銀河磁場の起源

祖父江義明

2012.6.25,26

SKA磁場会議、九州大学理

銀河磁場の測定

Synchrotron Radio Intensity/Polarization

1.Intensity (equipa)=> B_{tot}

2. Pol. degree => B_{ran}/B_{tot}

3. Faraday RM => parallel $B_{//}$

4. Faraday correction=> perp. $B_{\perp}$

=> 3D $\boldsymbol{B}$ Vector

(+ Zeeman effect, Optical Polarization)

Magnetic Topology

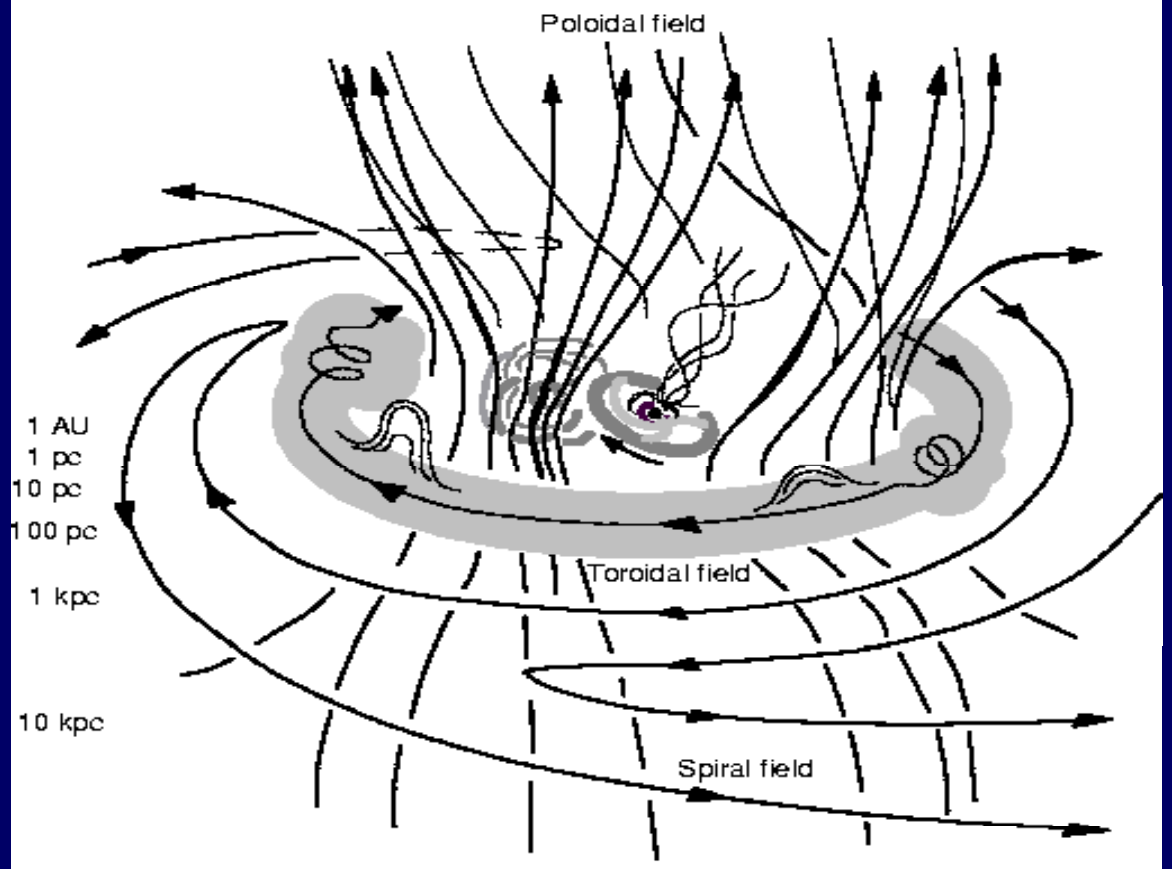
BSS=BiSymmetric Spiral

Ring=Ring

ASS=AxiSymmetric Spiral

V=Vertical

Magnetic View of the Galaxy



Magnetic View of the Galactic Center

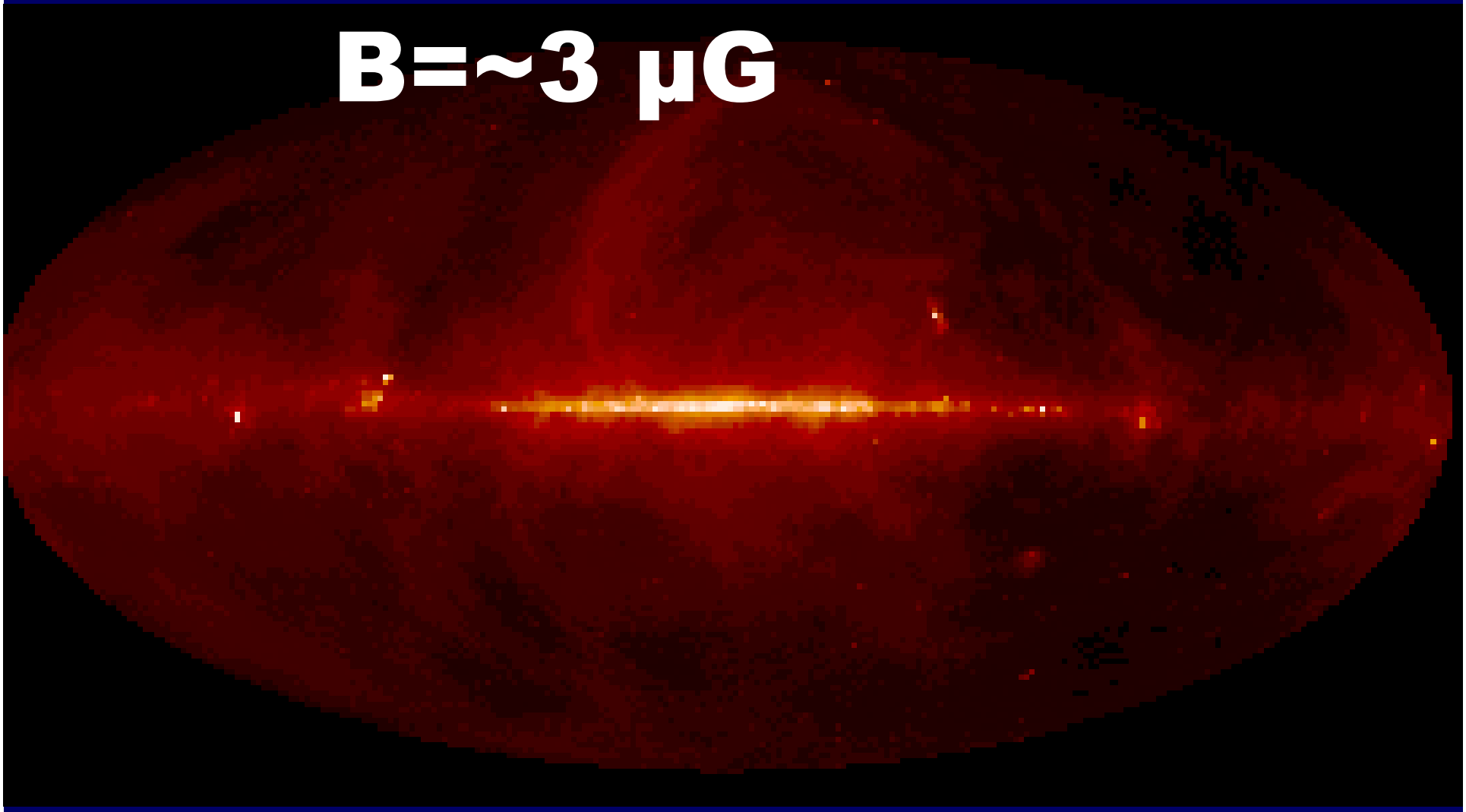
1. 銀河系

BSS

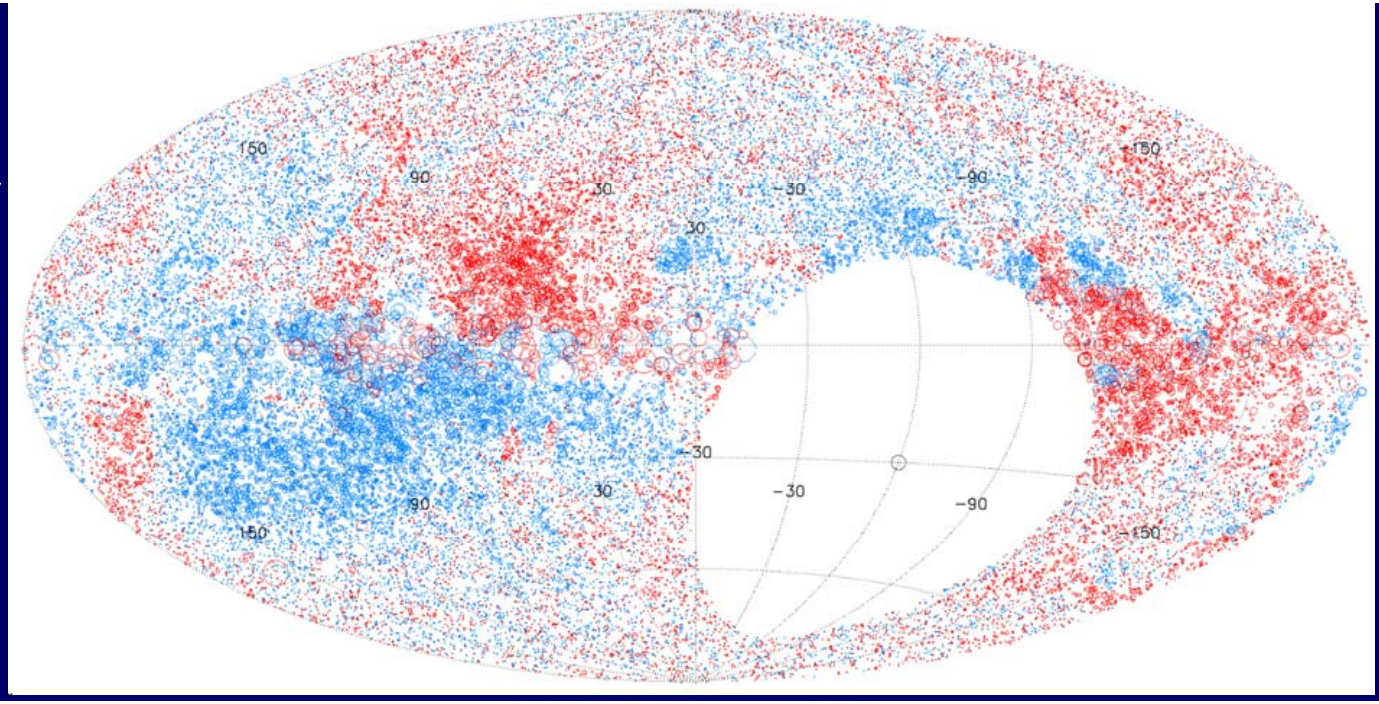
1. Radio Int. $\Rightarrow B$
2. RM-Long. Dia.
3. RM-sky Mapping
4. *B*-sky Mapping

