Introduction to Nuclear Fusion as An Energy Source - Homework 1

2026/4/23

Due date: 2026/5/7

Note: Please provide the results, the description of your code and simulation results. Any programming language is allowed.

There is a spherical tokamak with a major radius $R = 45$ cm, a minor radius $a = 32$ cm, and an elongation of $\kappa = 2$. The toroidal field $B_{\mathrm{T}} = 0.1$ T at 45 cm. The plasma current $I_{\mathrm{p}} = 100$ kA at $R = 45$ cm. A **proton** with an energy of 1 keV. Initial position at $R = 55$ cm, $Z = 0$ cm. Please write a code for simulating the trajectories of the protons, the trajectories of the guiding center in the following conditions. Please plot the trajectories in (1) 3D; (2) project to poloidal plane; (3) project to x-y plane, i.e., top view. If particles are trapped, please show the return points. **Explanation of the result is required!**

1. [10 points] Initial pitch angle = 0°, i.e., the initial velocity is parallel to the magnetic field at the initial point.
2. [10 points] Initial pitch angle = 15°, i.e., the angle between the initial velocity and the magnetic field is 15° at the initial point.
3. [10 points] Initial pitch angle = 30°, i.e., the angle between the initial velocity and the magnetic field is 30° at the initial point.
4. [10 points] Initial pitch angle = 45°, i.e., the angle between the initial velocity and the magnetic field is 45° at the initial point.
5. [10 points] Initial pitch angle = 60°, i.e., the angle between the initial velocity and the magnetic field is 60° at the initial point.
6. [10 points] Initial pitch angle = 75°, i.e., the angle between the initial velocity and the magnetic field is 75° at the initial point.
7. [10 points] Initial pitch angle = 90°, i.e., the initial velocity is perpendicular to the magnetic field at the initial point.