

ASSIGNMENT 2, TFY4240 ELECTROMAGNETIC THEORY MIDTERM PROJECT, FALL 2014

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You are out walking at night with your mother during your christmas holiday. Suddenly, you are awed by the appearance of a beautiful display of aurora borealis above your heads. Your mother asks you what the aurora is—after all, you should know, being a physicist. You wave your hands and tell her about charged particles. When she asks you how these charged particles actually move around, you are embarrassed: you have no idea! However, you quickly come up with a plan:

- (1) Model the Earth as a sphere with a magnetic dipole embedded at its centre (remember that the direction of the magnetic dipole is tilted with regard to the ecliptic). Plot the magnetic field in at least 2 of the 3 planes through the origin: the xy and xz planes. Choose the x axis from the Sun toward the Earth and the z axis perpendicular to the ecliptic.
- (2) Model the solar wind as charged particles (e.g. protons) coming in with (initially) constant velocity along the x axis. Experiment with different velocities to get a feeling for the effect of the magnetic field on the particles. Use the simple Euler's method¹ to solve the equation of motion in 3 dimensions.
- (3) Find a test condition to estimate the accuracy of your numerical solution.²
- (4) To save your results for later analysis, write the final particle trajectories for different initial conditions to one or several text files.³
- (5) Load some of those files⁴ and make some beautiful curve plots showing a projection of the particles' trajectory into your choice of the xy , xz , and yz planes (or any other convenient plane). (It is also possible to make 3D plots, but this is not a requirement. Often, such plots are very difficult to read on paper.)

¹Euler's method is described in some detail here: http://en.wikipedia.org/wiki/Euler_method

²Hint: magnetic fields do no work! See Griffiths, Eq. 5.11.

³Hint: <http://tinyurl.com/284gwez>

⁴Hint: <http://tinyurl.com/2dq9spn>