銀河磁場の起源

祖父江義明

2009.9.19, 銀河磁場WS
@京大花山天文台

Primordial Origin of Magnetic Fields in the Galaxy & Galaxies

- Tight Link between GC and Cosmic B –

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(1. Kagoshima U. &. U .Tokyo, 2.Nagoya Univ. 3. NAOJ)

1. Observations:

S, A, R, V fields in spiral galaxies

Milky Way : RM distribution and Bisymmetric B field

(Sofue, Fujimoto 1983)

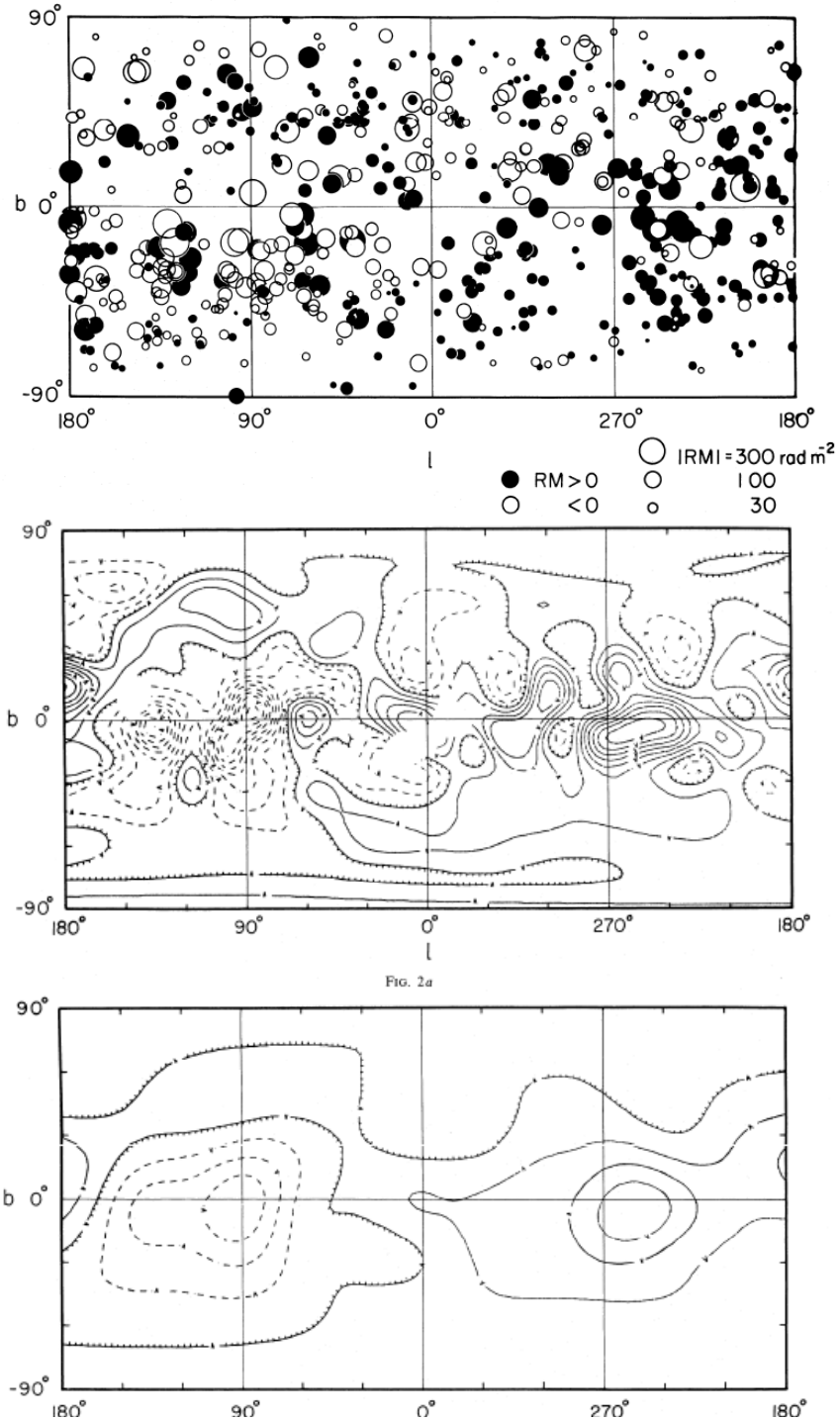
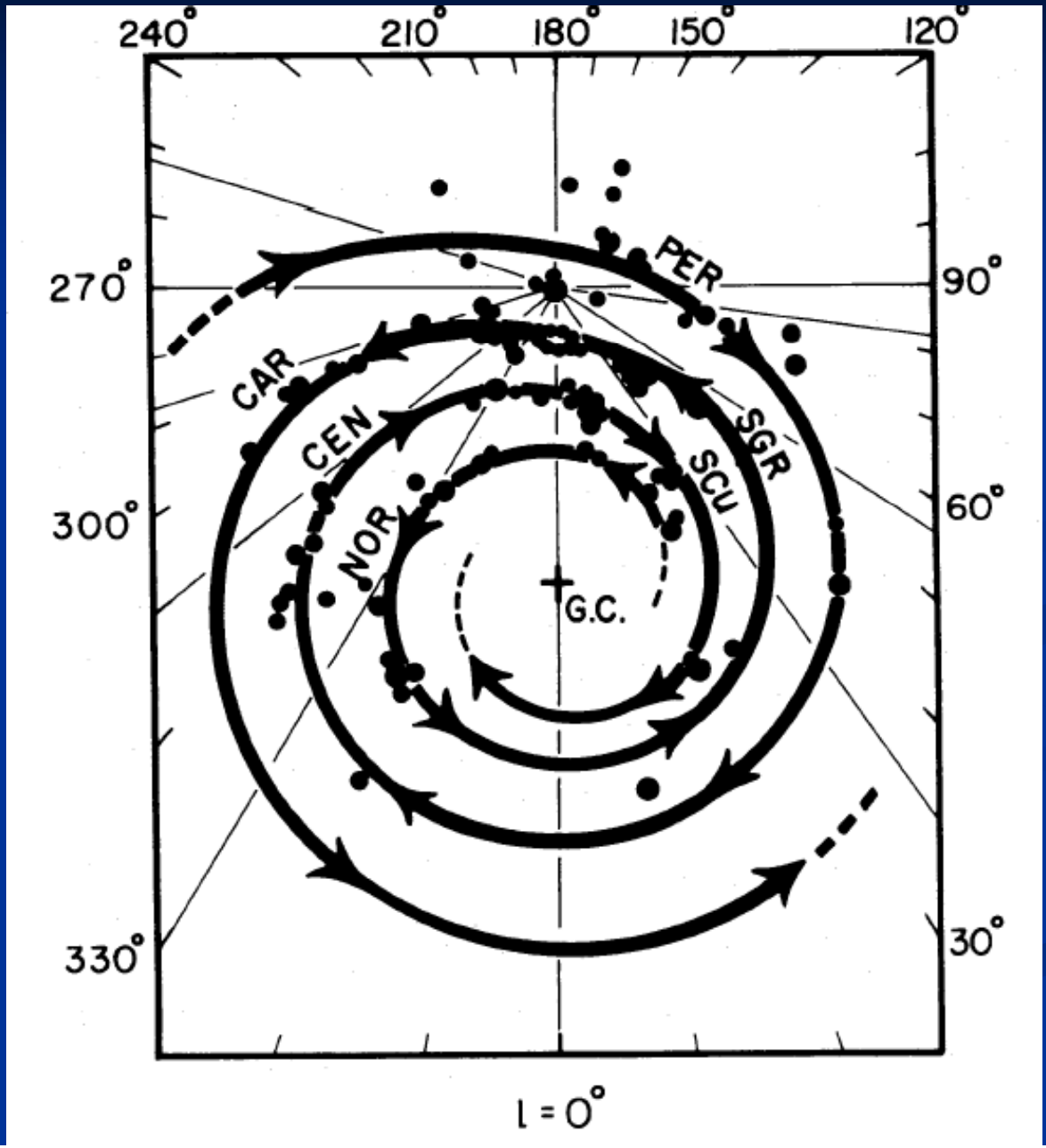
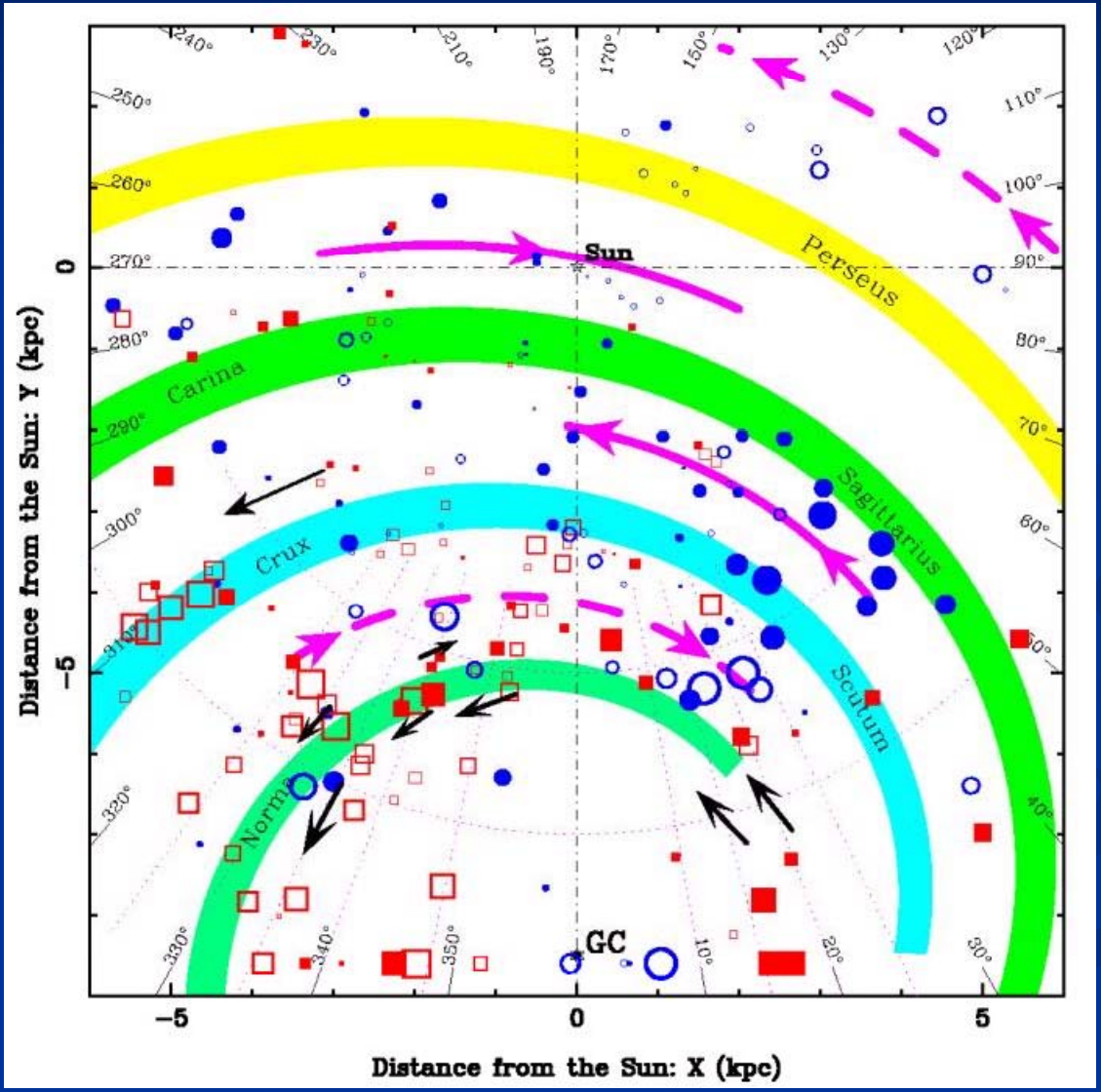


Fig. 2a

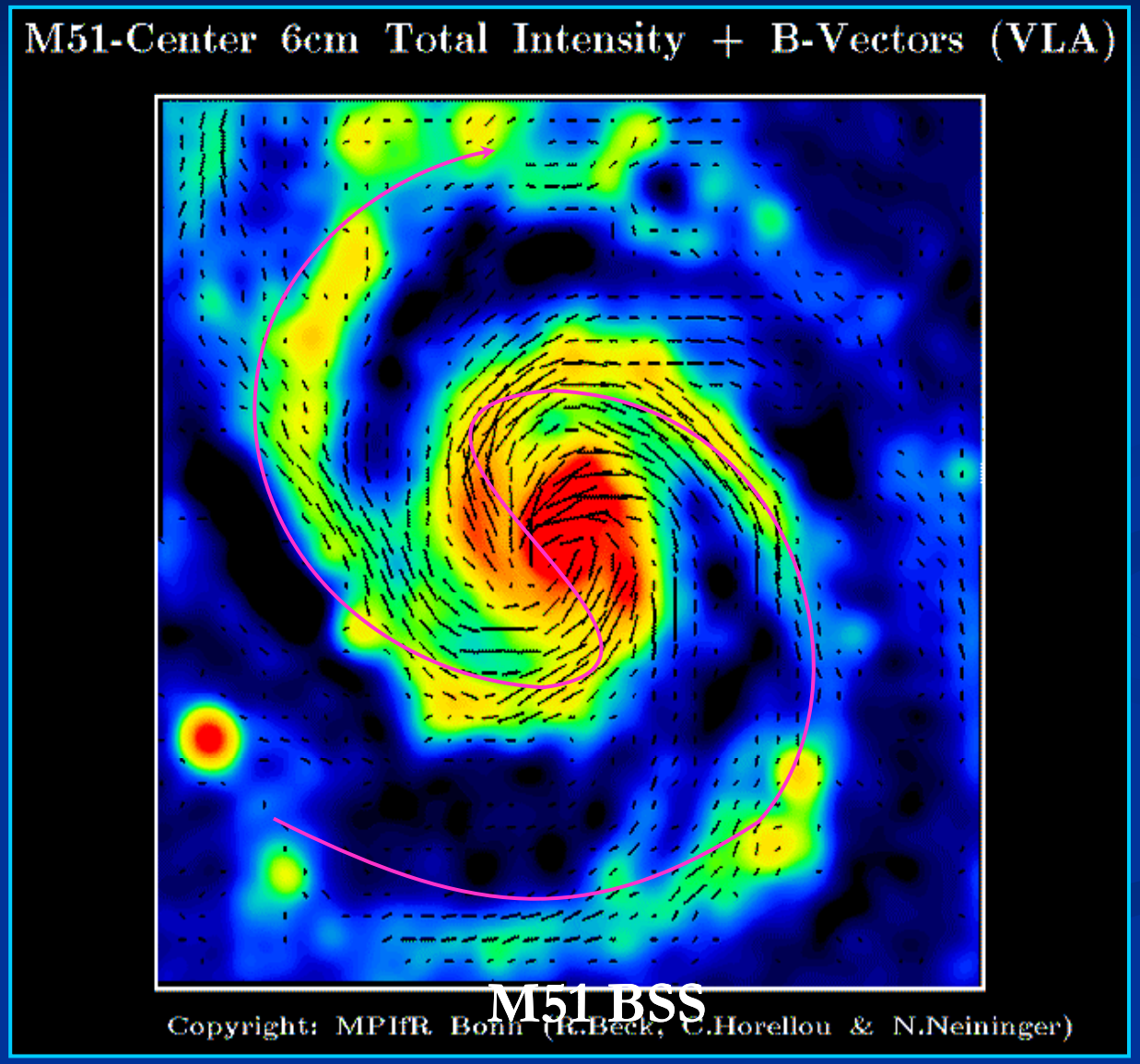
Milky Way : RM distribution and Bisymmetric B



Milky Way : RM+Pulsar distribution
Bisymmetric B field (Han 2000)

