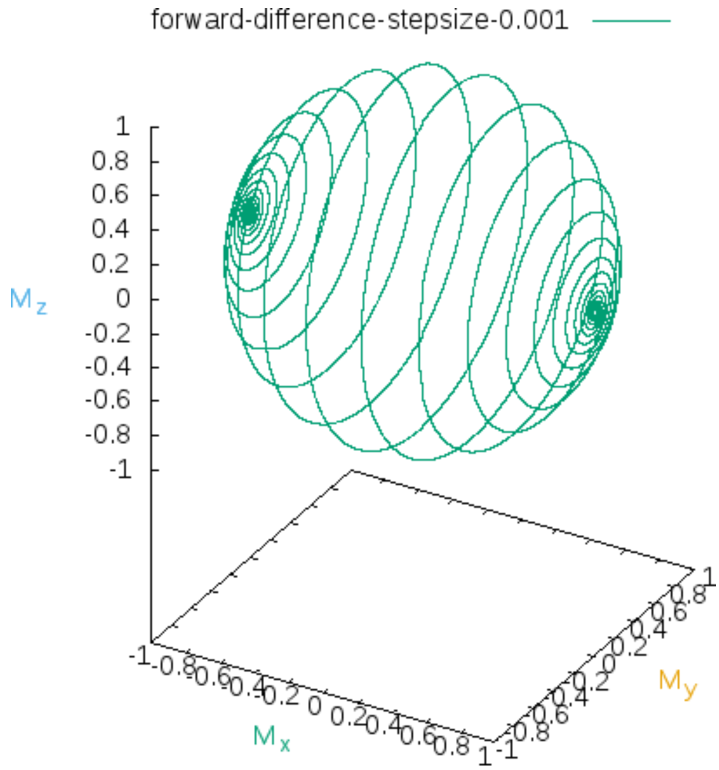
QUIZ 2

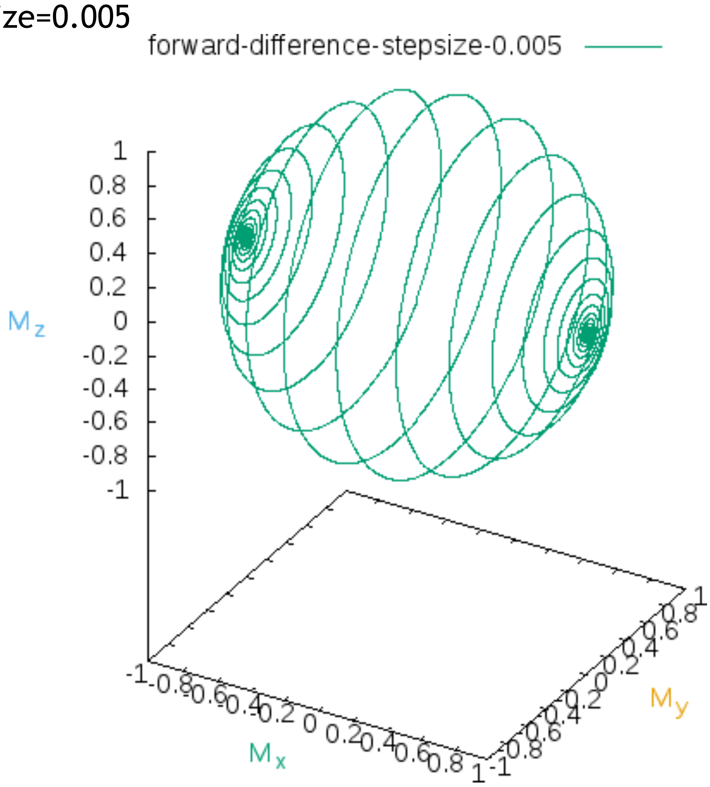
1. Forward Difference Method

By solving the differential equation using forward difference method for different stepsizes, we get the following graphs

