EF2200 Plasma Physics, 2011

Home Assignment

To be submitted electronically by 2359 of 120914 to nickolay@kth.se

The codes for this home assignment are available at:
http://www.pdc.kth.se/education/computational-plasma-physics/computational-plasma-physics

1. (1.0 Point) Run TrajMagnDipole.m code with a proton, starting from $x_0 = 4 \, R_e$, $y_0 = 0$, $z_0 = 0$ and pitch angle $30^\circ$ for a $t_{\text{fin}} = 200 \, s$ for two cases:
   - 10 Mev
   - 0.1 Mev

For the two cases:
   - Plot the 3D trajectory.
   - Plot the trajectory in the $(x,y)$ plane.
   - Plot the $z$ particle coordinate against the time.

In addition:
   - Describe the differences between the two cases. How do the bounce and drift periods change depending the proton energy? What is the physical reason for these differences?

2. (1.0 Point) Try to run TrajMagnDipole.m with a 0.1 MeV electron and pitch angle $30^\circ$ for a $t_{\text{fin}} = 200s$. This is a stiff numerical problem and the ODE solver will require a very high number of iterations (or sub-time-stepping).
   - Why to calculate the electron trajectory is more difficult than compute the proton trajectory in the same simulation set-up? What is the physical reason?
   - Is there a solution to remove this difficulty?

Run GC_TrajMagnDipole.m with a 0.1 MeV electron starting from $x_0 = 4 \, R_e$, $y_0 = 0$, $z_0 = 0$ and pitch angle $30^\circ$ for a $t_{\text{fin}} = 200s$.

Once your simulation is complete:
   - Plot the 3D trajectory.
   - Plot the trajectory in the $(x,y)$ plane.
   - Plot the $z$ particle coordinate against the time.

In addition:
   - Describe the differences between the 0.1 MeV proton (exercise 1) and electron (GC_TrajMagnDipole.m) cases. What are the physical reasons for these differences?
3. (1.0 Point) Run TrajMagnDipole.m with a proton with 10 MeV and pitch angle close to 90° (pitch_angle = 0 in your TrajMagnDipole.m) for a simulation period (tfin) of 50 s. This is a stiff numerical problem and the ODE solver might require many iterations (or sub-time-stepping). For this problem:
   - Plot the z particle coordinate against the time and evaluate approximately the bounce period.
   - Compare with the analytical result provided in the previous lecture and in the slide presentation.

**Bonus Points. (0.5 Point)** Write a Matlab/Octave function to evaluate the magnetic moment, and plot it against time for TrajMagnDipole.m (10 MeV proton, starting from \( x_0 = 4 \) \( R_e \), \( y_0 = 0 \), \( z_0 = 0 \) and pitch angle 30° for a tfin = 50s).