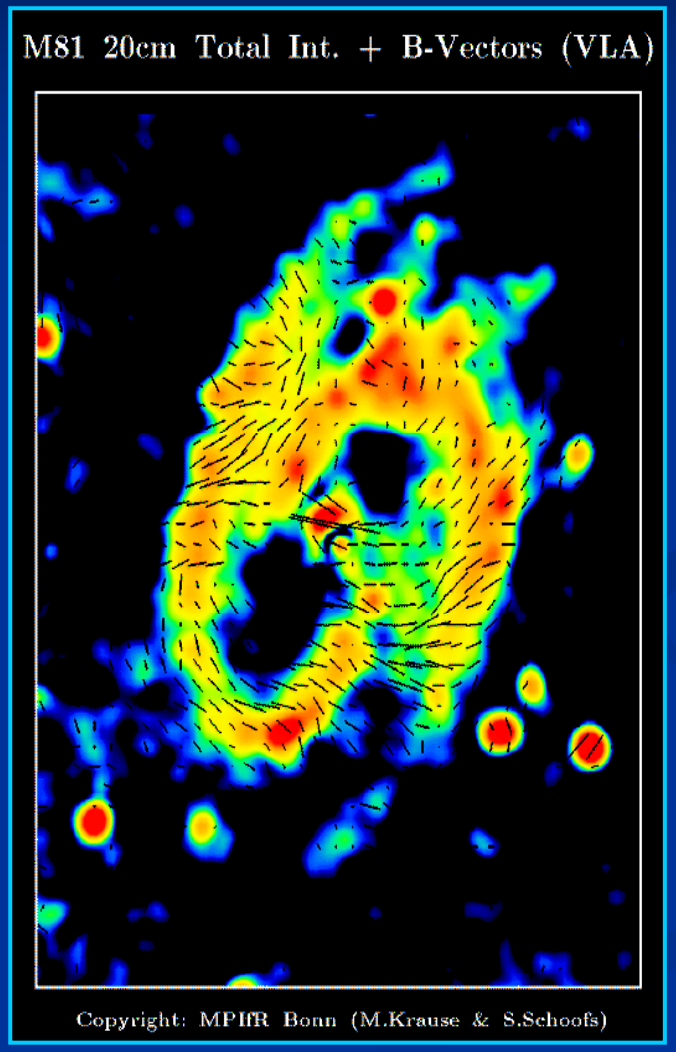


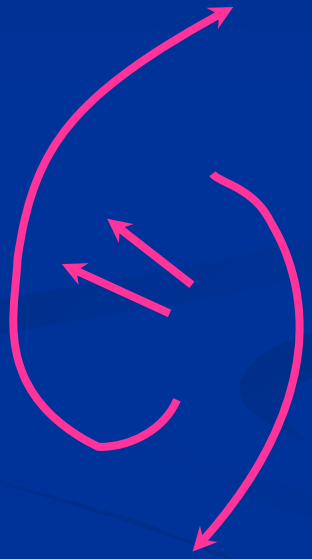
S, A, R, V fields in spiral galaxies



M51 BSS

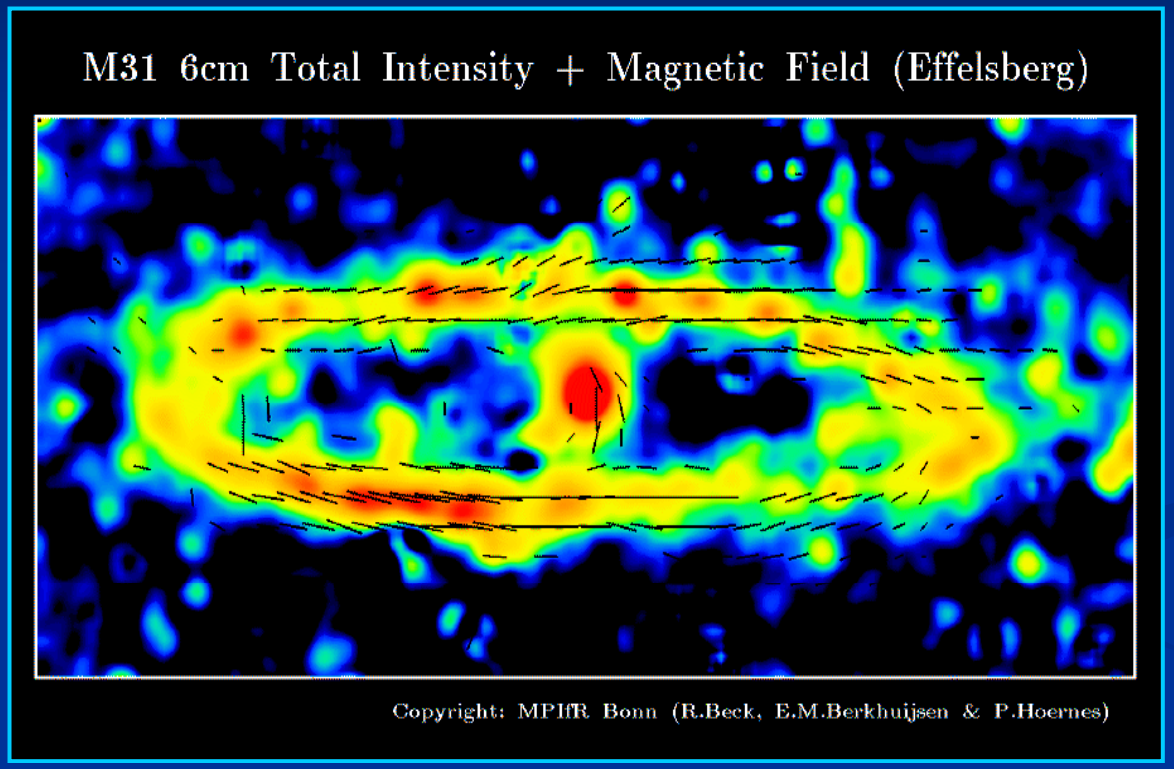
S, A, R, V fields in spiral galaxies

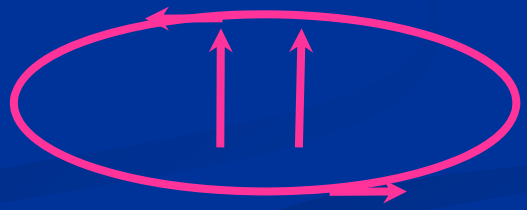




M81 BSS+VM31 Ring+V

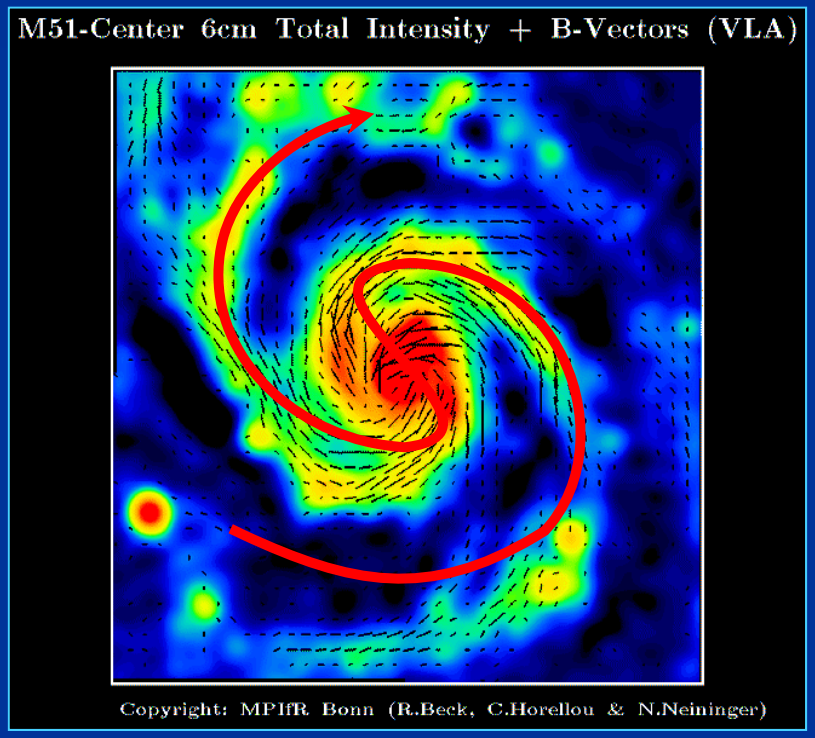
S, A, R, V fields in spiral galaxies

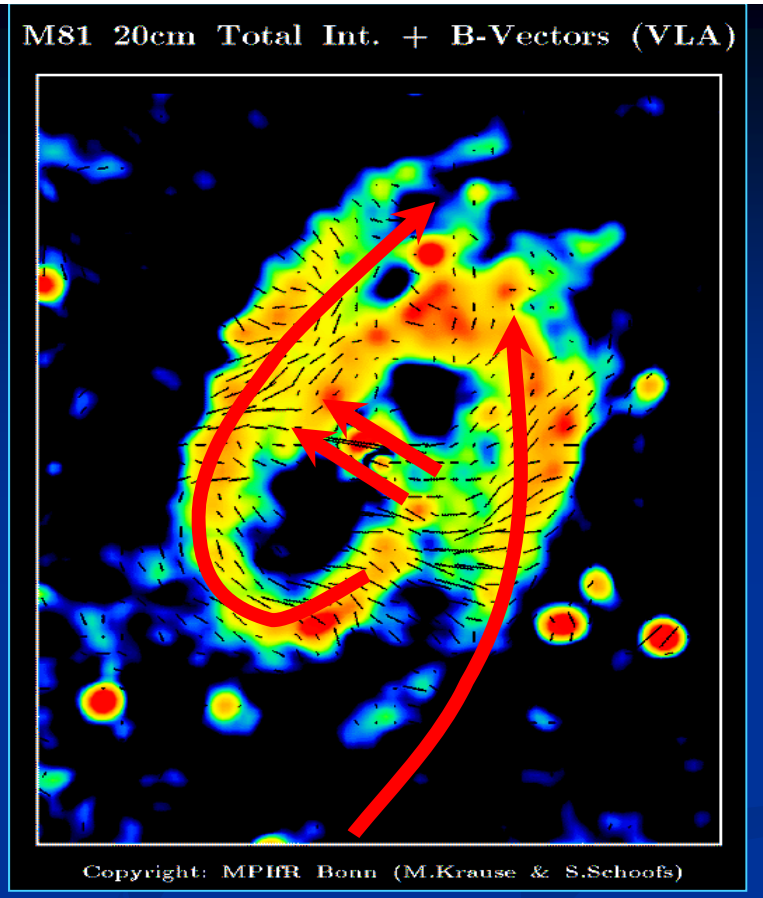


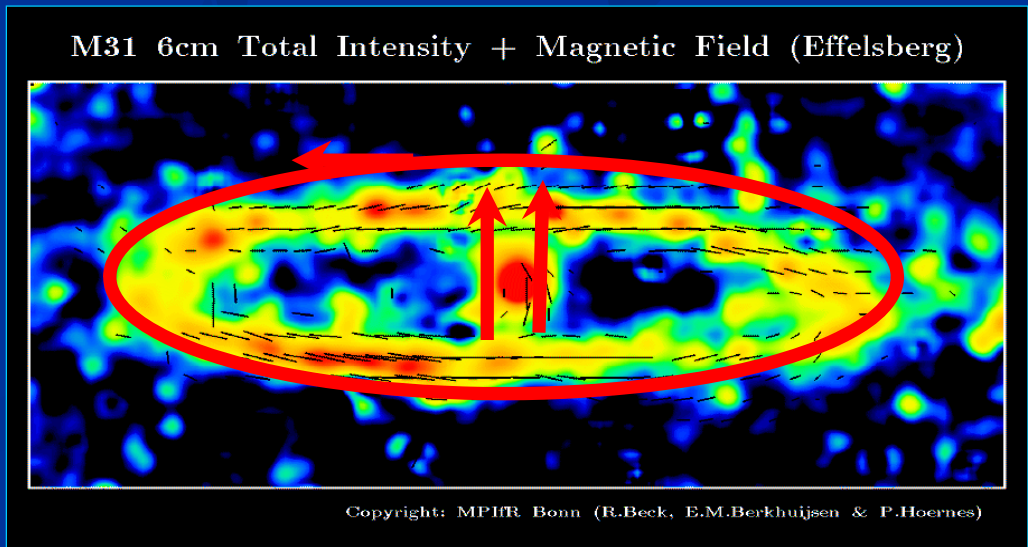


M31 Ring+V

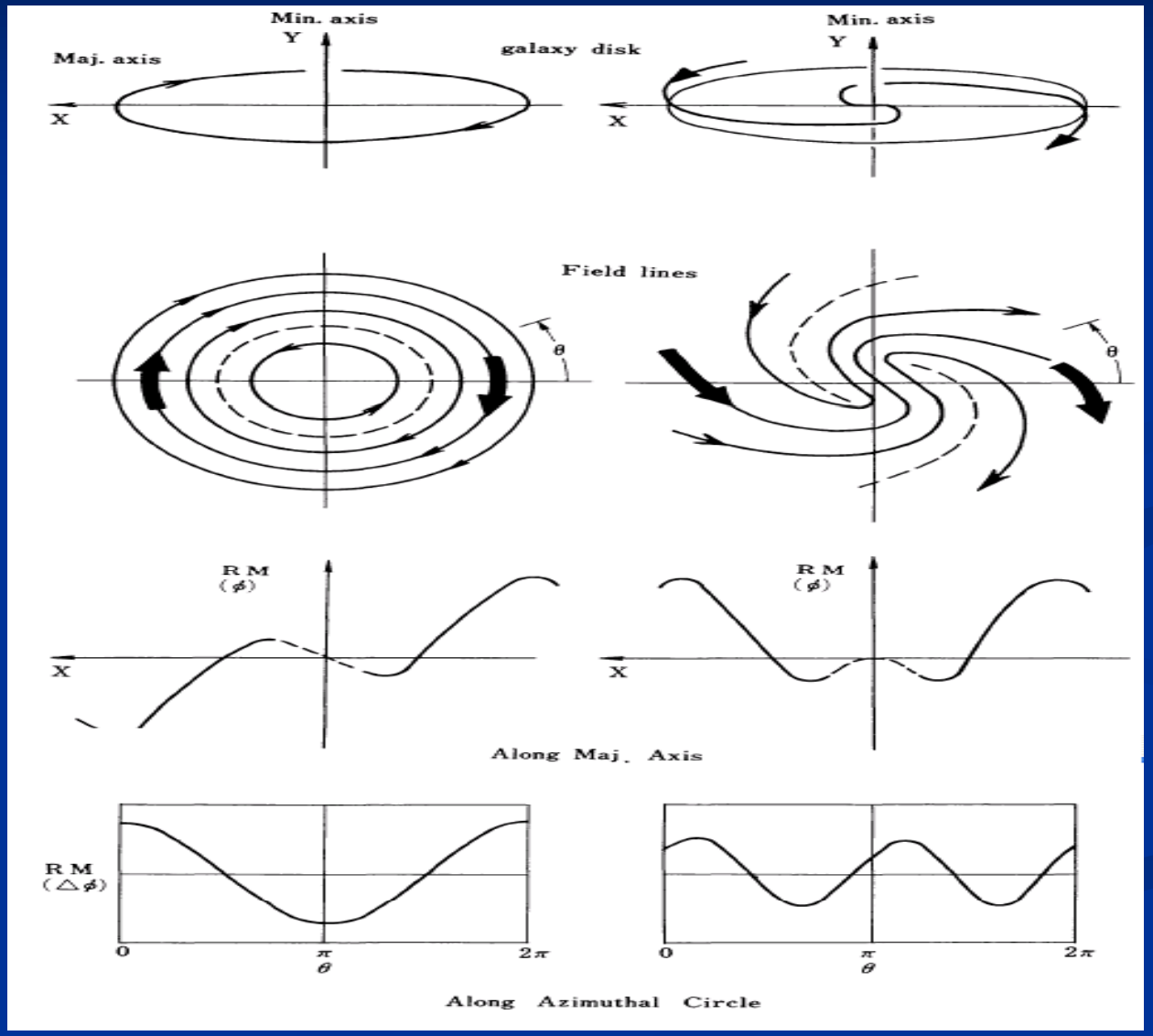
M51, M81, M31, Spiral/Ring ⊥ GC V field





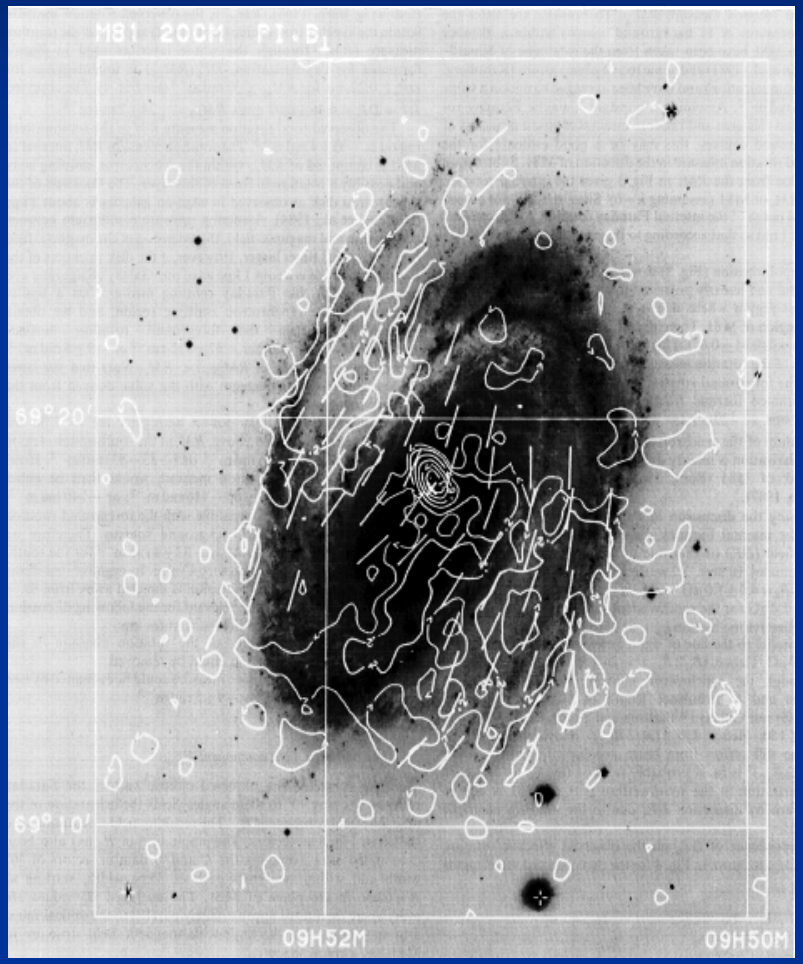


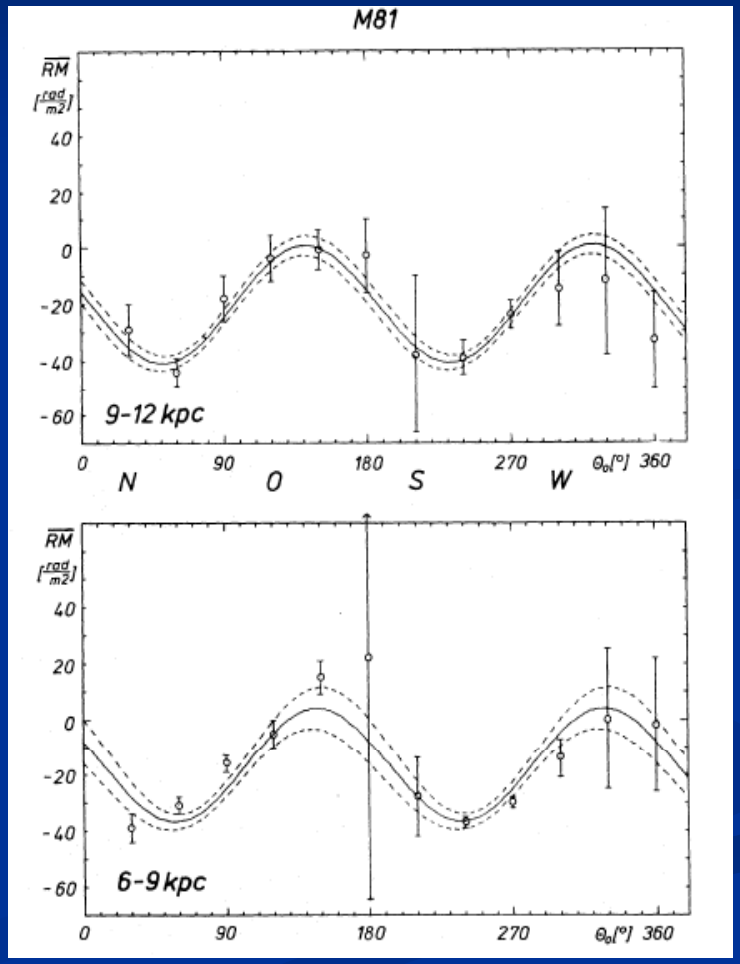
Galaxies: Polarization Angle, RM Variations

