Open
Field
Line

loop

solar surface

A

B

displacement

C

Reconnection of Loops and Open Field Lines

Particle Intensity (Arbitrary Units)

R(AU)	3.5	2.8	2.2	1.4	1.8	2.4	3.4	4.0
Λ (deg)	-54	-71	-80	-5	73	71	45	33

40 - 65 keV electrons

solar

S28   S36   N1   N6   N9

94/ 1   94/ 182   95/ 1   95/ 182   96/ 1   96/ 183

Galactic penetrating particles

94/ 1   94/ 182   95/ 1   95/ 182   96/ 1   96/ 183

0.5 - 1 MeV protons
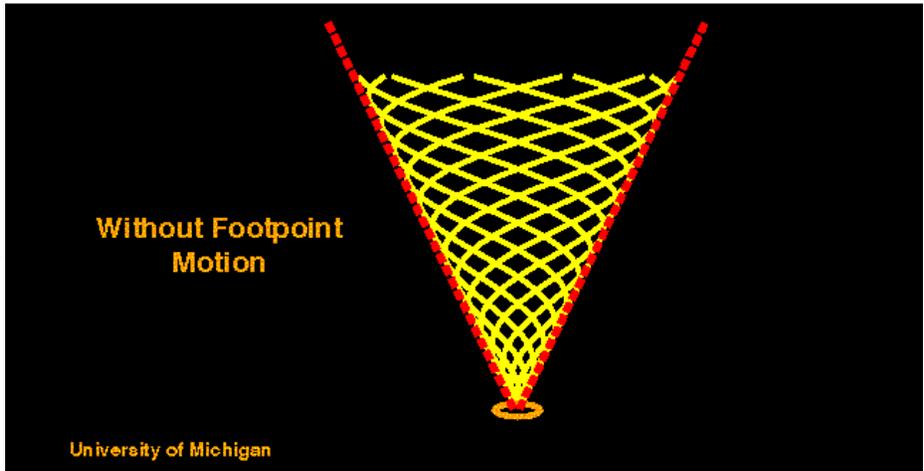
S28   S36   N4   N7   N9   N11

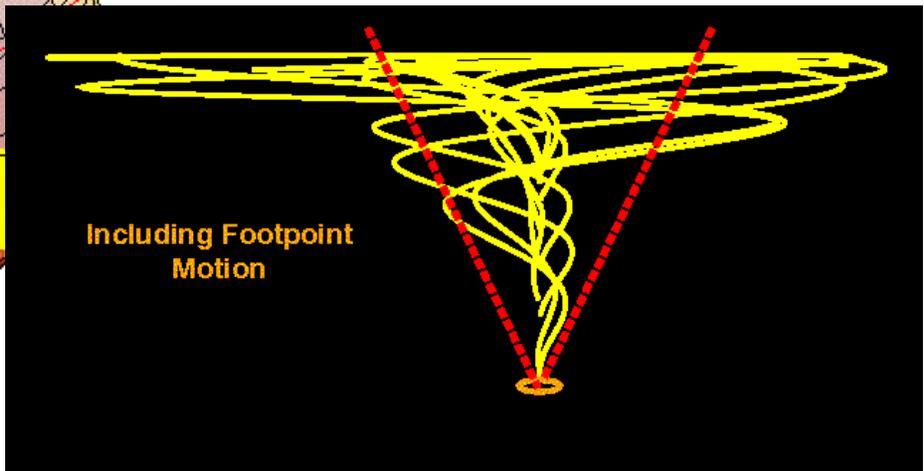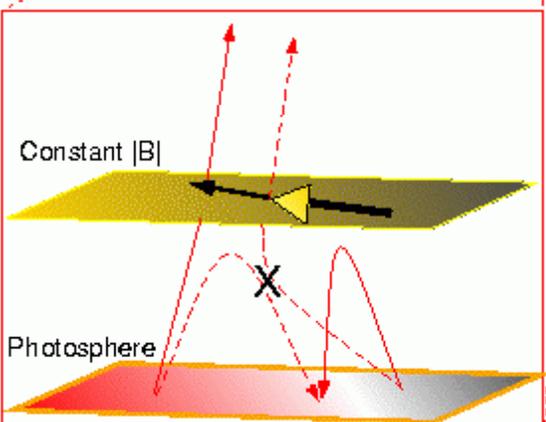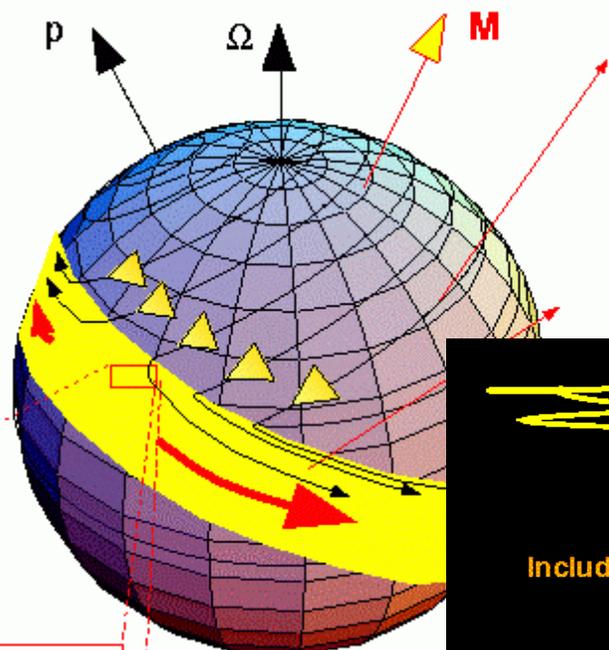94/ 1   94/ 182   95/ 1   95/ 182   96/ 1   96/ 183