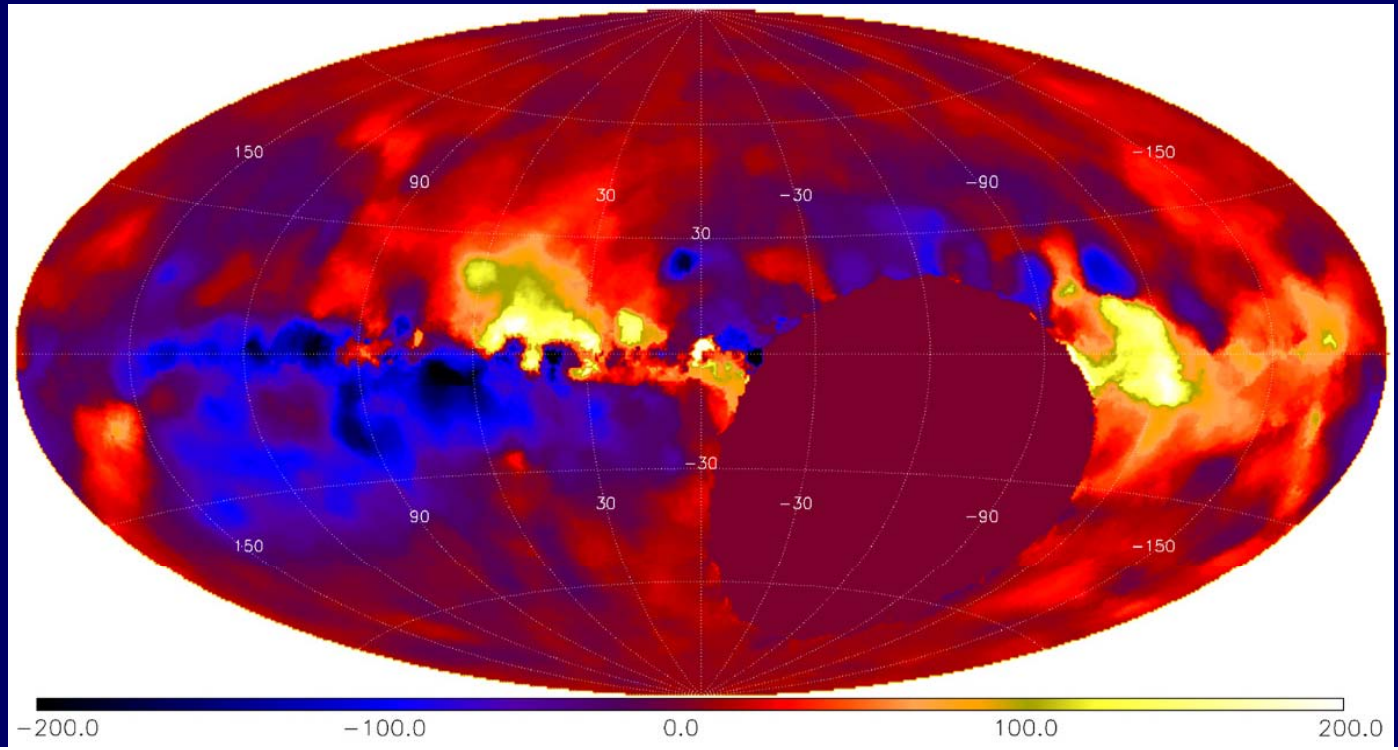
Equipartition: P(mag)=P(CR)

B=~3 μG

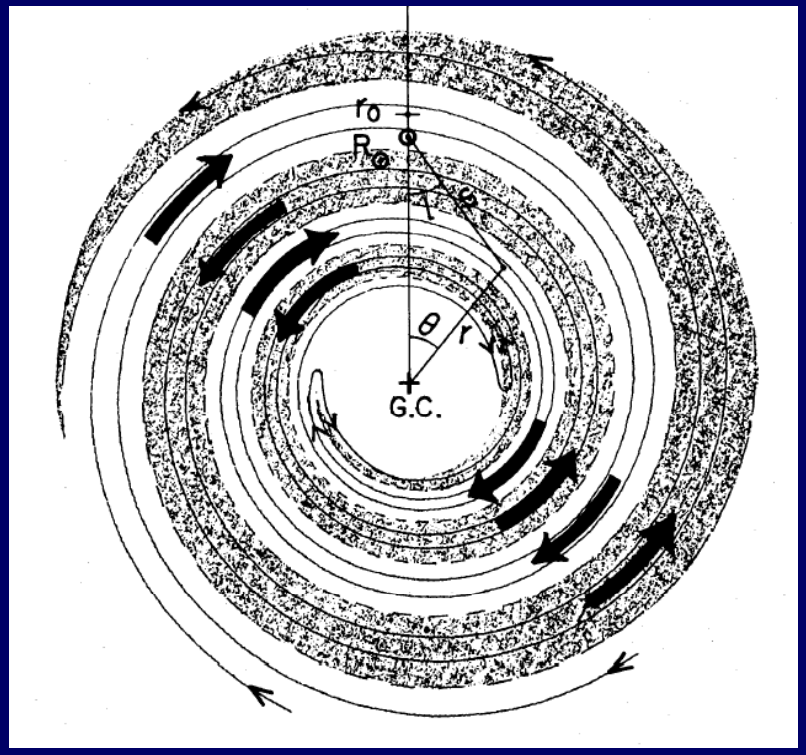


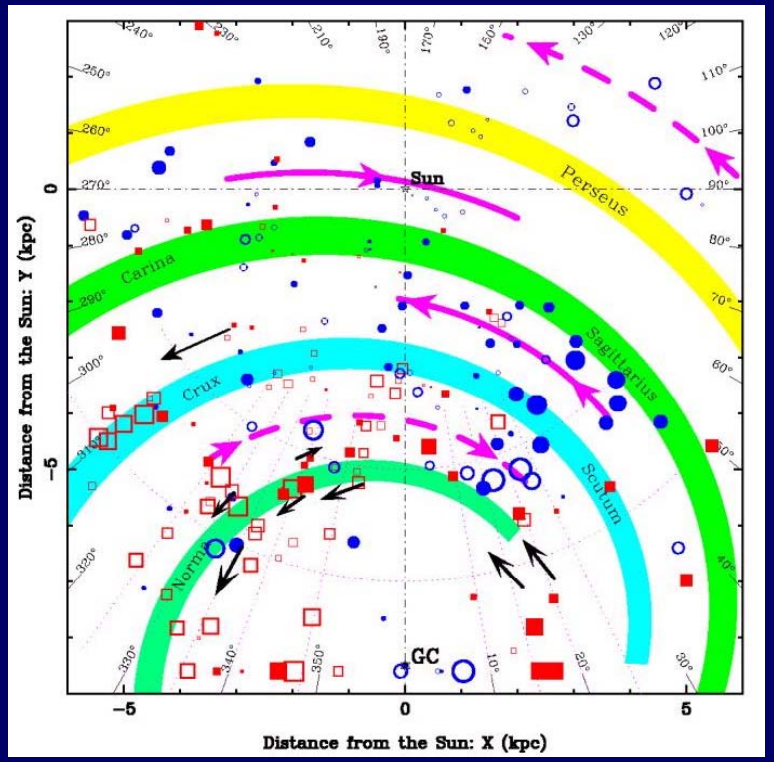
RM Sky (Taylor 2009)



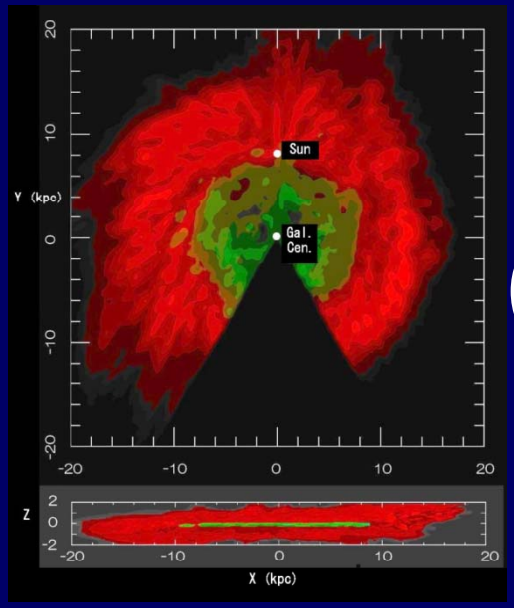


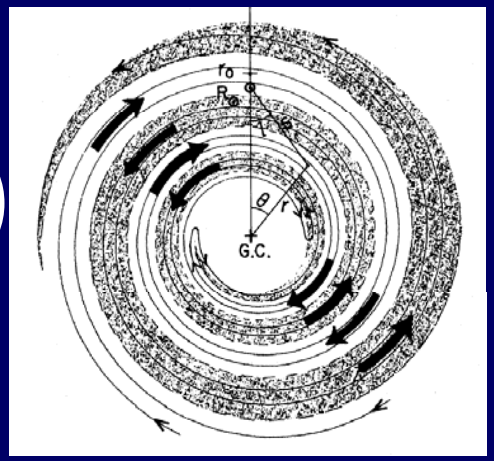
Milky Way : RM+Pulsar distribution
Bisymmetric B field (Han 2000)

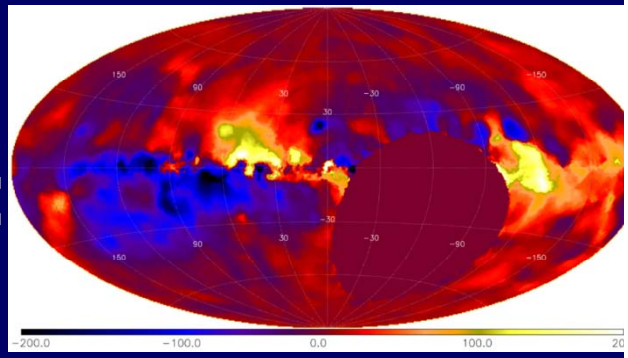




$\int Ne(HI+CO)\ B_{//}\ ds\ |_{(l,b)} = RM\ sky$







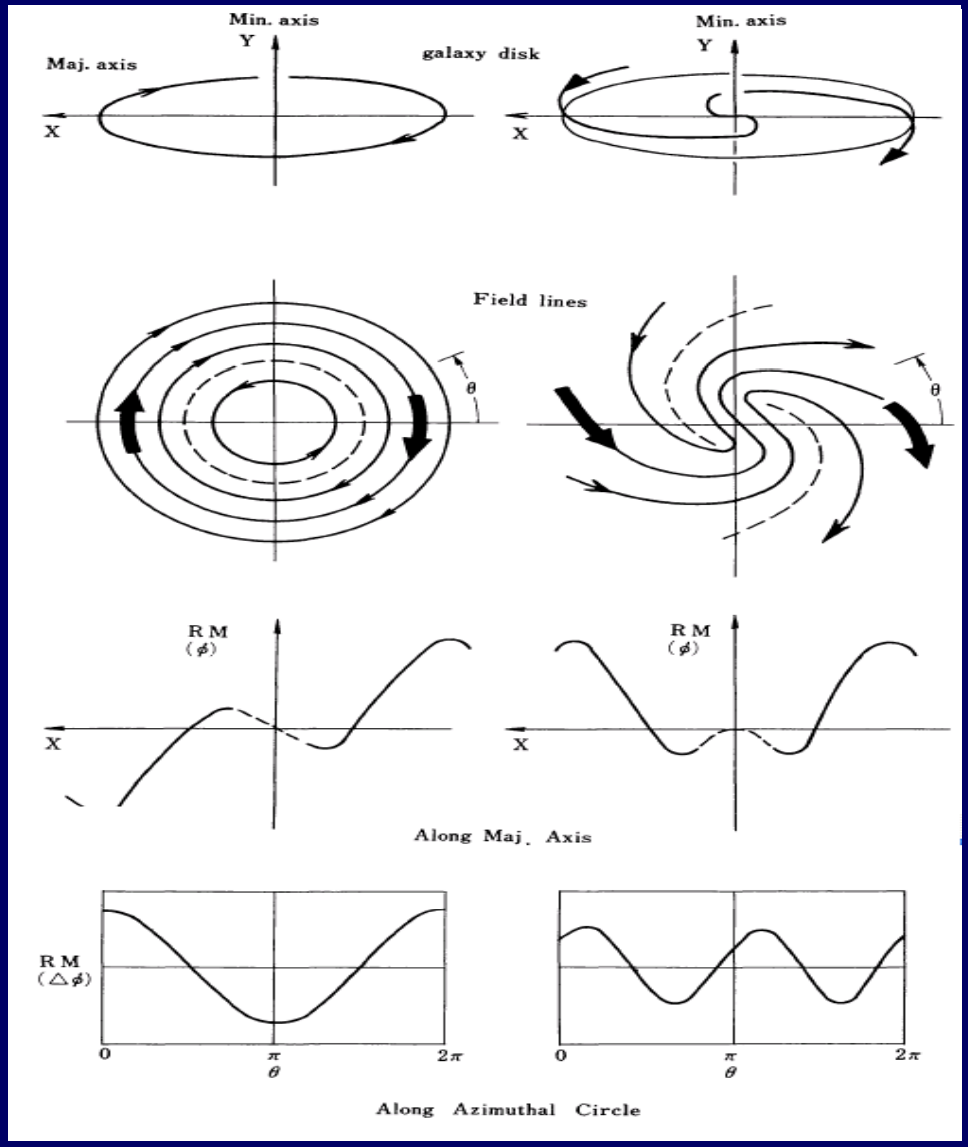
(=> Ozawa's talk)