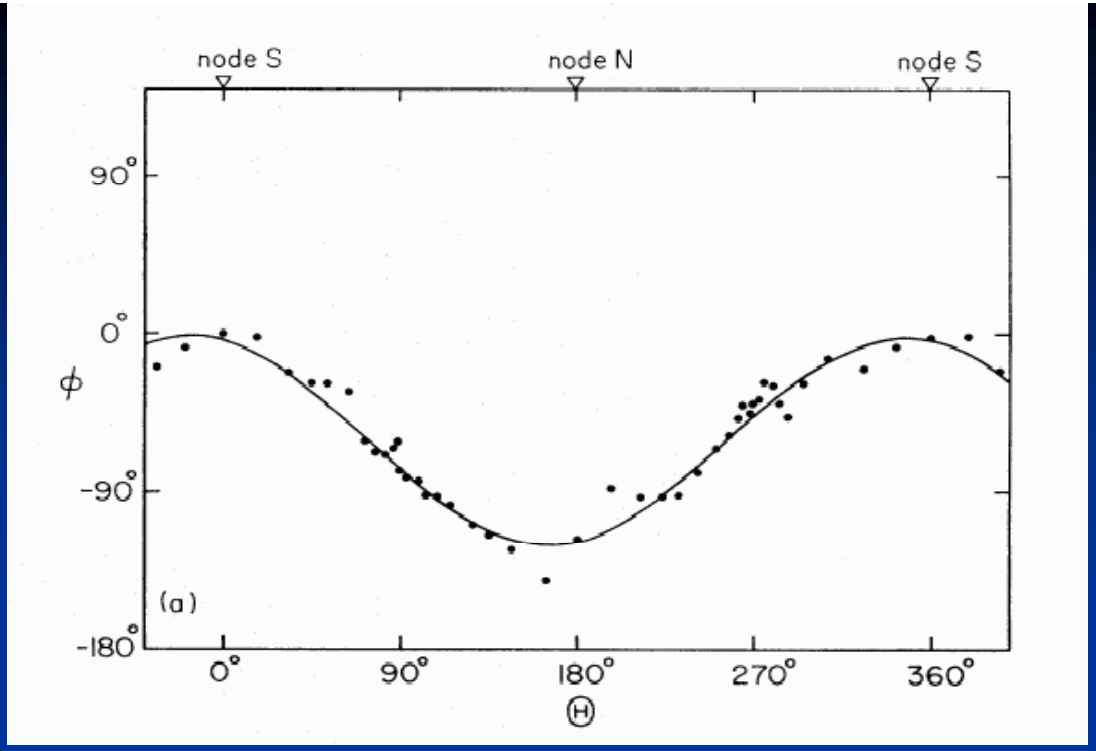


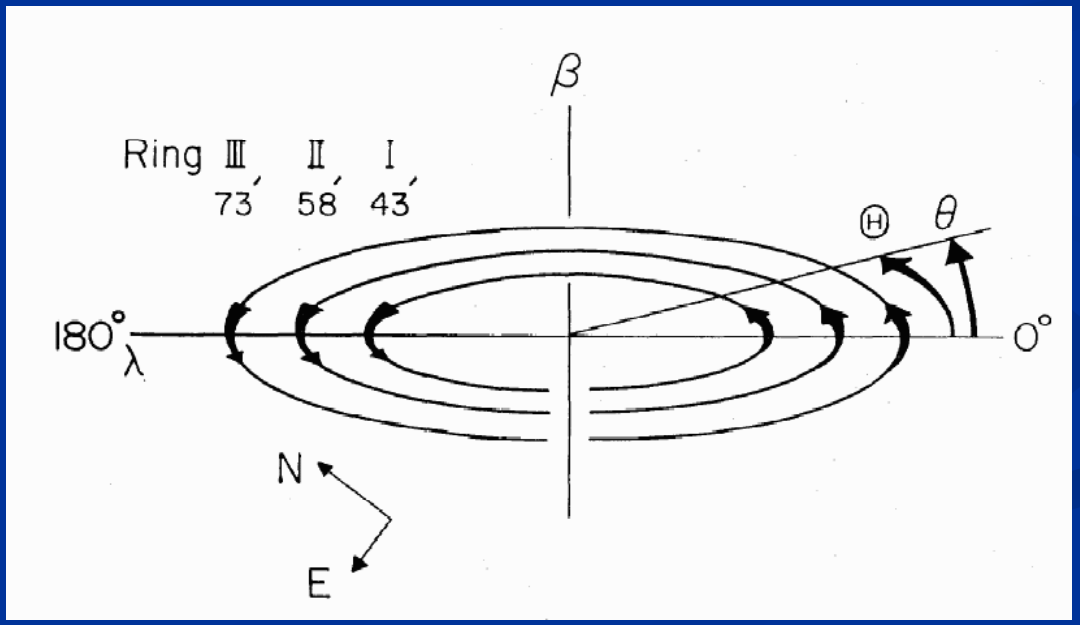
M81 B, RM(azimuth)

(Krause et al. 1989)



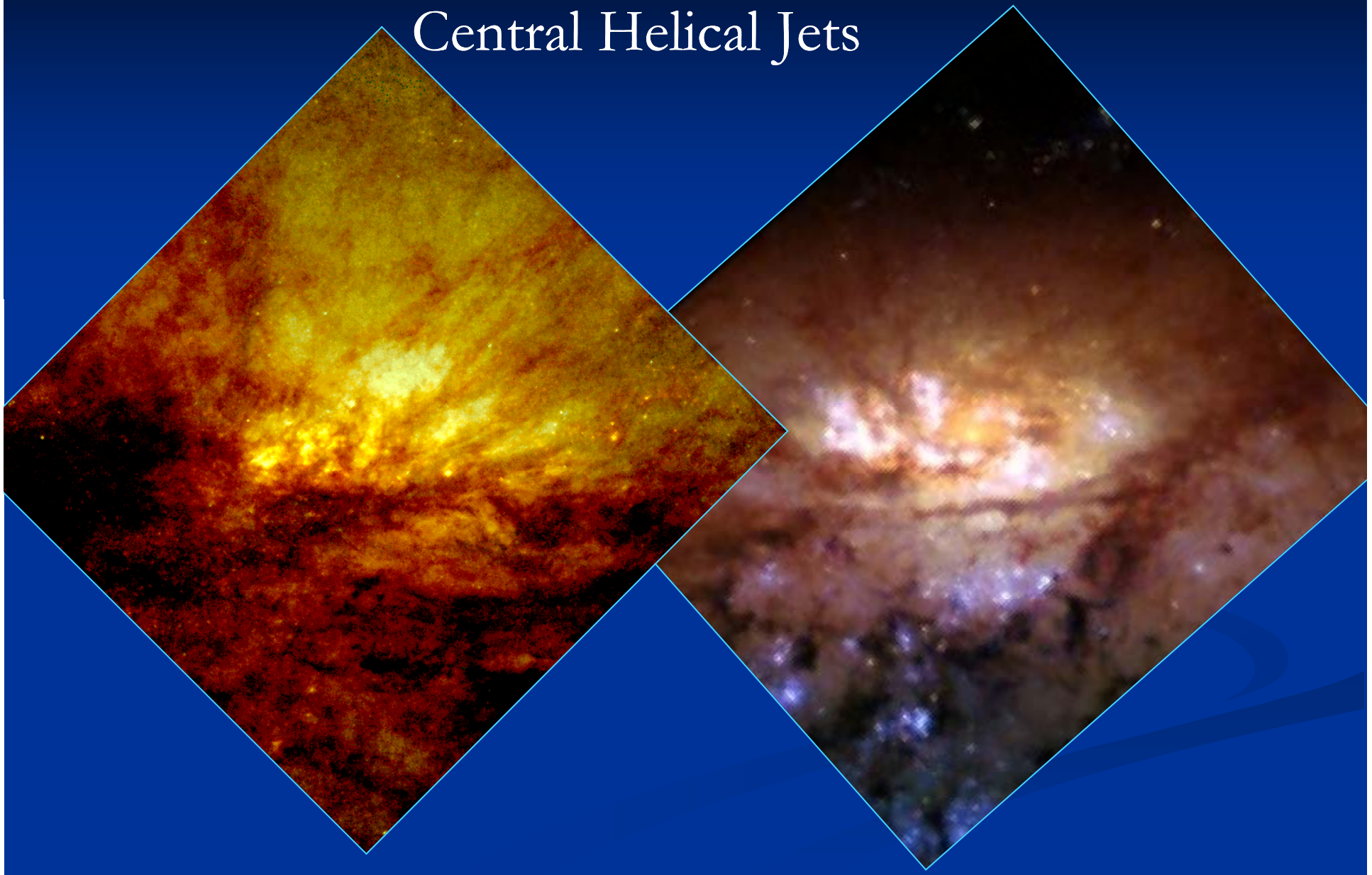



node S
node N
node S
90°
0°
-90°
-180°
φ
(a)
0°
90°
180°
270°
360°
Ⓗ


β
Ring Ⅲ Ⅱ Ⅰ
73′ 58′ 43′
Ⓗ θ
180° λ
0°
N
E

NGC 253, NGC 2903

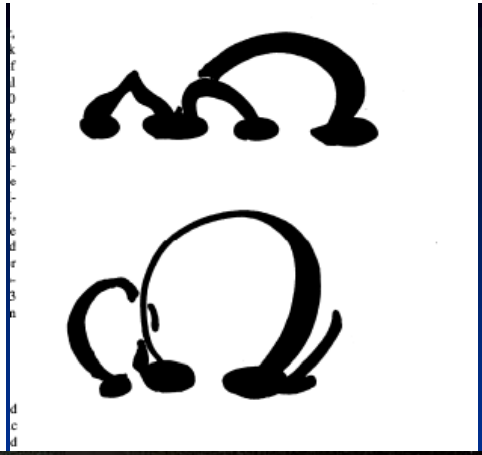
Central Helical Jets

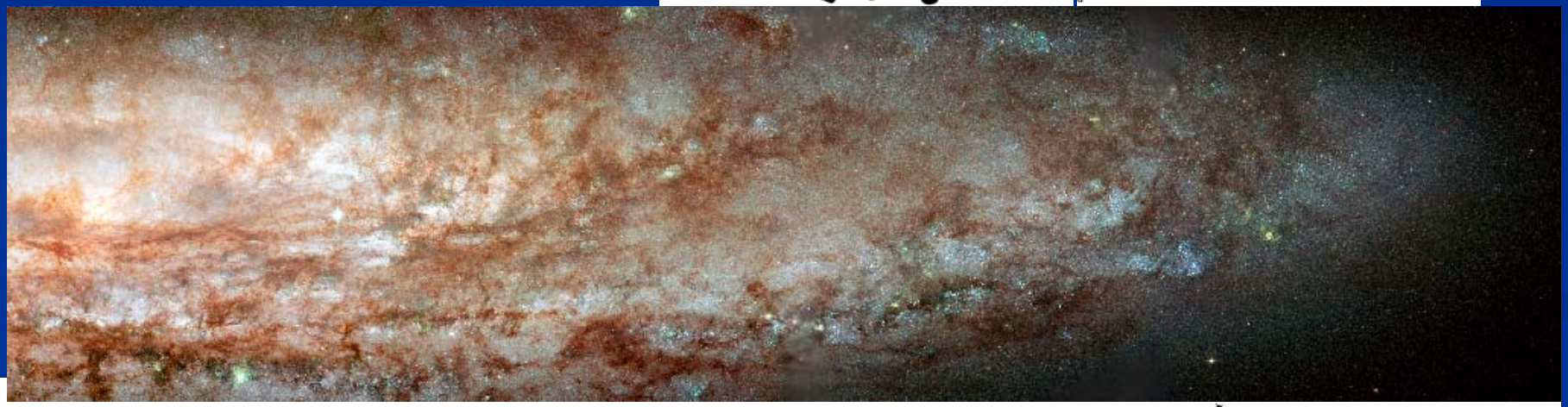


Vertical B, NGC 253

NGC253 (Helical dust jets, HST)

