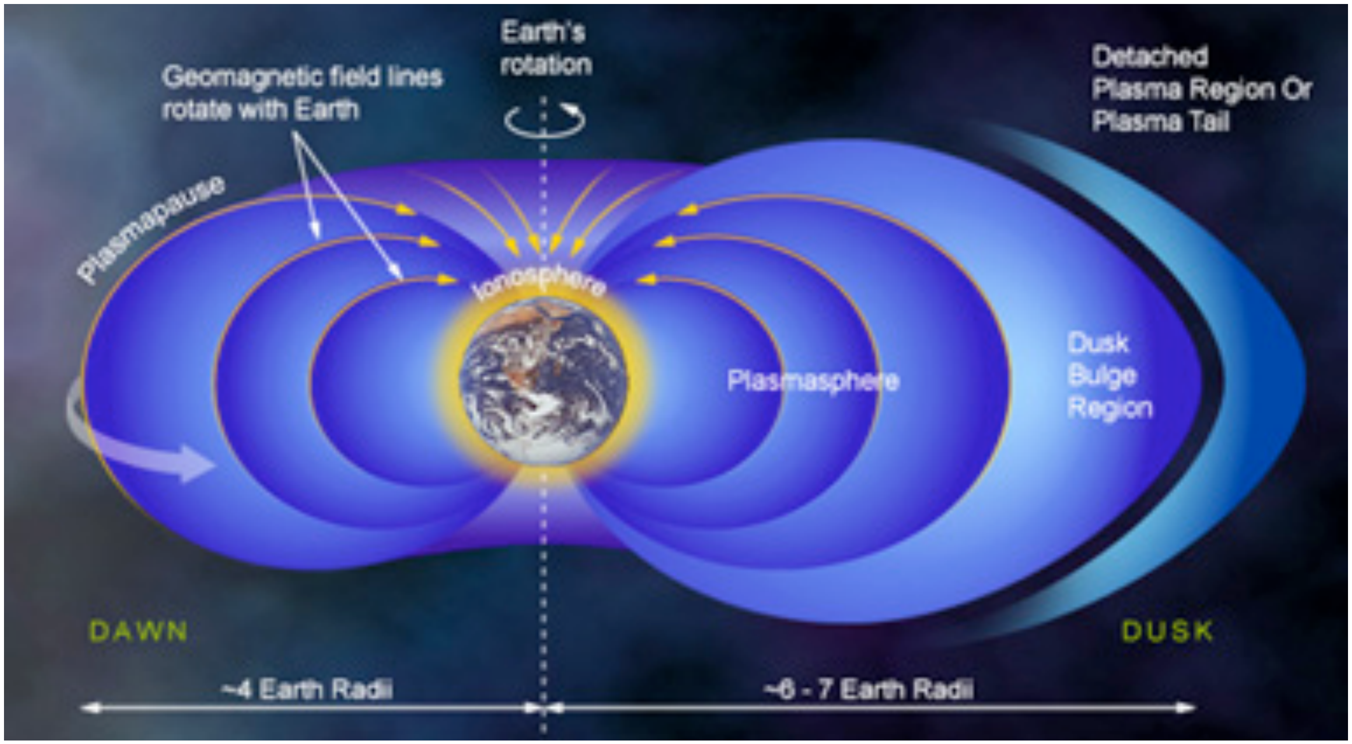
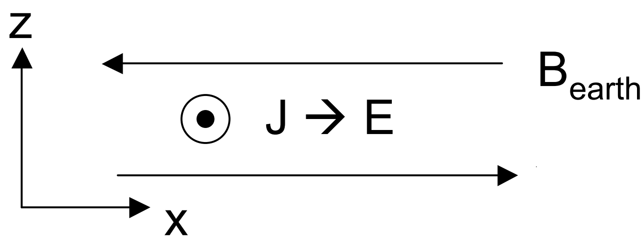
But what about the dawn-dusk asymmetry?



Two Electric fields govern particle drift outside of the ring current

1) Solar Wind Induced Electric Field

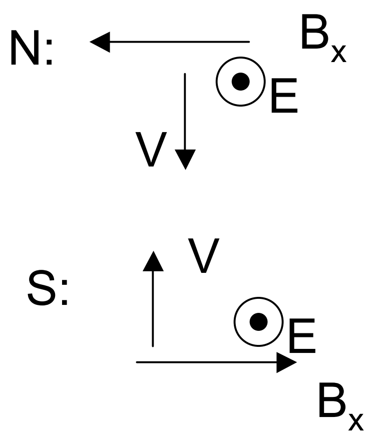


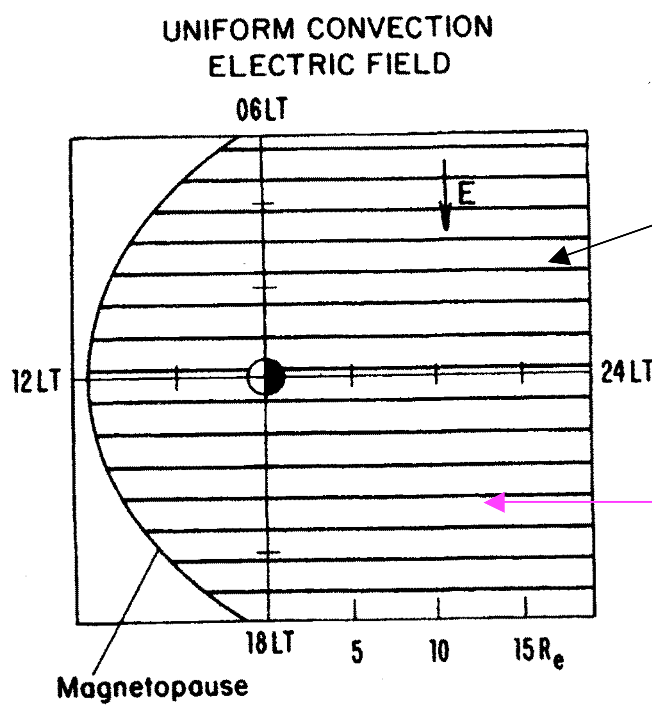
Maintains current sheet that supports the tail

Off equator – E x (B_x)