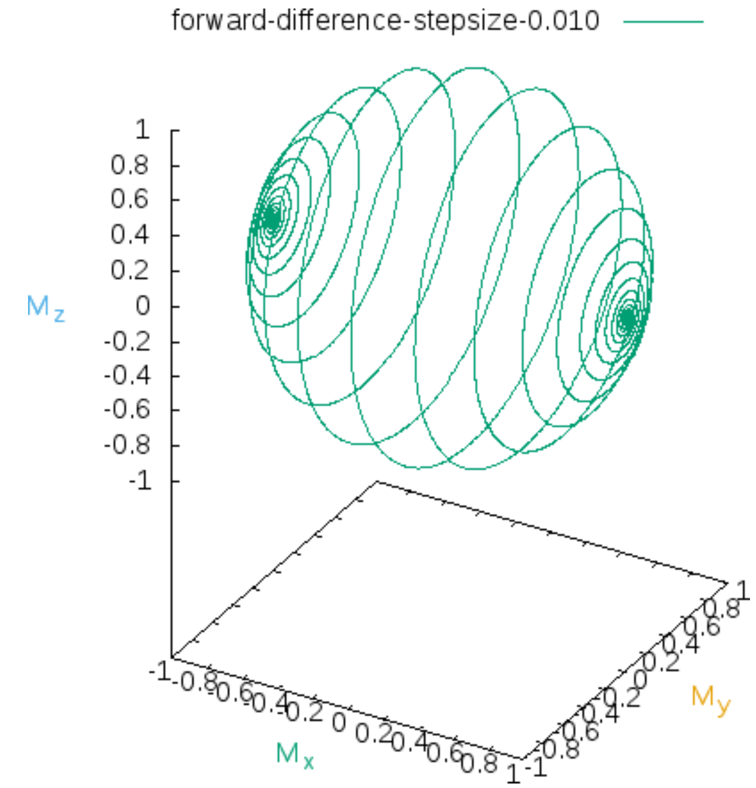
a) For stepsize=0.001



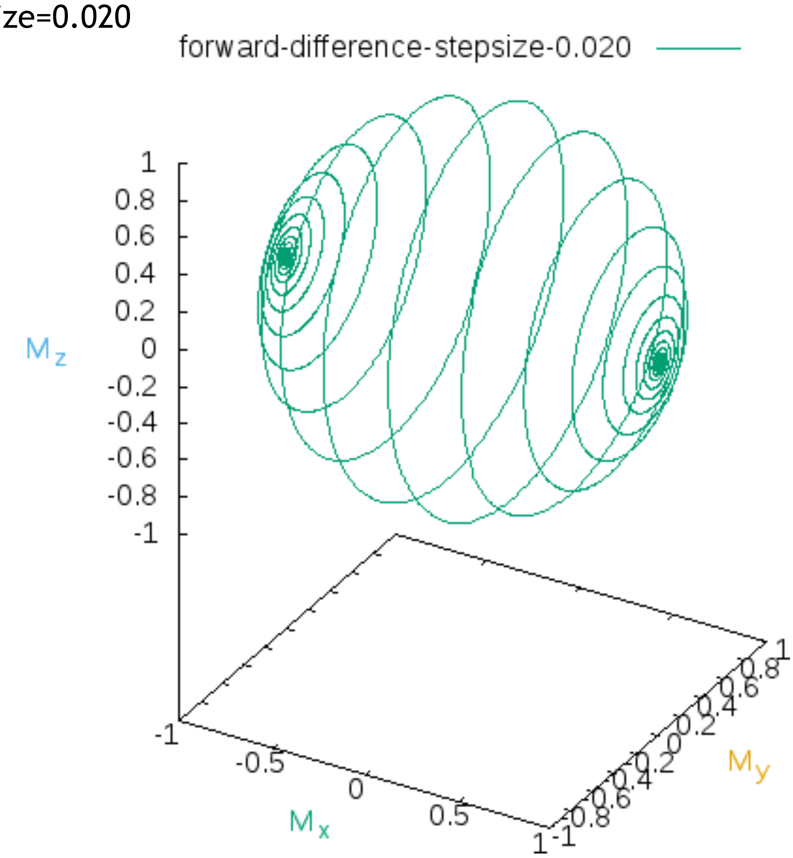
b) For stepsize=0.005



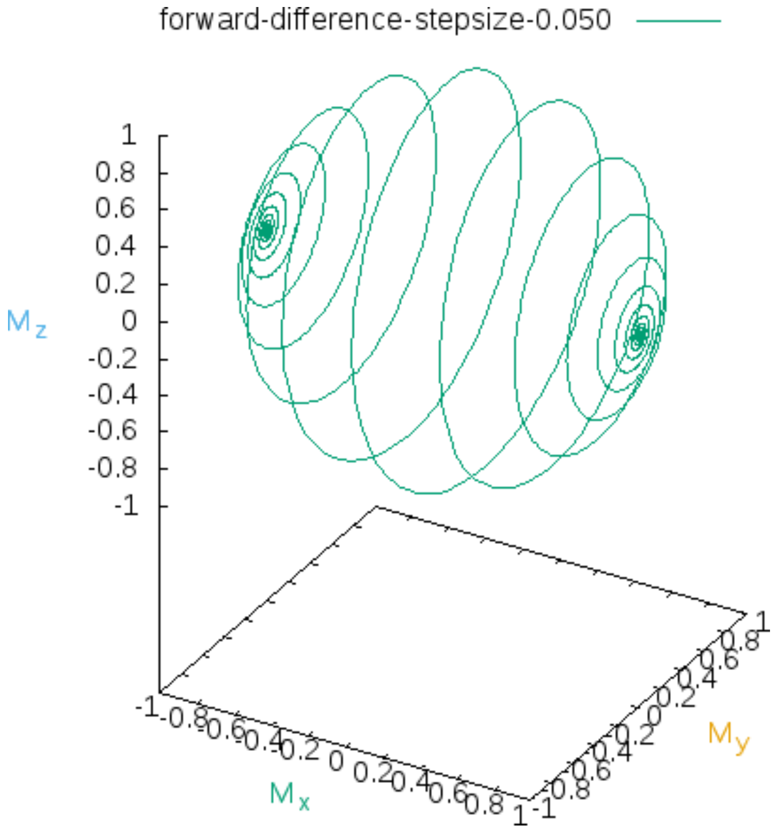