NGC253
Jets, Loops

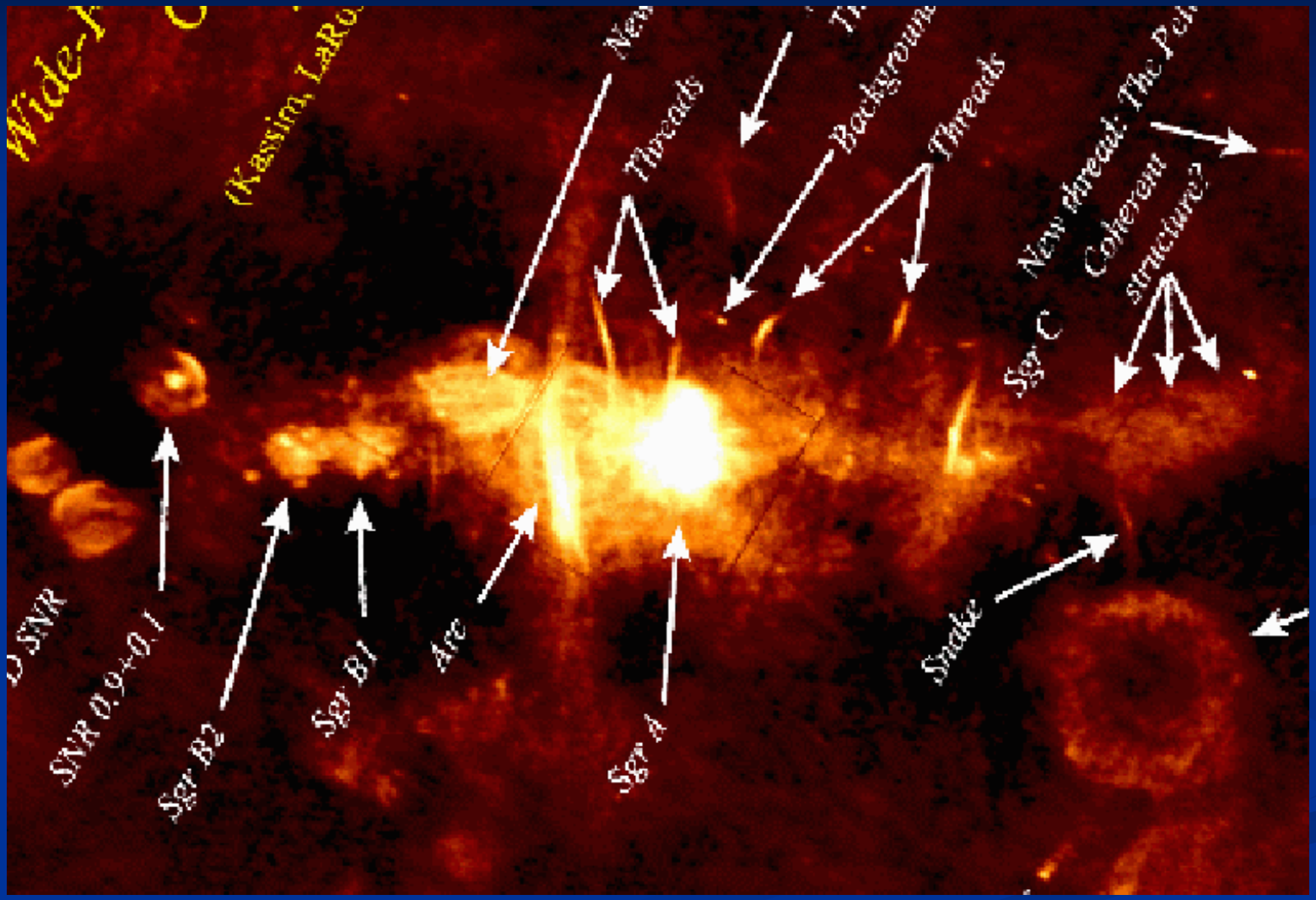




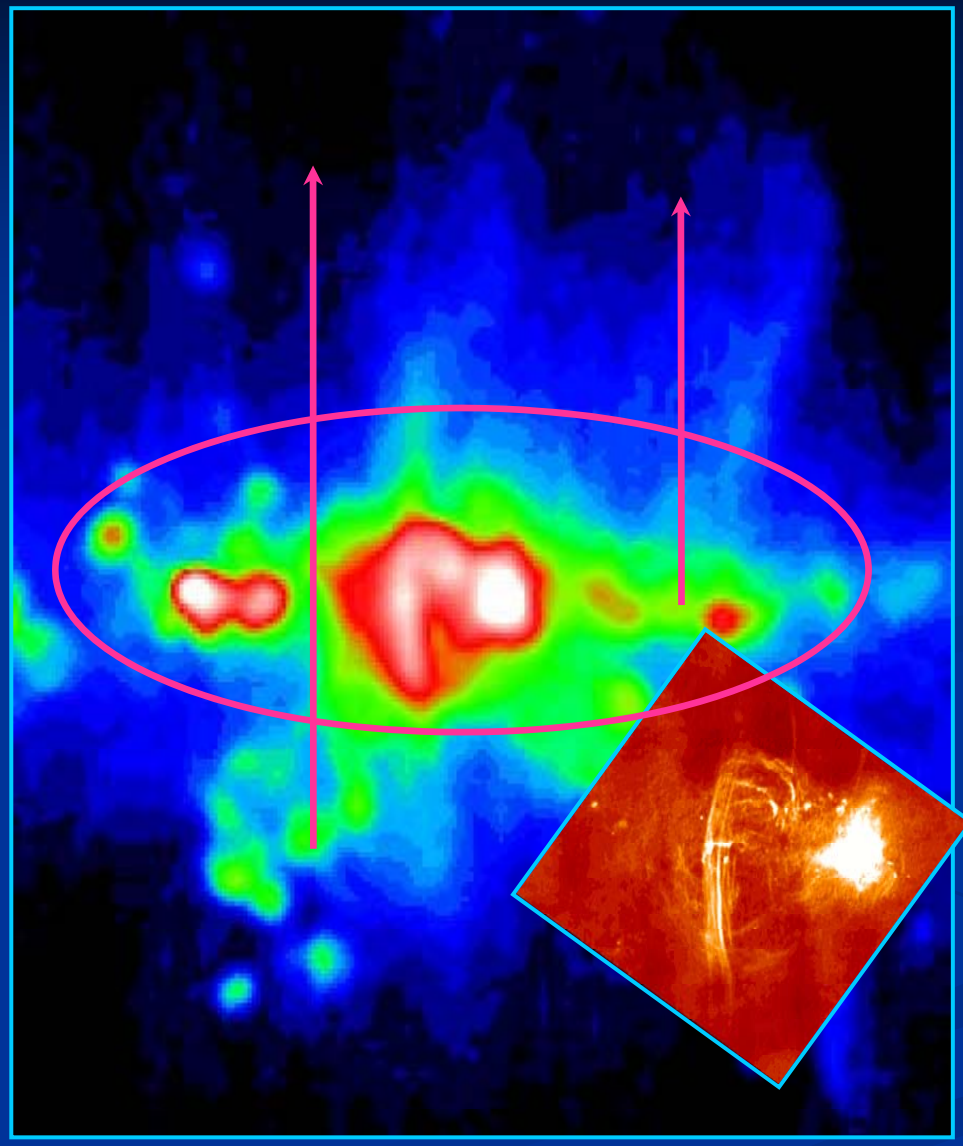
Loop: N2903

- 300 MHz

Threads

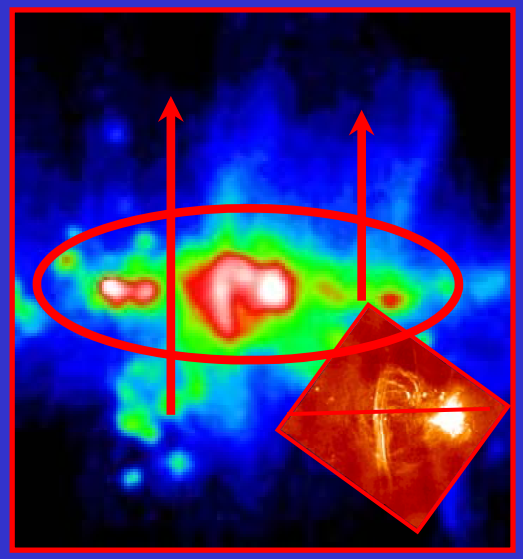


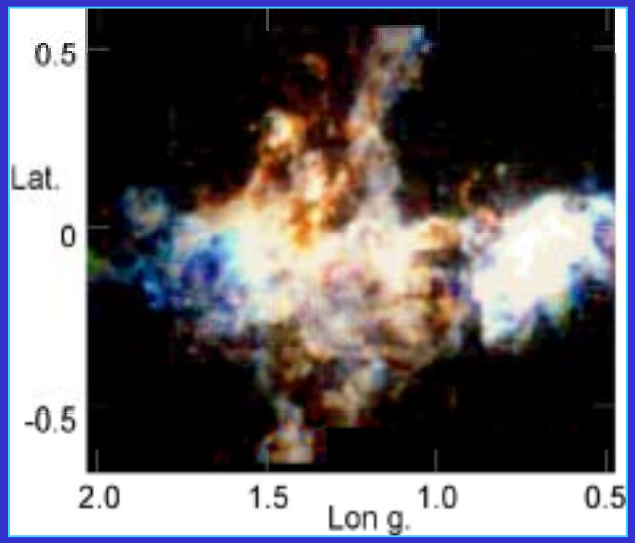
Galactic Center

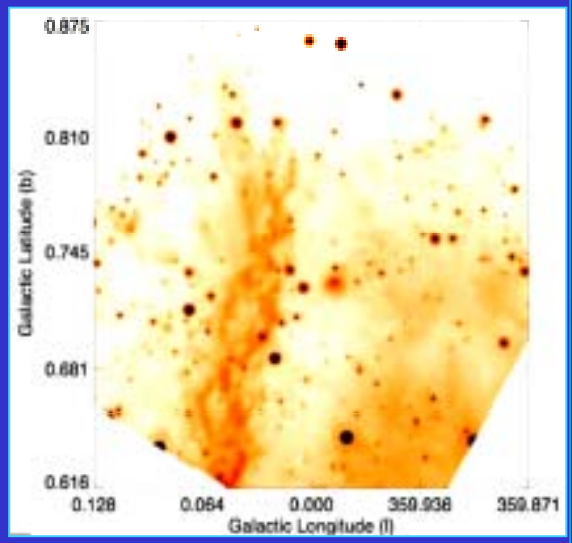


GC (Radio Arc)

Galactic Center Vertical B: Helical B, Jets, Loops

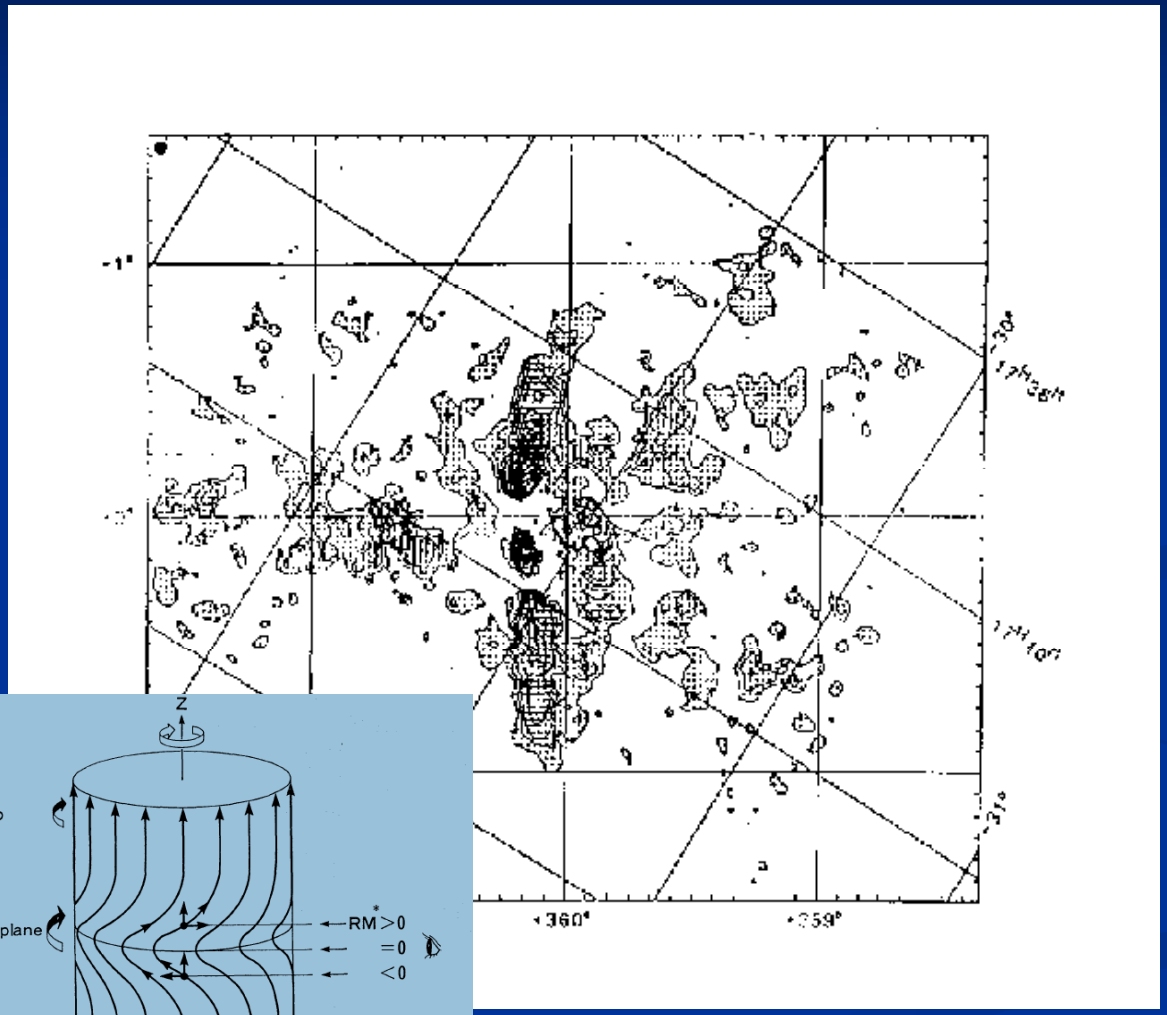


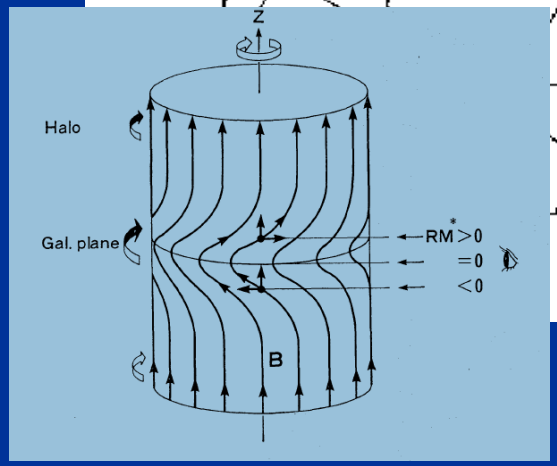


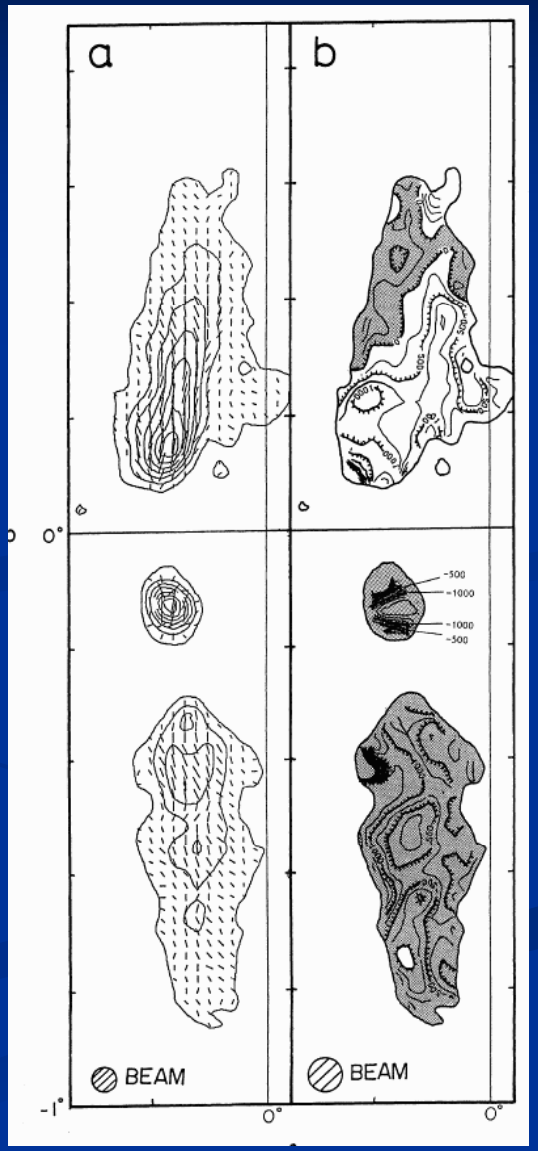


⊥ Galactic Center Vertical B

NRO 45m, Bonn 100m Tsuboi et al, 1986, Sofue,et al. 1987

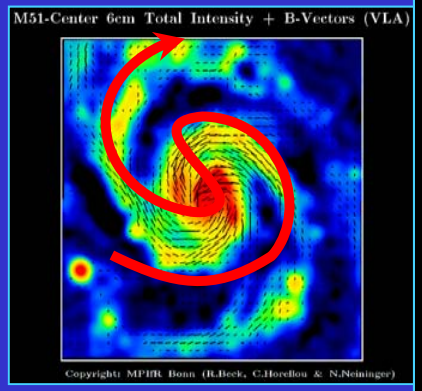


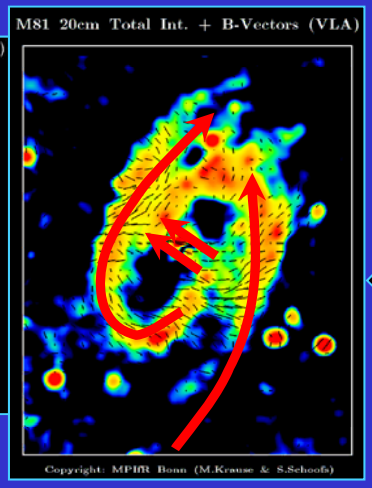




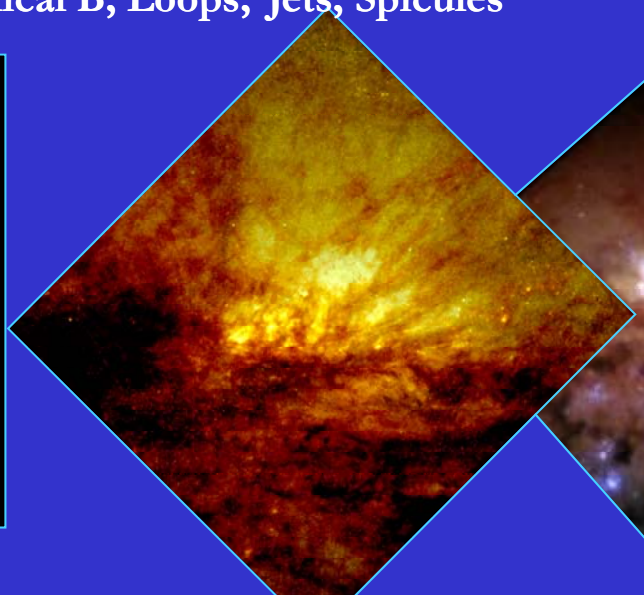
1. Vertical B in GC vs Spiral/Ring/Loop Fields in the Disks

M51, M81, M33,
Spiral/Ring + GC V field

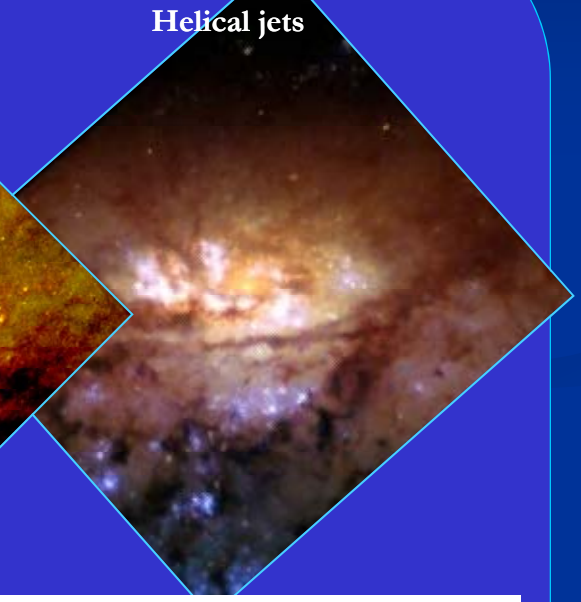


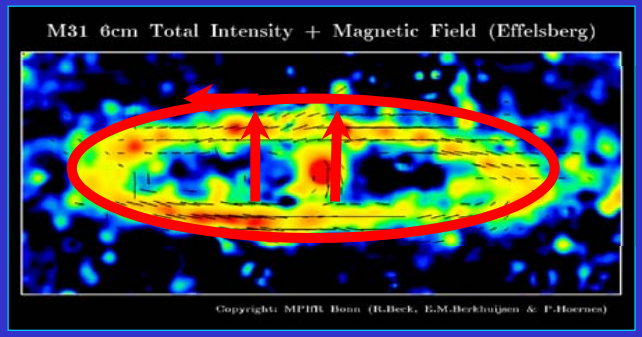


NGC 253
Helical B, Loops, Jets, Spicules



NGC 2903,
Helical jets

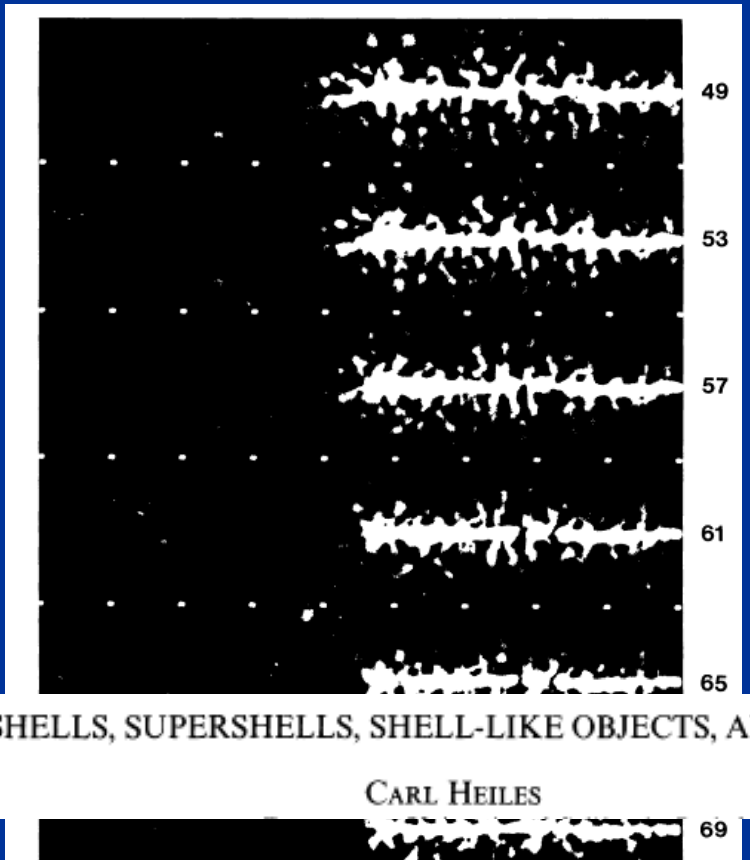




Galactic Shells, Loops, Jets, Helix
1970's~ HI, Dust, cold gas

HI shells, worms

(Heiles 2004)