2. 系外銀河

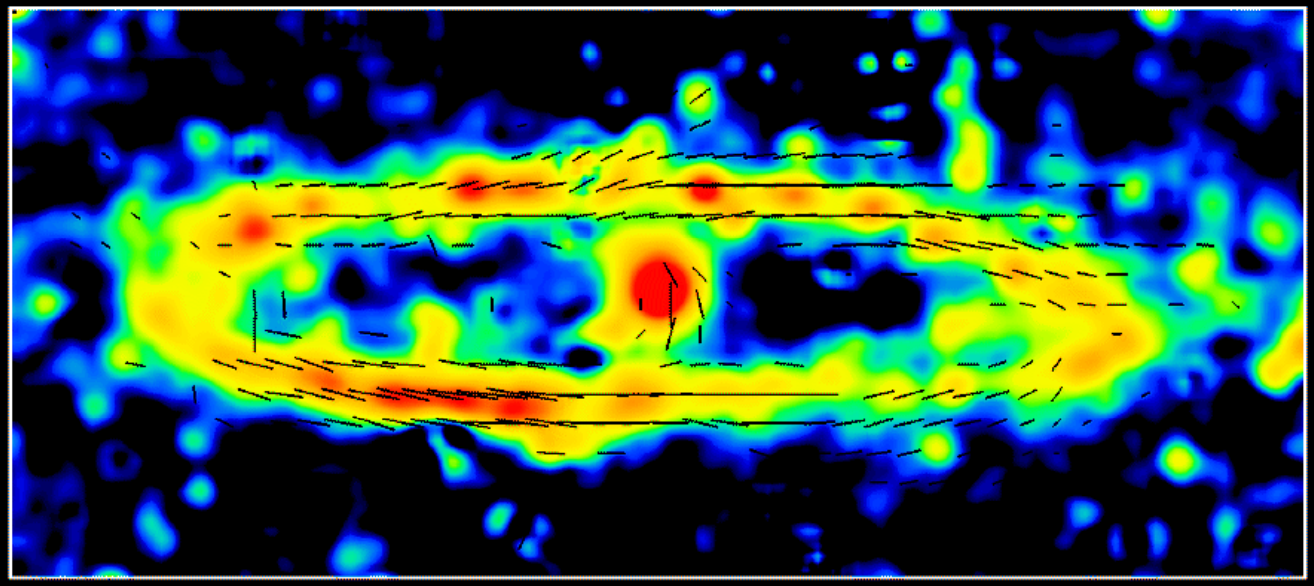
BSS, ASS, Ring, V

1. Int. $\Rightarrow B$
2. RM (PA)-Azimuth/Long Dia.
3. RM-Mapping
4. ***B***-vector Mapping

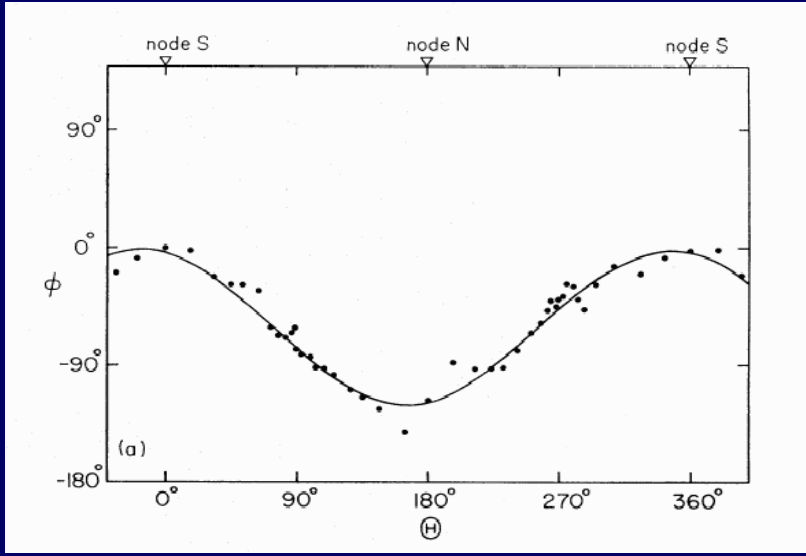
RM obs.


Min. axis
Y
Maj. axis
X
galaxy disk
Min. axis
Y
X
Field lines
θ
θ
RM
(φ)
X
RM
(φ)
X
Along Maj. Axis
RM
(△φ)
0
π
θ
2π
0
π
θ
2π
Along Azimuthal Circle

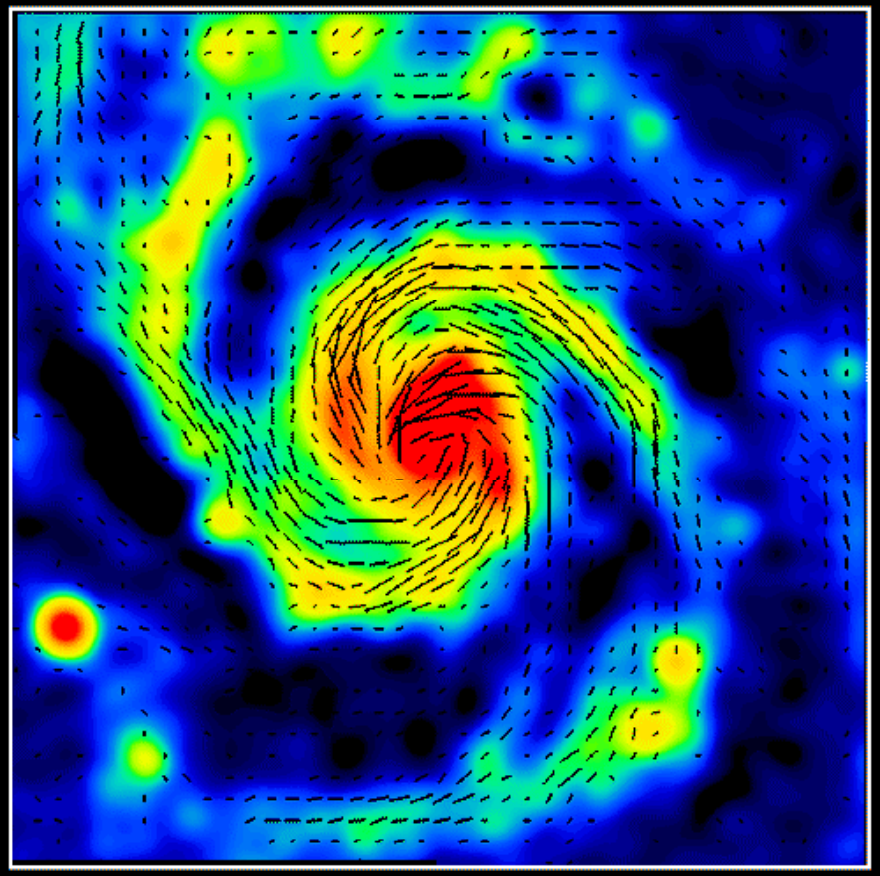
M31 6cm Total Intensity + Magnetic Field (Effelsberg)



Copyright: MPIfR Bonn (R.Beck, E.M.Berkhuijsen & P.Hoernes)

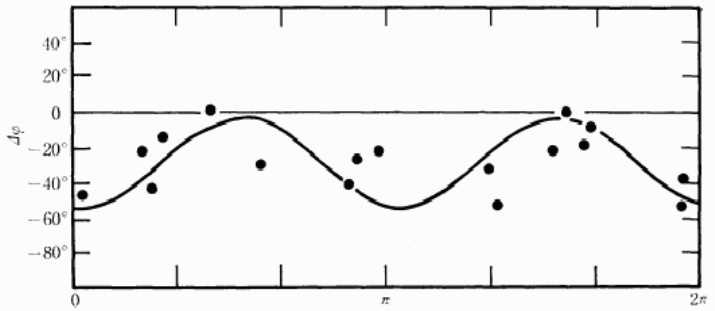


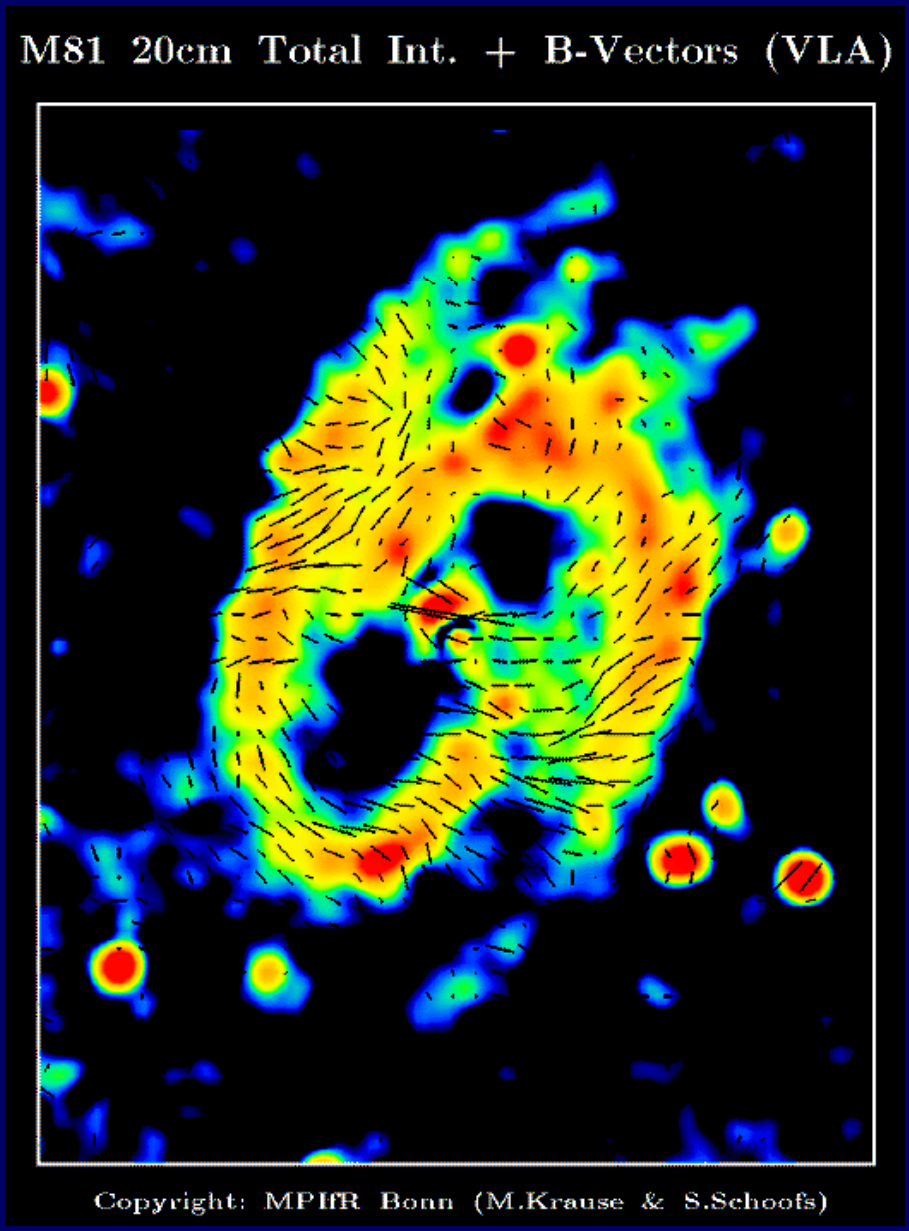
M51-Center 6cm Total Intensity + B-Vectors (VLA)