Drift off equator

$$\mathbf{E} \times \pm \mathbf{B}_x$$





Equipotentials

Drift in equator

$$\mathbf{v} = \frac{\mathbf{E} \times \mathbf{B}}{B^2}$$

2) Corotation Induced Electric Field

$$\mathbf{E}_c = -(\omega \times \mathbf{r}) \times \mathbf{B}_{dip}$$

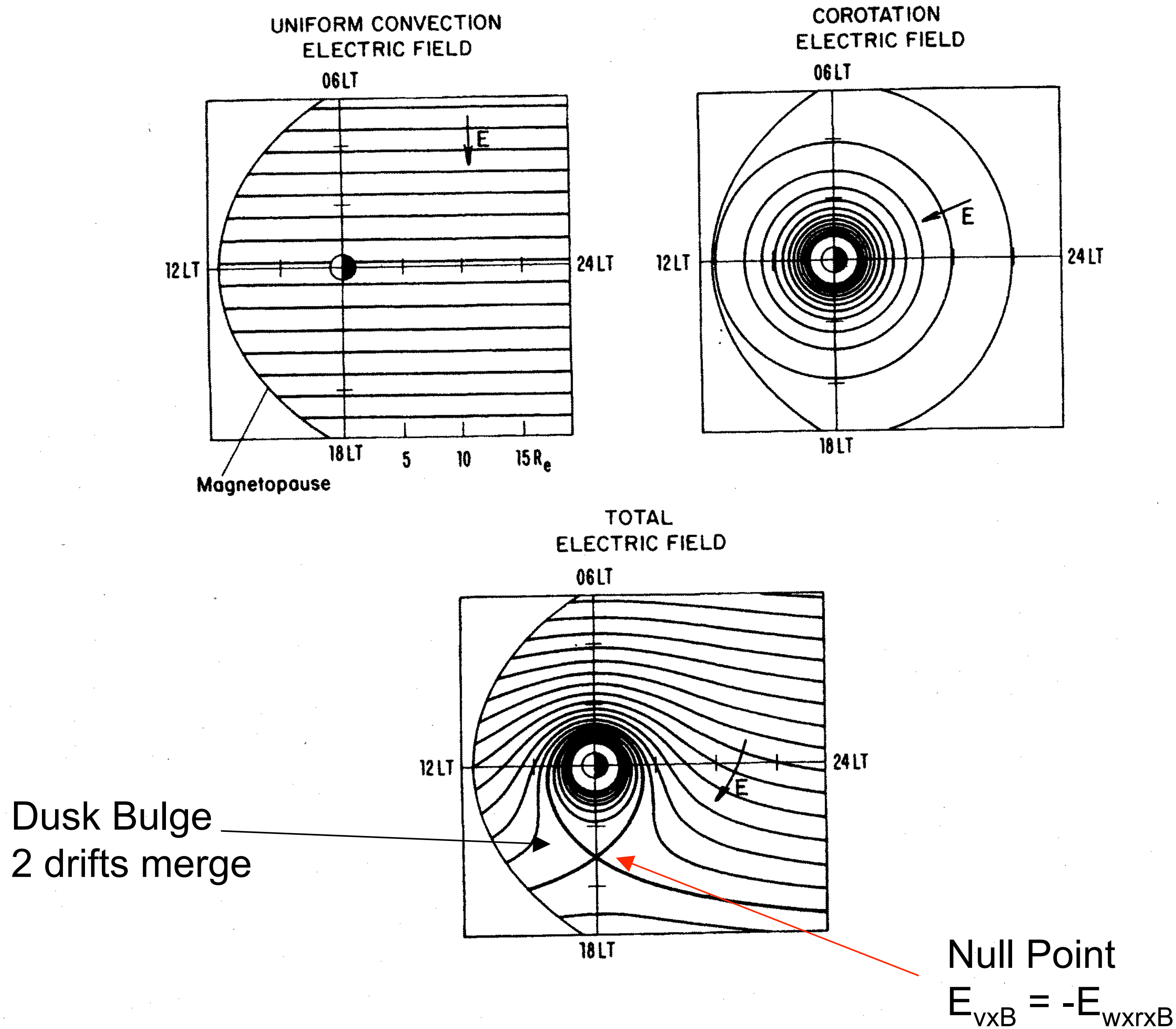
$$\mathbf{B} = B_0 \frac{R_E^{\ 3}}{r^3}\left(-2\sin\lambda\,\hat{\mathbf{r}} + \cos\lambda\,\hat{\lambda}\right)$$ Dipole formula

$$\omega \times \mathbf{r} = \omega r\,\hat{\mathbf{z}} \times \hat{\mathbf{r}} = \omega r(\sin\lambda\,\hat{\mathbf{r}} + \cos\lambda\,\hat{\lambda}) \times \hat{\mathbf{r}}$$

$$= \omega r \cos\lambda\,\hat{\phi}$$

$$\mathbf{E}_c \approx -\omega B_0 \frac{R_E^{\ 3}}{r^3}\cos\lambda\left(-2\sin\lambda\,\hat{\lambda} + \cos\lambda\,\hat{\mathbf{r}}\right)$$

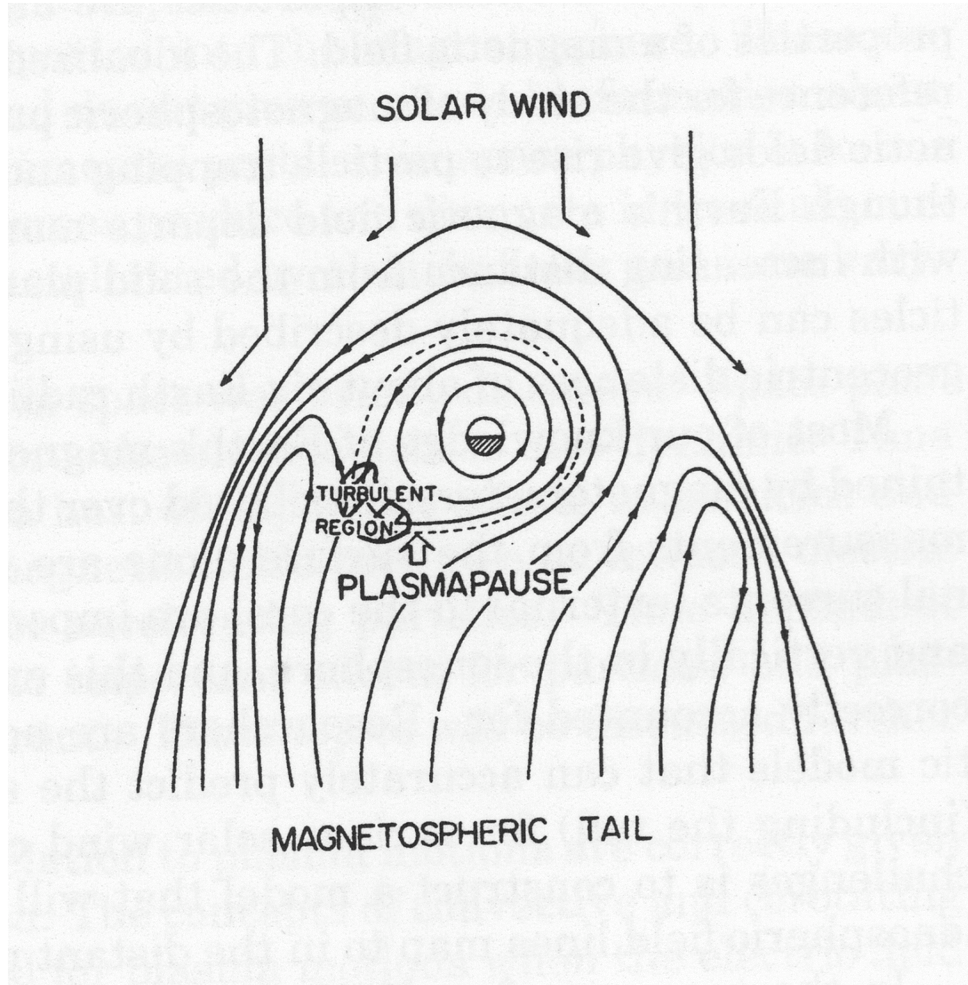
At the equator ($\lambda = 0$), E_c is radially inward