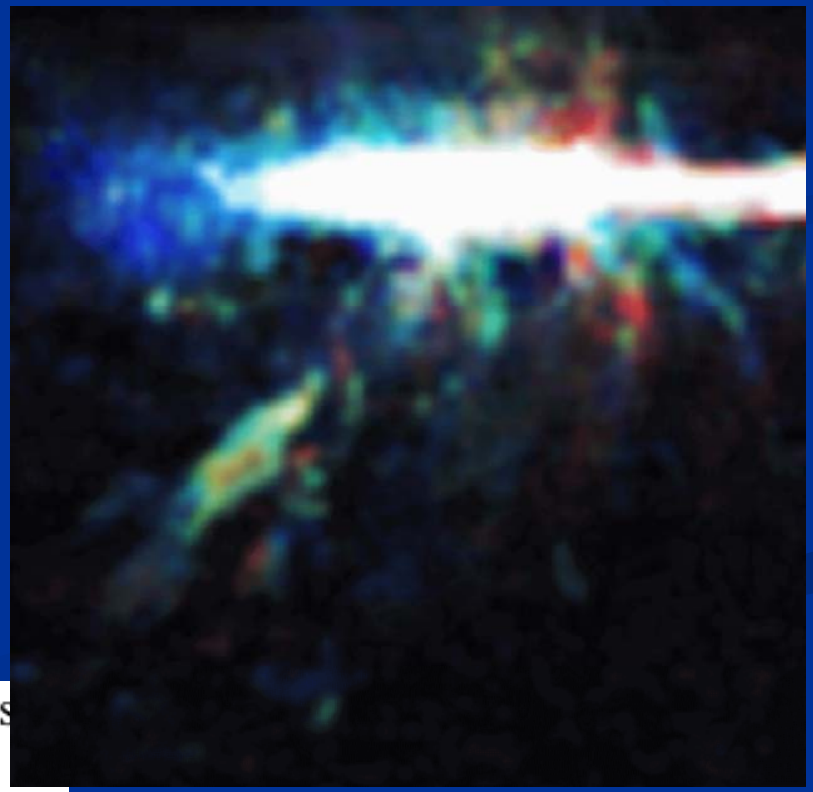


H I SHELLS, SUPERSHELLS, SHELL-LIKE OBJECTS, AND "WORMS

CARL HEILES

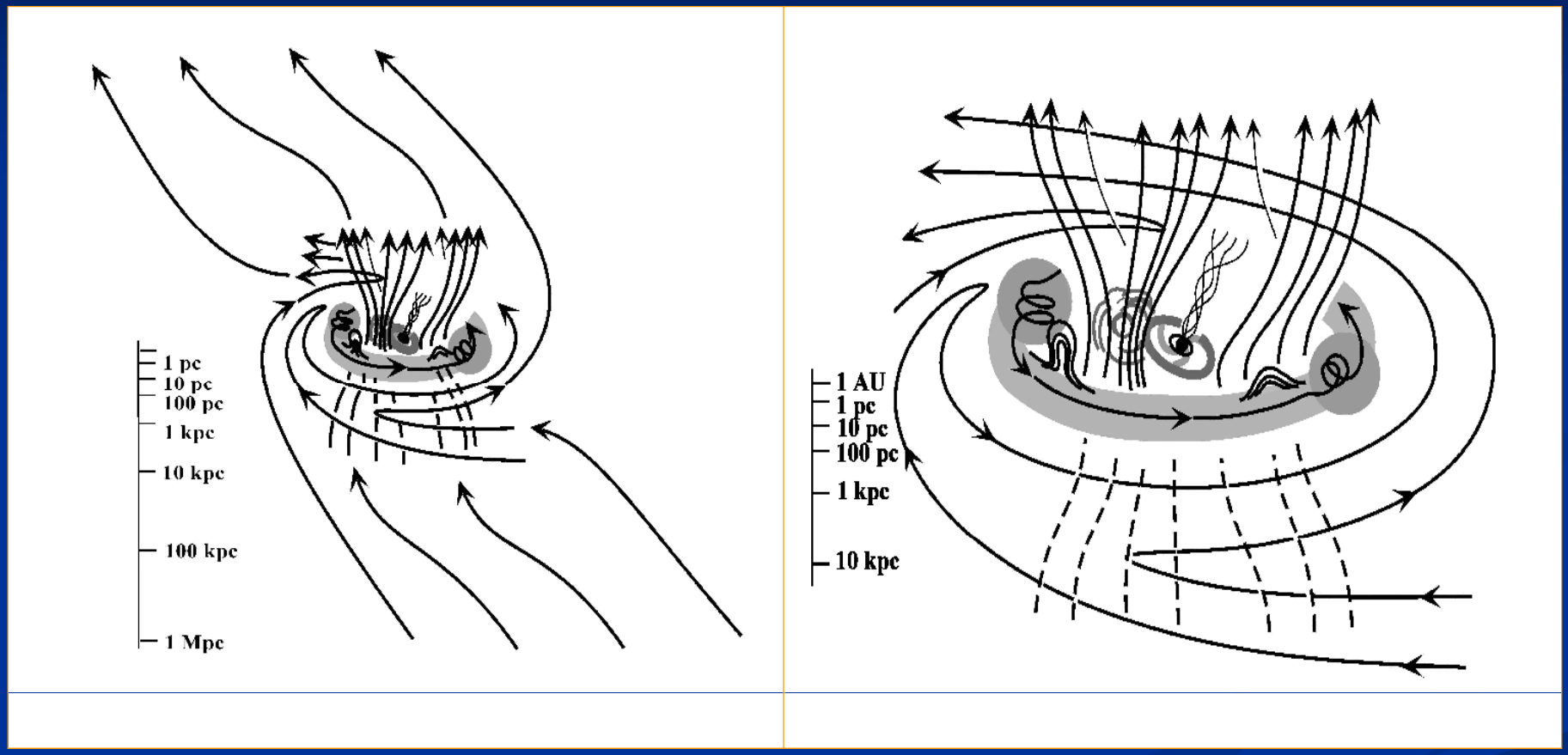
G40 1-kpc HI jets

(Sofue 2004)

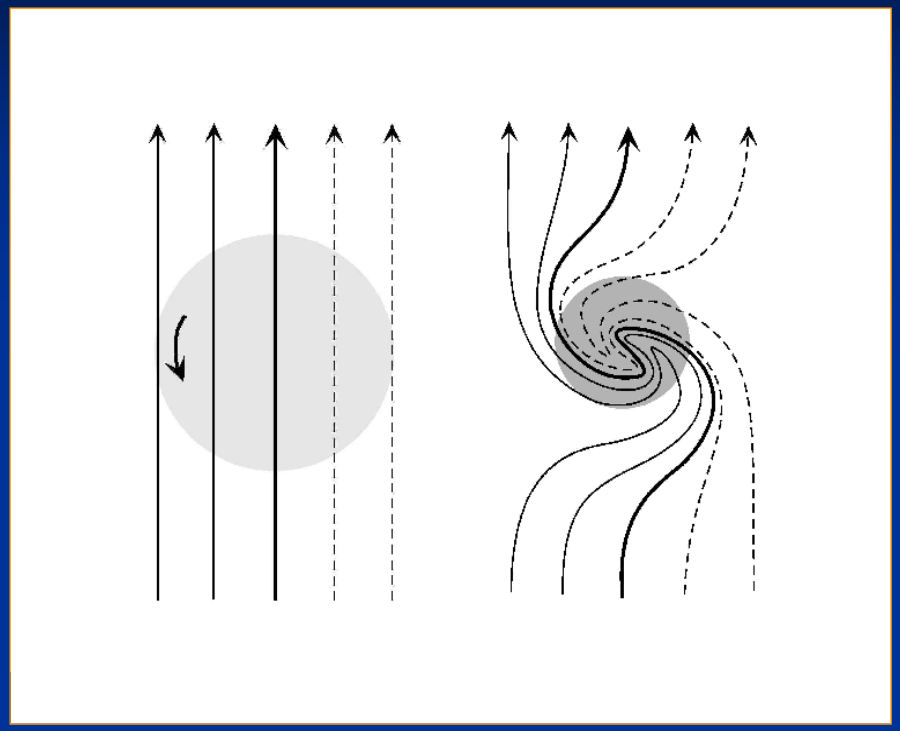


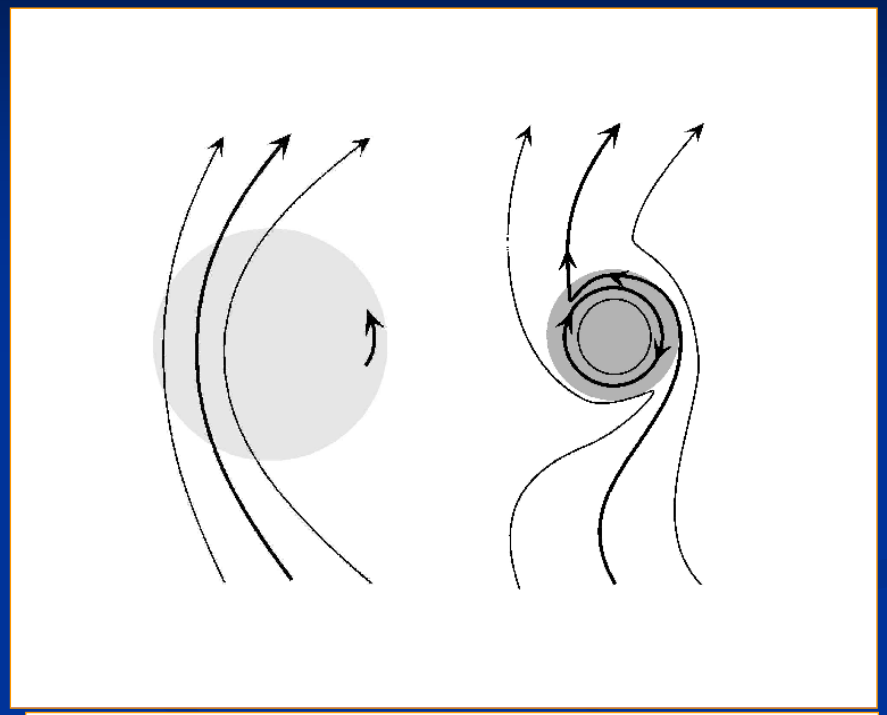
2. PRIMO
Primordial Magnetic Origin Model

