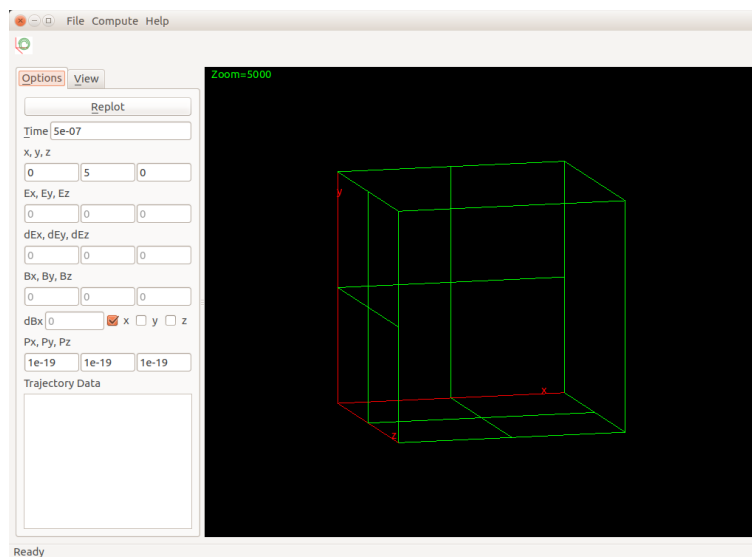


Trajecstory 0.4

User's Guide

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1. Introduction

Trajecstory is a program that plots trajectories of a single electron in electric and magnetic fields. In this version the fields are kept constant.

For students of Physics, the utility of such a program is immediately obvious, and no further explanation is required. For others, it has no utility, and further explanation is pointless.

2. The User Interface

The program window, shown above, consists of two parts. On the right is a window where the trajectory is plotted. When the program starts it shows the three Cartesian axes in red, on which is superimposed the outline of a green cube of dimensions 10 cm to a side. The rear, left and bottom faces are bisected by green lines, in order to help visualize the relative depth and distances.

On the left are two tabs. The “Options” tab contains the provision to input the initial conditions of the electron and the magnitude of the field components. The “View” tab contains controls to vary the size and orientation of the image which is displayed on the right.

The units and the physical quantity required to be entered is displayed when the mouse cursor hovers above any control.

Above these is a toolbar which contains one icon labeled “Compute trajectories”. Above the toolbar is a menu bar.

Inside any control, pressing the tab-key moves the cursor to the next control in the sequence.

The image displays two panels of the software's user interface. The left panel is the 'Options' tab, featuring a 'Replot' button and input fields for Time (5e-07), position (x,y,z = 0, 5, 0), electric field (Ex, Ey, Ez = 0, 0, 0), field variation (dEx, dEy, dEz = 0, 0, 0), magnetic field (Bx, By, Bz = 0, 0, 0), and dBx (0) with checkboxes for x, y, and z. The right panel is the 'View' tab, featuring a 'Reset' button, sliders for Rotate and Translate, a Zoom slider, and buttons for Background color and Trajectory color.

In the above, the electric field is in volts/cm, and the magnetic field is in Gauss.

E_{xyz} is the background electric field at the origin and everywhere else. The variation the electric field is specified by dE_{xyz} . This variation is also *per centimeter*. So, for example, if $E_x = 25$ volts/cm, and $dE_x = 10$, it indicates that the field increases by 10 volts/cm *every* cm, from the origin onwards. Thus it increases to 125 volts/cm at $x = 10$ cm, and correspondingly it has a negative value of -75 volts/cm at $x = -10$ cm.

The values B_{xyz} specify the magnetic field in Gauss at the origin at everyelse. The variation of the magnetic field, however, is implemented *only for the x-component of B*. Further, B_x can vary only along *one* of the x, y, or z directions. This is specified via the check-boxes to the right of the dBx input box.

As in the case for dE.xyz, if dB.x is 10, it indicates that the field increase by 10 gauss *every* cm. Thus if B.x = 25 gauss at the origin x=0, and the variation is also along the x-axis, then it increases to 125 gauss at x=10. If the variation is along the y-axis, however, B.x increases from 25 gauss at y=0 to 125 gauss at y=10.

3. The Main Menu

3.1 File

This menu item is a place holder and contains only two sub-items. “Save” for saving the computed trajectory and , “Exit”, which is used to exit the program.

3.2 Compute

This item contains one sub-item which provides the same function as the “Replot” button on the “Options” tab.