Date UT
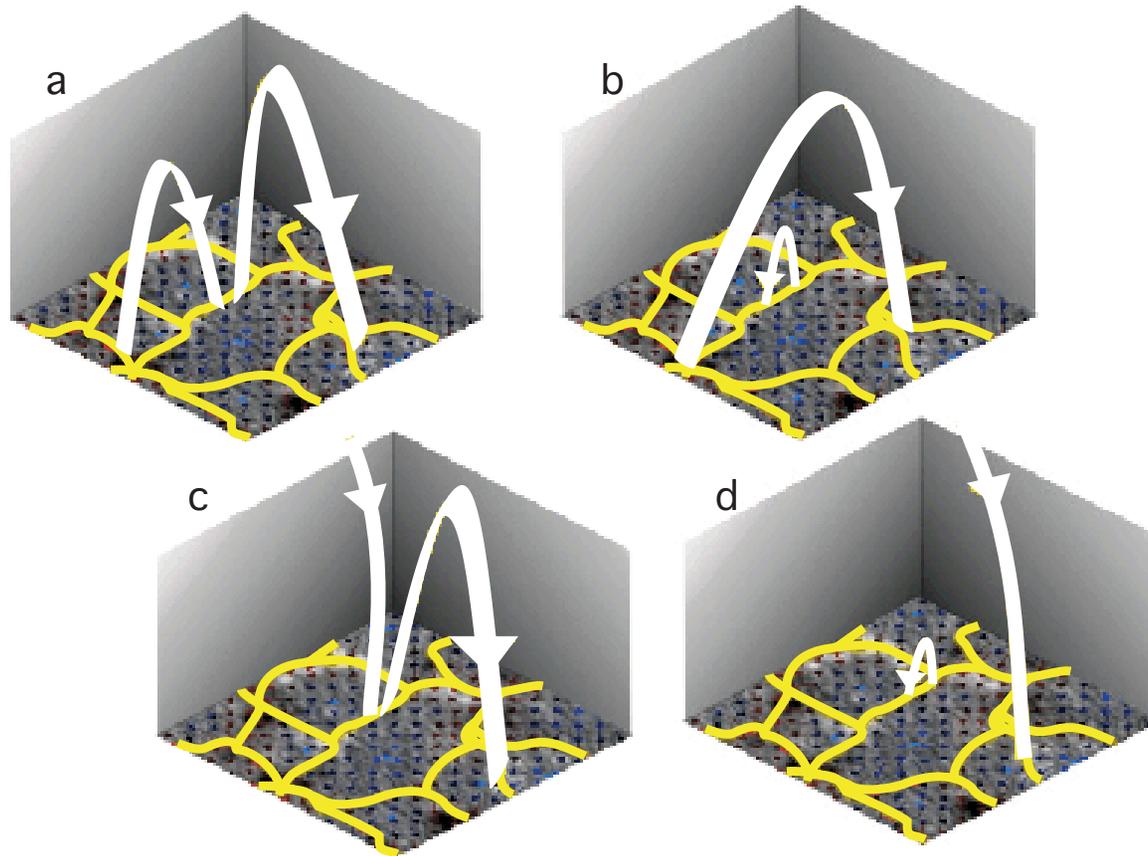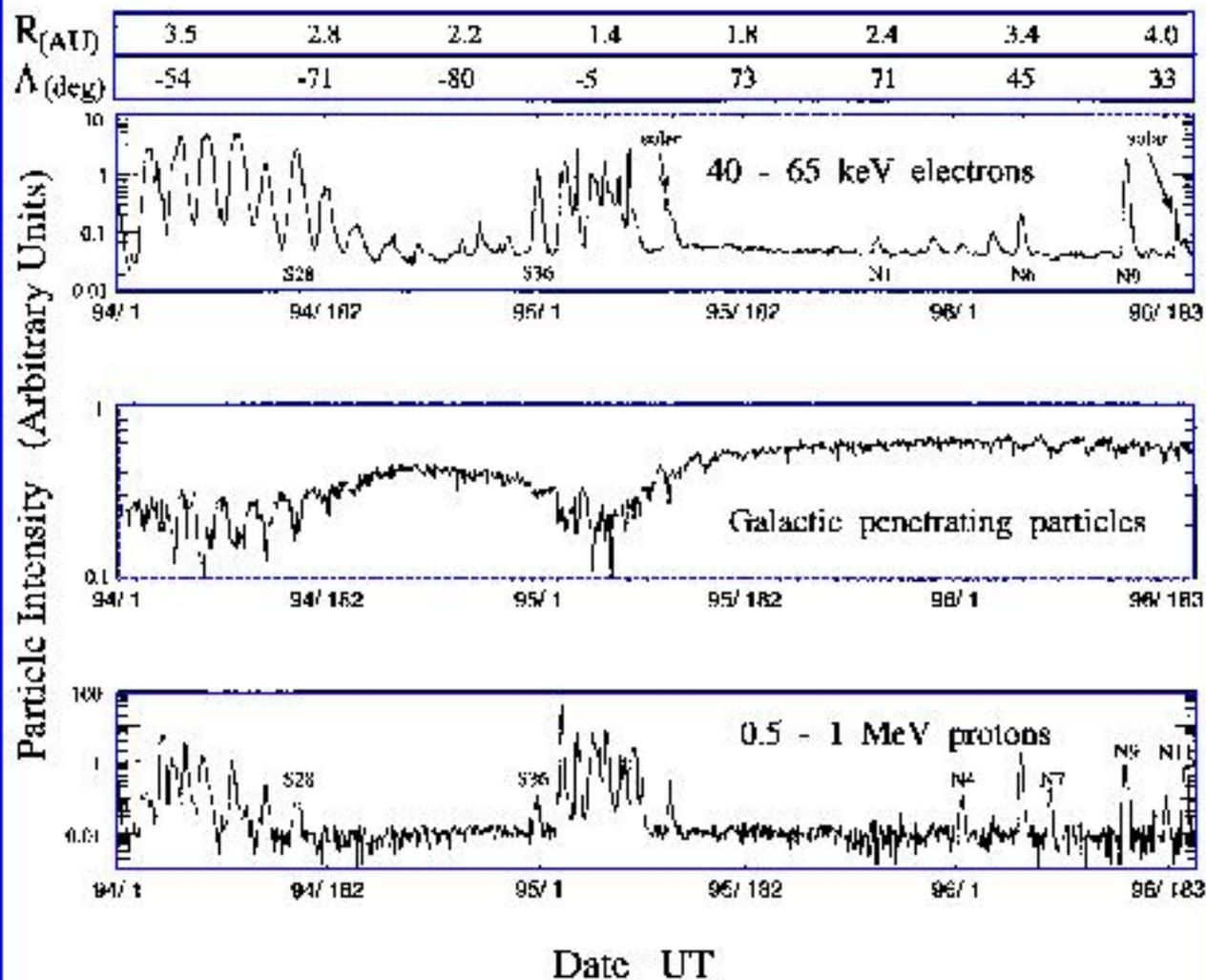
Figure 1. Overview of HI-SCALE measurements of corotating interaction region (CIR) associated particle variation in southern (S) and northern (N) hemispheres (1994 day 1 to 1996 