PHYS6004 exam report 2013-14

The most common problems in the exam are described here.

A1. The induction equation was often quoted without the rate of change of B, in other words, not an equation at all. In the case of the thin current sheet, one implication of the small R_M is that reconnection is possible in this region, where diffusion dominates.

A2. Calculation the gyro radius and period was mostly correct, with a few problems with units for angular frequency, hence confusing a factor of 2π. Betatron acceleration – or adiabatic heating – was the process to be explained for the increase in energy of the proton.

A3. The power incident on the Earth's magnetic field from the solar wind should have been several orders of magnitude smaller than the total solar irradiance. Most answers tackled it in a very logical way and many were of the right order (10^{14} W). A difference between the two is that the energy from the solar wind is mostly diverted around the field, with only 2% entering when reconnection events occur with the interplanetary magnetic field.

A4. The Parker spiral question required the use the frame of reference fixed on the Sun. This frame should have been mentioned or explained, which it wasn't in all answers.

B1. The definition of a plasma was mostly answered well for three marks. However, the question to find the components of the bulk plasma velocity caused problems. The definition is clearly explained in notes, and was derived in lectures. In fact a very similar problem to this one was done in detail in a lecture towards the end of the course. The bulk plasma velocity requires the mass density for both ions and electrons, as it is actually the centre-of-mass velocity.

Simple definitions of parameters that were used in several problem sheet examples sometimes caused problems e.g. pitch angle, which is the angle between two vectors, $\underline{V}$ and $\underline{B}$, so a simple diagram would have been a good idea (many did so). The L-value was another that sometimes confused , but it has been used in many examples, both on sheets and in groupwork exercises. My advice to do all the set problems stands!

B2. Reconnection answer should have involved a diagram of the process containing the general features of magnetic fields, inflow and outflow velocities, diffusion region, current sheet and mention of separatricies. Nobody (I think) remembered that there must be an electric field perpendicular to $\underline{B}$ for the frozen-in condition to apply outside the diffusion region. For full marks it was not enough to describe purely the process of reconnection in the magnetosphere.

The question on the reconnection efficiency in the magnetosphere caused some trouble. The electric field needed to be calculated to obtain the voltage across the Stern gap, and also the whole magnetosphere.

To calculate the area of the polar cap, it was necessary to consider the flux through the area of the open field lines, which is equal to the flux in the polar cap.

B3. The plasma beta question was mostly answered very well, but a few did not understand that in the solar wind it is the dynamic pressure that dominates, not the thermal pressure.