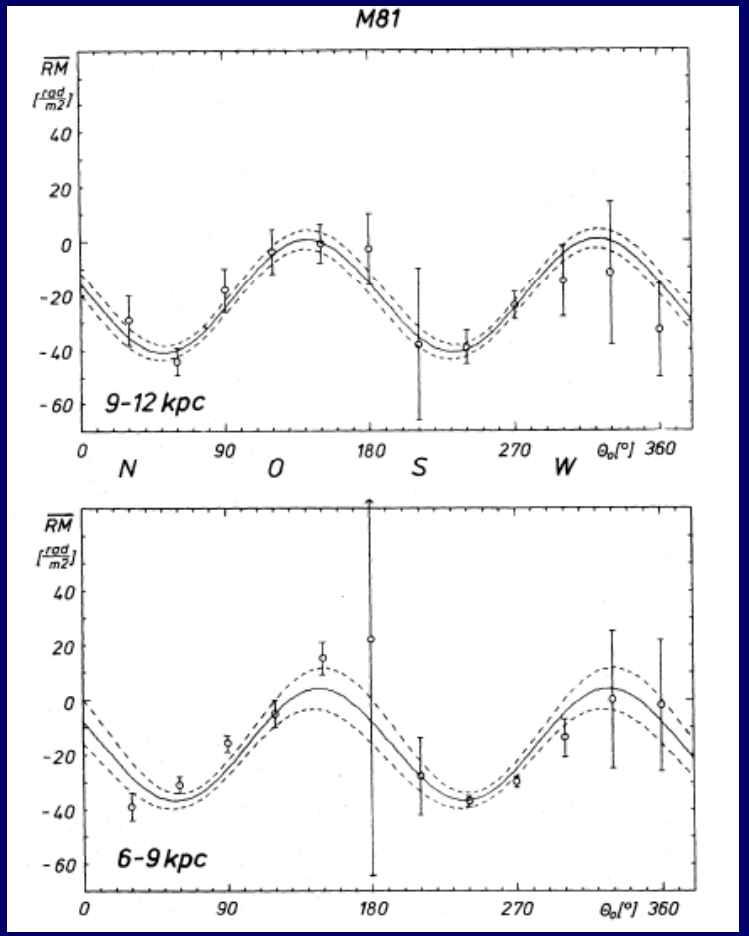


Copyright: MPIfR Bonn (R.Beck, C.Horellou & N.Neininger)

M. Tosa and M. Fujimoto



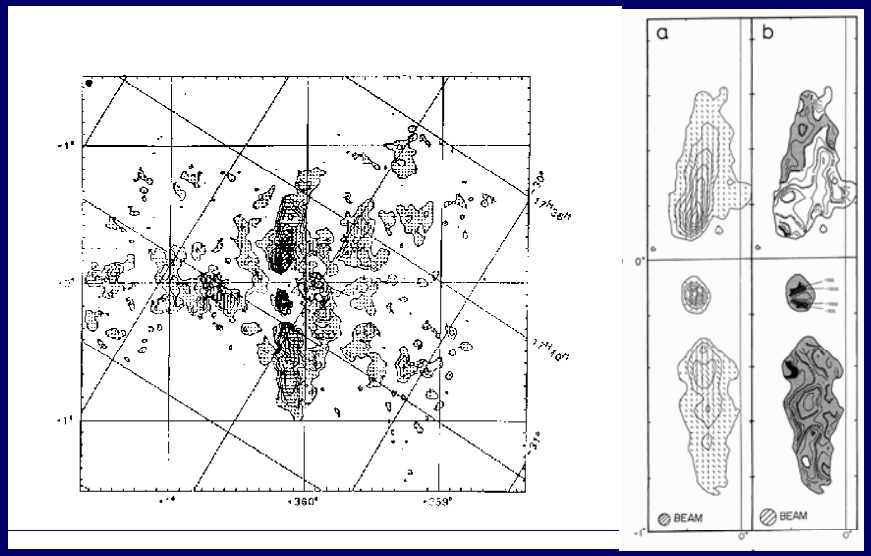

M81 20cm Total Int. + B-Vectors (VLA)
Copyright: MPIfR Bonn (M.Krause & S.Schoofs)


M81
RM [rad/m²]
40
20
0
-20
-40
-60
9-12 kpc
0
90
180
270
360
Θ₀[°]
N
O
S
W
RM [rad/m²]
40
20
0
-20
-40
-60
6-9 kpc
0
90
180
270
360
Θ₀[°]

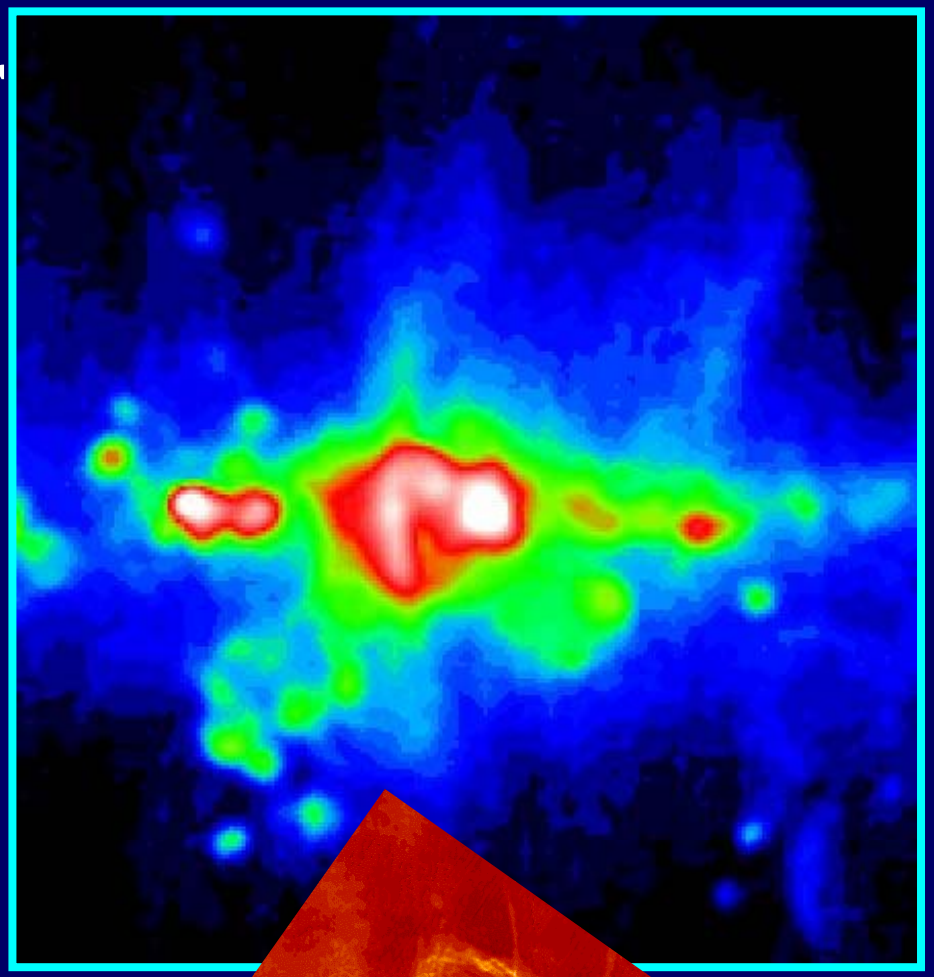
3.銀河中心
垂直磁場

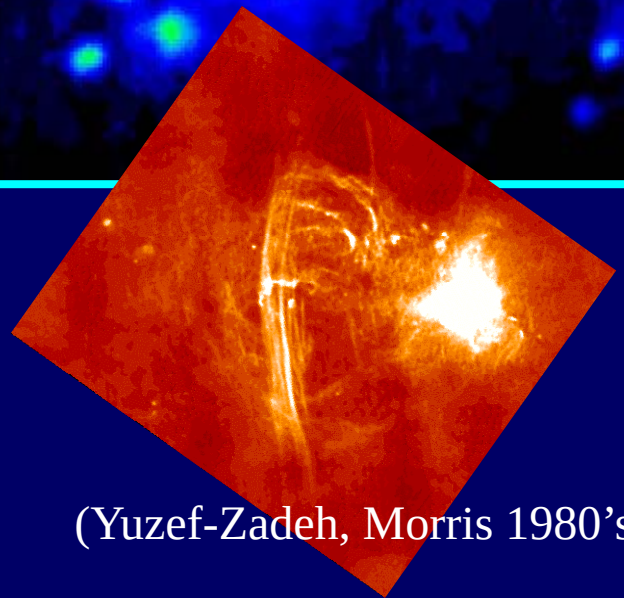
The Galactic Center Vertical B

NRO 10GHz Sofue et al. 1980’

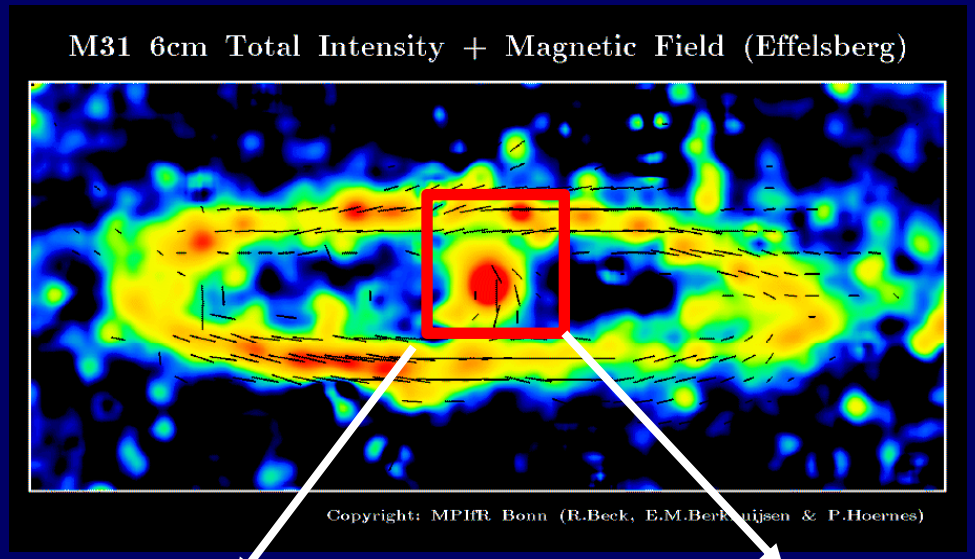


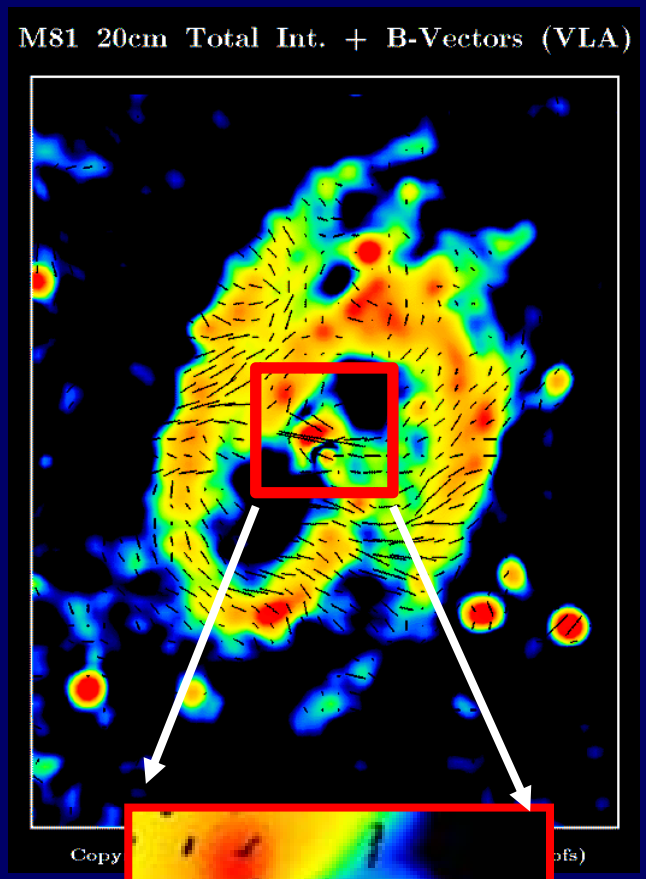
(Tsuboi et al. 1980’s Sofue et al. 1980’)





