Computational assignment 2

In this assignment your task is to write an orbit-following code for solving the trajectory of a charged particle in a magnetic field. You should implement the equations of motion for both the full gyro motion

$$\dot{\boldsymbol{x}} = \boldsymbol{v} \tag{1}$$

$$\dot{\boldsymbol{v}} = \frac{q}{m}\boldsymbol{v} \times \boldsymbol{B} \tag{2}$$

and the guiding center (lecture notes equations (100-102)).

For the magnetic field, you can use a simple analytic representation of a tokamak-like geometry with toroidal and poloidal magnetic fields in cylindrical coordinates:

$$\boldsymbol{B} = \frac{1}{R}\nabla\Psi \times \hat{e}_\phi + \frac{F}{R}\hat{e}_\phi \tag{3}$$

$$\Psi(R, z) = (R - R_0)^2 + z^2 \tag{4}$$

$$F = R_0 B_{\phi 0} \tag{5}$$

To calculate the trajectory you should integrate the equations of motion in time using a reasonably high-order Runge Kutta method (such as ode45 in Matlab). If done correctly, you should get orbits in the poloidal plane that close on themselves. Check your implementation by comparing the guiding center and gyro orbit trajectories for the same initial conditions and checking the convergence of the solution with varying time steps.

Then explore different orbit topologies by launching test particles with varying initial positions and velocities. In your report you should describe your implementation (include the source code) and present your results. Also discuss the computation time and efficiency of the two methods.