*User's Guide for **S**ingle **Par**ticle **Mo**tion **S**imulation - **S_PARMOS***

1. Included files:
The Single Particle Simulation package consists 11 files:

s_parmosM2.fig	gui interface
s_parmosM2.m	main m file
calculate_B.m	procedure for calcualting magnetic field
calculate_E.m	procedure for calcualting electric field
acceleration.m	procedure for calculating the particle acceleration
global_variables.m	table of all variables
initialization.m	initialize the virtual reality world
prepare_information.m	prepares information about the simulation parameters, like particle initial position, velocity, mass, charge, electric and magnetic field function... for the main simulation function
simulation_run.m	simulation loop
vectorParameters.m	calcualtes vector parameters for the force and velocity vectors the parameters are vector length, heigth, position, tip position....
sim1.wrl	vrml file for virtual world

2. Running the program:

All files should be copied to the same directory. When the user sets the »Current Directory« at Matlab to the directory where files are, the should type »s_parmosM2« in »Command Window«.
The programs starts and a new window (GUI window) is visible (figure 1).

Figure 1: Simulation window. The settings made are for a ExB drift demonstration.

3. Setting the simulation parameters:

The GUI window is divided into four parts: **Magnetic field**, **Electric field**, **Particle information, Simulation**.

In the Magnetic field and Electric field part, there is a pull-down menu, where the user can choose between different fields, like : field in z or x direction, exponentialy decreasing field, custom field…
Once field is chosen, user is asked to define parameters which define the field. For each field a comment is written in order to help the user with defining of parameters.

In the »Simulation« part of GUI, there are **two radio buttons for drawing trajectory and drawing guiding center**. If switched on, additional traces trajectory and guiding center are drawn during simulation.
The theoretical condition for defining guiding center is as follows:

- the particle larmour radius should be much smaller then the dimension in which magnetic field changes
  $abs(\rho_L \, d(\ln B)/dx) << 1$
- the cyclotron frequency should be much greater than the rate of magnetic field change in time
  $abs(1/\omega_B \, d(\ln B)/dt) << 1$

During simulation two vectors are drawn from the particle. A vector for particle velocity and a vector for particle acceleration. If the vectors appear of unappropriate length (too short or too long) the user can alter their length with two sliders at the »Simulation« part of GUI (the »**adjust force vector visualization**« slider and »**adjust velocity vector visualization**« slider).

4. Running the simulation:

After all parameters are set, the button »**Start simulation**« should be pressed and a window with viritual world is opened (figure 2).

Figure 2: A virtual reality world. Simulation is in progress. A ExB drift is shown. Electric field is paralel with x axis and magnetic field is paralel with z axis. Both are constant. Buttons for force vector, velocity vector, guiding center and particle trajectory are switched on.

The user can see field lines of magnetic (yellow) and electric field (blue, if set), a coordinate system and the particle with a force vector (magenta) and velocity vector (yellow). The simulation starts automatically.

During the simulation the user can switch on and off the particle trajectory and guiding center drawing. The simulation can also be paused with the »**Pause simulation**« button and then restared with »**Restart simulation**« button. The »**Go Start simulation**«, »**Pause simulation**« and »**Restart simulation**« buttons are one and the same.

5. Recomended way to use the simulation:

- select a magnetic field
- set the correct parameters (also time parameters) of the magnetic field (optional)
- select an electric field
- set the correct parameters (also time parameters) of the electric field (optional)
- set particle information parameters
- switch on/off gravitational field (in z direction)
- push »Show fields« or »Go Simulate!« button to inspect the fields or to start the simulation
- while simulation alter the »simulation« panel options
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Some aditional examples:

Figure 3: Torus magnetic field. The strength of the magnetic field is decreasing like 1/R.

Figure 4: Torus magnetic field with aditional poloidal field.