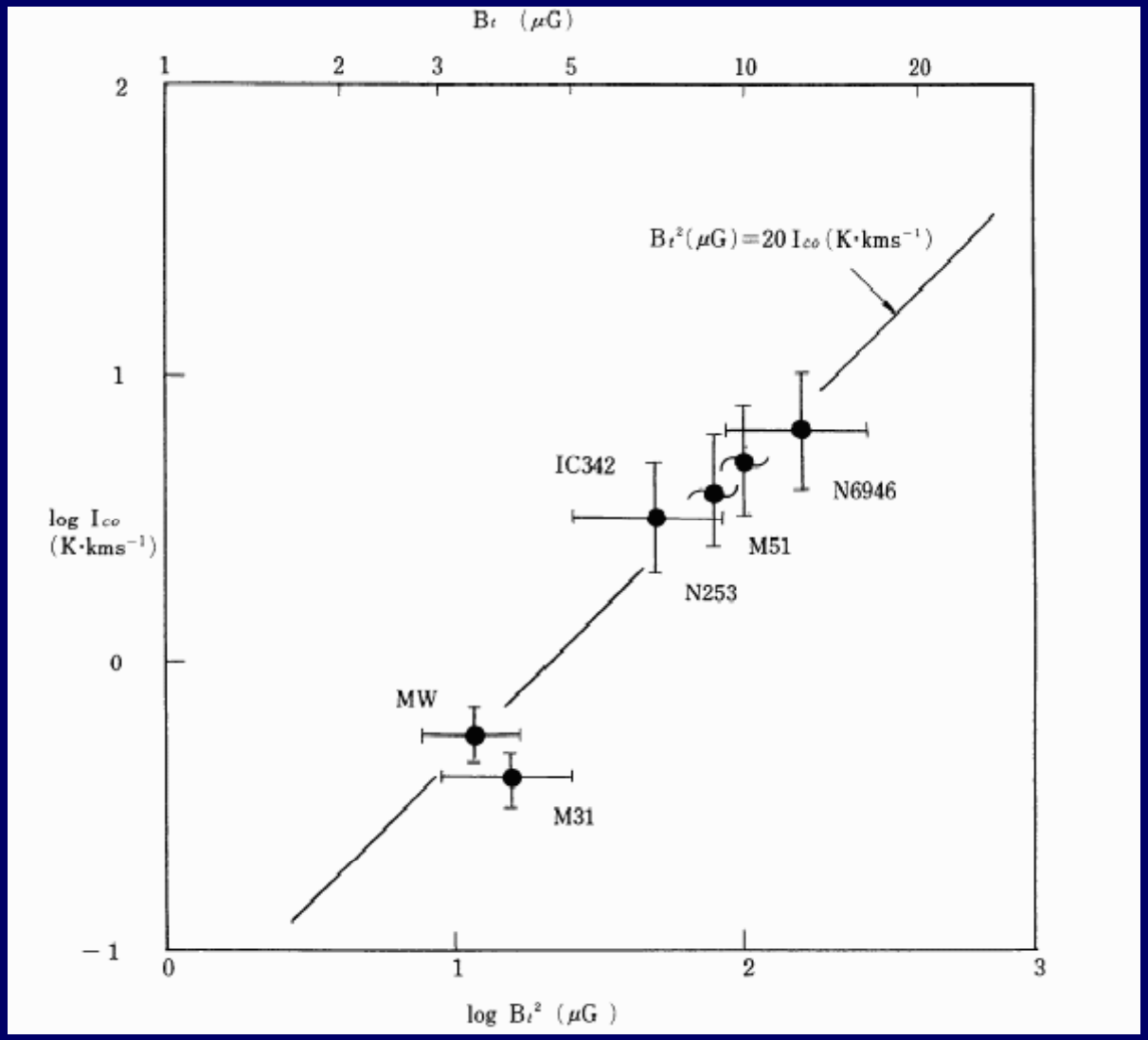
(Yuzef-Zadeh, Morris 1980’s)


M31 6cm Total Intensity + Magnetic Field (Effelsberg)
Copyright: MPIfR Bonn (R.Beck, E.M.Berkhuijsen & P.Hoernes)

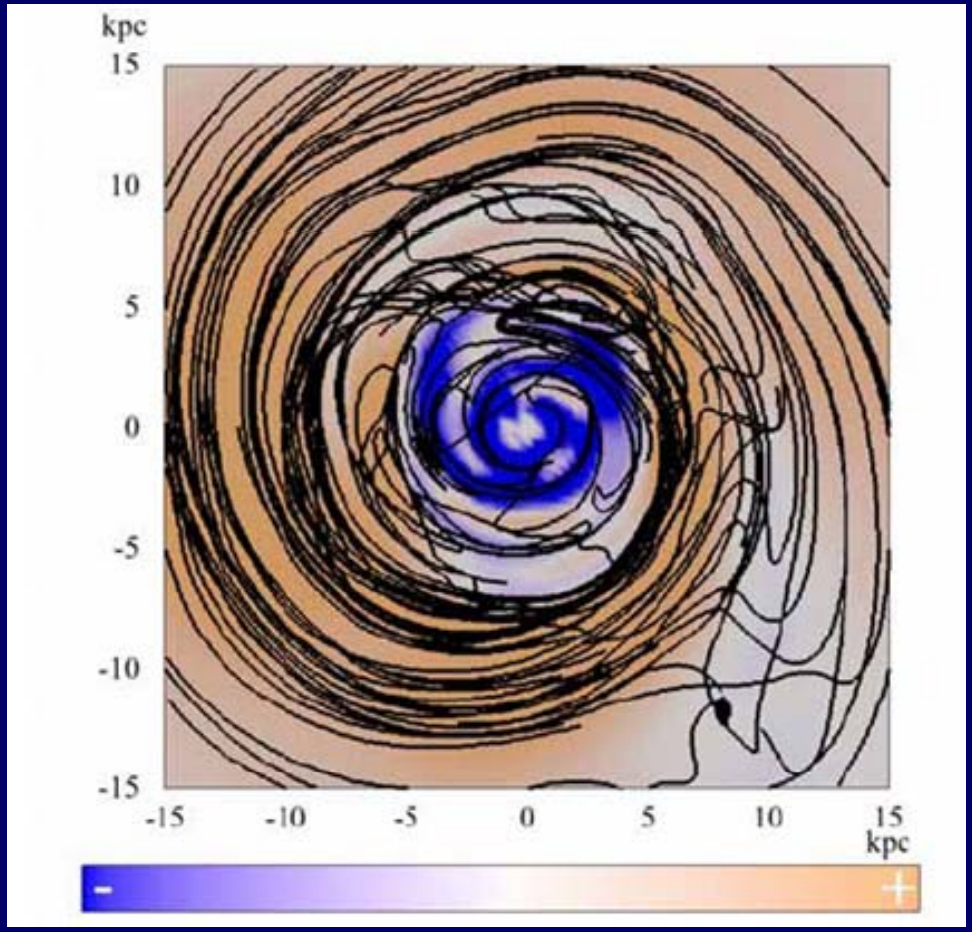

M81 20cm Total Int. + B-Vectors (VLA)

4. 磁場の起源

宇宙磁場, ダイナモ, MRI


B_t (μG)
1
2
3
5
10
20
2
1
0
−1
$B_t^2(\mu G) = 20\, I_{co}\,(K\cdot kms^{-1})$
IC342
N6946
M51
N253
MW
M31
log I_{co}
($K\cdot kms^{-1}$)
0
1
2
3
log B_t^2 (μG)

