Basic Plasma Phenomena

- $e\Phi/kT$ very small
- Kinetic temperature/Maxwellian distribution
- Thermal Equilibrium/ Average energy = (3/2)kT (3-D)
- Screening $\Phi = \Phi_o e^{|x|/\lambda_D}$ Debye Length

$$\lambda_D = \left(\frac{\varepsilon_o k T_e}{n e^2}\right)^{1/2}$$

- Plasma Response time/plasma frequency

$$\omega_p^2 = ne^2/m\varepsilon_o$$

- Lorentz transformation

$$\vec{E}'_{||} = \vec{E}_{||} \quad \text{while} \quad \vec{E}_{perp} = \gamma\,(\vec{E}_{perp} + \vec{v}\times\vec{B})$$

$$\vec{B}'_{||} = \vec{B}_{||}\ , \text{while} \quad \vec{B}'_{perp} = \gamma\,(\vec{B}_{perp} - \frac{1}{c^2}\vec{v}\times\vec{E}\ )$$

- Dipole field equation $|B| \sim 1/r^3$ *trig fn.
- equation of a field line $r = r_o \cos^2\lambda$

Guiding Center motion

- Gyroradius, gyrofrequency $\boldsymbol{\Omega} = -q\boldsymbol{B}/m$
- Guiding center equation:

$$\langle \bar{V}_G \rangle = \bar{v}_{\parallel} + \underset{\uparrow\ \text{ExB term}}{\bar{V}_B} + \underbrace{\frac{\bar{B}}{eB^2} \times \mu \bar{\nabla} B}_{\text{Gradient Drift}} + \underbrace{\frac{p_{\parallel} v_{\parallel}}{e} \frac{\bar{B} \times (\bar{B} \cdot \bar{\nabla}) \bar{B}}{B^4}}_{\text{Curvature Drift}}$$

- Gyration, bouce, drift
- Drift velocity $\boldsymbol{V_D} = \boldsymbol{F} \times \boldsymbol{B}/(qB^2)$
- $\boldsymbol{F} = -\mu \nabla \boldsymbol{B}$
- Adiabatic Invariants

- Bounce Motion (parallel motion)
- Constancy of $\mu = \frac{m v_\perp^2}{2B}$
- Magnetic bottle, Pitch angle, mirror point

$$B_m = \frac{B_0}{\sin^2 \alpha_0}$$

- Longitudinal Drift

$$V_G = \frac{\bar{B} \times \nabla \bar{B}}{e B^3} \left(\varepsilon_\perp + 2 \varepsilon_\parallel \right)$$

Polarization Drift

$$\bar{V}_p = \frac{m}{qB^2}\frac{\partial \bar{E}}{\partial t}$$

Radial Diffusion

(Grad-B drifting particles experience a cross-magnetosphere Electric field which varies at the Drift Period)

Corotation of the Plasmasphere

(The inner magnetosphere rotates once/day because of the conducting, magnetized, rotating ionosphere generating an electric field which gives just the right the ExB drift)

Alfven Shielding Layer

(Energetic particles, approaching from the magnetotail, make a partial ring current, leaving predominantly positive charge on the Dusk side, and Negative charge on the Dawn side)

Collective Plasma Phenomena

- Liouville's equation

$$\frac{df}{dt} = \frac{\partial f}{\partial t} + \bar{v} \cdot \nabla f + \frac{\vec{F}}{m} \cdot \nabla_v f = 0$$

- Vlasov or Collisionless Boltzman Equation

$$\boxed{\frac{\partial f}{\partial t} + \bar{v} \cdot \bar{\nabla} f + \frac{Ze}{m} \left(\vec{E} + \bar{v} \times \bar{B} \right) \cdot \bar{\nabla}_v f = 0}$$

- Moment equations (continuity, Force (or momentum) and Energy Eqtn

MHD

- Formal Derivations of equations
- Pressure tensor, Magnetization current

$$\bar{J}_m = \bar{\nabla} \times \bar{M}$$

- Approximations for MHD
- Maxwell stress tensor, Poynting's Theorem
- Closure of the moment equations: equation of state

