

## Planetary Magnetospheres - Problems

### 1 – What if...?

- A. How would the magnetosphere change if you moved the Earth to 10 AU?
- B. What would happen if you doubled Earth's dipole magnetic field strength? Keeping Earth at 1 AU
- C. What would happen if Earth spun x3 faster? i.e. 1 day = 8 hours?
- D. What would happen to the magnetosphere if you moved Jupiter to 0.1 AU?

### 2 - Order of Magnitude Estimates

- A. Information is transferred along magnetic field lines by Alfvén waves. Estimate the time an Alfvén wave takes to “tell” the ionosphere that reconnection has happened on the dayside magnetopause. Do this for both Earth and either Mercury or Jupiter.
- B. A fluxtube reconnects on the dayside magnetopause. Estimate the time it takes the end of the fluxtube that is in the magnetosheath to travel from the dayside magnetopause to the distance of the X-line in the magnetotail – say, 5  $R_M$  for Mercury, 100  $R_E$  for Earth, 200  $R_J$  for Jupiter.
- C. The other end of the above recently-reconnected fluxtube is in the ionosphere. If the ionospheric end of the fluxtube traverses the polar cap in the same time as the “free” end traverses down the tail to the X-line, what sort of speed is implied for the anti-sunward flow in the ionosphere? Again, both Earth and either Mercury or Jupiter, please.

### 3 - Length of Magnetotail

The polar cap is the region of open field lines – lines that are attached to the Earth at one end and are swept along by the solar wind at the other. Observations at high latitudes suggest that the Earth's polar cap boundary is at the magnetic latitude of about  $78^\circ$

- A. What is the total magnetic flux through the Earth's polar cap?
- B. What is the total magnetic flux through the region of open field lines on the magnetopause?
- C. Making some simple assumptions, calculate the area of the region of open field lines on the magnetopause.
- D. Observations of the ionosphere indicated that there is a total potential drop of about 65kV. Estimate the width of the region of open field lines on the magnetopause.
- E. Now estimate the length of the magnetotail.
- F. The distance to the Moon is 60  $R_E$ . How does this compare with the length of the magnetotail? How often does the Moon spend in the magnetotail?
- G. Estimate the fraction of the whole magnetopause that is threaded by open field lines.

### 4 – Getting a feel for the Earth's magnetic field

- A. How fast are the flows in the Earth's geodynamo? Could you walk/run/drive that speed?
- B. How fast is the Earth's north pole moving? Or south – are they the same? Could you walk/run/drive that speed?
- C. How much stronger/weaker is the field at the top of the Earth's core than the surface?