MHD MRI Amplification: Matsumoto 2005



ダイナモ起源

宇宙磁場起源

div B = 0

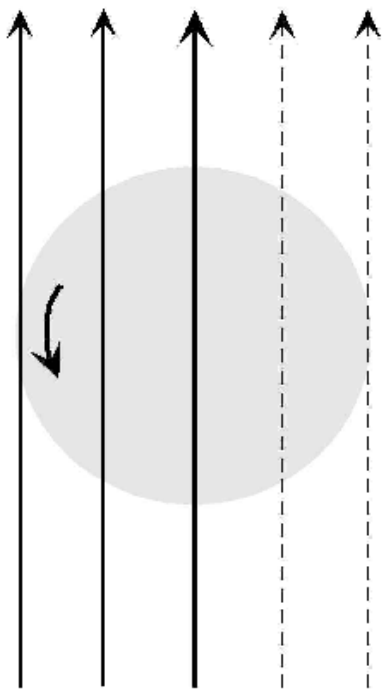
宇宙磁場起源

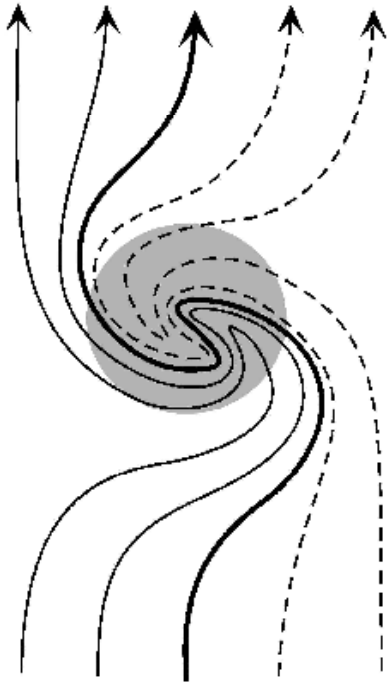
B_{cos}=1 nG

$B_{gal}=(R_{gal}/R_{cos})^{-2}\sim 1\mu G$

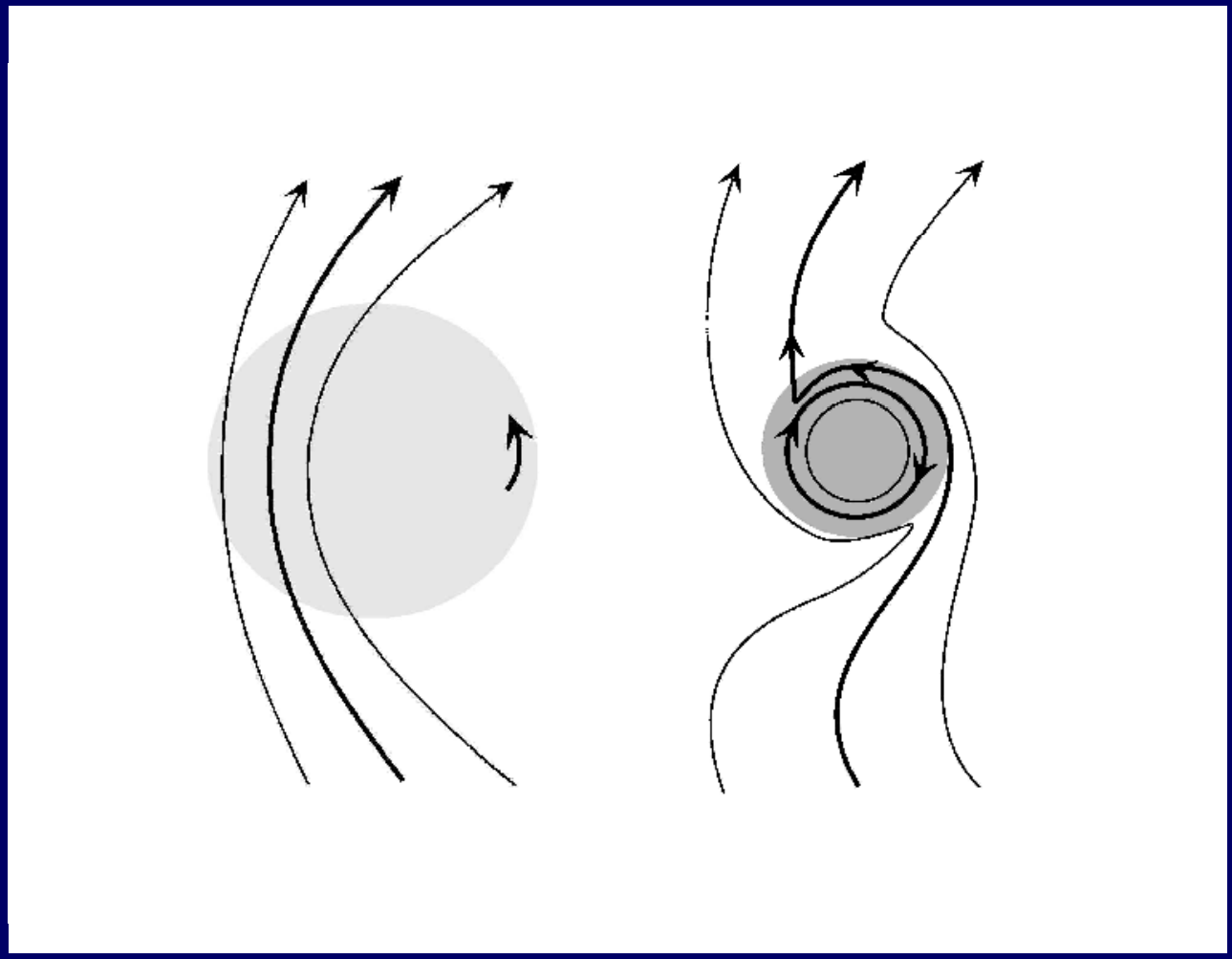
$B_{GC}=(R_{GC}/R_{cos})^{-2}\sim 1mG$

BSS



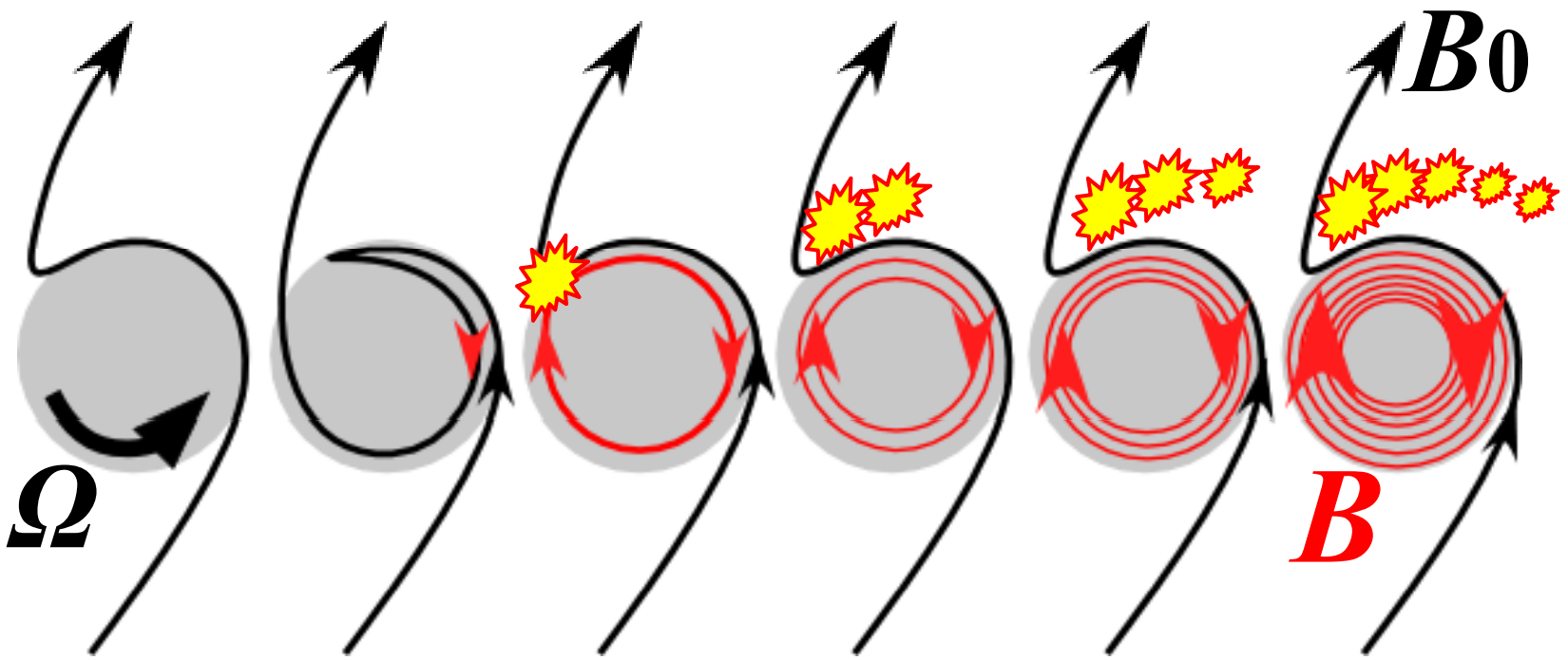


Ring



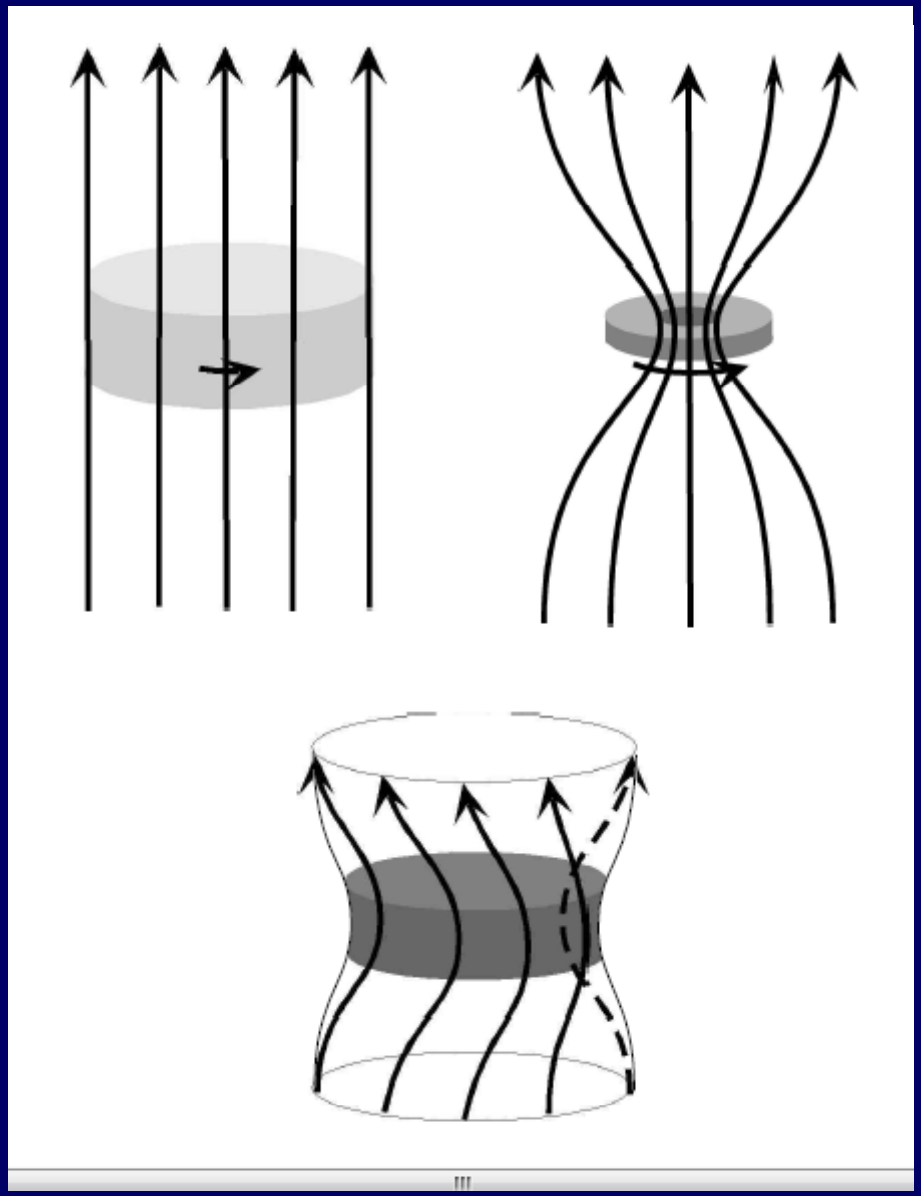
New Mecha!

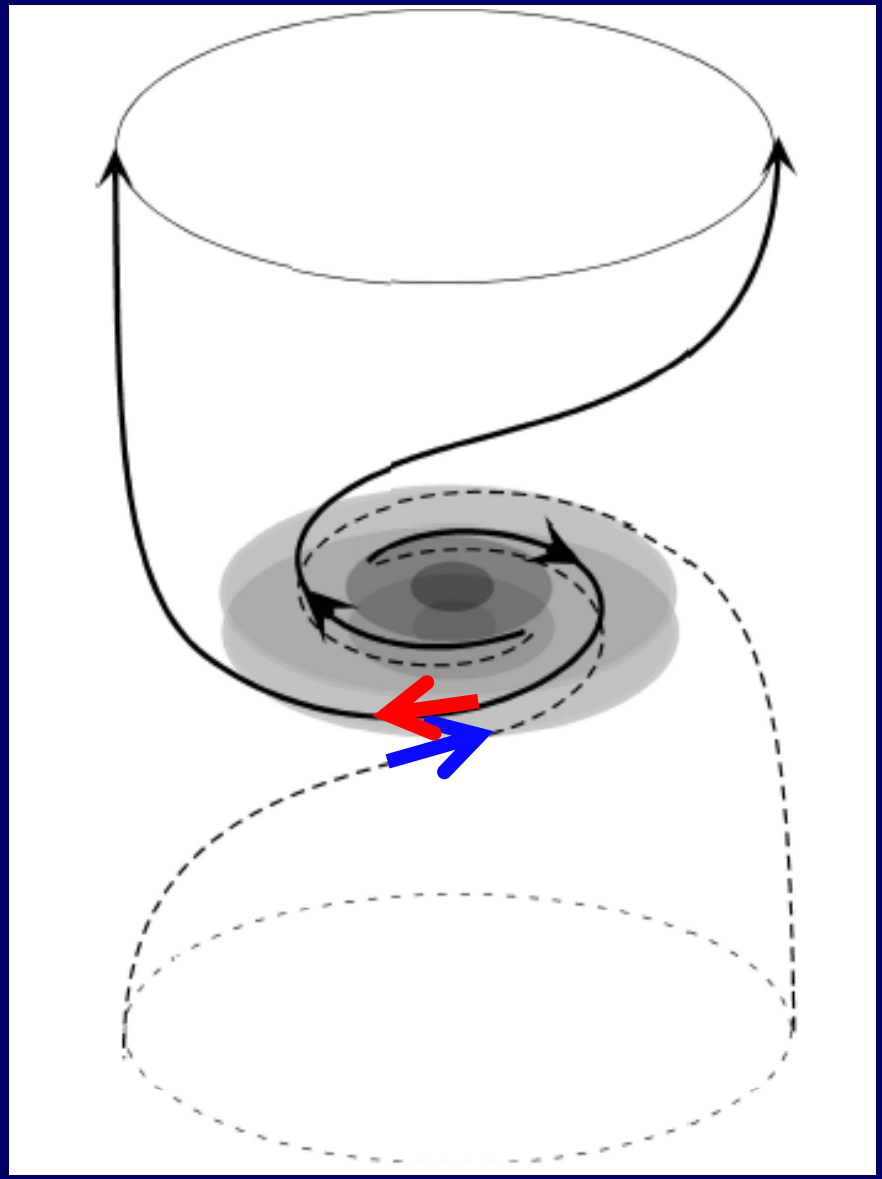
Ring Field by "RRA"
"=Rotational Reconnection Amplification"



