Solar Physics 2010: Exercises to Lecture 11
Due Date: 15 June 2010 at 09:00

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1 Electric and magnetic energy densities

Show that the electric energy density is completely dominated by the magnetic energy density for non-relativistic plasmas. Hint: the electric energy density is given by $\epsilon_0 E^2$ and the magnetic energy density is given by $\frac{B^2}{2\mu_0}$. Use $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ to relate the magnitude of the two fields.

2 Stix Problem 8.1: Displacement Current

Give an estimate of the displacement current, which was neglected.

3 Stix Problem 8.3: Frozen Field

Use the equation of continuity to show that for a frozen field the equation

$$\frac{\mathrm{d}}{\mathrm{dt}}\left(\frac{\vec{B}}{\rho}\right) = \left(\frac{\vec{B}}{\rho}\cdot\nabla\right)\vec{v} \tag{1}$$

holds, a result first derived in 1946 by C. Walén.

4 Stix Problem 8.4: Induction Equation

A velocity field $\vec{v} = (-\alpha x, -\alpha y, 2\alpha z)$ with $\alpha > 0$ is given. Find the steady solution of the induction equation (with constant η) under the assumption that $\vec{B}$ points into the z-direction. What is the central field strength of the flux tube generated by the converging flow if the total flux is given? Calculate the radius of the circle that encloses 90% of the flux (Moffatt, 1978).