c) For stepsize=0.010



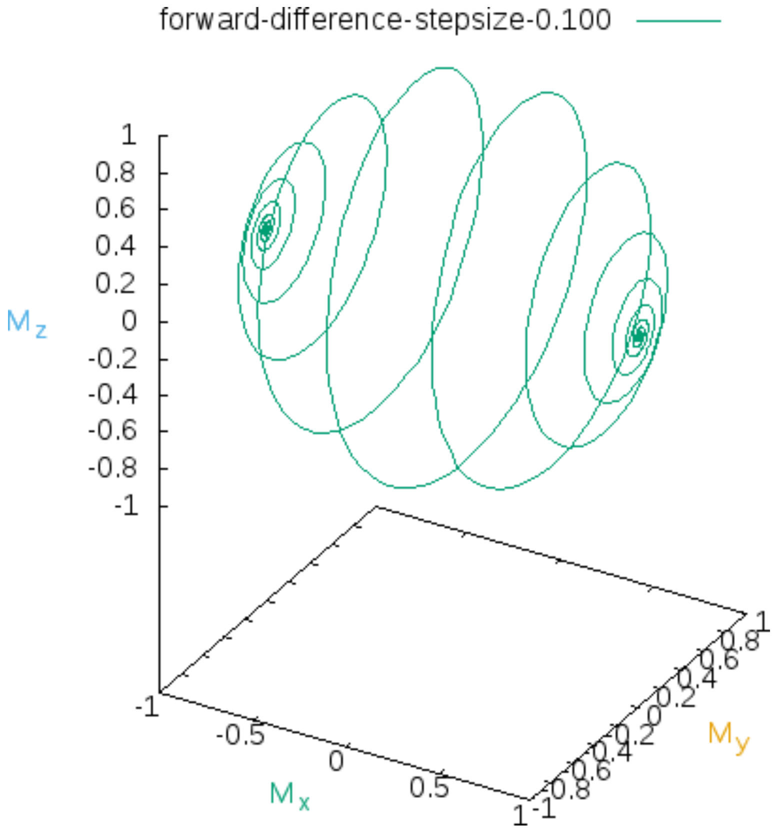
d) For stepsize=0.020



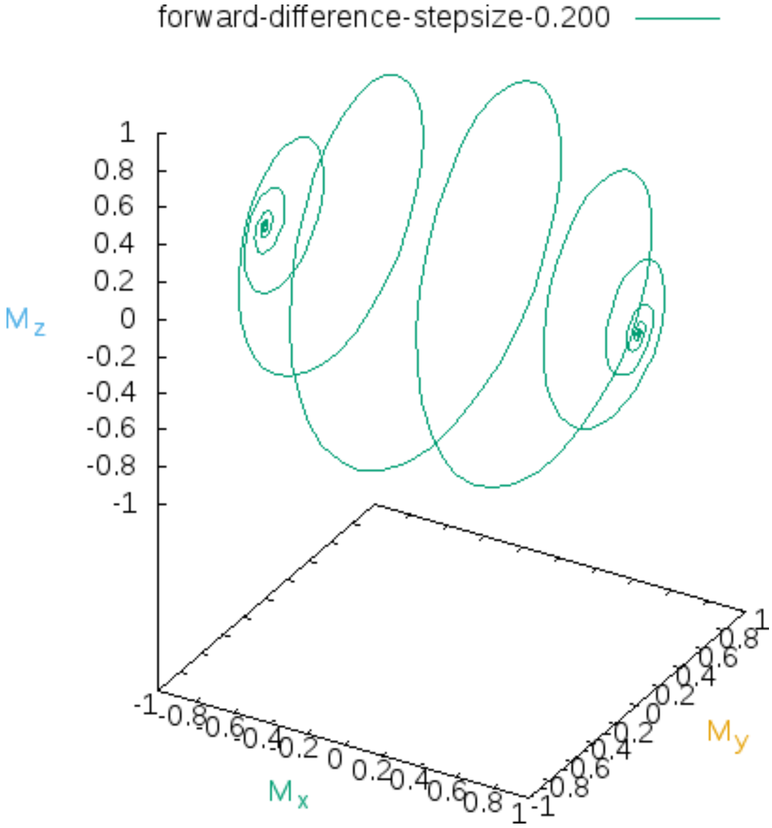
e) For stepsize=0.050



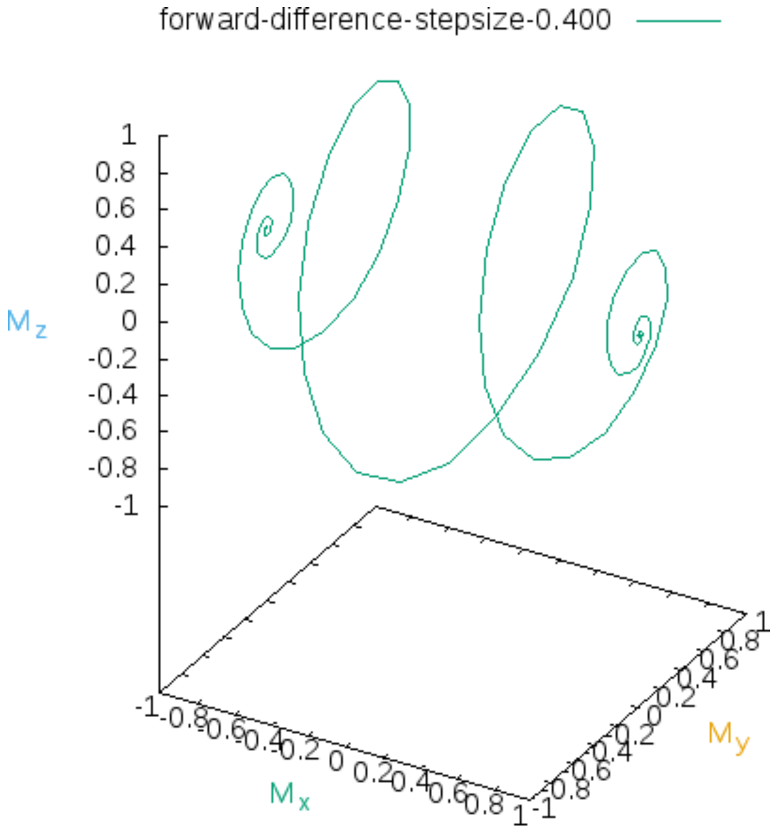