3.3 Help

This item enables the display of this help file, the license under which the program is distributed and information about the Qt-toolkit used to build the user interface.

4. Key Bindings

Some of the user-interface items in the program have keys bound to them, so that the action that is produced by the clicking of the left mouse button can be performed via the keyboard. Some or all of the following can be used on the tabs.

Menus:

File menu:

Alt-f : Pops down the File menu

Alt-f-s : Saves the last computed trajectory in a text file with the name “default.dat.trajectory”.

Alt-f-x : File-Exit. Also Alt-F4 will do the same.

Compute menu:

Alt-c : Pops down the Compute menu.

Alt-c-t : Compute the electron trajectory

Help menu:

Alt-h: Pops down the help menu.

Alt-h-h : Displays this PDF helpfile, which should in the same directory as the executable.

Alt-h-a : Displays information about the author, copyright and the GPL license.

Alt-h-q : Displays information about the Qt toolkit.

Options tab:

Alt-v : Switch to the View tab

Alt-r : Replot the trajectory

Alt-t ; Move the cursor to the Time control

Alt-g : Open a color selection dialog to change the background color of the trajectory window.

Alt-j : Open a color selection dialog to change the color of the trajectory

View tab:

Alt-o : Switch to the Options tab.

Alt-r : Redraw the view to the default setting.

5. Storage and Data

If you wish you can save the most recently computed trajectory to a text file. The file is named “default.dat.trajectory” and resides in the current working directory.

This name cannot be changed, and any existing file with this name will be overwritten every time the program saves a fresh trajectory.

The first line contains thirteen (!) numbers, comprising the electric and magnetic field data in the following sequence:

E.x, E.y, E.z, dE.x, dE.y, dE.z, B.x, B.y, B.z, dB.x, Across-X, Across-Y, Across-Z

In the above, the electric field is in volts/cm, and the magnetic field is in Gauss.

E.xyz is the background electric field at the origin and everywhere else.

The last three numbers (Across-xyz) are either 0 or 1. Of the three, *two* will *always* be 0. The third may be either 0 or 1. The number which is equal to 1 indicates that the x-component of the magnetic field varies along that direction.

After the first line, subsequently, there are as many lines as there are points in the trajectory. Each line contains five numbers representing one point of the trajectory, starting from the first point which is at time=0. The numbers are as follows:

SerialNo of the point (integer, starting from 0)

Time (seconds, starting from 0)

x-coordinate (centimeters)

y-coordinate (centimeters)

z-coordinate (centimeters)

There are 20000 lines in the file, one for each data point.

6 Availability, Compilation and Installation

Trajectory is available as source code to compile on your own machine, as well as a binary to install and use.

6.1 Compiling the source

In order to compile the source code, you need the Qt Software Development Kit and the GNU Scientific Library development files. These can be retrieved from the repositories of your Linux installation using the standard package manager which has been provided with your system. The Mesa (OpenGL alternative) development files are also required, as well as the standard C/C++ development tools.

The development libraries of Qt are also available from www.qt-project.org.

The GSL is also available from <https://www.gnu.org/software/gsl/>.

Untar and unzip the downloaded package with the command:

tar -zxvf tr-0.3-dist.tar.gz

This will create a sub-directory called `tr-0.3-dist`. If you are using QtCreator, which is an integrated development environment for Qt, the project file to load into QtCreator will be available in this location. Open QtCreator, and load the project file `tr.pro` which is available in the source package. Select the version you want to build (debug version or release version) and hit Ctrl-B. If there are no problems, this should build the binary.

The program has been compiled and tested on version 4.8.7 of Qt, on Ubuntu Linux 17.04. Ctrl-r executes the binary. The binary may be kept in directories separate from the source subdirectory, depending on how QtCreator is configured. This location will be available within QtCreator.

If you are not using QtCreator, then the Qt development libraries and the GNU Scientific Library (GSL) should be pre-installed on your system. Also required is the GNU C/C++ compiler and development files, as well as the "make" utility. Inside the subdirectory "`tr-0.3-dist`" is a Makefile, and running the "make" command should build the executable.

The location of the locally compiled binary will be available from within QtCreator. From this location you may like to copy the binary to another place so that everyone working on the computer can run it. In a terminal window, first become superuser:

```
su  
<type the root password>
```

Then change to the subdirectory containing the binary and do:

```
cp ./tr /usr/local/bin/tr
```

Copy the help file to the same location:

```
cp ./trhelp.pdf /usr/local/bin/trhelp.pdf
```

That's it.