UNIFORM CONVECTION
ELECTRIC FIELD
06LT
E
12LT
24LT
18LT
5
10
15Re
Magnetopause
COROTATION
ELECTRIC FIELD
06LT
E
12LT
24LT
18LT
TOTAL
ELECTRIC FIELD
06LT
12LT
24LT
E
18LT
Dusk Bulge
2 drifts merge
Null Point
$E_{vxB} = -E_{wxrxB}$

Plasma Streamlines

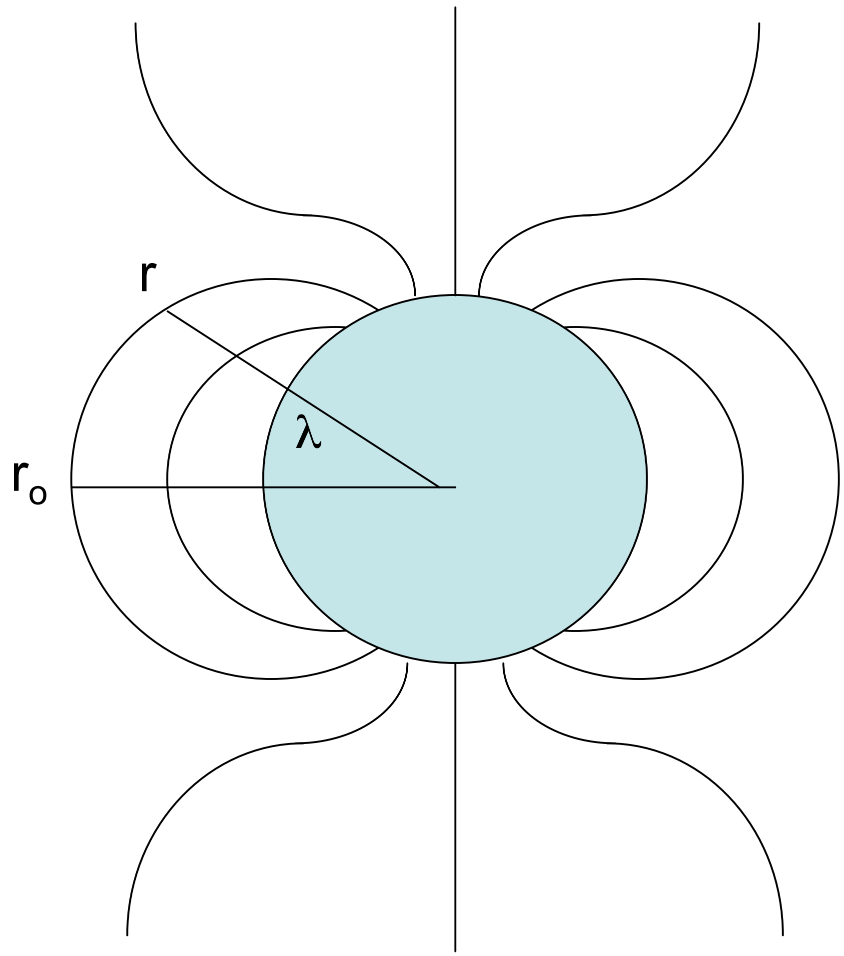
$$\mathbf{v} = \frac{\mathbf{E} \times \mathbf{B}}{B^2}$$