f) For stepsize=0.100



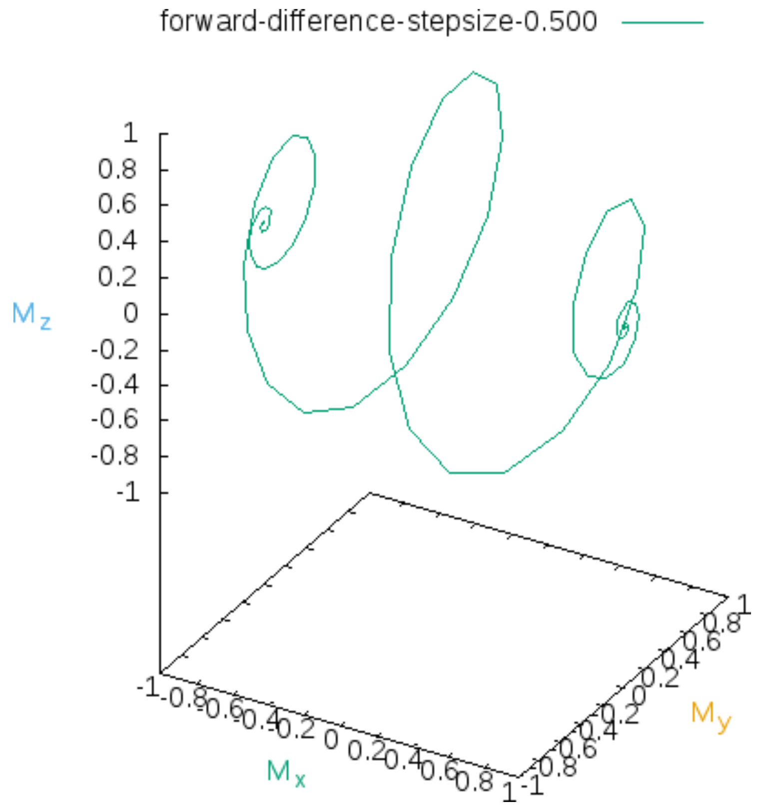
g) For stepsize=0.200



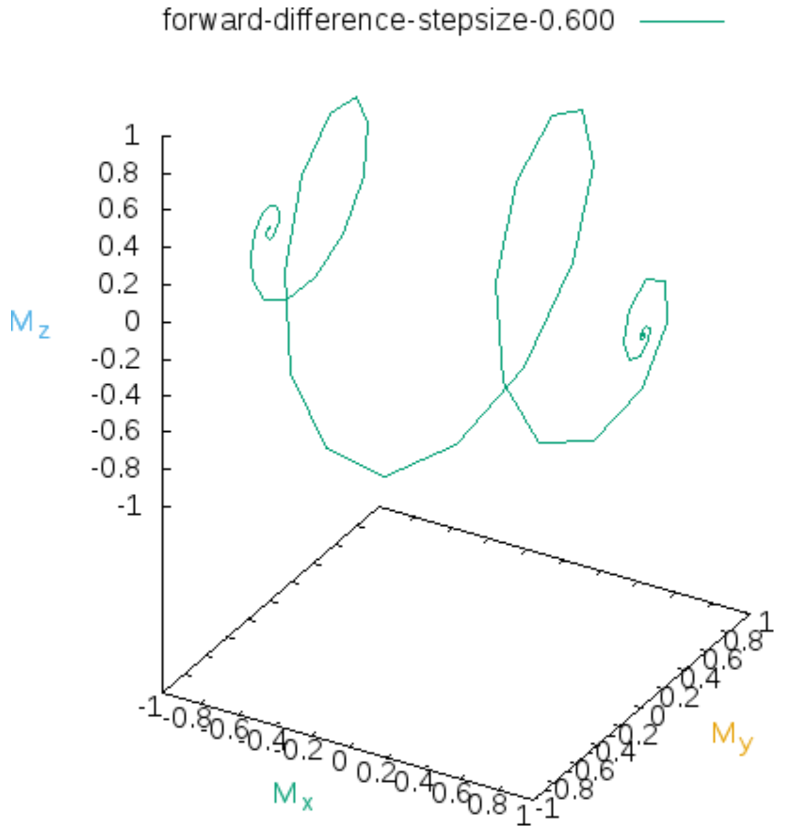
h) For stepsize=0.400