  (assumptions?) d/dt ($\dfrac{P}{\rho^{5/3}}$) =0

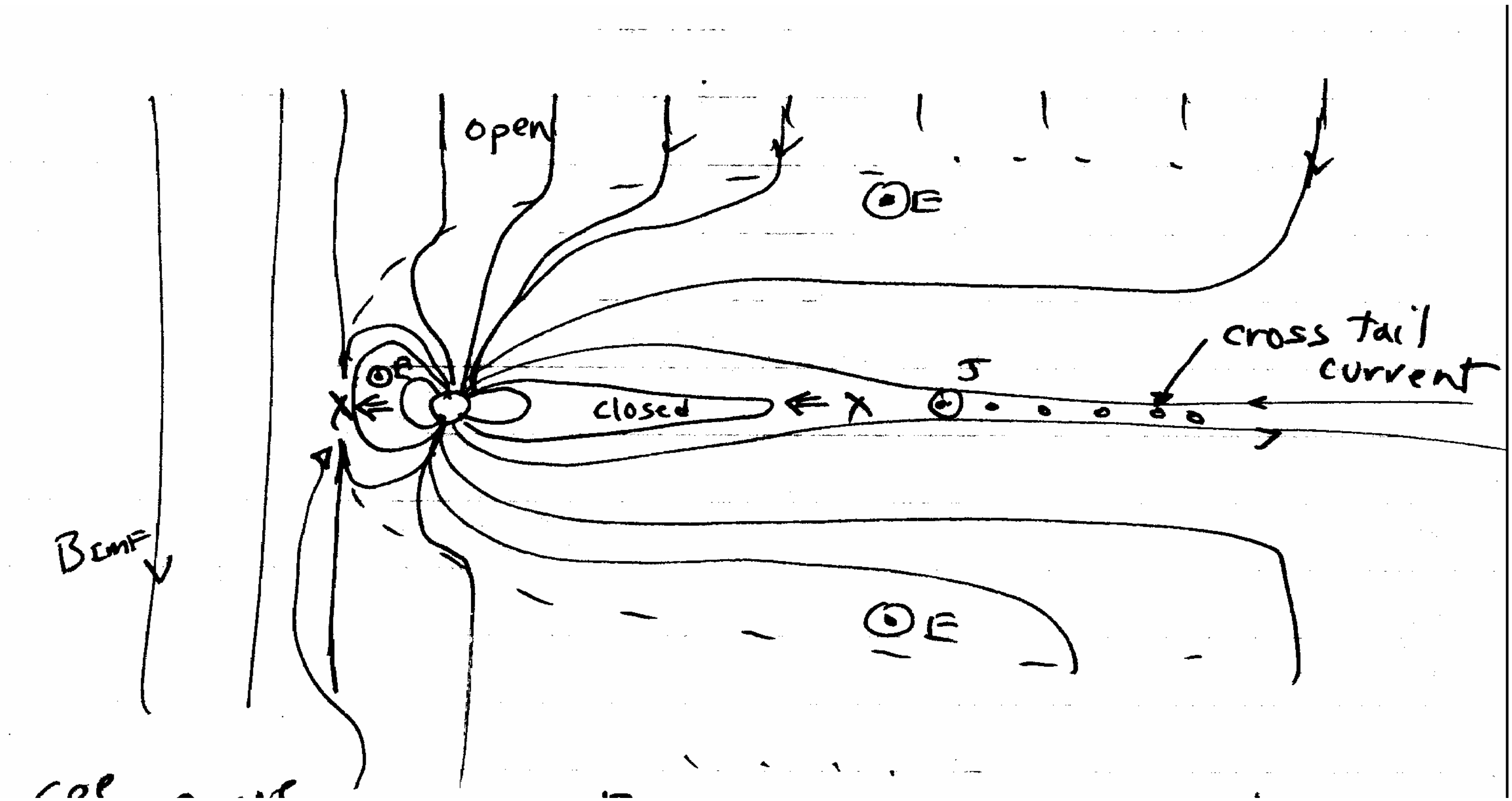
- Field line motion

$$\frac{\partial \bar{B}}{\partial t} = \nabla \times (\bar{V} \times \bar{B}) + \frac{1}{\mu_0 \sigma} \nabla^2 \vec{B}$$

- Frozen in condition

$$\bar{V} = \frac{\bar{E} \times \bar{B}}{B^2}$$

Ionosphere/Magnetosphere reconection, field aligned currents Ionosphere conductivity



Wave Intro

- Dialectric Tensor
- Electrostatic waves ($d\boldsymbol{B}/dt = 0$)

(so $E = -\nabla\Phi$, or $\nabla^2 \Phi = -\rho/\varepsilon_o$) (Poisson's Eqtn)

- Alfven waves