day 208). Heliospheric radius (R) and latitude (Λ) of Ulysses are indicated in top bars. Daily averages in arbitrary units are as follows: (top) 40–65 keV electron intensity; (middle) anticoincidence rate due to penetrating galactic particles; and (bottom) 0.5 – 1.0 MeV proton intensity. Southern electron recurrences are continuously numbered through S36 following the sequencing of CIRs initialized by Bame et al. [1993]. Northern electron recurrences are numbered N1–N11.
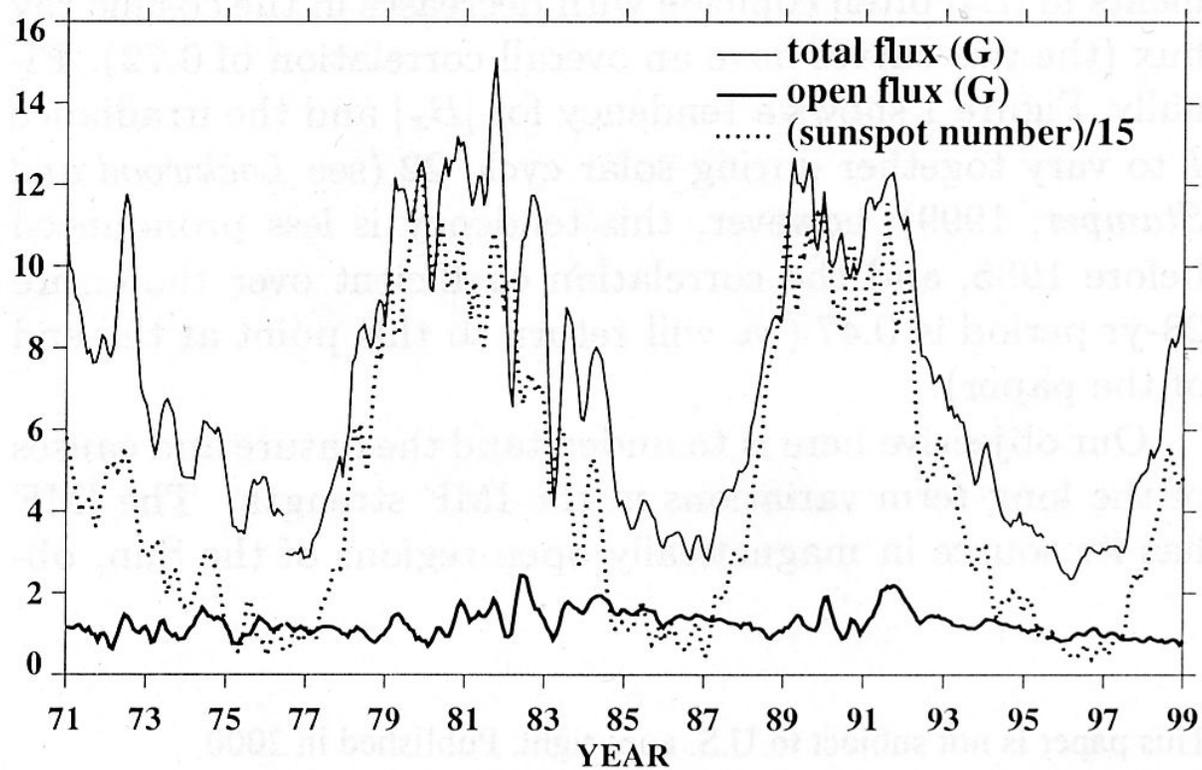
Parker, 1958

