

Solar Physics, Exercise 5

19 April 2011 at 12–14 in D106

Submit by 15 April 2011 noon

1. Show that the losses of mass and angular momentum for the Sun are connected by a relation

$$\frac{dJ}{dt} = \frac{2}{3} r_A^2 \Omega \frac{dm}{dt}.$$

Calculate the rate of the loss of angular momentum for the present Sun and estimate the time needed for stopping the solar rotation at this rate. How much more efficient is the magnetic braking for the Alfvén radius $r_A = 12 r_\odot$ than for the radius r_\odot ?

2. Consider the dynamo equation

$$\frac{\partial \langle \mathbf{B} \rangle}{\partial t} = \nabla \times (\langle \mathbf{v} \rangle \times \langle \mathbf{B} \rangle + \alpha \langle \mathbf{B} \rangle - \eta_t \nabla \times \langle \mathbf{B} \rangle).$$

Set $\langle \mathbf{v} \rangle = 0$ (pure α effect) and assume that $\langle \mathbf{B} \rangle$ represents a force-free solution of the equation. What is the condition for exponential growth of the magnitude of $\langle \mathbf{B} \rangle$?

3. Find out (Google!) and explain how the Zeeman effect is used to measure the photospheric magnetic fields and their directions.
4. Assume that the magnetic field in the upper half space, $z > 0$, can be given as a potential field. Assume that the vertical component of the magnetic field, B_z , is measured at $z = 0$, and show that the potential in the upper half space is given by

$$\Phi(\mathbf{r}) = \frac{1}{2\pi} \int_{z'=0} \frac{B_z(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dx' dy'.$$