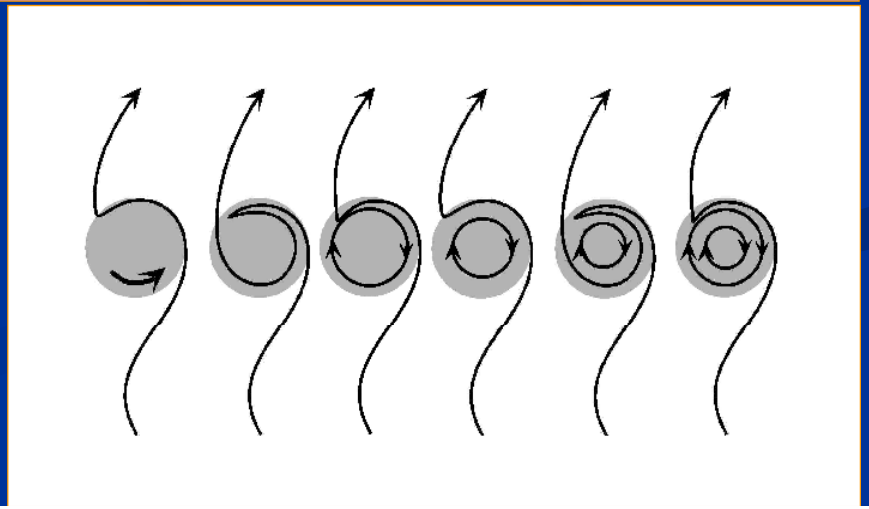
The Galaxy


1 pc
10 pc
100 pc
1 kpc
10 kpc
100 kpc
1 Mpc
1 AU
1 pc
10 pc
100 pc
1 kpc
10 kpc

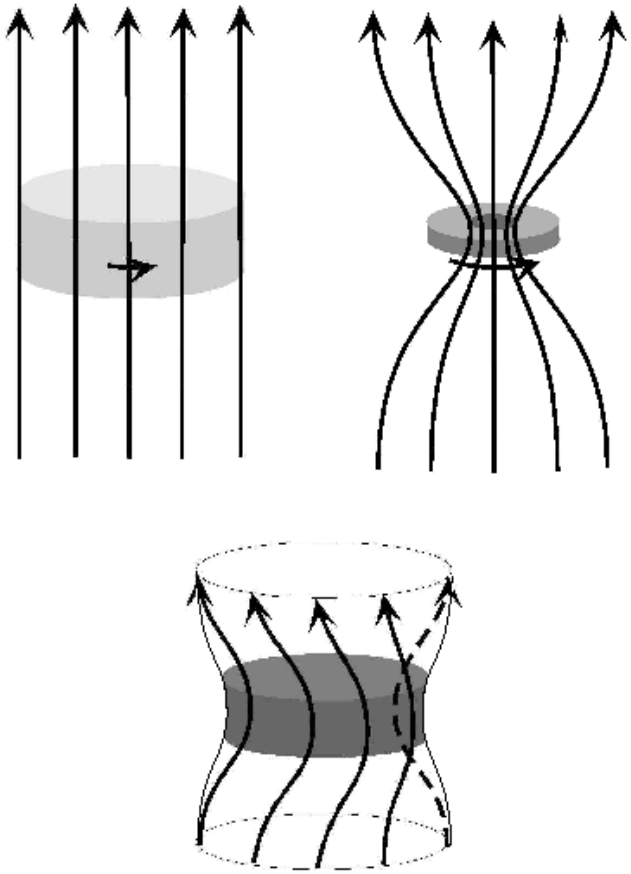
BSS & R fields

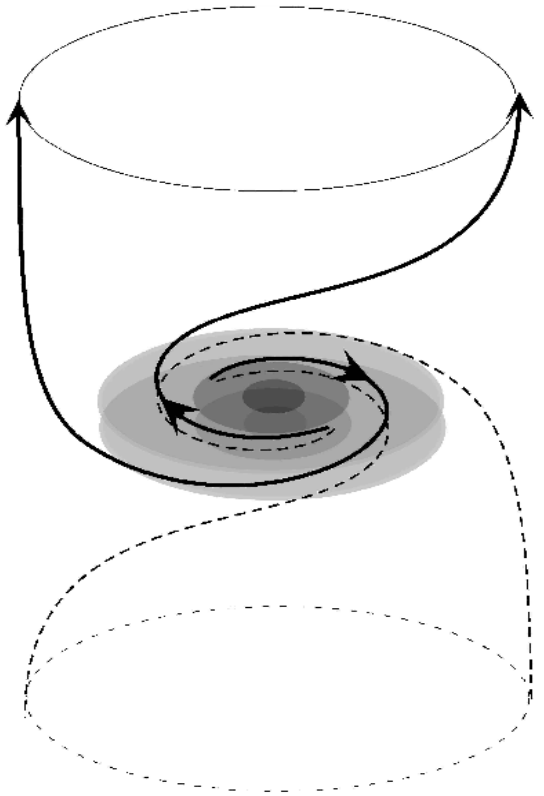




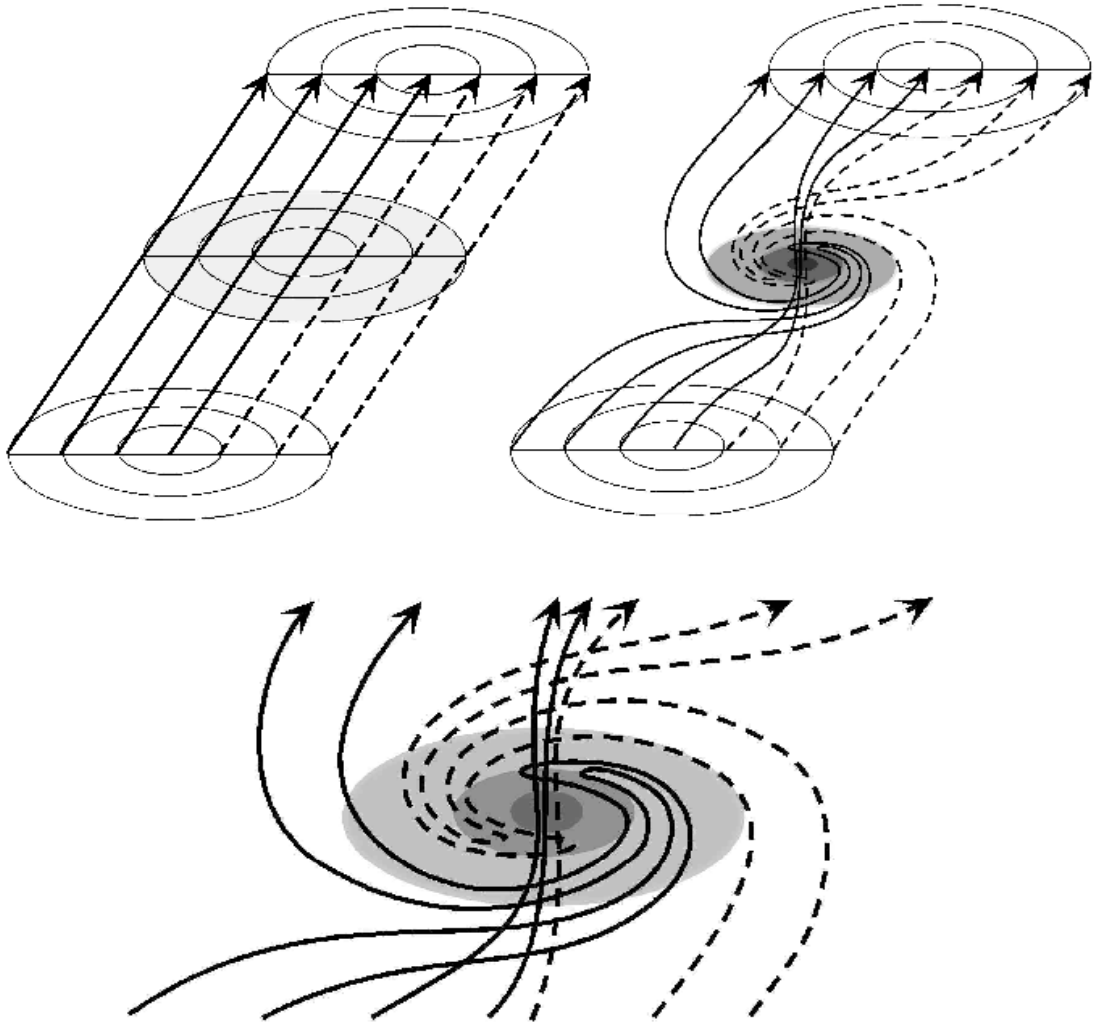


V & ASS fields

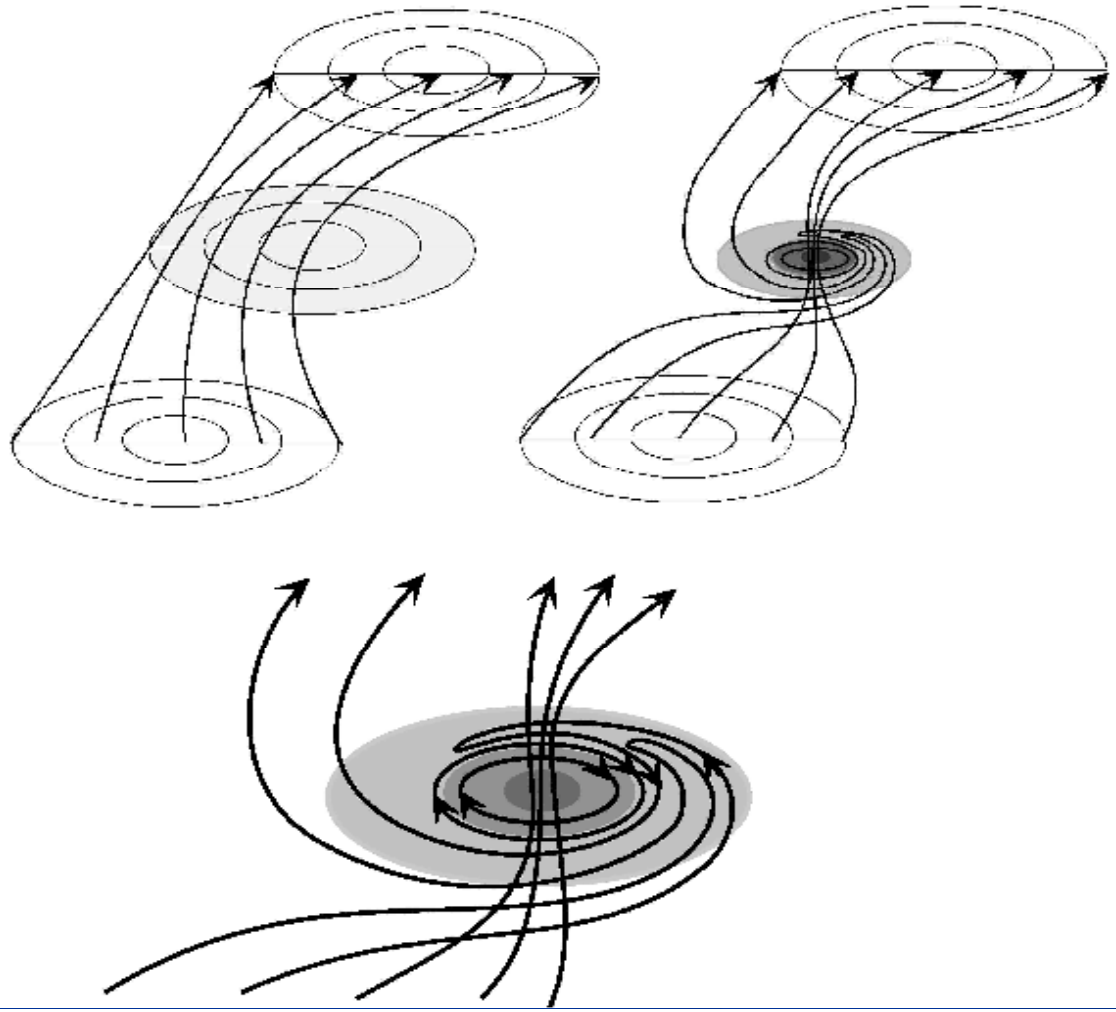




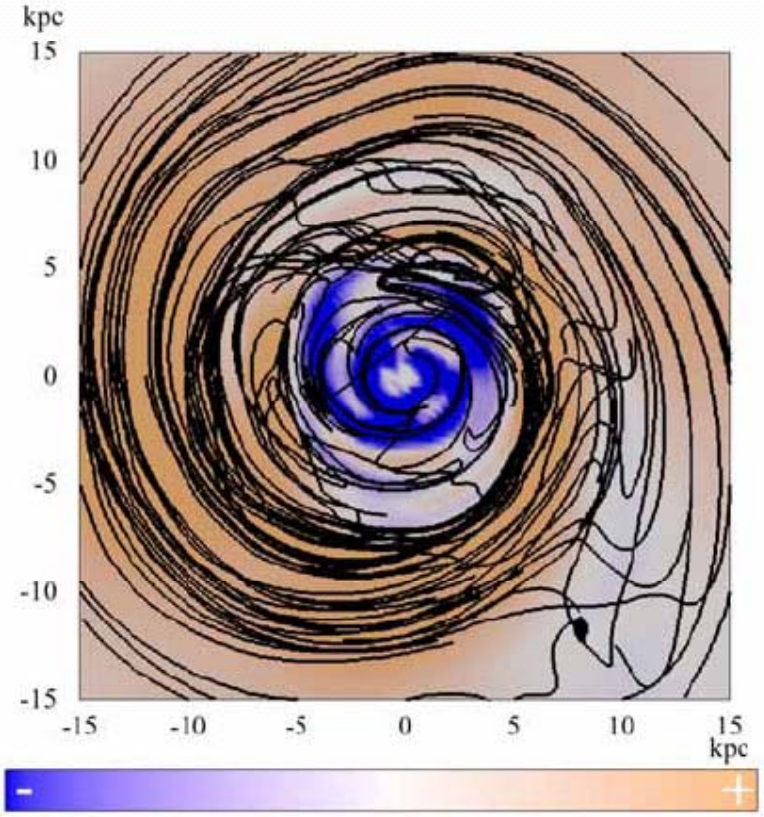
SV



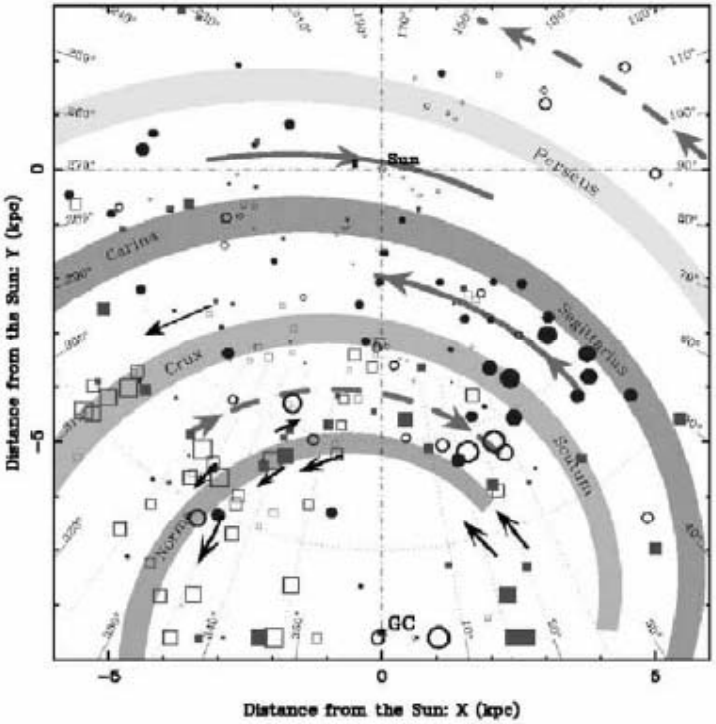
SARV



3. PRIMO
MHD Simulation



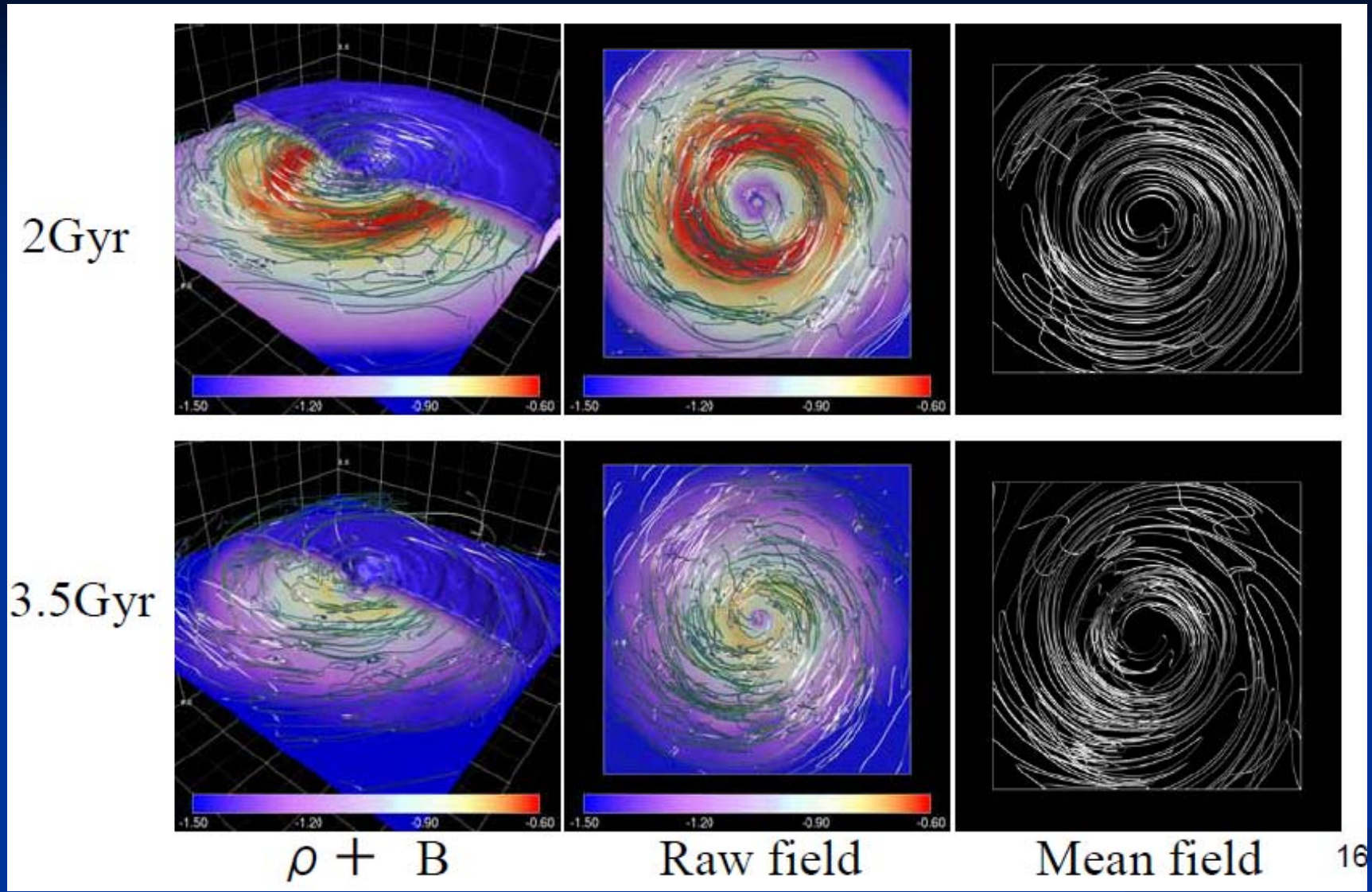
Azimuthal field at t=3.8Gyr at z=0.25Kpc



Galactic magnetic field obtained by Rotation Measure

(Han et al. 2001)

- Matsumoto 2005



- Matsumoto 2005

Bisymmetric B configuration by local theory

(Sawa Fujimoto 1986)

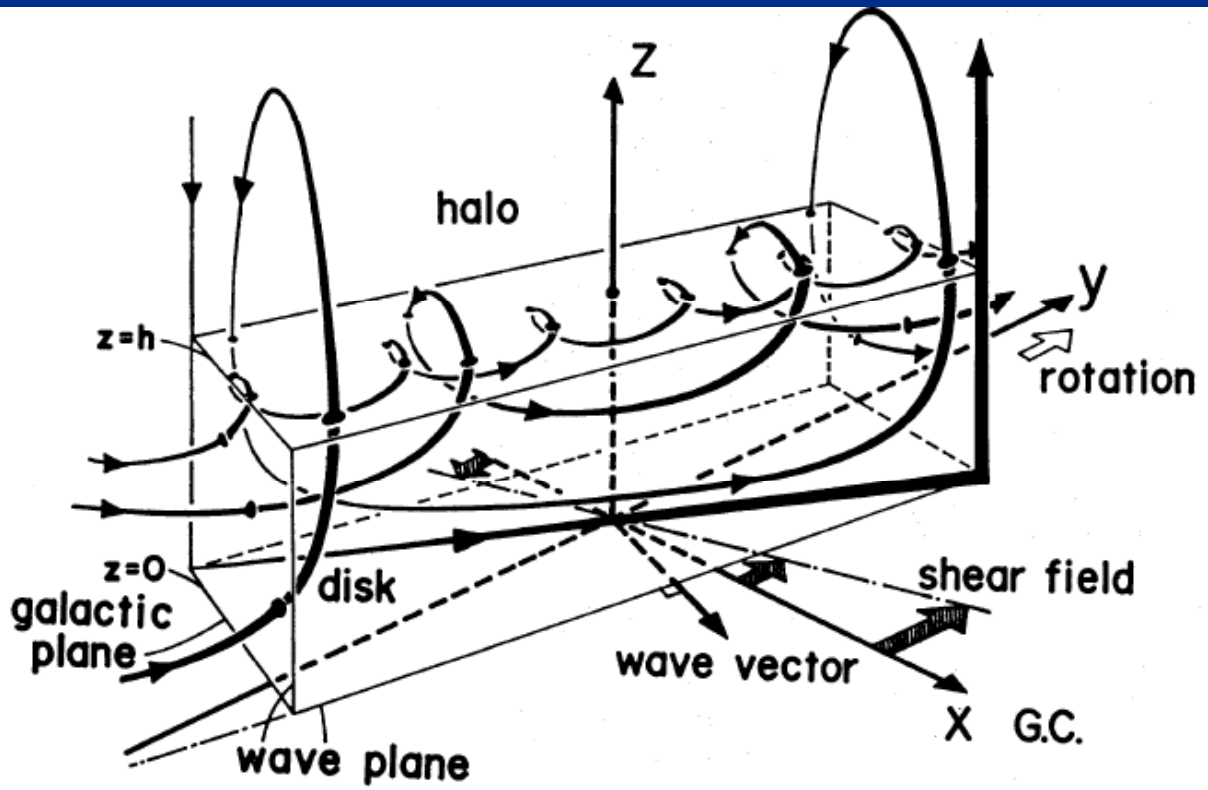
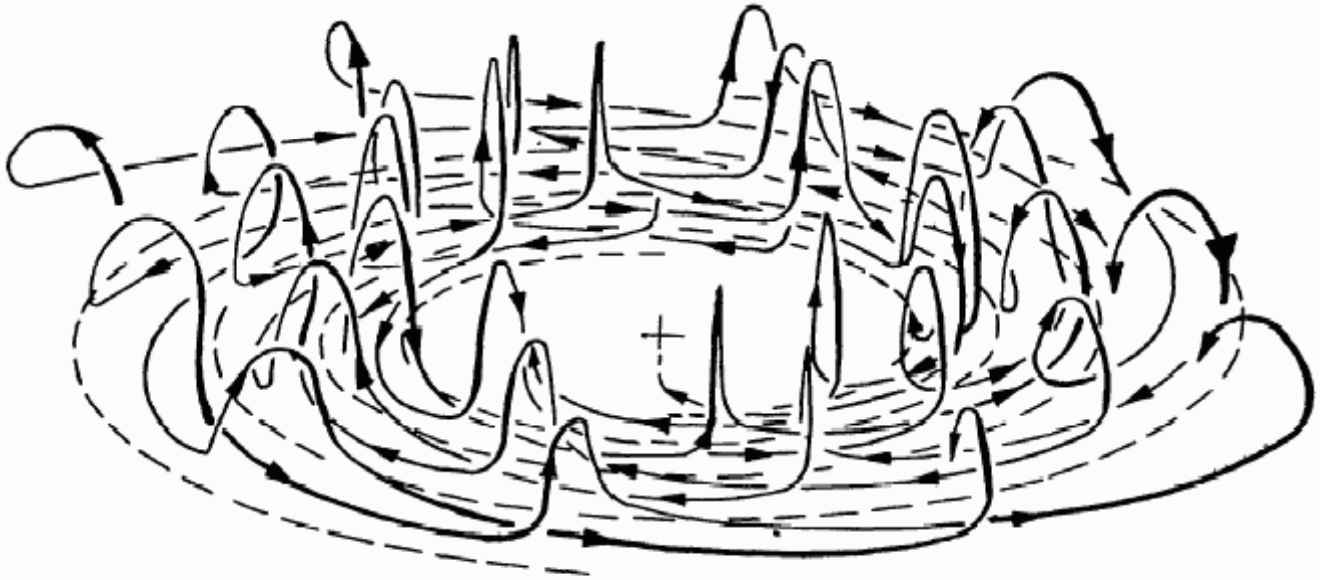


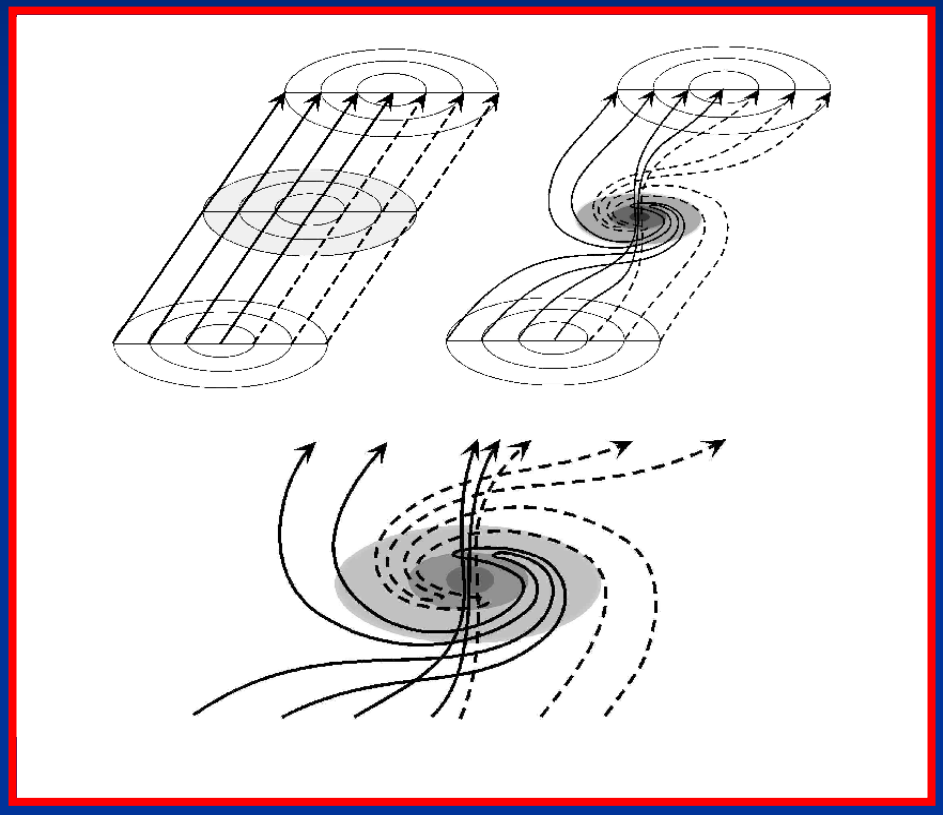
Fig. 4. A bird's-eye view of the magnetic field configuration for the first mode in the trailing sense in panel (a) of figures 2 and 3.

