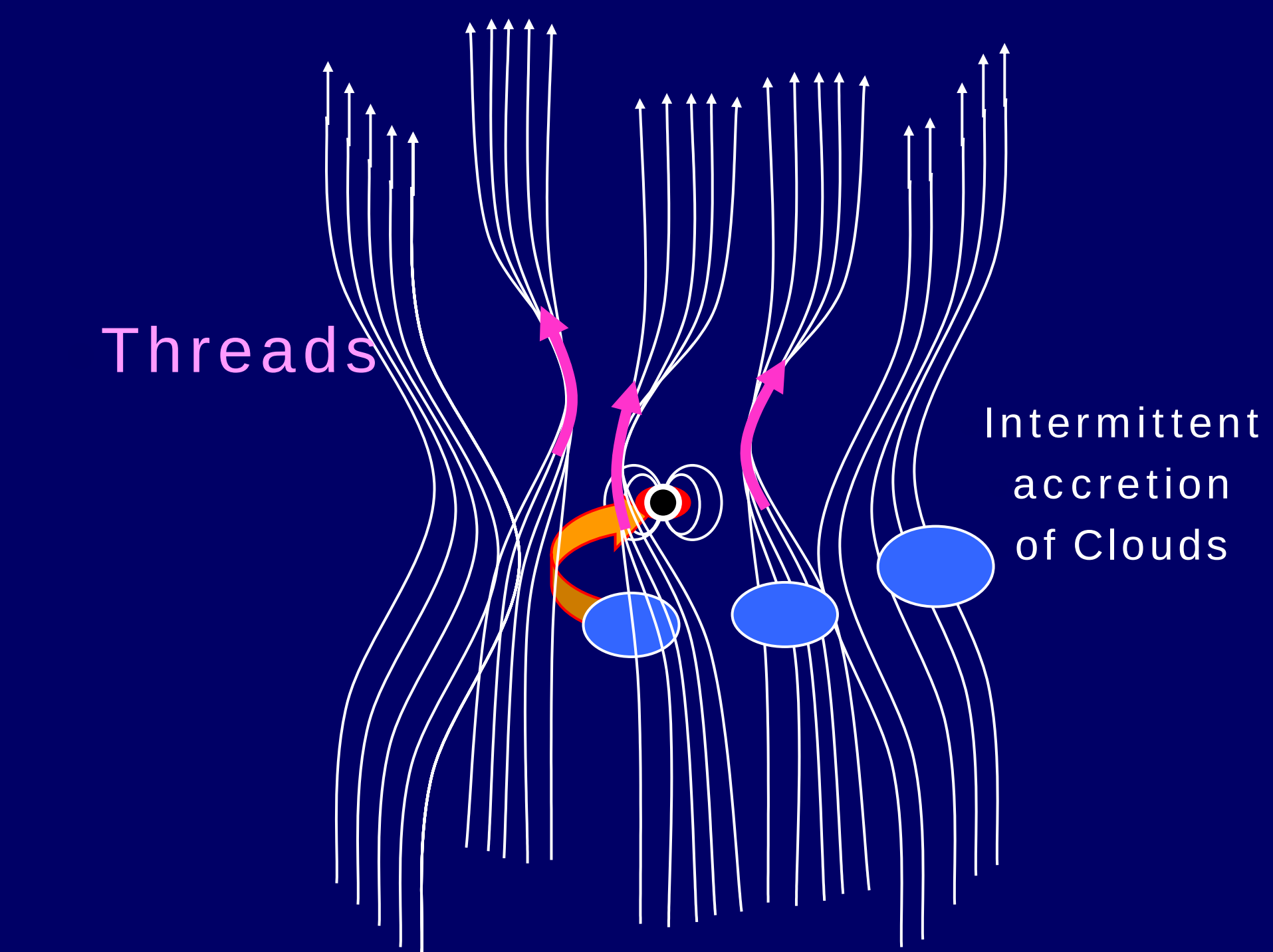

Accretion +
Amplification


Winding,
Twisting


Winding,
Twisting,
Kinking


Reconnection

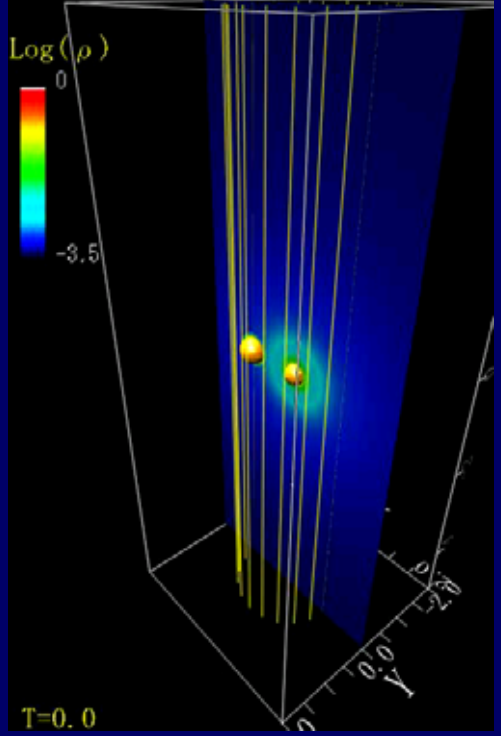

Thread


Threads
Intermittent
accretion