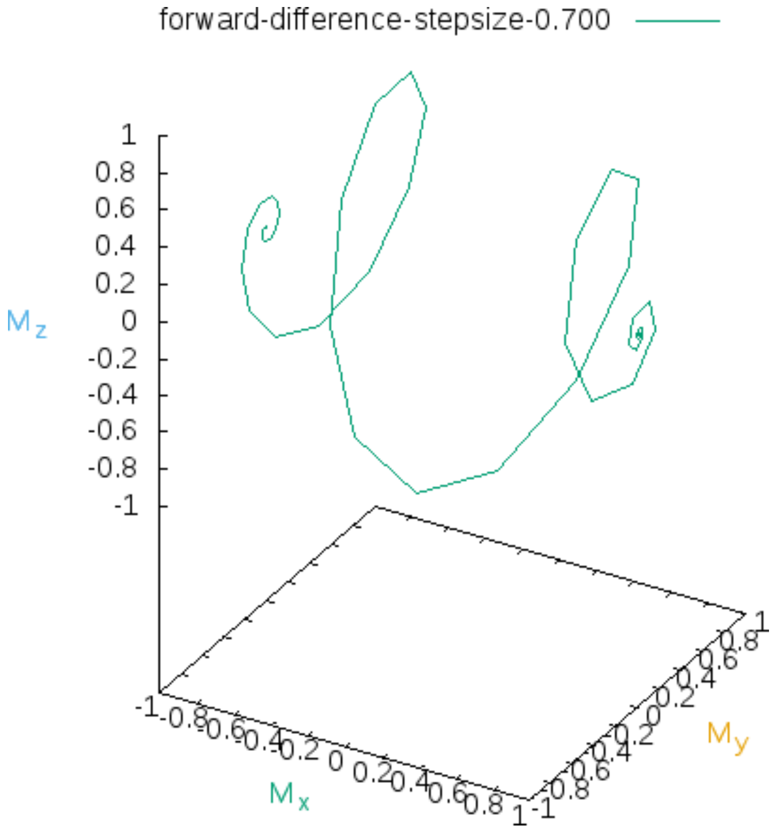
i) For stepsize=0.500



j) For stepsize=0.600



k) For stepsize=0.700

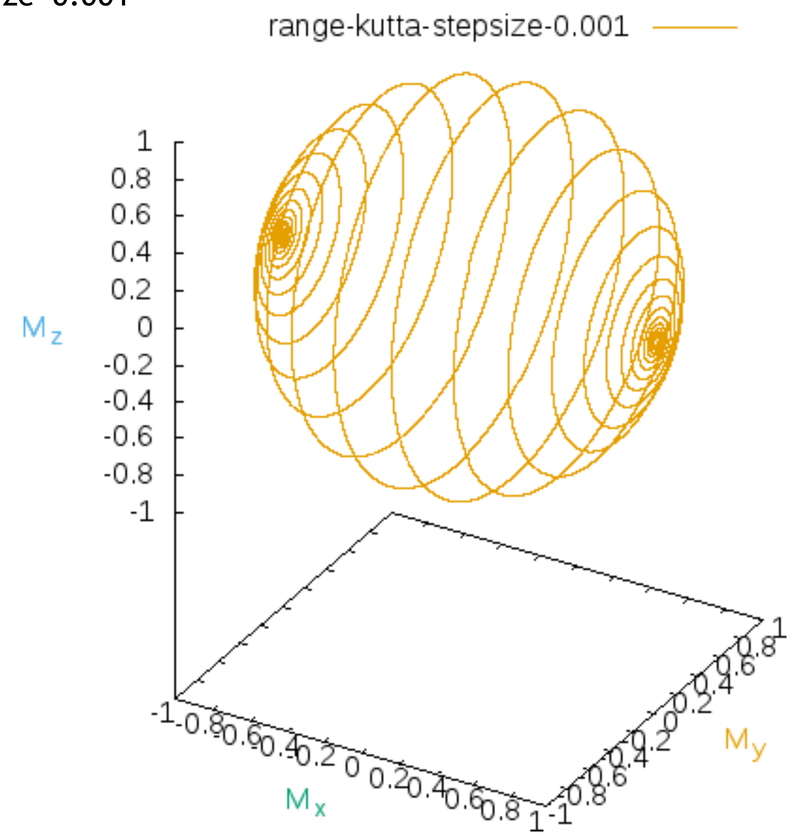


From these graphs we infer that a stable solution gives a spherical plot. When we solve using the forward difference method, we get stable solutions for stepsizes less than or equal to 0.020.

