EF2200 Plasma Physics, 2014

Home Assignment

To be submitted electronically by Sept. 26 2014 to markidis@pdc.kth.se

The codes for this home assignment are available at:

http://www.pdc.kth.se/education/computational-plasma-physics/computational-plasma-physics/

1. **(0.1 Point)** Run `GradBdrift.m` code with the given set-up for two cases:
   - $x_0 = 0.1$, $u_0 = 0.3$, $t_{\text{fin}} = 50$
   - $x_0 = 0.1$, $u_0 = 0.01$, $t_{\text{fin}} = 400$

   For the two cases:
   - Plot the trajectory
   - Calculate the initial Larmor radius.

   In addition, describe the difference between the two cases.

2. **(0.2 Point)** Run `TrajMagnDipole.m` code with a proton, starting from $x_0 = 4 \text{ R}_e$, $y_0 = 0.0$, $z_0 = 0.0$ and pitch angle $30^\circ$ for a $t_{\text{fin}} = 200$ s for two cases:
   - 10 MeV
   - 0.1 MeV

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

   In addition, describe the difference between the two cases. How the bounce and drifts periods change depending on the proton energy? What is the physical reason for these differences?

3. **(0.3 Point)** Run `TrajMagnDipole.m` with a 0.1 MeV electron and pitch angle $30^\circ$ for a $t_{\text{fin}} = 200$ s. This is a stiff numerical problem and the ODE solver will require a very high number of iterations (or sub-time-stepping). Answer these questions:
   - 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 $x_0 = 4 \text{ Re}$, $y_0 = 0$, $z_0 = 0$ and pitch angle $30^\circ$ for a $t_{\text{fin}} = 200\text{s}$.

Once the simulation is complete:

- Plot the 3D trajectory
- Plot the trajectory in the (x,y) plane
- Plot the z-coordinate of the trajectory against 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?

4. **(0.4 Point)** Run `TrajMagnDipole.m` with a proton with 10 MeV and pitch angle close to $90^\circ$ for a simulation period ($t_{\text{fin}}$) of 50 s. This is a stiff numerical problem and the ODE solver will require a very high number of iterations (or sub-time-stepping).

For this problem:

- Plot the z-coordinate of the trajectory against time and evaluate approximately the bounce period
- Compare the results with the analytical result provided in the previous lecture and in the slide presentation

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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 $x_0 = 4 \text{ Re}$, $y_0 = 0$, $z_0 = 0$ and pitch angle $30^\circ$ for a $t_{\text{fin}} = 50\text{s}$).