of Clouds

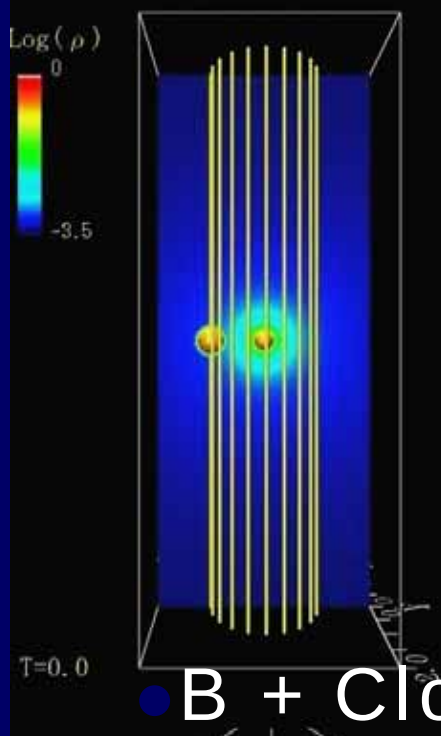
MHD Simulation of Threads and Arc

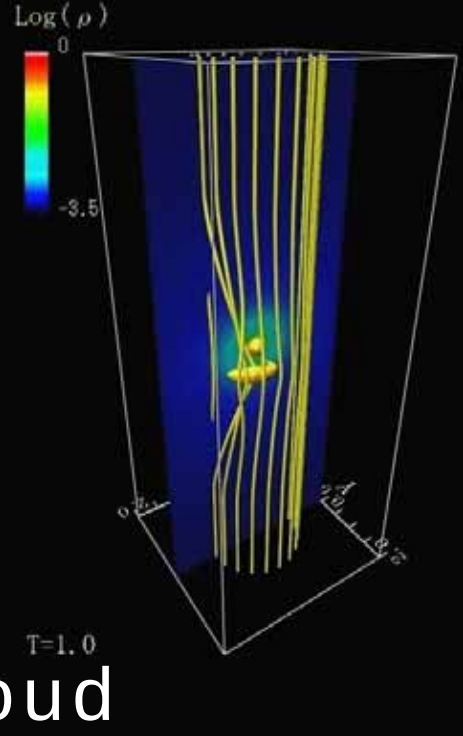
Non-axisymmetric 3D

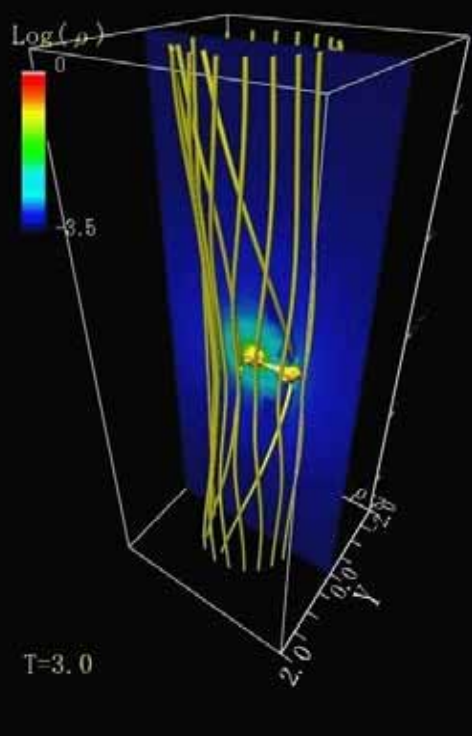
(Method: Kigure et al. 2005)