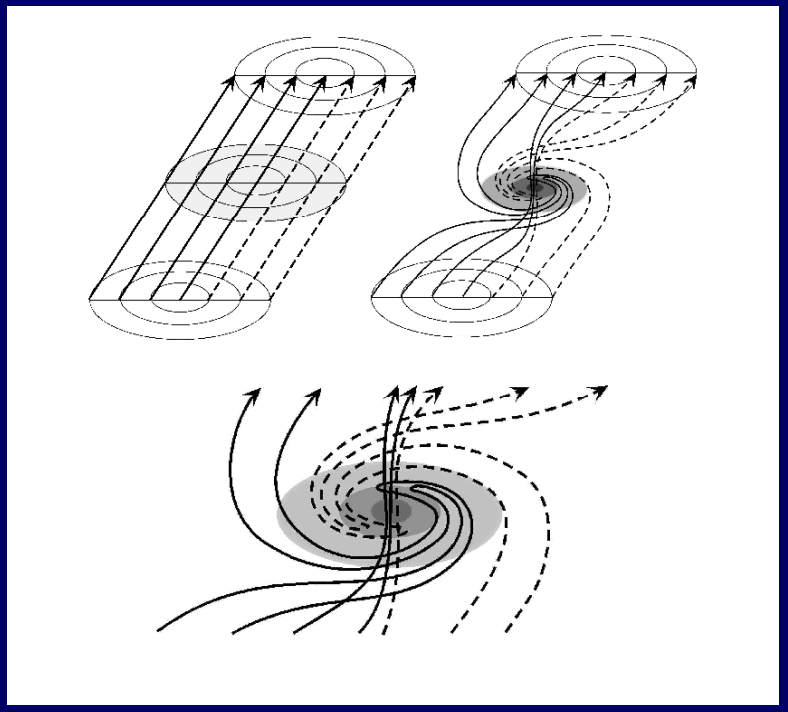
$$B=B_0\,\Omega t/2\pi=B_0\,t/P$$

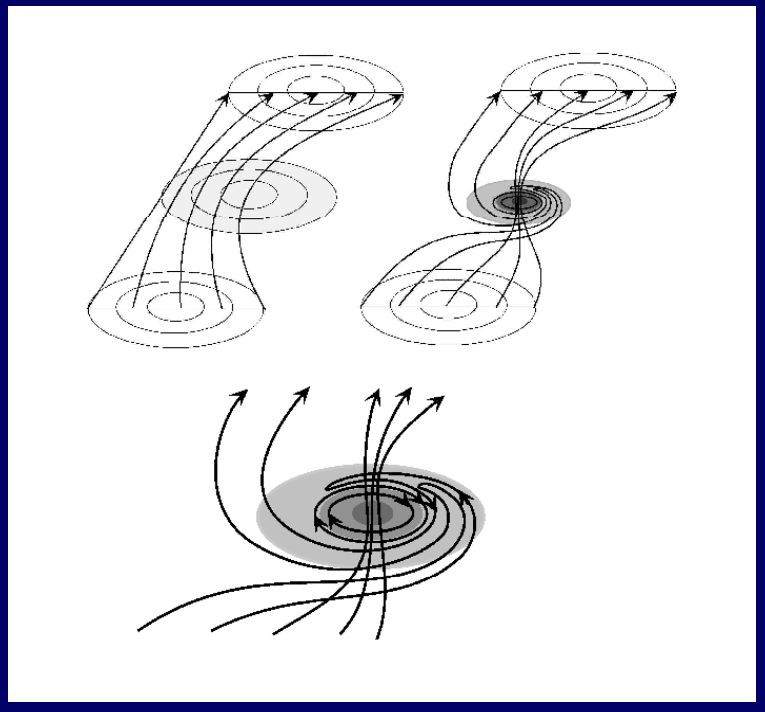
V, ASS





BSS, Ring , ASS, V



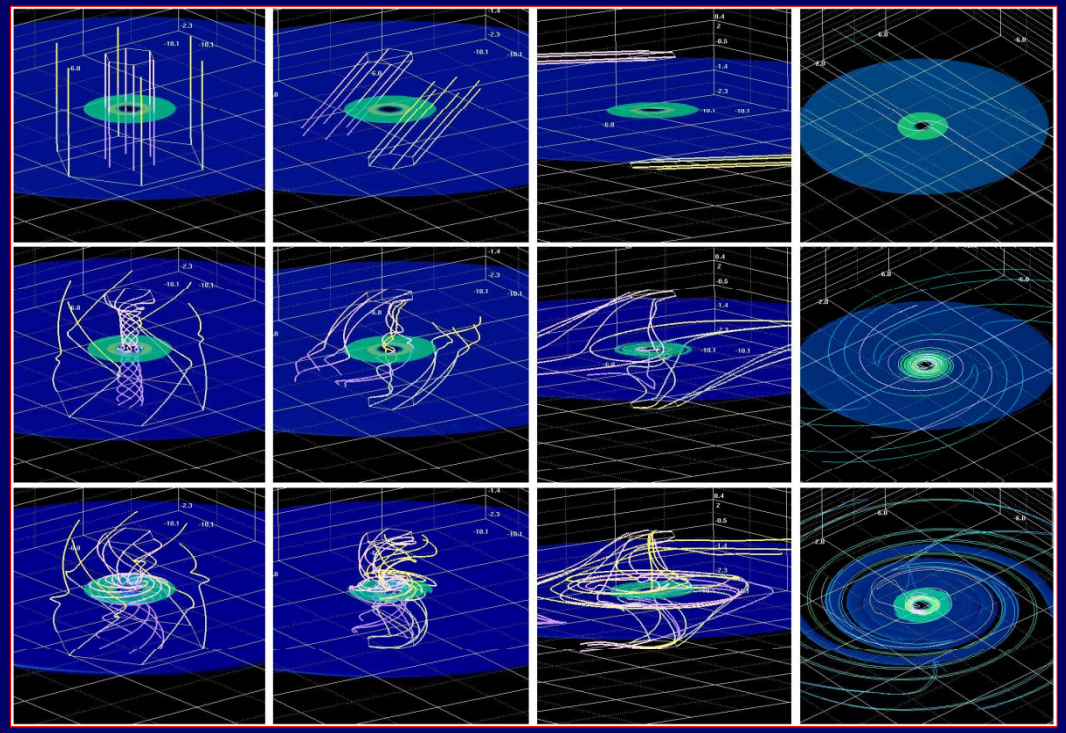


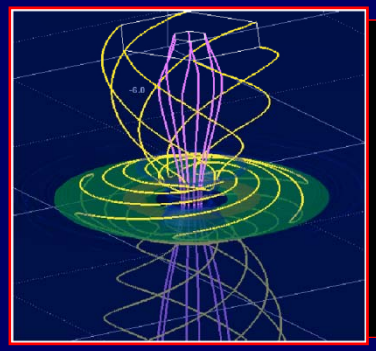
5.MHD シミュレーション

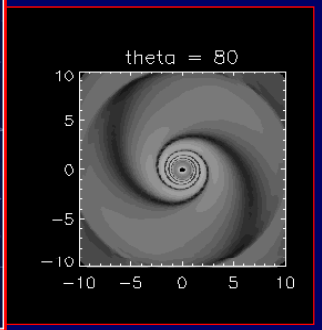
(=>Machida’s talk)