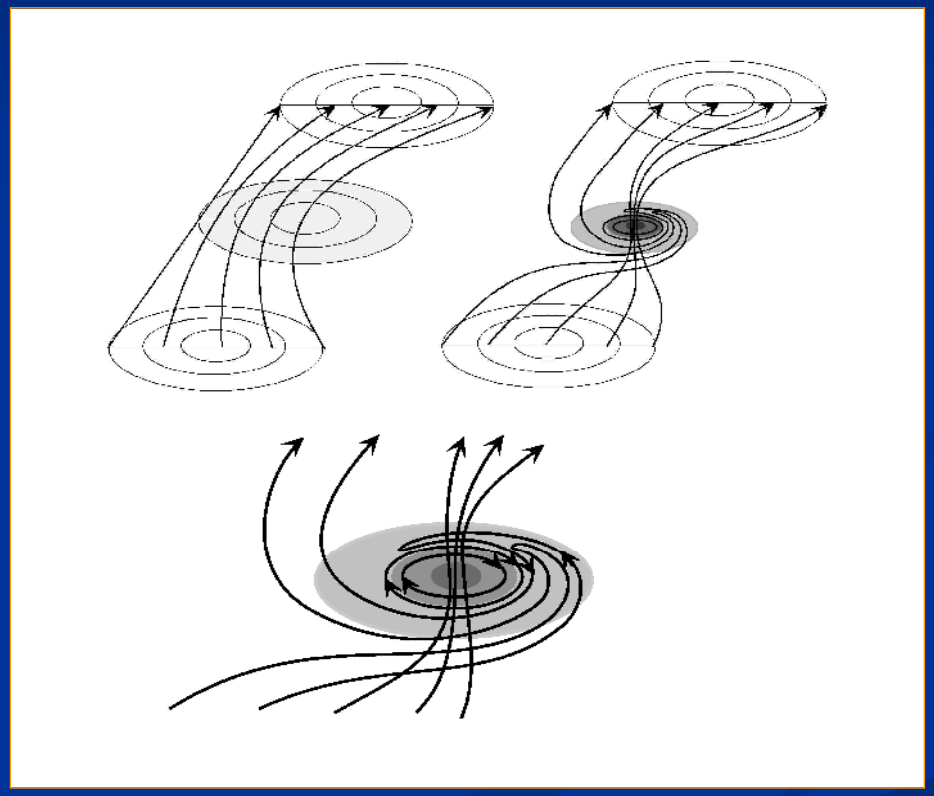


BSS magnetic field (Fujimoto & Sawa 1986).