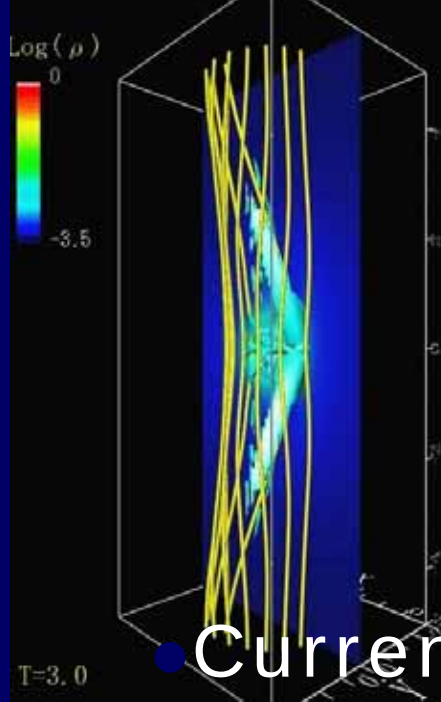
171x100x480
r,phi,z meshes



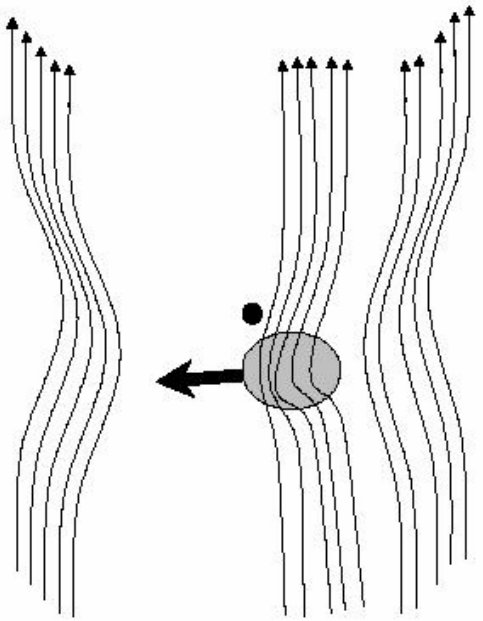


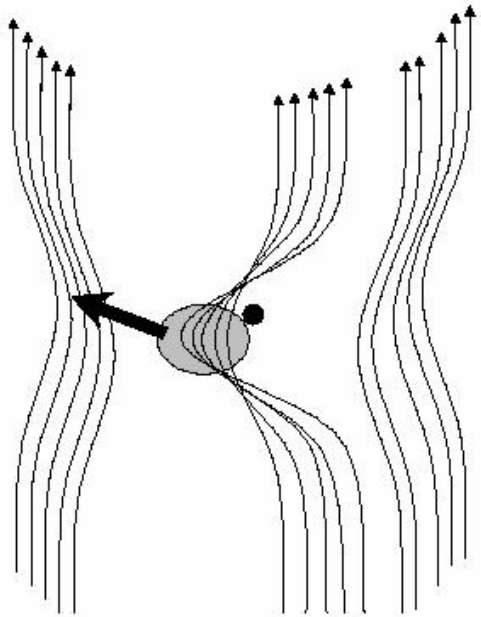


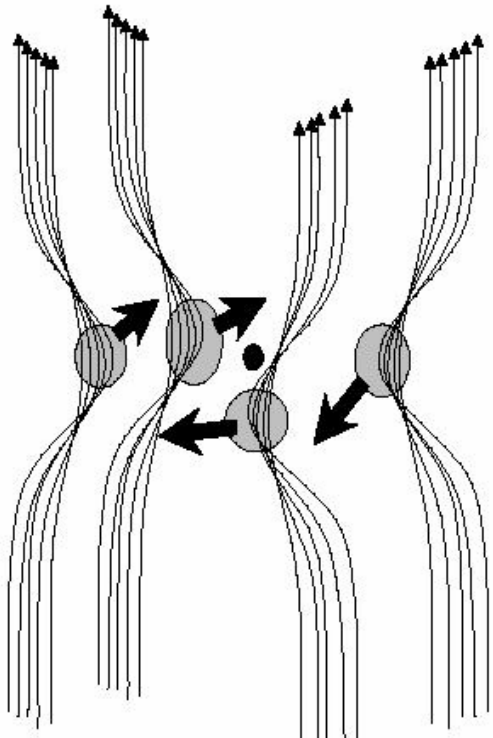
- B + Cloud

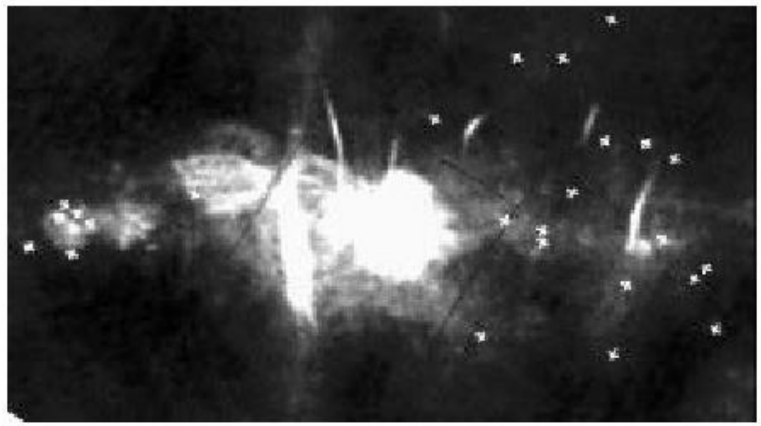


- Current

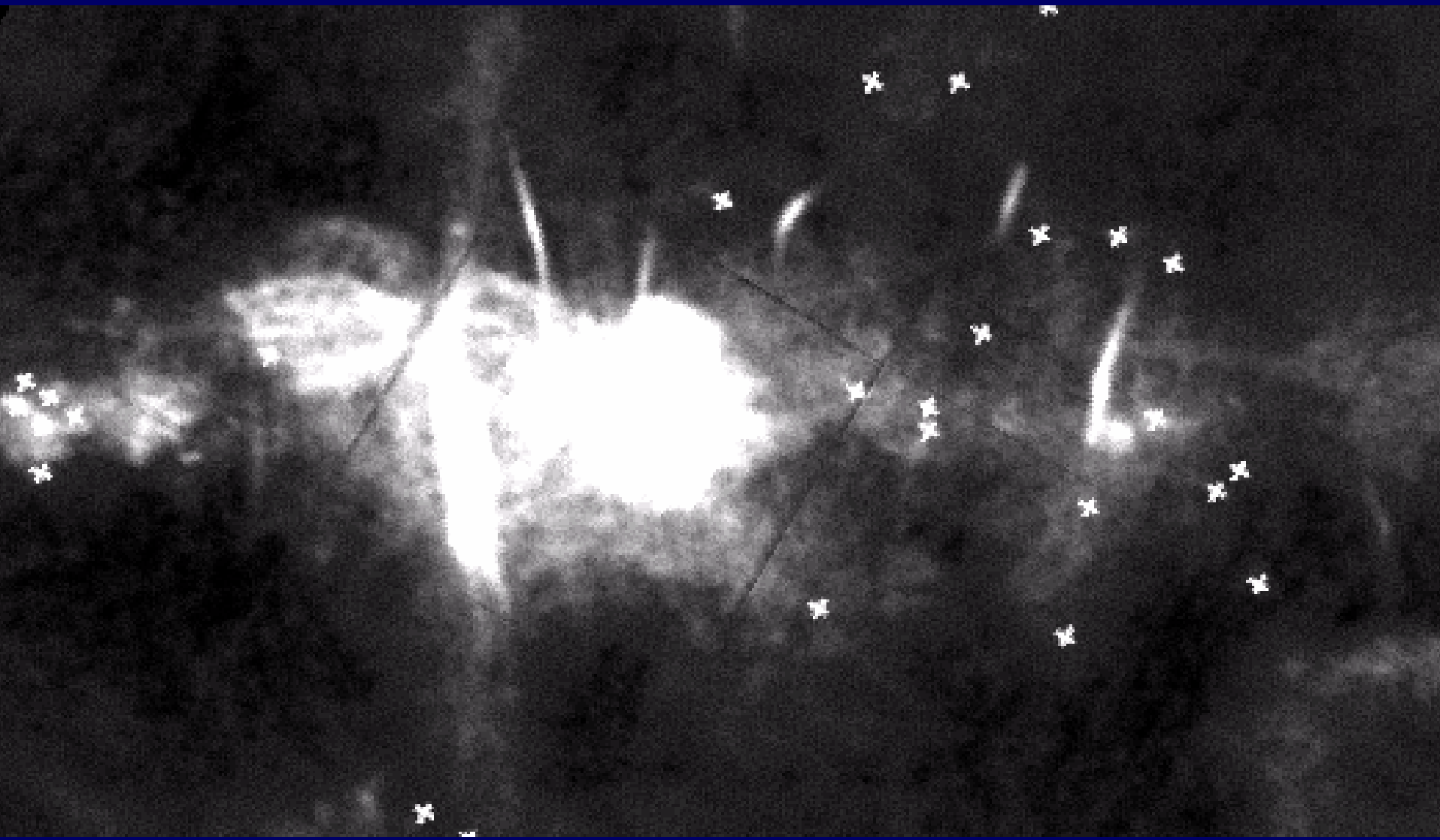








90 cm (LaRosa et al. 2000)



High contrast of radio brightness

Flux of released energy along the current sheet (thread) by

$B_z \times B_\phi$ term = Poyinting flux

$$f = B_z B_\phi V/4\pi \quad \text{thread}$$

$$f_0 = B_{z0} B_{\phi 0} V_0/4\pi \quad \text{ambient}$$

Ratio of tread/ambient fluxes

$$r = f/f_0 = B_\phi/B_{\phi 0}\ V/V_0 >> 1$$

because $B_{\phi 0} \sim 0$

Radio brightness

$$\Sigma = 2k\, T_b/\lambda^2$$

$$= \delta f/\nu \sim \delta\, (B_\phi/B_0) B_0^2\, V / 4\pi\nu$$

δ =Efficiency of Poynting flux to Radio flux (CR accel. Etc)

$$\nu \sim 1 \text{ GHz}$$

$$V \sim 100 \text{ km/s},$$

$$B_0 \sim 100\ \mu\text{G}$$

From simulation $B_\phi/B_0 \sim 0.1$.

Hence, $T_b \sim 10^{-4}\ \delta$ K.

Observation: $T_b \sim 0.1 - 1$ K

$$\delta \sim 10^{-4} - 10^{-5}$$

Thread properties understood by Current sheet model:

- Local, Isolated, narrow
- Non-axisymmetric
- No energy injection
- High contrast against backgr.