6.2 Installing the binaries under Linux

If you don't want to compile the source yourself, a package containing the 64-bit precompiled binary of the program is also available. However, they require the Qt and GSL libraries at run-time, which are quite large and, since you can get them from the repositories for your installation of Linux, have not been included in the binary packages.

If the run-time libraries are not present on your installation you will need to download and install them from the standard repositories of your Linux distribution. This can be done using the package manager available on your system.

1. Download, untar and unzip the package with the command:

```
tar -zxvf tr-0.3-bin-amd64.tar.gz
```

This will create a subdirectory "`tr-0.3-bin-amd64`" called and extract all the files there. This contains the help file, the license and copyright info, and the executable.

2. Change to the newly created subdirectory:

```
cd tr-0.3-bin-amd64
```

3. Run the binary (you need to type the "dot-slash" before the name):

```
./tr
```

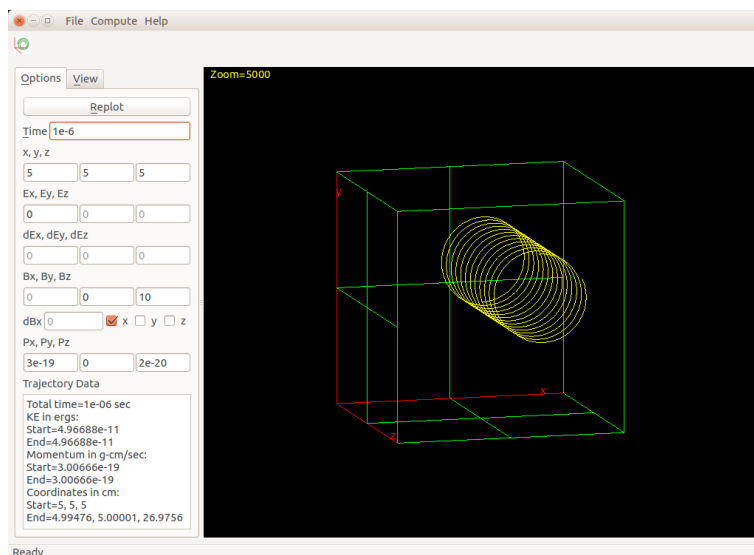
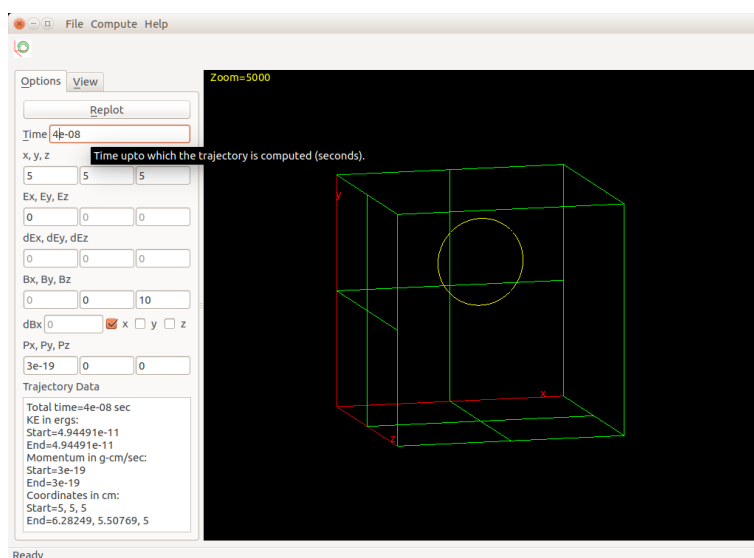
Remember that the precompiled binary requires the Qt and GSL run-time libraries. If these are not found there will be an error message to that effect when executing the binary. You should copy the binary to a place which is accessible to everyone working on the machine, as described in sec. 6.1 above.