p   Ω   M

X

Photosphere

THZ/UMI 00

p

Ω

M

Constant |B|

X

Photosphere

Including Footpoint
Motion

Without Footpoint
Motion

University of Michigan
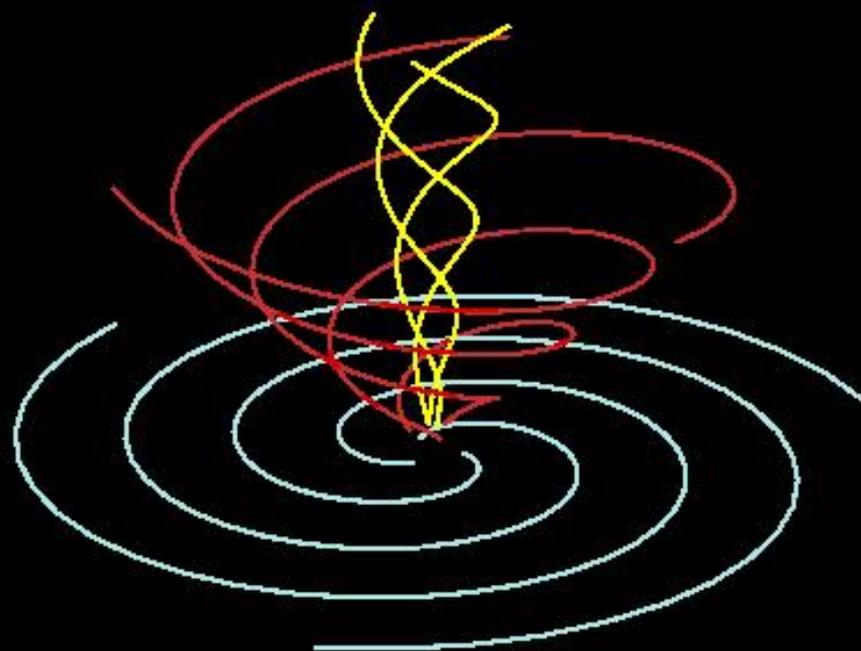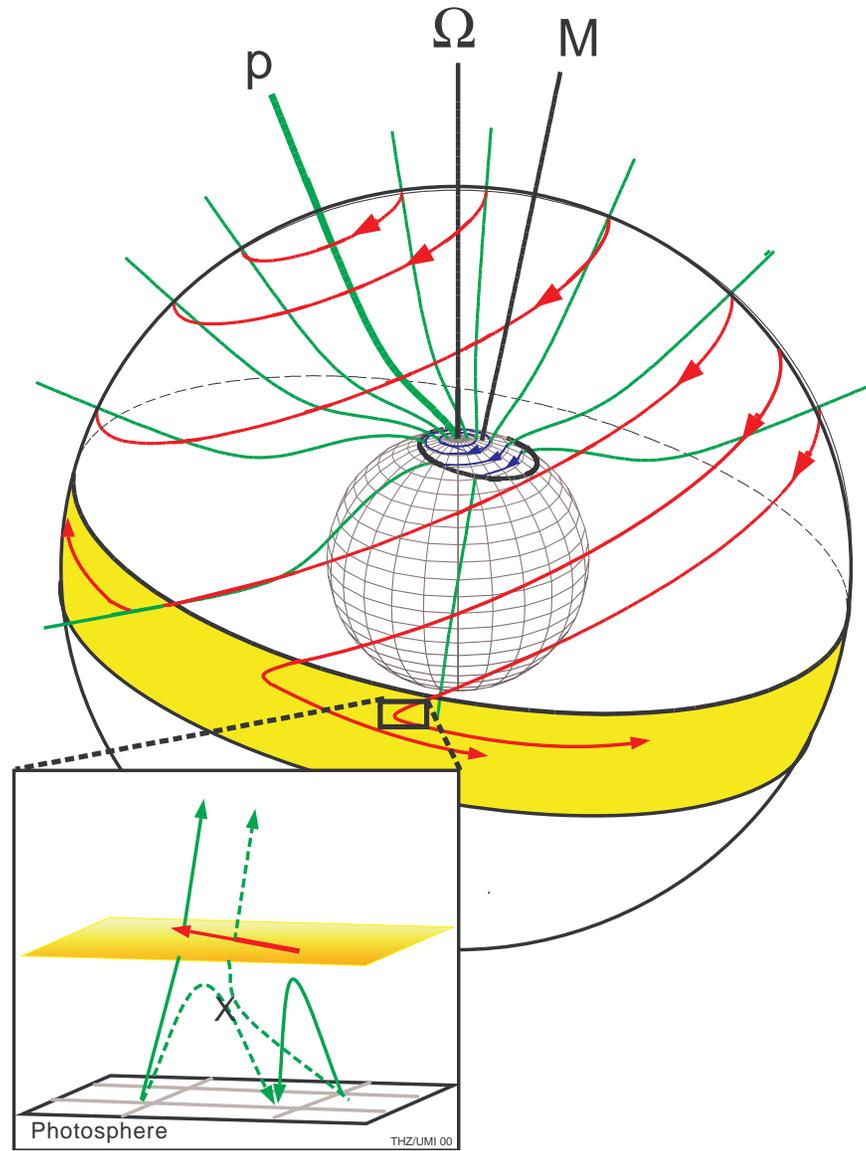