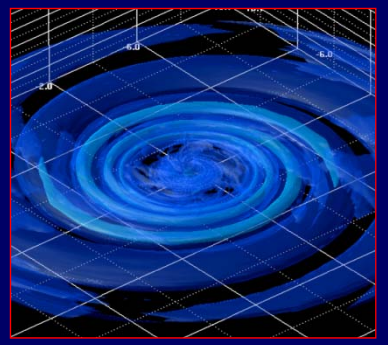
MHD Simulation

Sofue, Machida, Kudoh 2010



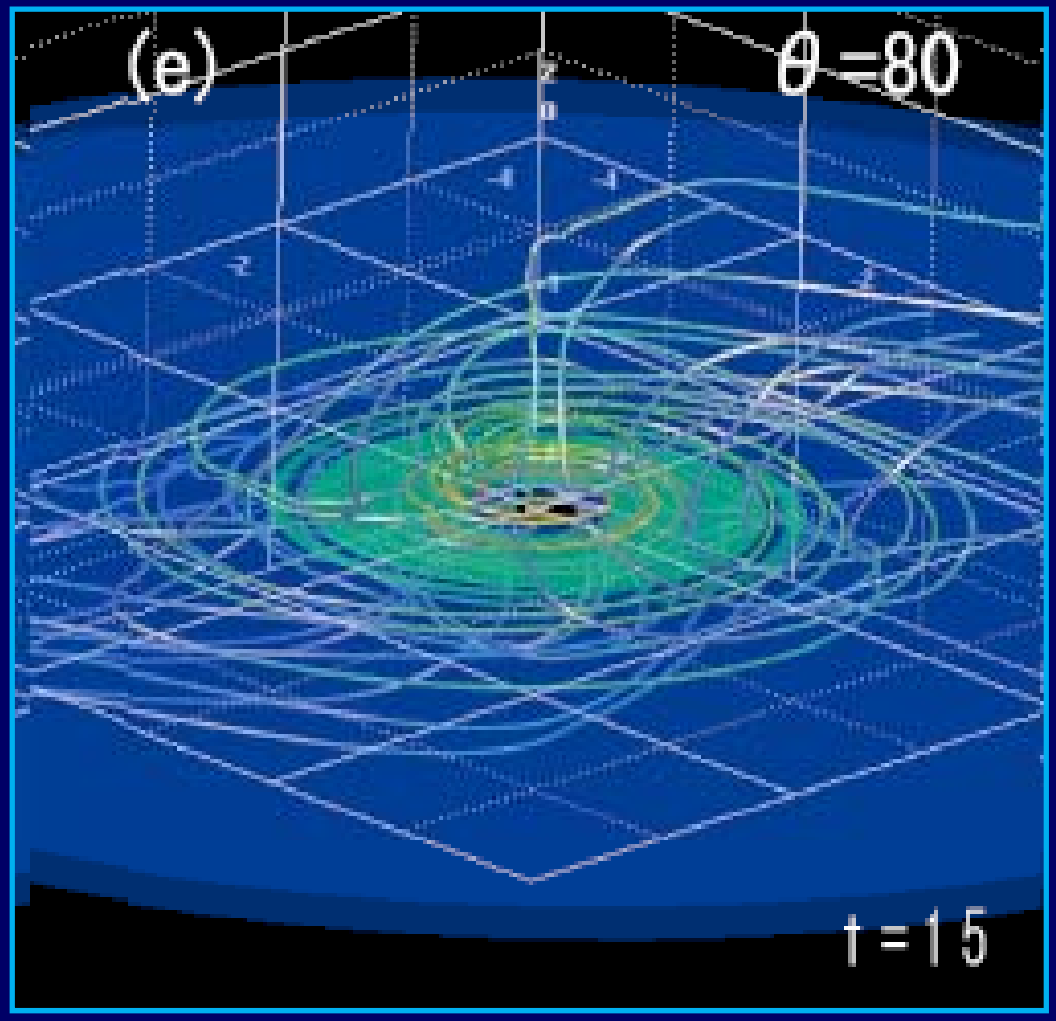






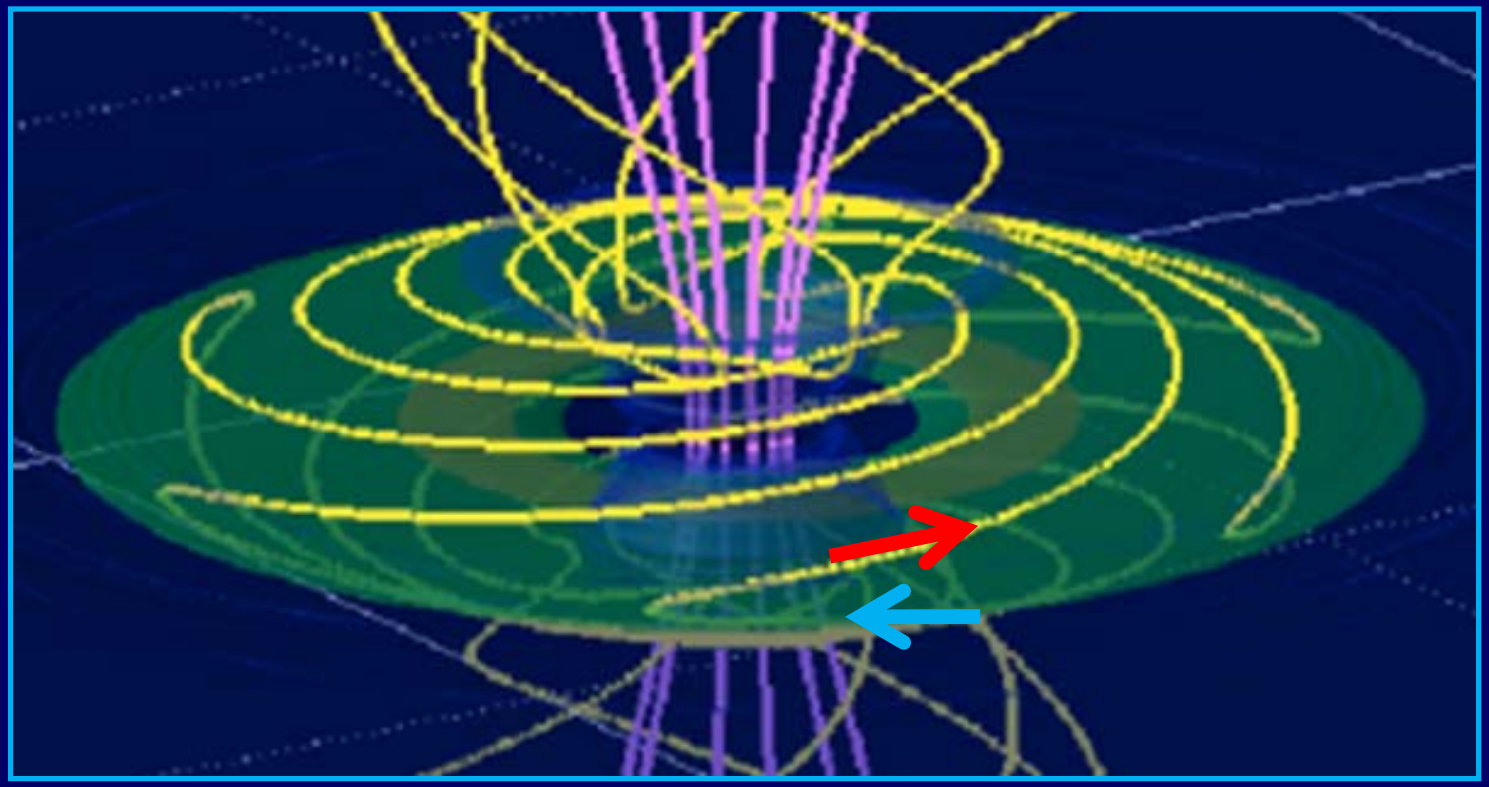
B^2

MHD Simulation （Sofue, Machida, Kudoh 2010)



MHD Simulation (Sofue, Machida, Kudoh 2010)

ASS Axy-symmetric Spiral = G-Plane Reversal



Uniform cosmic B

=> Composite Galactic B

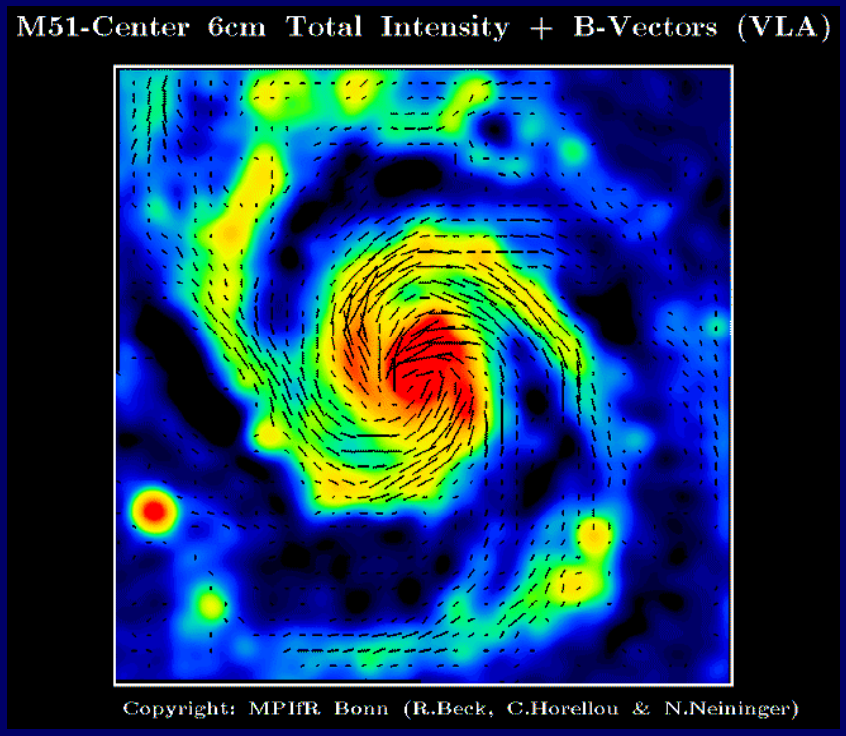
=BSS + ASS + Ring + V fields

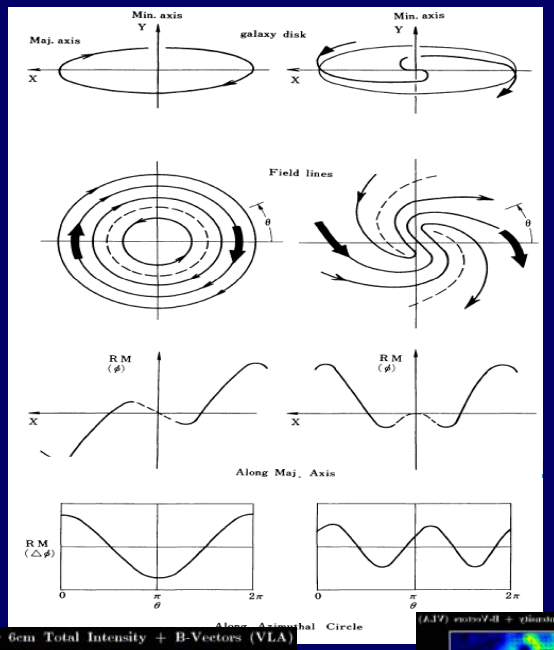
B_{cos}=1 nG

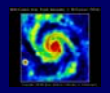
$B_{gal}=(R_{gal}/R_{cos})^{-2}\sim 1\mu G$

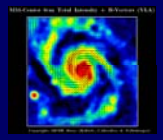
$B_{GC}=(R_{GC}/R_{cos})^{-2}\sim 1mG$

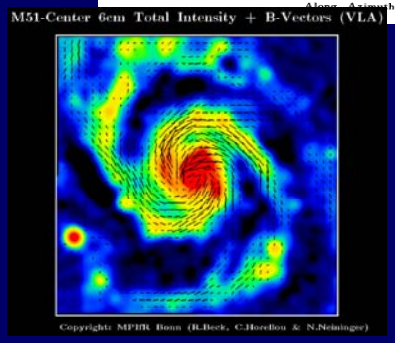
Proposed SKA Observations: Galaxies RM Mapping

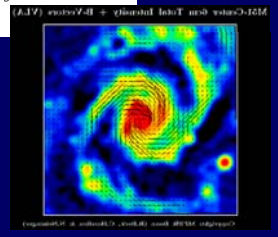


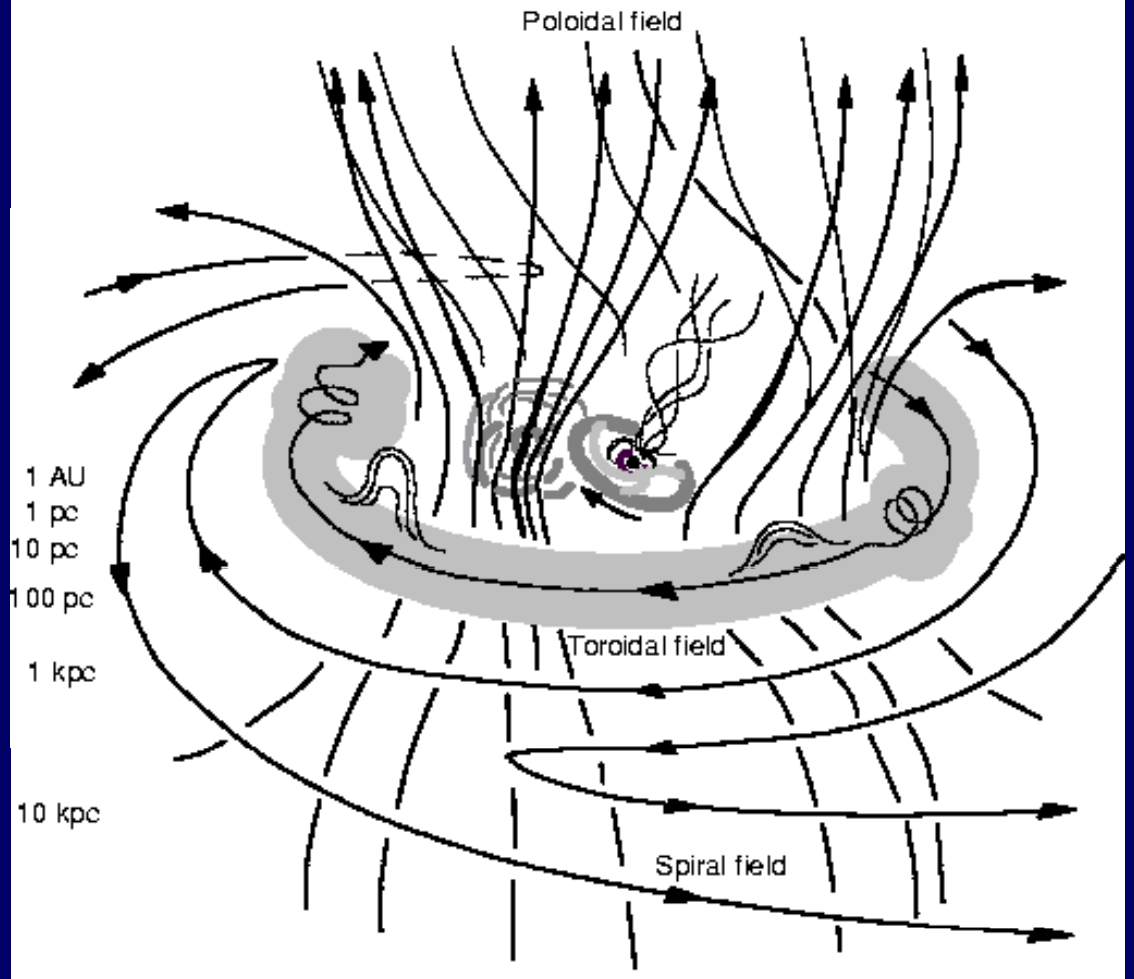












Magnetic View of the Galactic Center