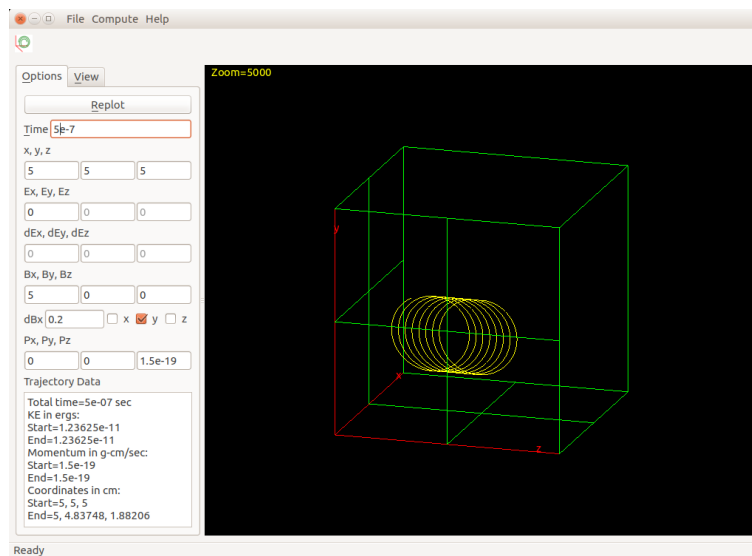
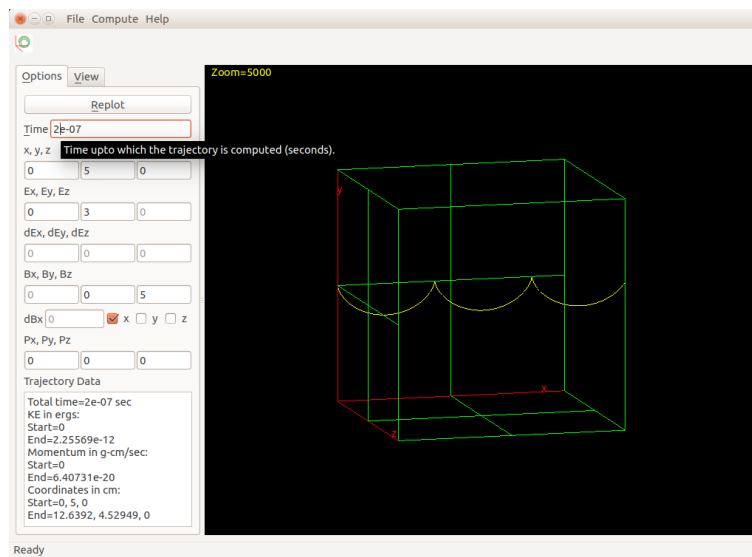
7. Units and Example Trajectories

The program uses *mixed* CGS units. The electric field is in *volts per centimeter*, the magnetic field is in *gauss*, the momentum is in *gram centimeter per second*, and position is in *centimeters*. As explained above the variation in the electric and magnetic fields is also *per centimeter*.

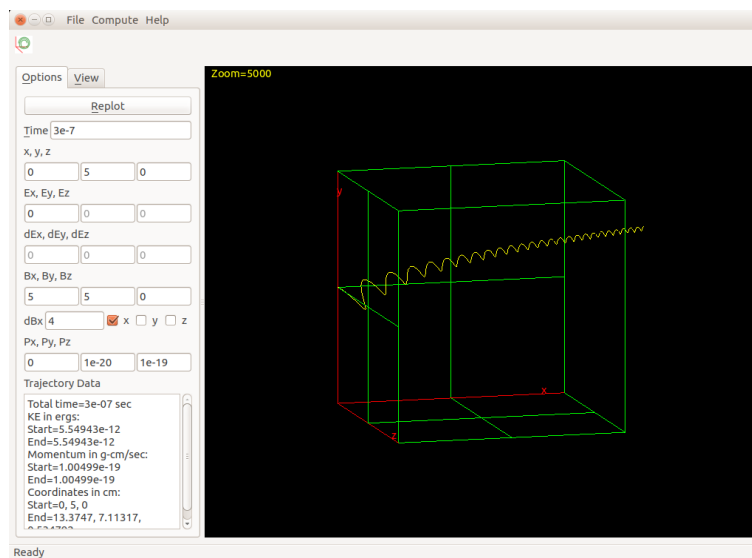
Here are some screenshots of the types of trajectories under different conditions. The picture contains the data used to generate the trajectory.