Figure 3. Variation of the total (closed and open) solar magnetic flux Φ_{tot}, open flux Φ_{open}, and sunspot number R_Z. Both Φ_{tot} and Φ_{open} have been divided by $4\pi R_S^2$ to convert them into equivalent field strengths (G) averaged over the solar surface.
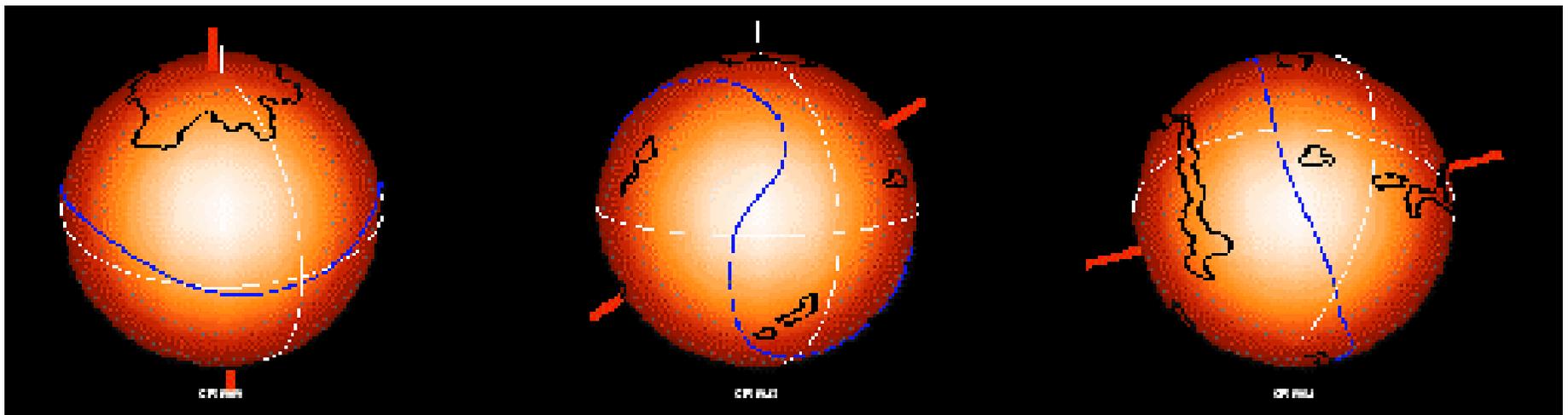