along potential lines



Plasmapause where co-rotation breaks down

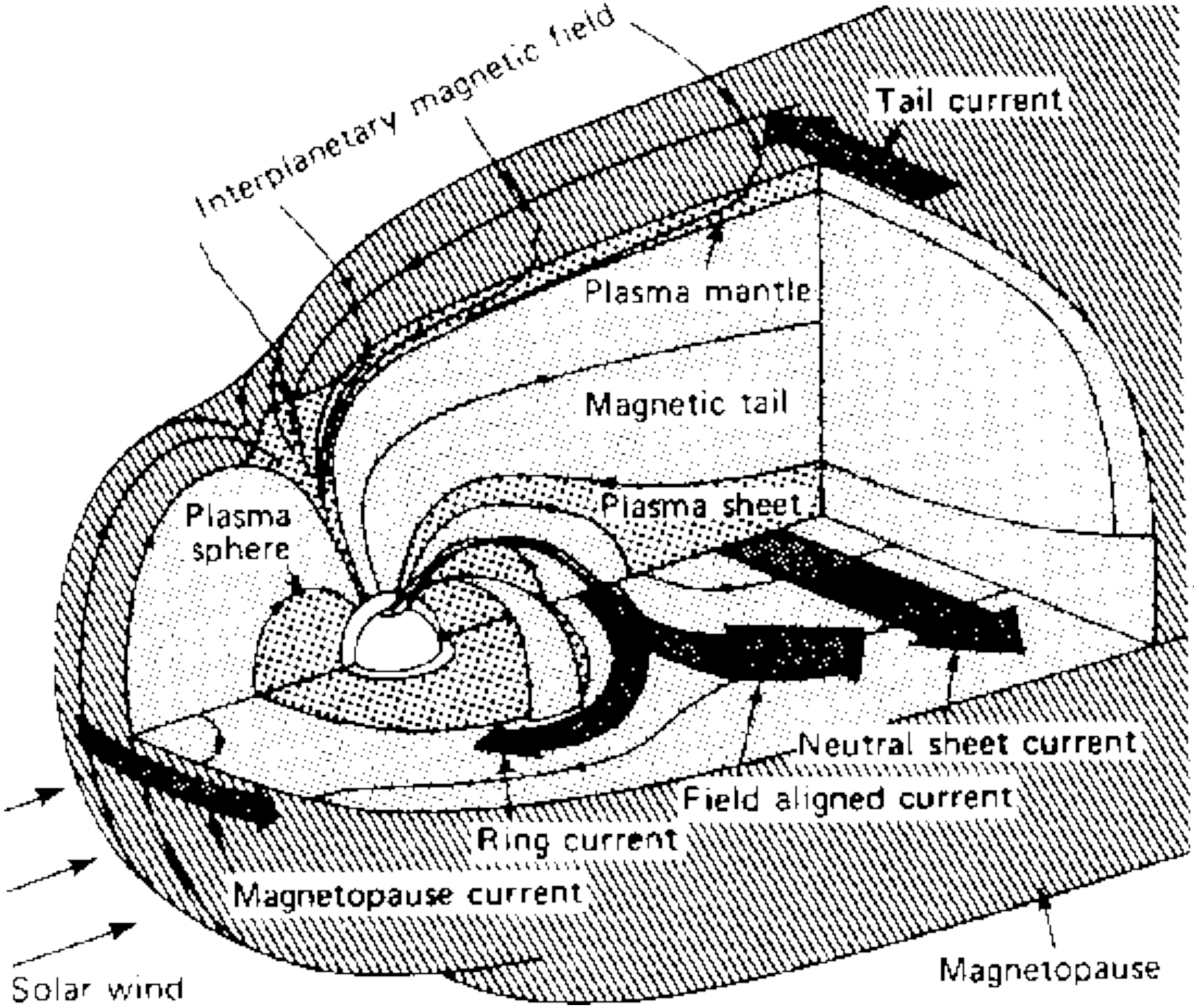
Currents and Aurora

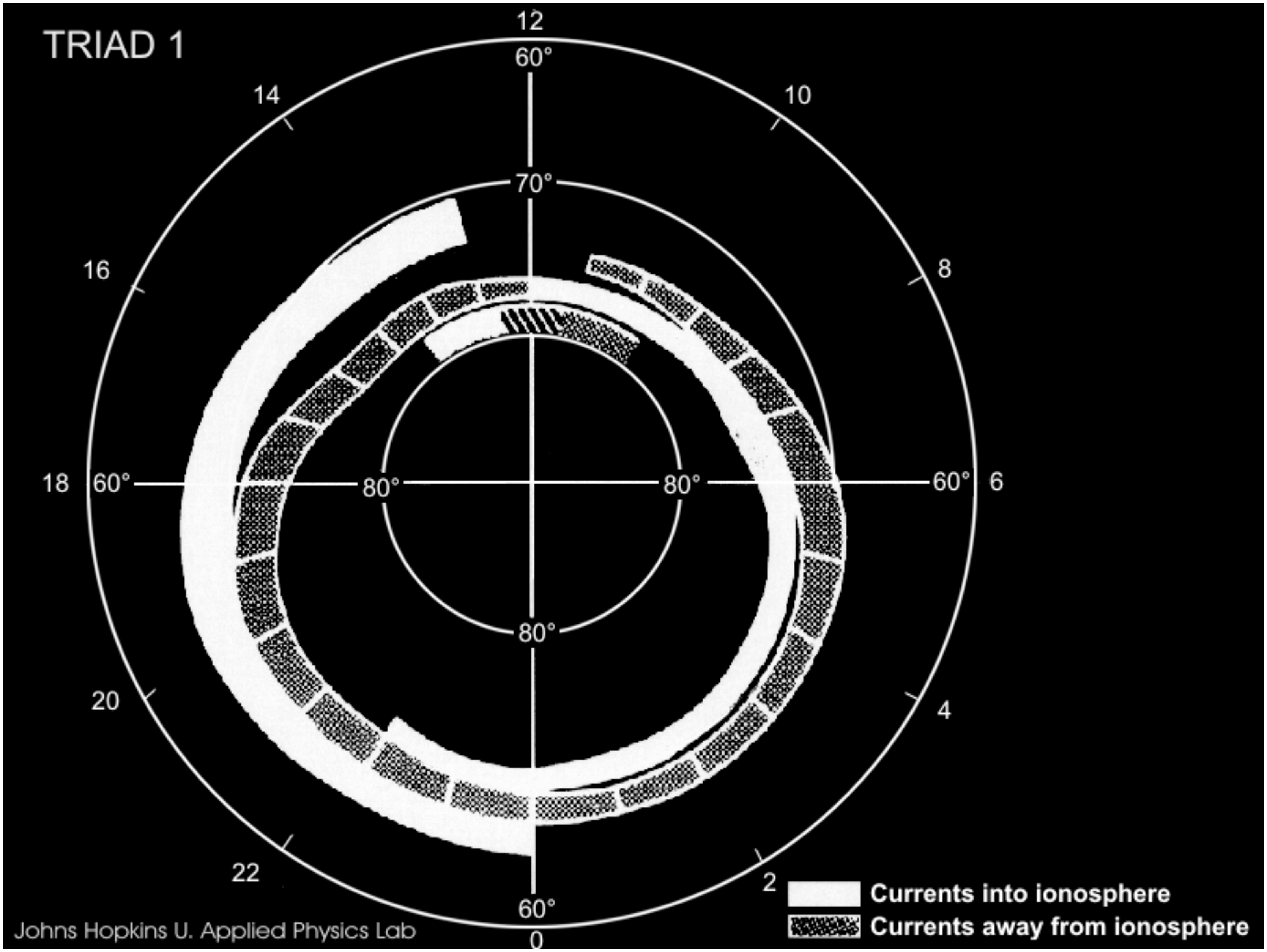


$$\lambda = \frac{\pi}{2} - \theta$$

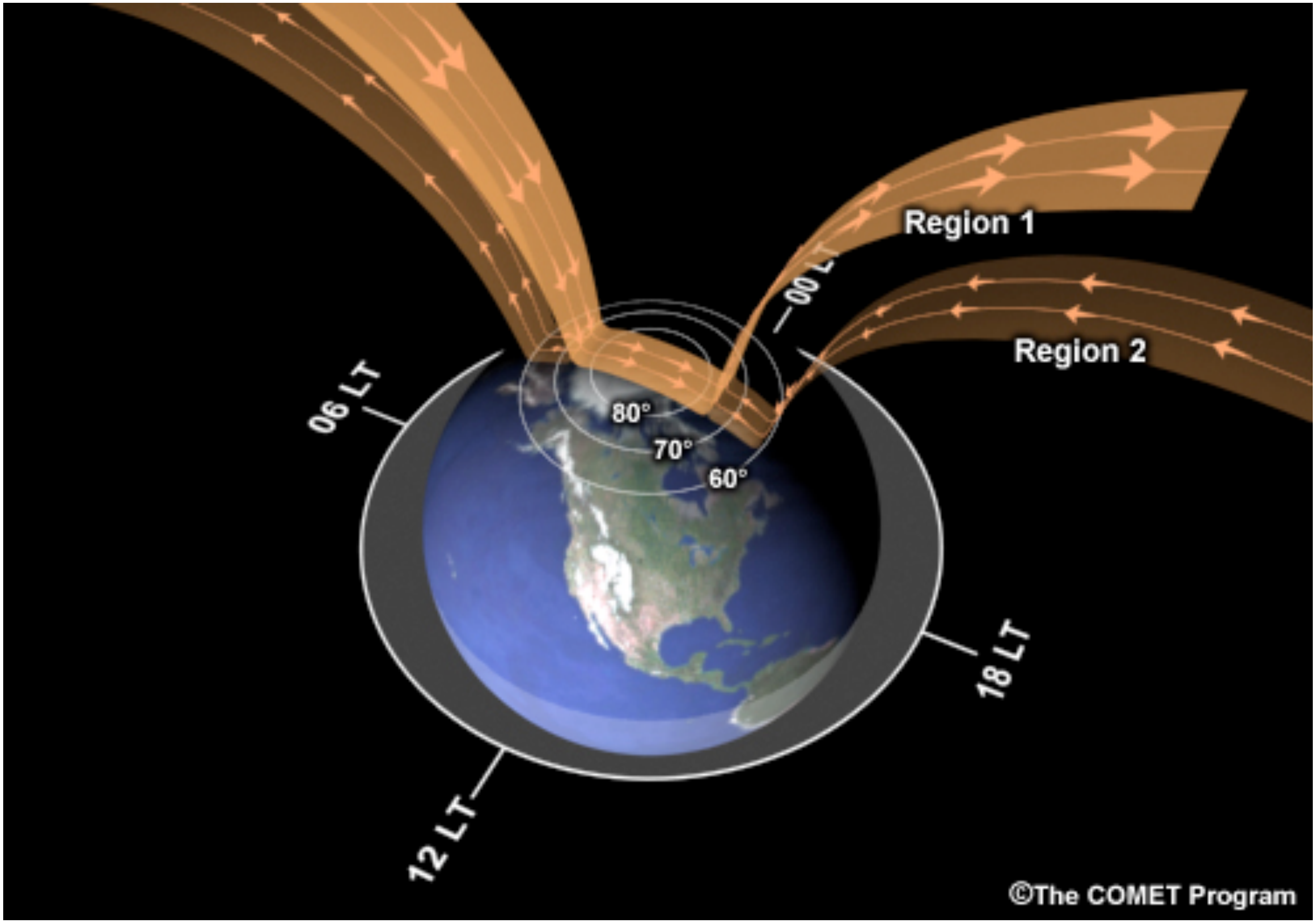
$$r = r_0 \cos^2 \lambda$$

$$B_{dip}(r, \lambda) = \frac{\mu_o M}{4\pi r}(1 + 3\sin^2 \lambda)^{\frac{1}{2}}$$


Interplanetary magnetic field
Tail current
Plasma mantle
Magnetic tail
Plasma sphere
Plasma sheet
Neutral sheet current
Field aligned current
Ring current
Magnetopause current
Solar wind
Magnetopause

