Exercises for Space Plasma Physics: II. Solar System Plasmas

1. How is a magnetosphere created?

2. What are magnetic storms and substorms?

3. Describe the physical mechanism, how a magnetic storm can destroy transformators. Would a large magnetic storm cause more harm in USA or in Europe? Are large magnetic storms now (year 2012) more or less likely than some five years ago?

4. In auroras we often see red light in high attitudes and green light lower down. Why? Hint: For oxygen it takes less than a second to emit green light, but stays up to about two minutes in excited state before it emits red.

5. Auroras occur in the so called Auroral oval. Why not over the poles? And why do auroral like emissions occur at the poles in laboratory experiments with a terella?

6. Are typical solar-system plasmas like magnetospheres and the solar corona thermodynamic equilibrium? Are they in force-equilibrium?

7. Show that Maxwell's $\nabla \cdot \vec{B}$ and $\nabla \cdot \vec{E}$ equations can be seen (used) as initial condition. If the divergence equations are fulfilled at an initial time, the other two (evolutionary) Maxwell equations ensure that these conditions are fulfilled for all times.

8. Use the electromagnetic potentials

$$\begin{aligned} \vec{B} &= \nabla \times \vec{A} \\ \vec{E} &= -\nabla\vec{\Phi} - \frac{\partial \vec{A}}{\partial t} \\ \nabla \cdot \vec{A} &= -\frac{1}{c^2}\frac{\partial \mathbf{\Phi}}{\partial t} \quad \text{(Lorenz Gauge)} \end{aligned}$$

   to derive wave equations for the potentials from Maxwell equations. How can one obtain the charge density and electric current density in a plasma?