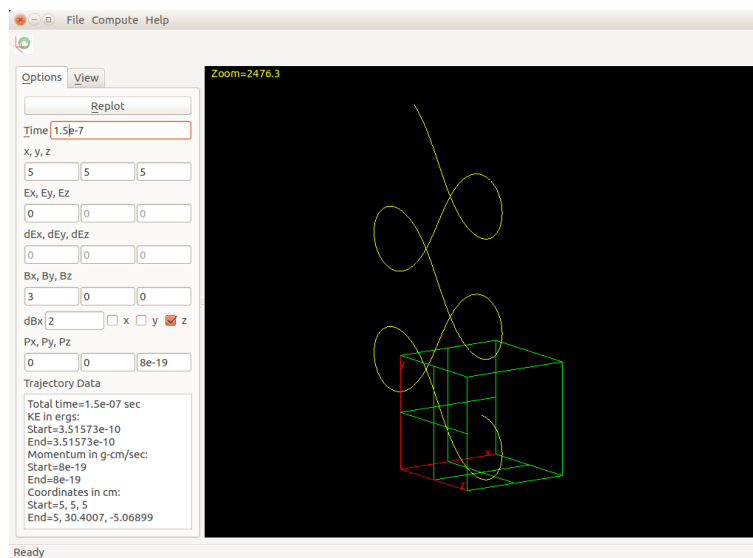
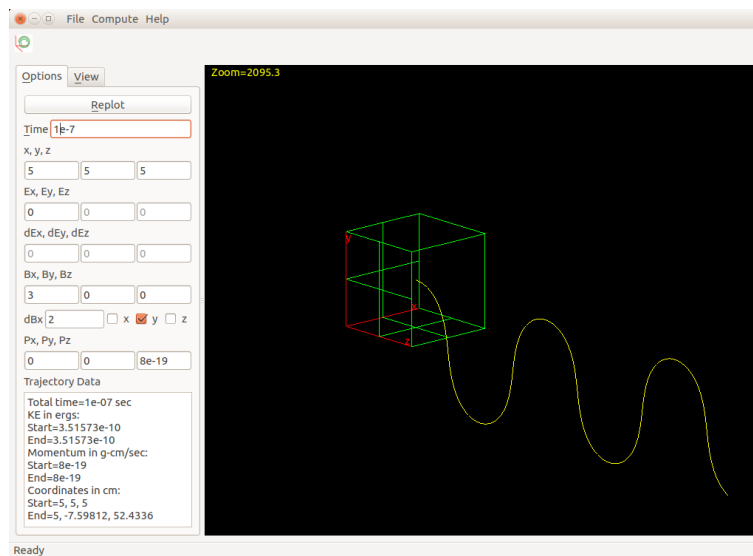
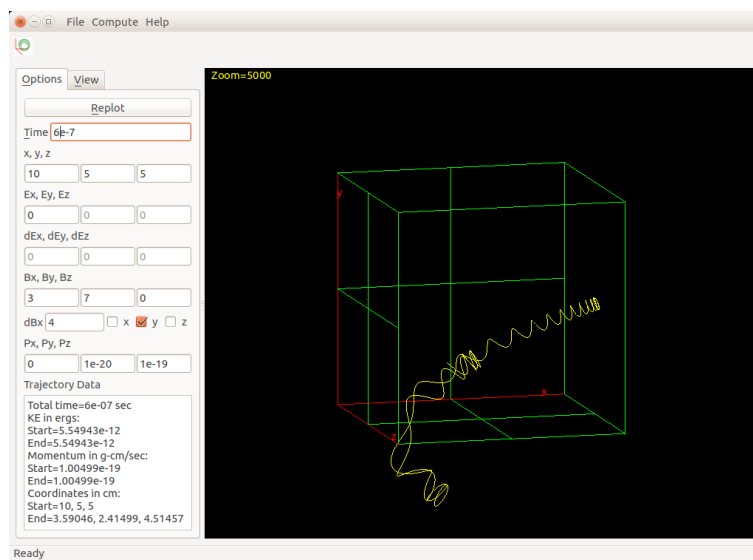
First the simple ones.





And then some complicated ones.





There are trajectories which are even more weird. Feel free to send me the craziest you can find.

8. License and copying policy

Trajecstory is Copyright, (c) Kartik Patel, and is released under the GNU General Public License, version 2 or later. Please read the COPYING file for detailed terms and condition of this license.

This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version. This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details. You should have received a copy of the GNU General Public License along with this program; if not, write to the Free Software Foundation, Inc., 675 Mass Ave, Cambridge, MA 02139, USA.

9. Contacting the author

Any feedback, bug reports, complaints, rants, abuses?

Please contact me at letapk@gmail.com

The latest version of this program will be available from: <http://kpatel.x10host.com>

That covers it, more or less. Email me if there is anything left out, or if you face any problems while compiling or installation.

Enjoy!