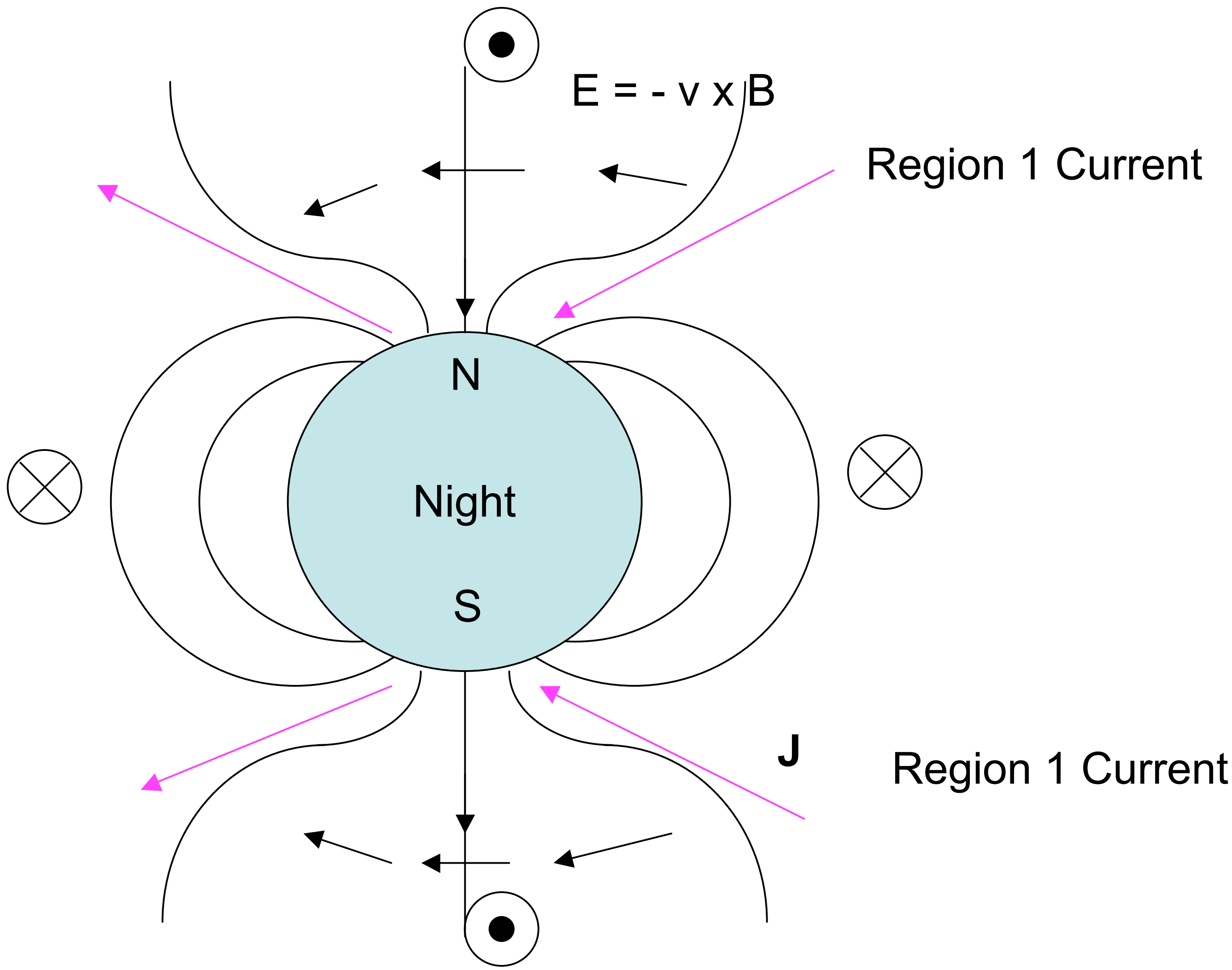


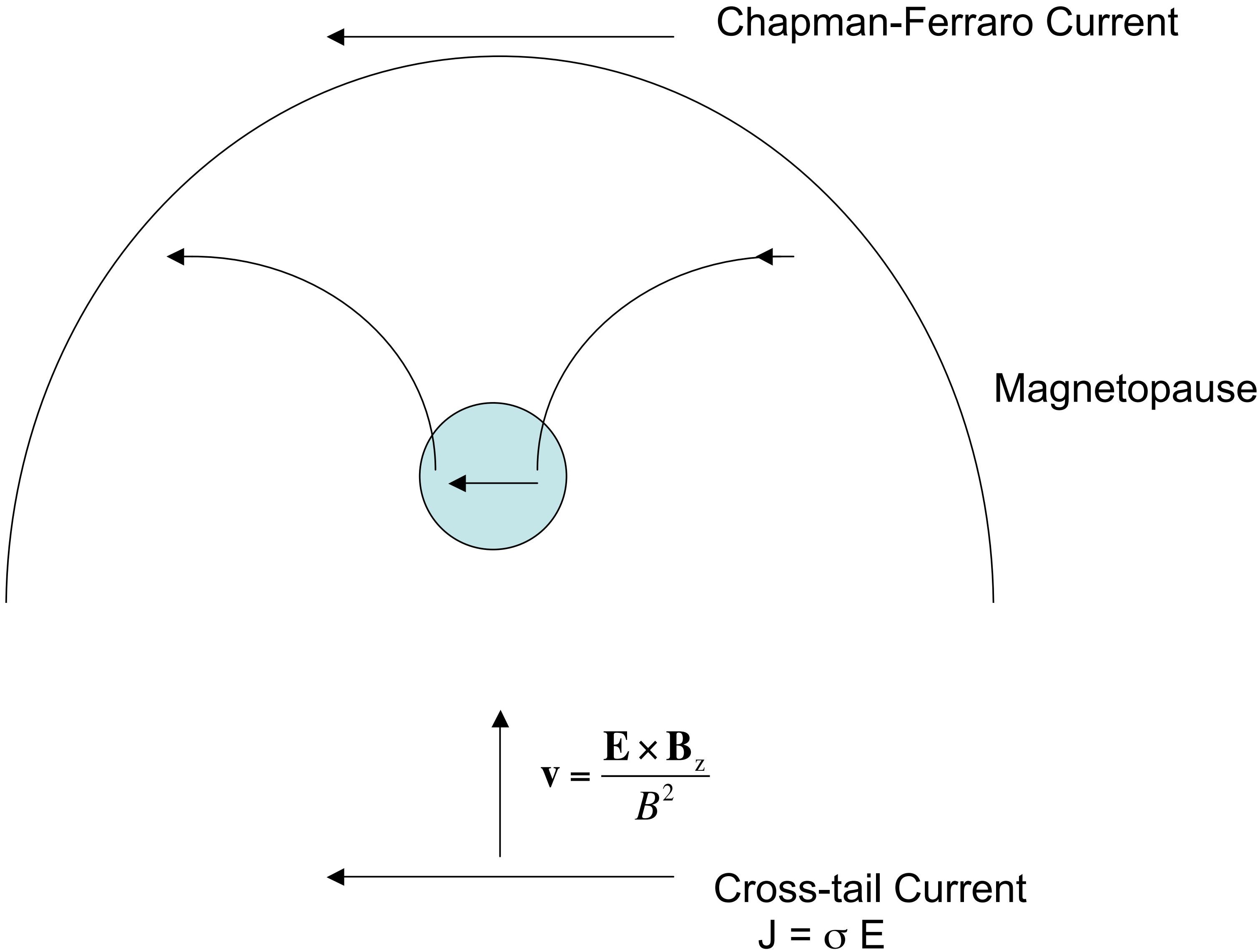
Birkland Currents

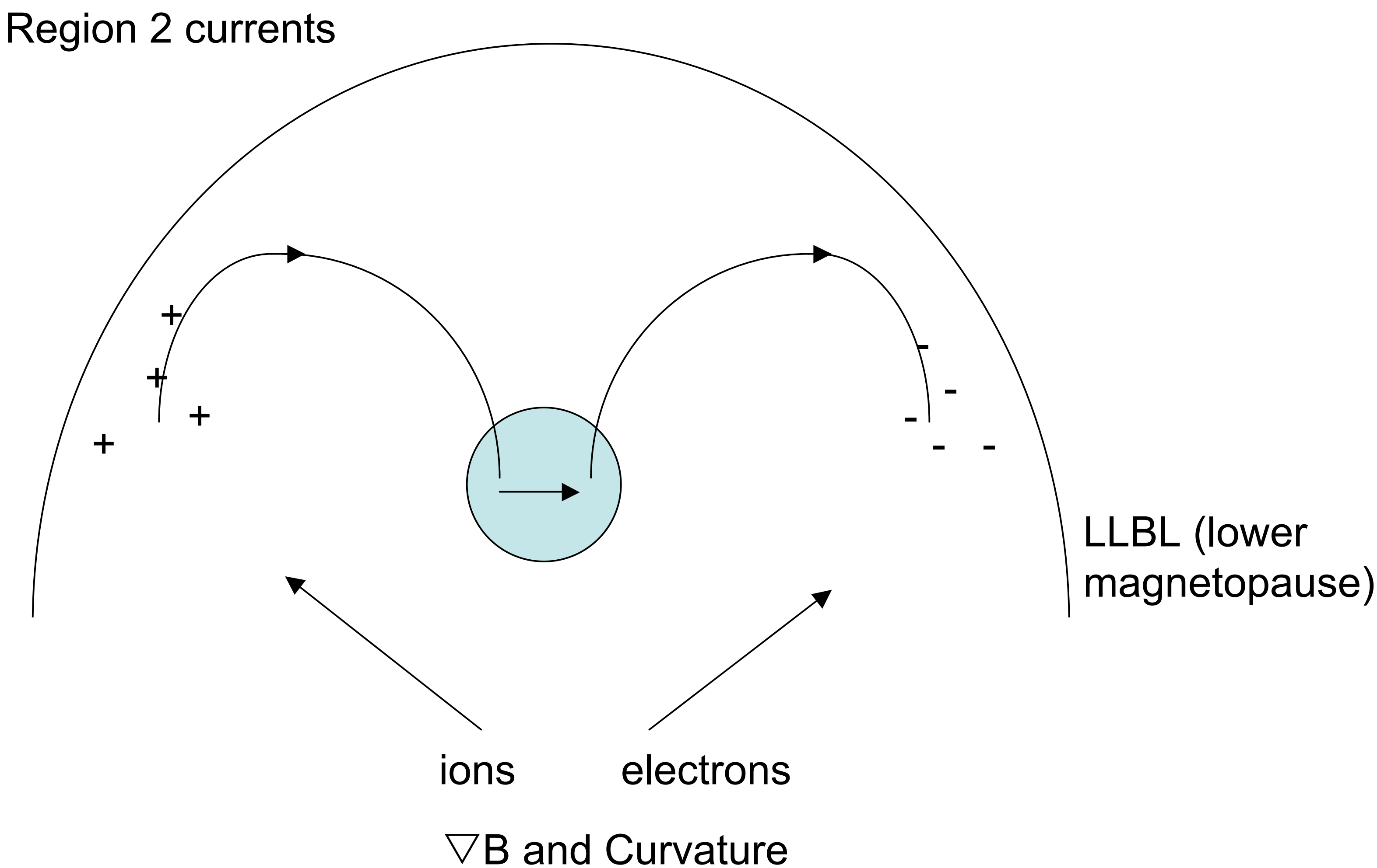


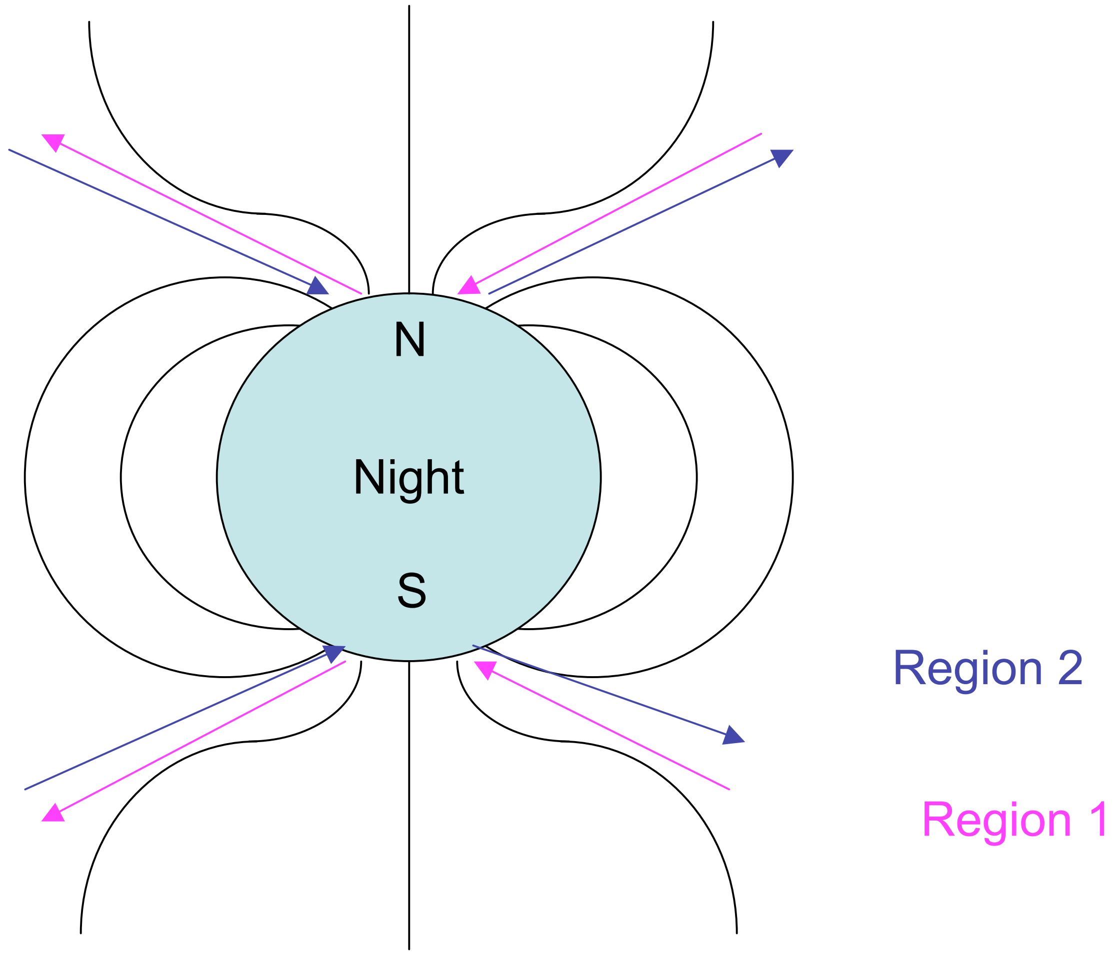