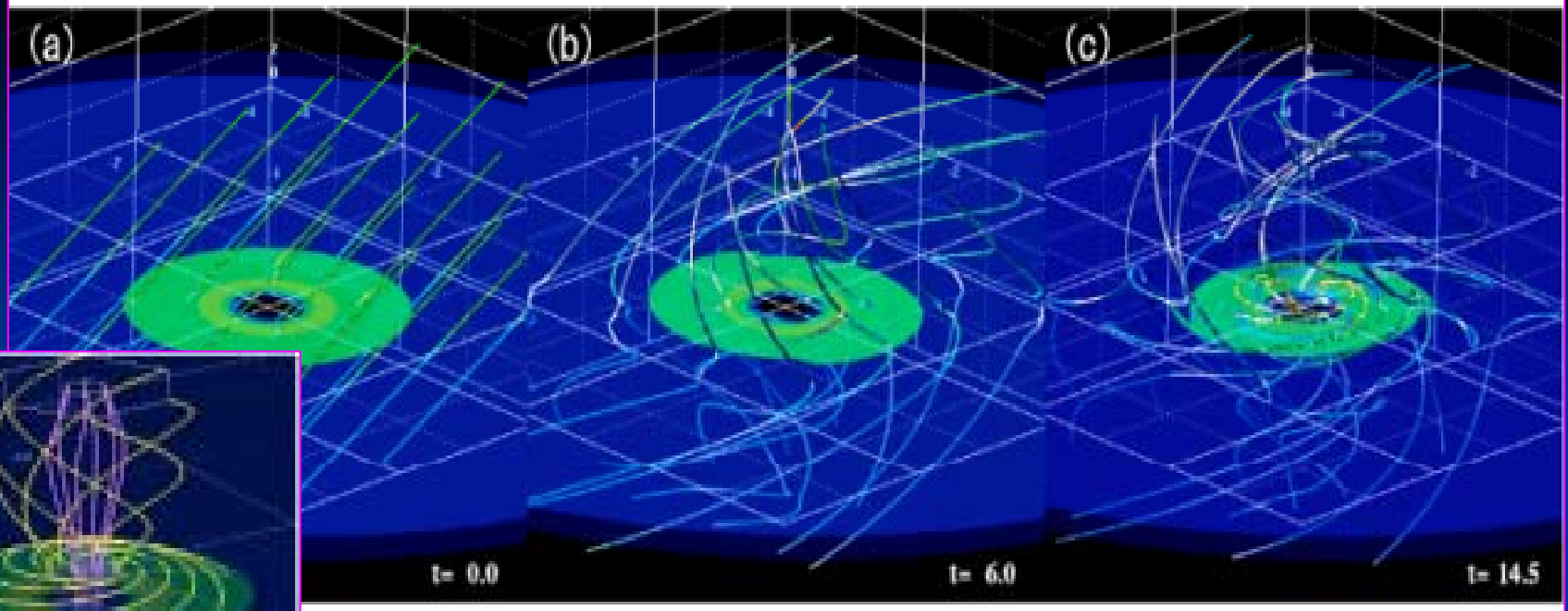
S+V Simulation

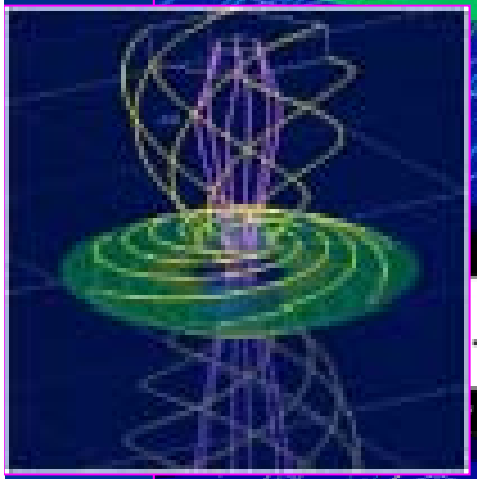
S+A+R+V



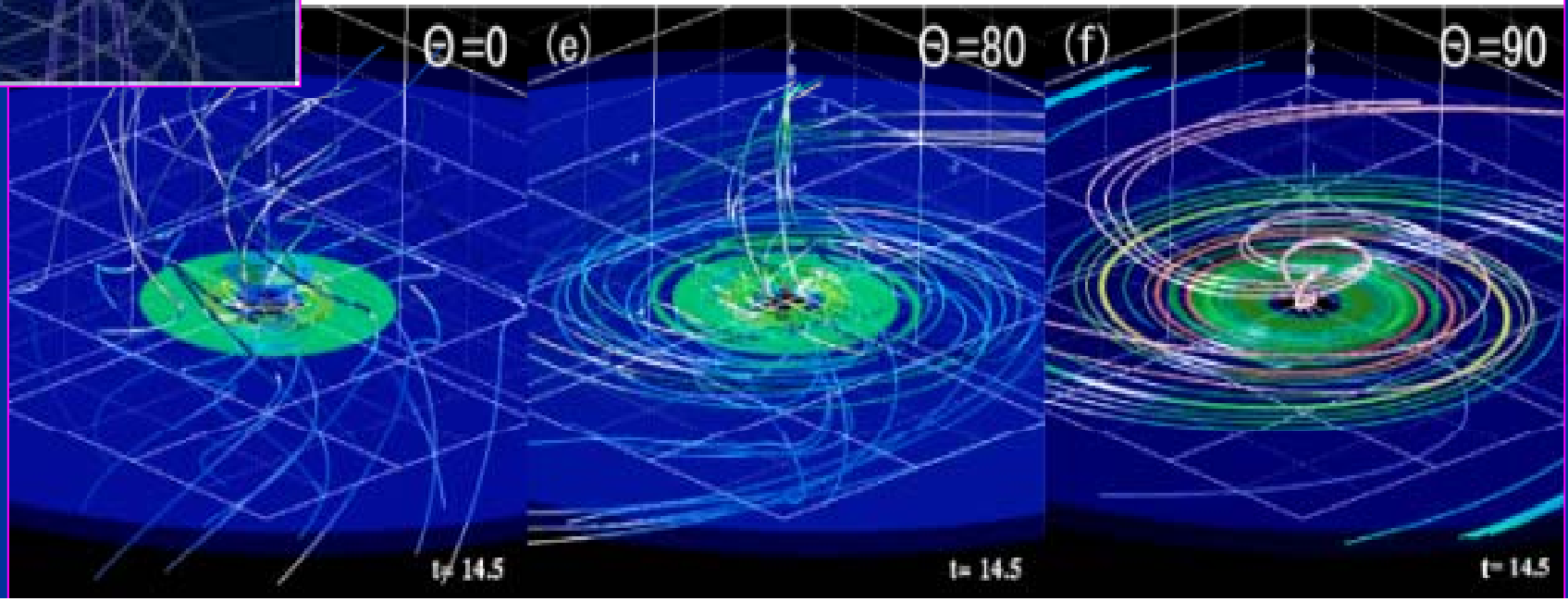


Time evolution Θ=45

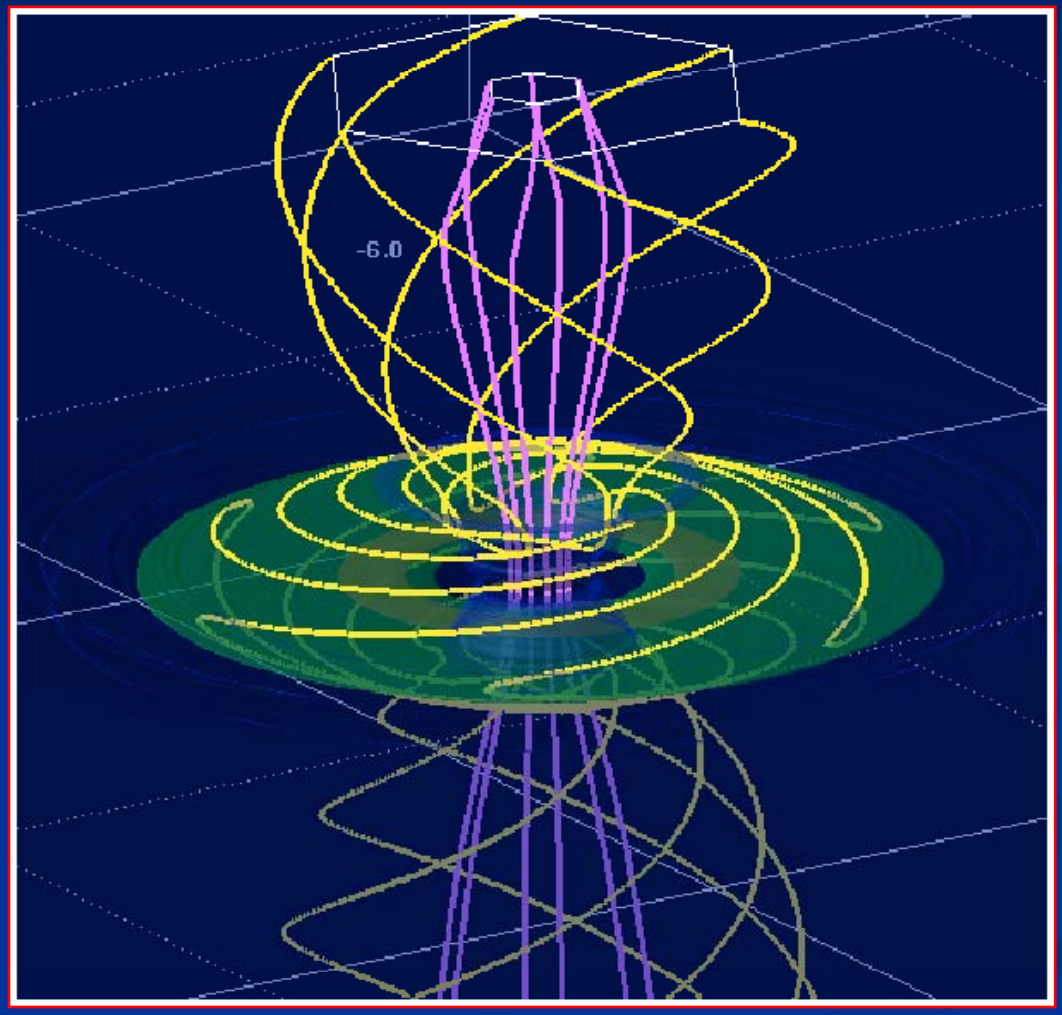




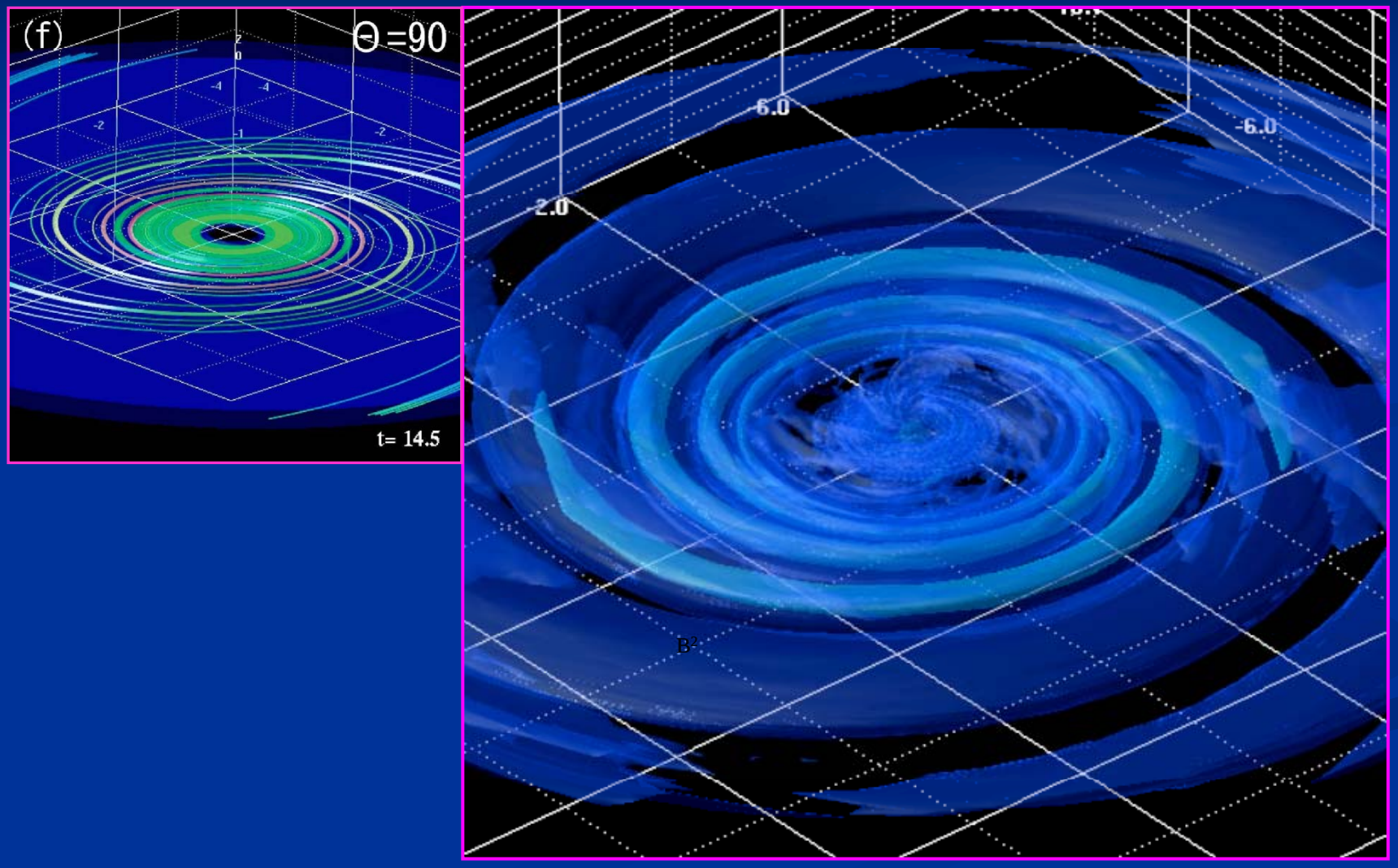
f the other models at *t=14.5*



i=0

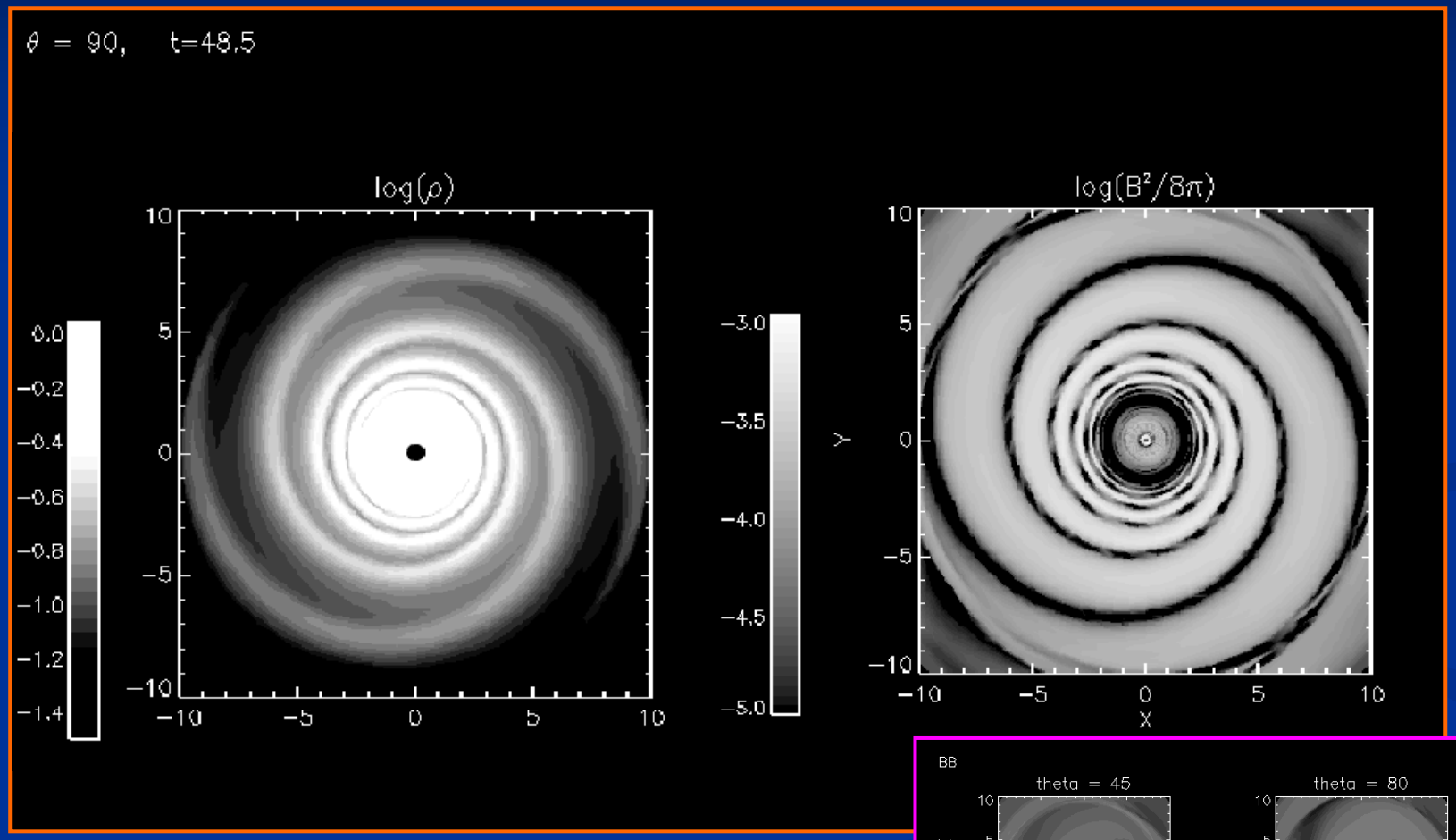


$B^2/8\pi$, i = 90 deg, 10 kpc disk



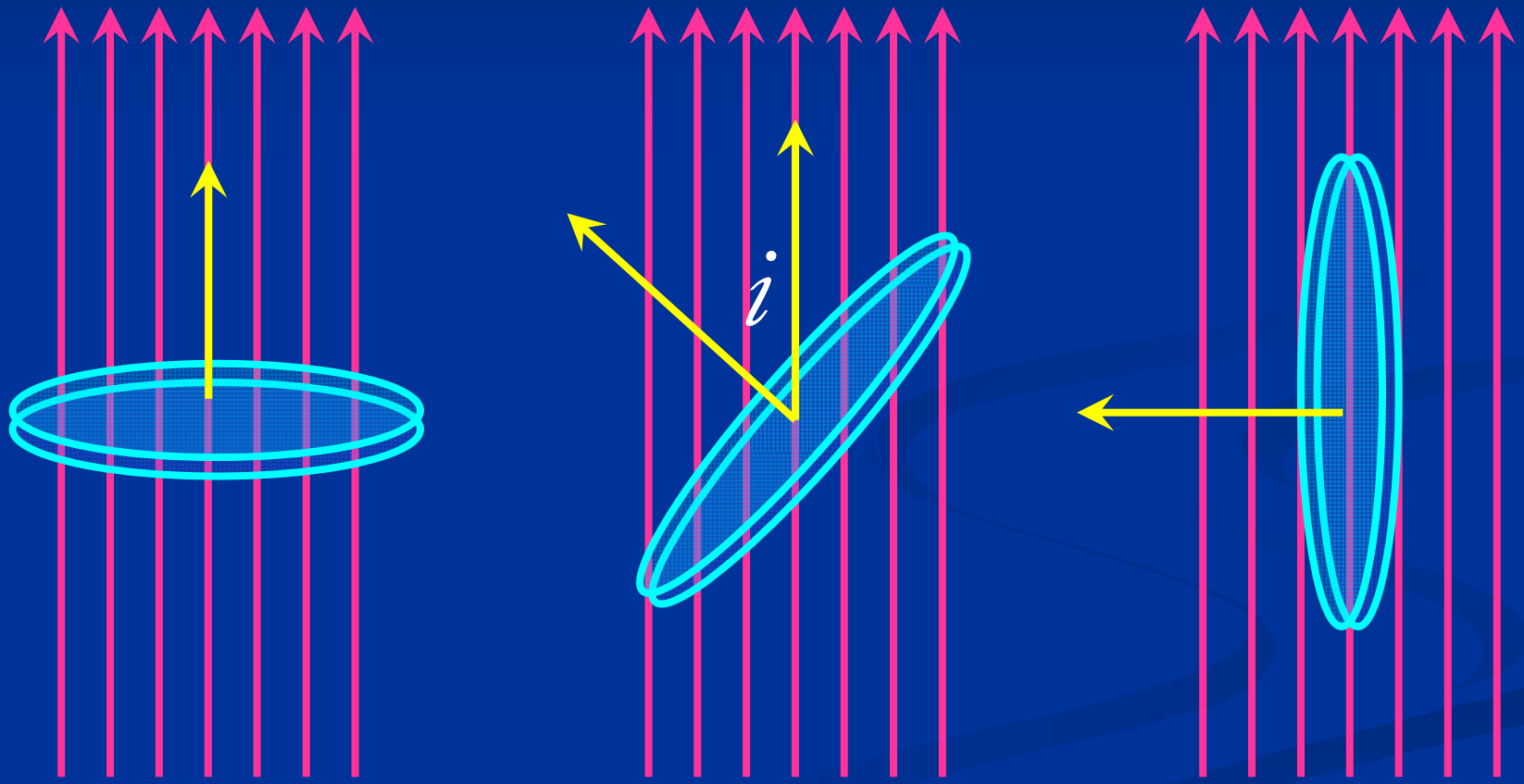
i=90

Gas Density vs Magnetic Pressure



Inclination i

$B_\varphi \backsim B_{z0} \cos i$



Higher accretion, Stronger braking, by More Vertical Field

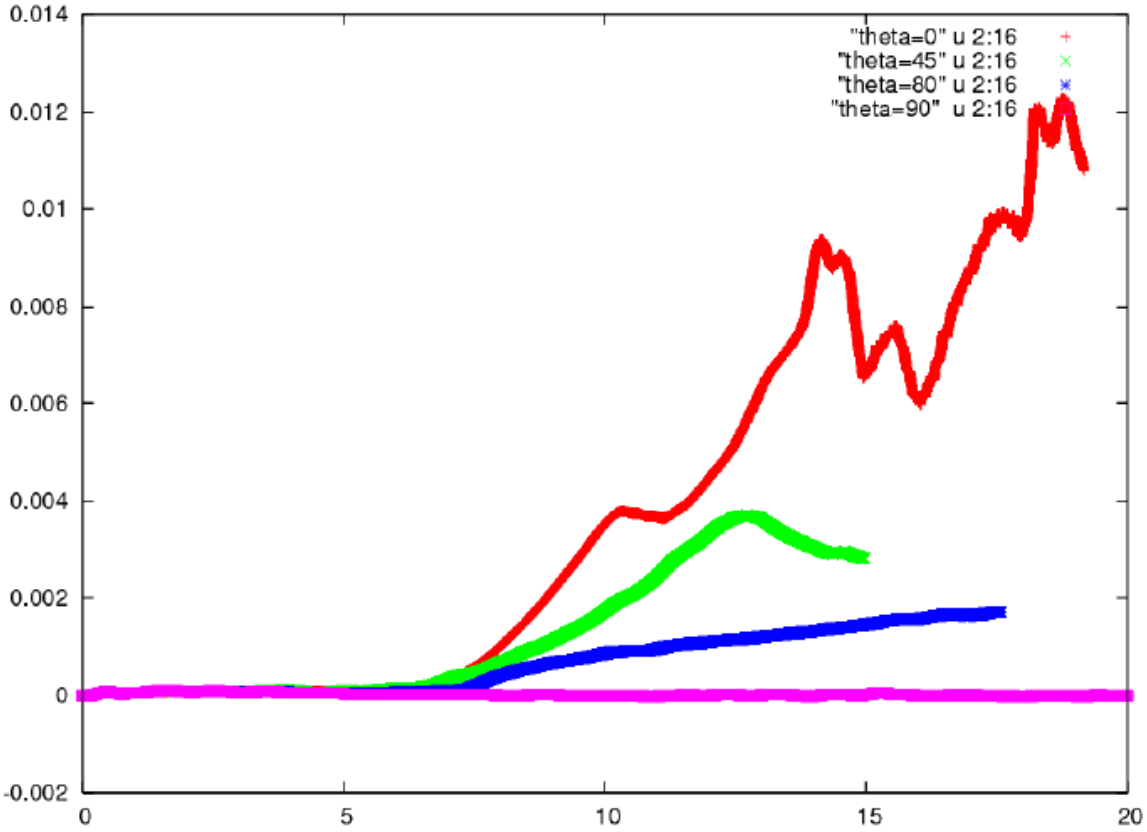
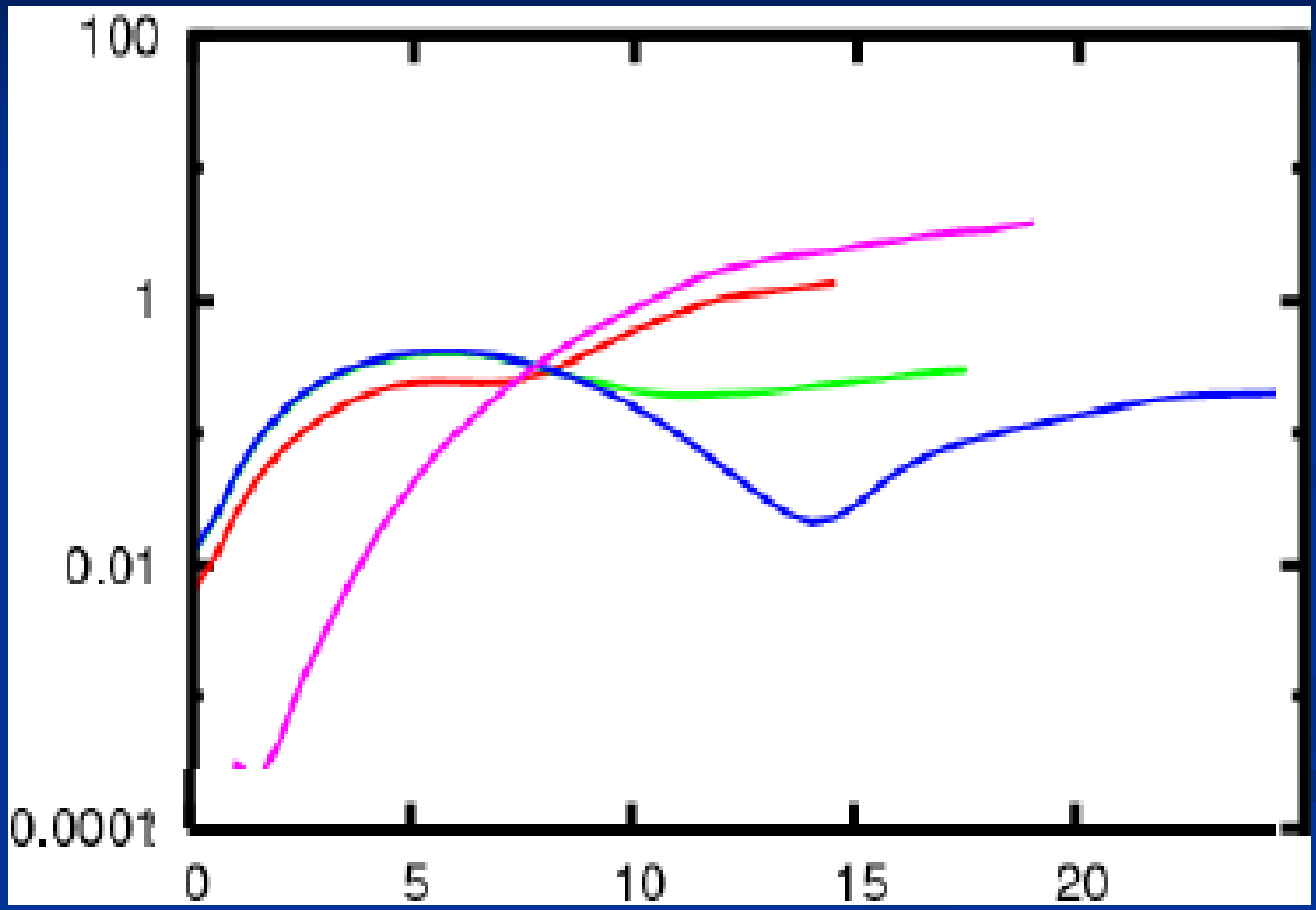


図 13: $\varpi = 0.3$ での質量降着率の時間進化

Stronger Vertical B => Stronger Bφ



Plasma β, Bφ

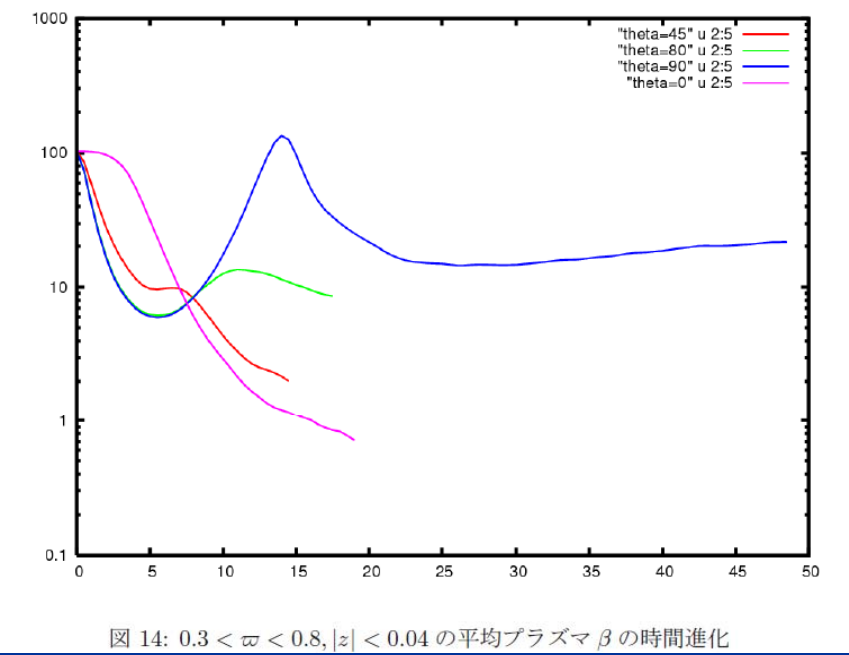


図 14: $0.3 < \varpi < 0.8, |z| < 0.04$ の平均プラズマ β の時間進化

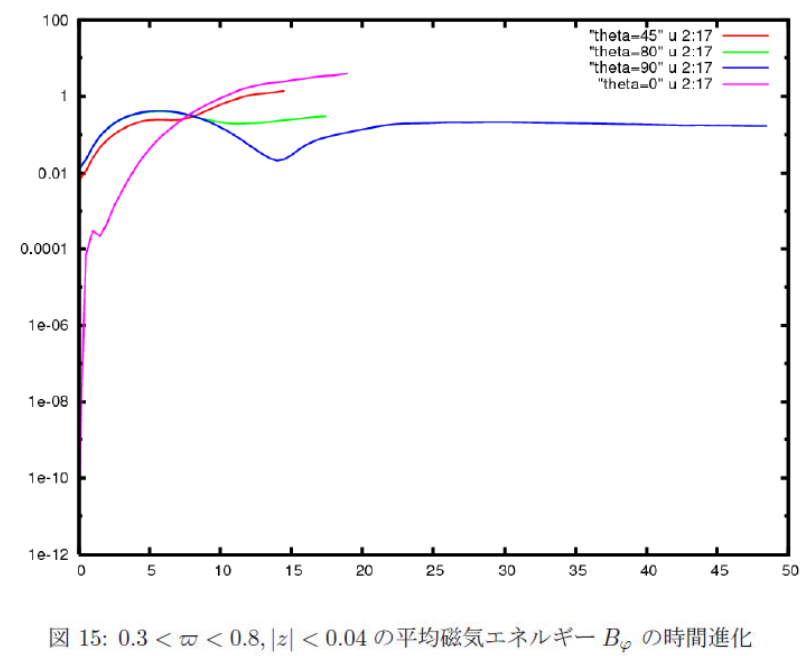


図 15: $0.3 < \varpi < 0.8, |z| < 0.04$ の平均磁気エネルギー B_φ の時間進化

Three-D MHD Simulation Movies

5. FUTURE

(1) PRIMO: analysis of Simulation

(2) Comparison with Observations

(3) GMHD = Self-Gravitating MHD
Galaxy Formation
Massive BH

(4) SKA Magnetism

Toward SKA Magnetism:
GMHD Project from Japan

MHD + Grav

MHD

+ Poisson eq.

+ Star formation

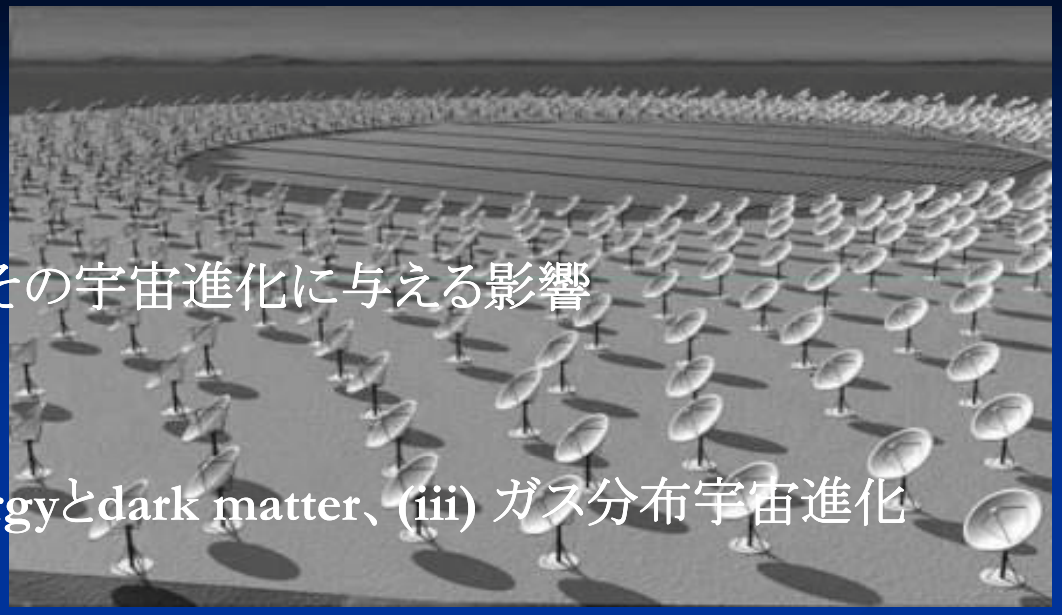
Grav. + MHD

Galaxy formation

(=SF Accretion disk in DM)

+MHD

SKAで狙うサイエンス



- **Dark Age**
  - (i) 宇宙最初の星の誕生、(ii)その宇宙進化に与える影響
- 銀河進化と宇宙論
  - (i)銀河サーベイ、(ii)dark energyとdark matter、(iii) ガス分布宇宙進化
- 宇宙磁場：
  - (i) 宇宙磁場の起源、(ii) 構造形成における磁場の役割
- 重力理論の検証
  - (i) 重力波の検出、(ii) 強重力場での相対論検証
- 宇宙生命
  - (i) 地球型惑星の探査、(ii) 生命に繋がる高有機分子の探査、(iii) SETI,
  - ○　銀河文明探査