Wang, J.-M.,, J. Lean, and N. R. Sheeley, Jr., The long-term variation of the Sun's open magnetic flux, *Geophys. Res. Lett., 27*, 505-508, 2000.
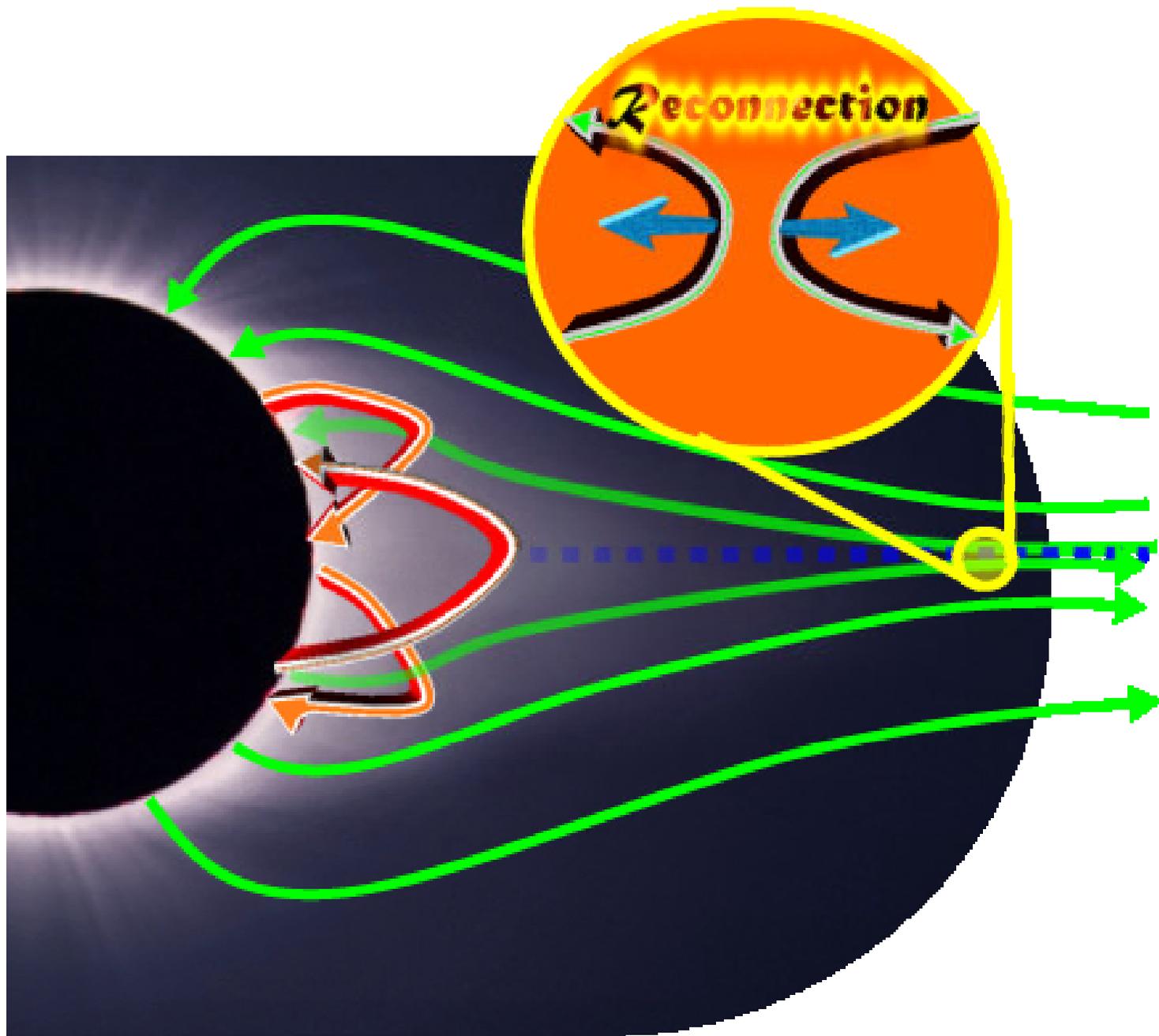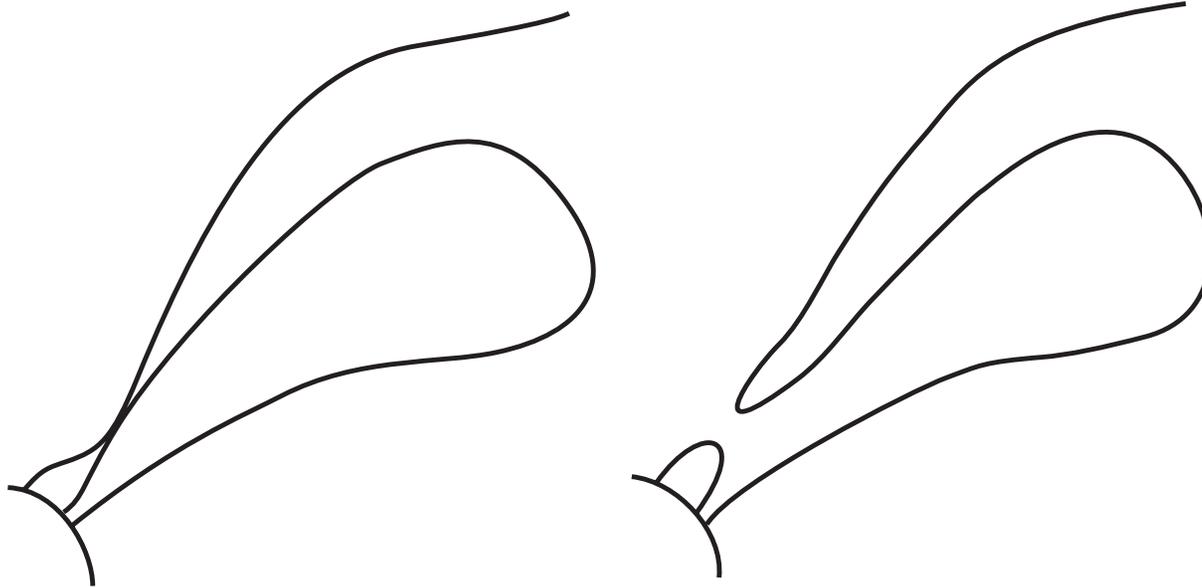
Heliospheric Current Sheet