Region 1
Region 2
00 LT
06 LT
12 LT
18 LT
80°
70°
60°
©The COMET Program

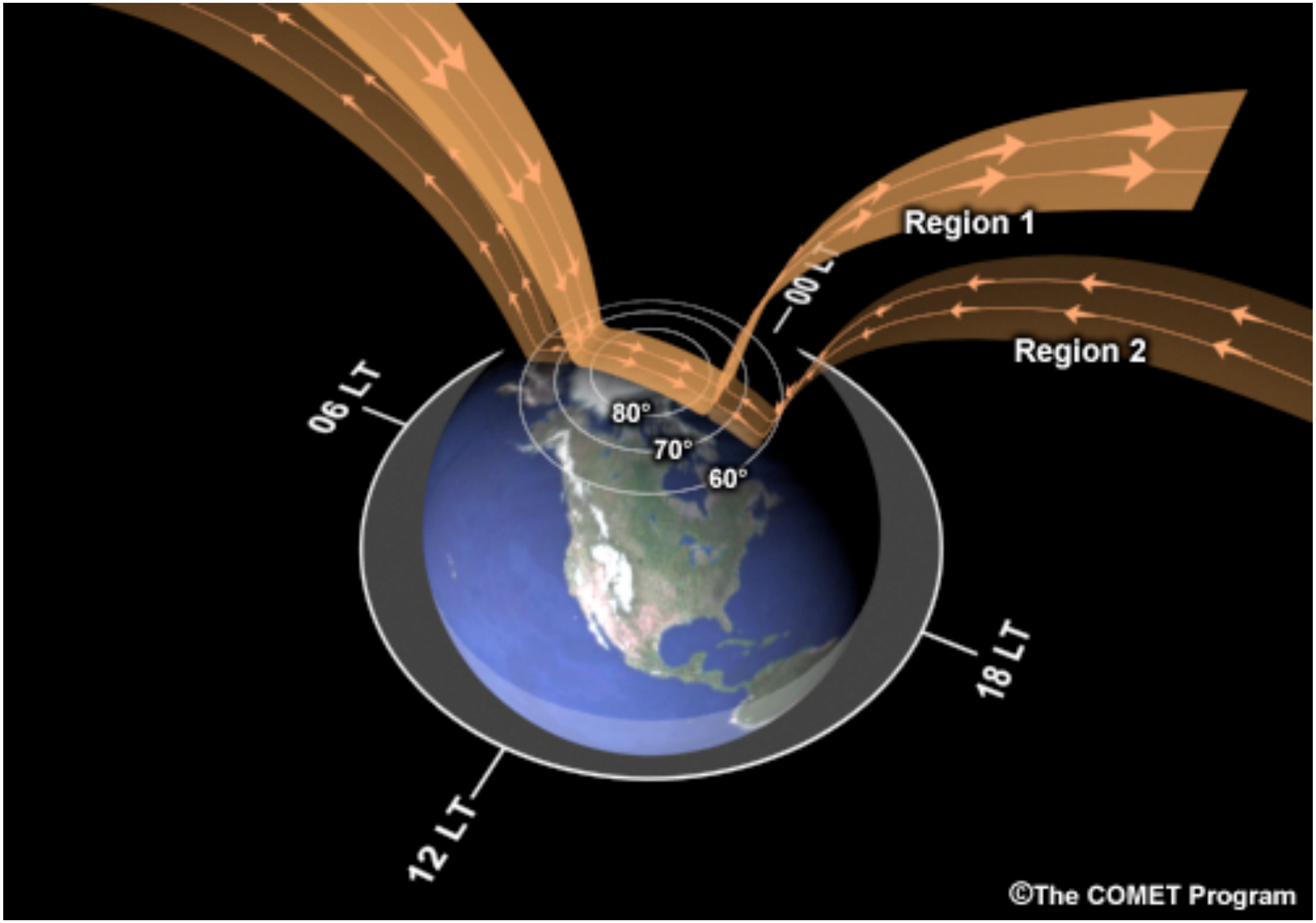
Region 1 Current – Convection of the fieldlines




Chapman-Ferraro Current
Magnetopause
$\mathbf{v} = \frac{\mathbf{E} \times \mathbf{B}_z}{B^2}$
Cross-tail Current
J = σ E


Region 2 currents
+
+
+
+
-
-
-
-
-
LLBL (lower magnetopause)
ions
electrons
∇B and Curvature