Location of Current Sheet During Solar Cycle

Sanderson et al. 2001.

Reconnection

Interchange Reconnection
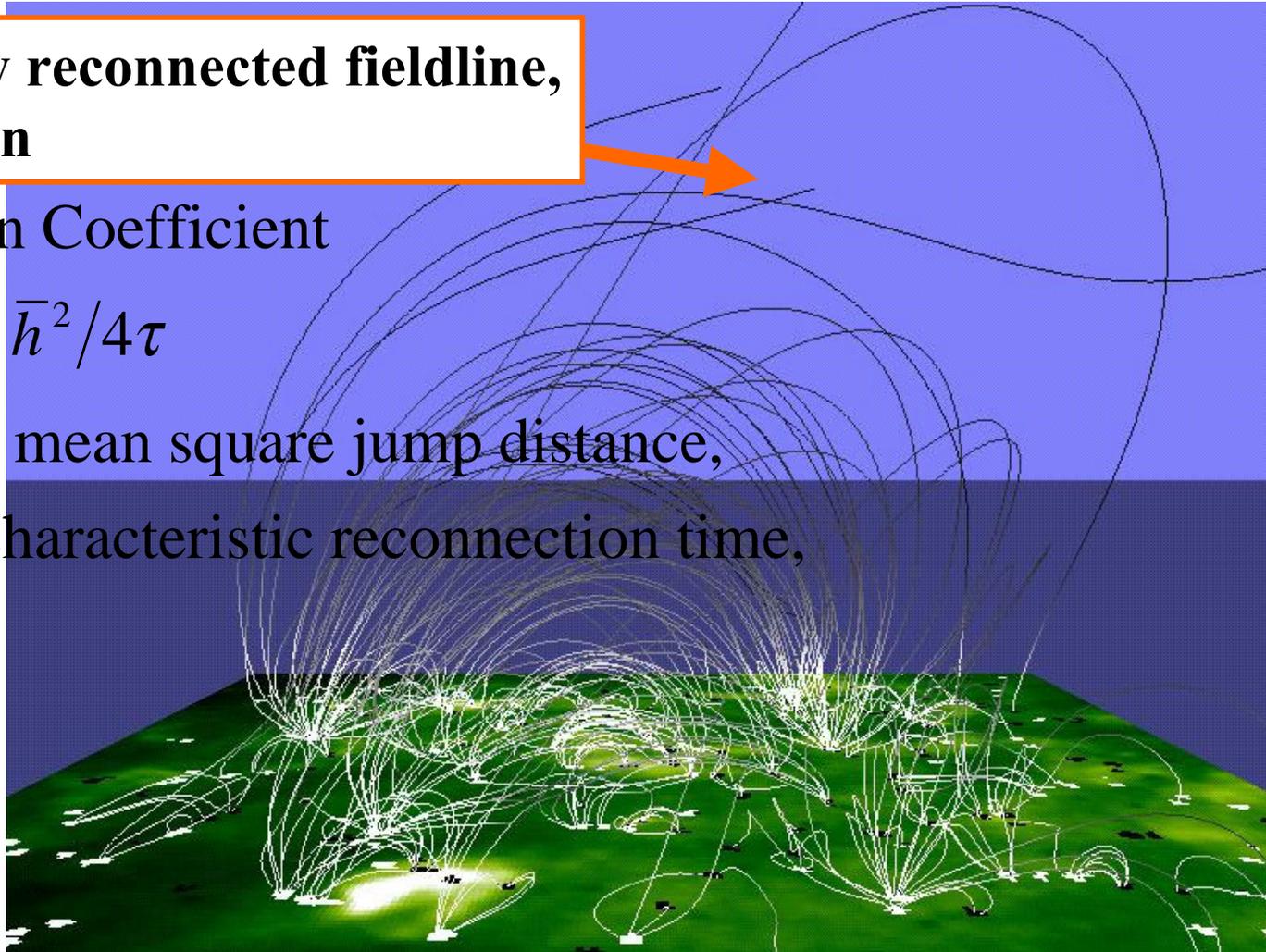
Diffusion through Reconnection

Recently reconnected fieldline, in motion

Diffusion Coefficient

$$\kappa = \overline{h}^2 / 4\tau$$

$\overline{h}^2$ is the mean square jump distance,

τ is the characteristic reconnection time,

Transport Equation

Open magnetic flux, B_{open}

(the number of open field lines per unit of surface area)

$$\frac{\partial B_{open}}{\partial t} = \nabla^2 \left(\kappa B_{open} \right) - \nabla \cdot \left(B_{open} \mathbf{u} \right)$$

$\kappa = \overline{h}^2 / 4\tau$ is the diffusion coefficient, with

$\overline{h}^2 =$ mean square jump distance,

$\tau =$ characteristic reconnection time,

$\mathbf{u}$ is the convection velocity, e.g. due to differential rotation.

Diffusion Terms

Diffusion due to convective motions:

$$\kappa_{convection} B_{open} = \frac{(\delta h)^2 B_{open}}{2\delta t}$$

δh is the length of a lane; δt is the time for convection along δh.

Diffusion due to reconnection with loops:

$$\kappa_{reconnection} B_{open} = \frac{\overline{h}^2 B_{open}}{4\tau} = \frac{\delta h^2 B_{loop}}{2\delta t}$$

$\overline{h}^2$ is the mean squared loop length; τ is the characteristic reconnection time; B_{loop} is the average magnetic field strength in loops.

Diffusion due to reconnection in the canopy: $\kappa_{canopy} B_{open}$