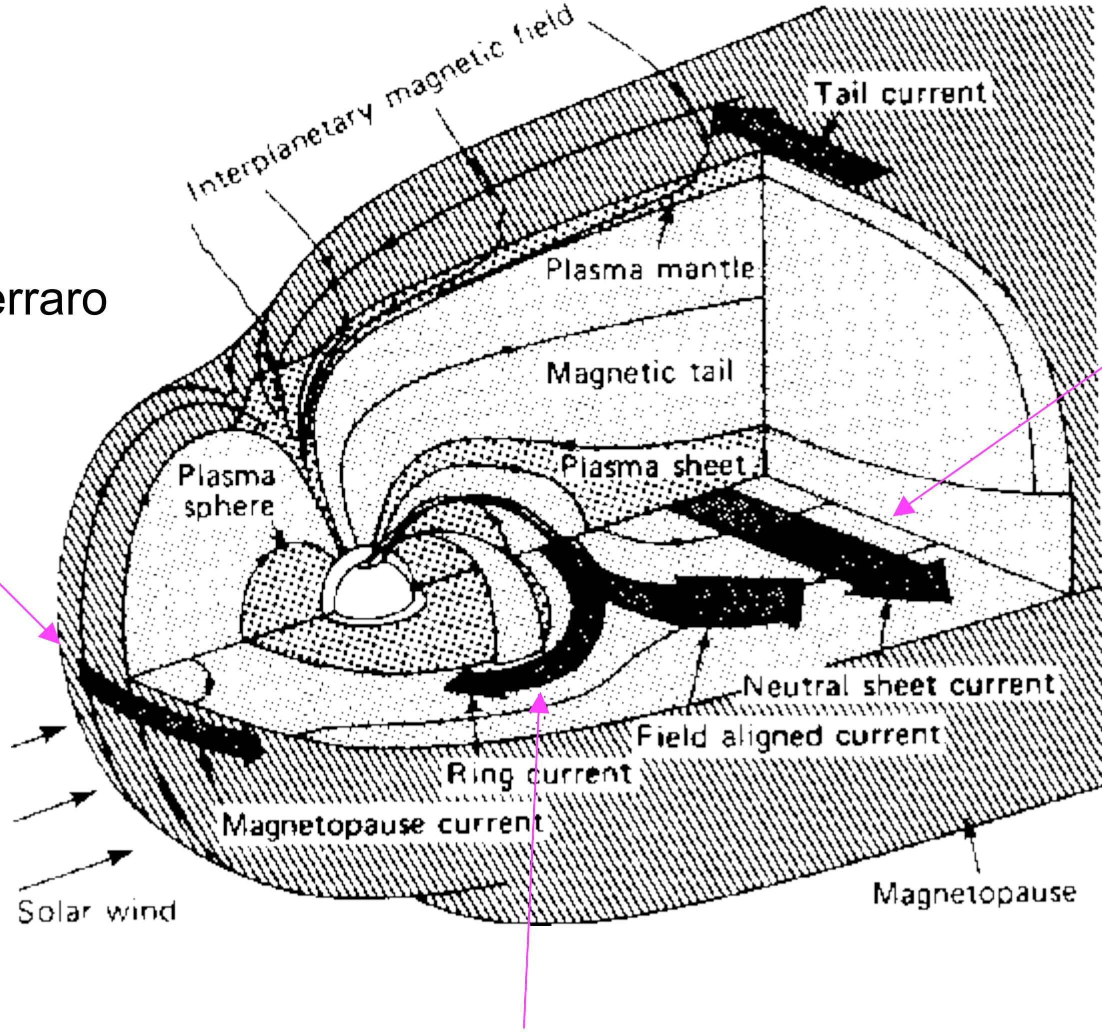

N
Night
S
Region 2
Region 1



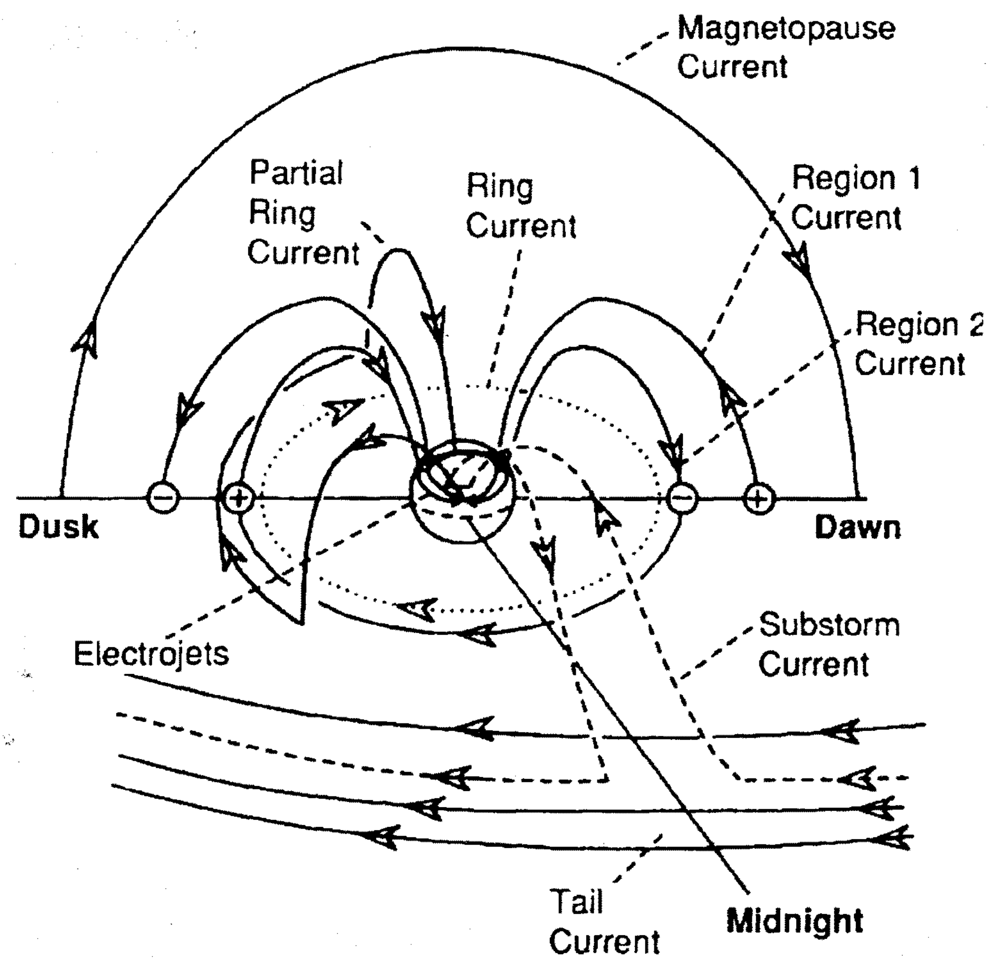
Region 1
Region 2
00 LT
06 LT
12 LT
18 LT
80°
70°
60°
©The COMET Program

Chapman-Ferraro Current

Current Sheet Electric Field



Gradient and Curvature Drifts


Magnetopause
Current
Partial
Ring
Current
Ring
Current
Region 1
Current
Region 2
Current
Dusk
Dawn
Electrojets
Substorm
Current
Tail
Current
Midnight