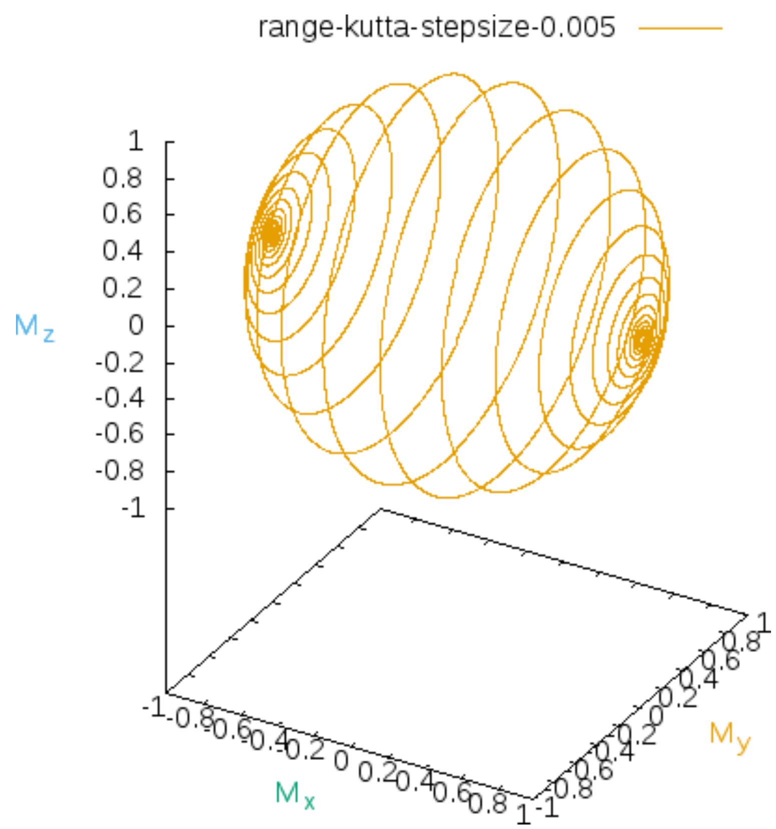
2. Fourth order Runge Kutta Method

By solving the differential equation using fourth order Runge Kutta method for different stepsizes, we get the following graphs

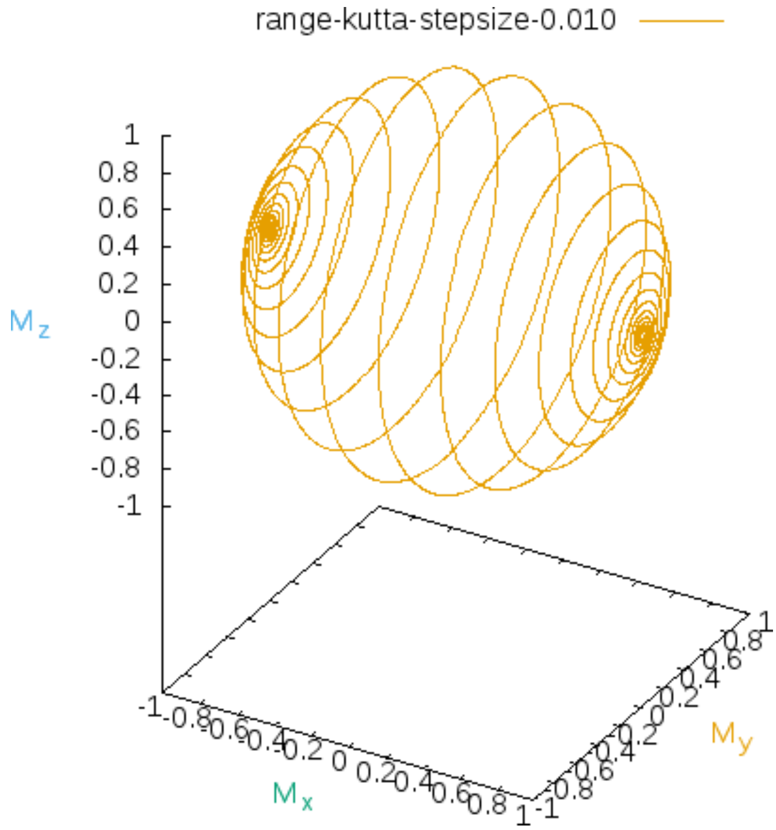
a) For stepsize=0.001



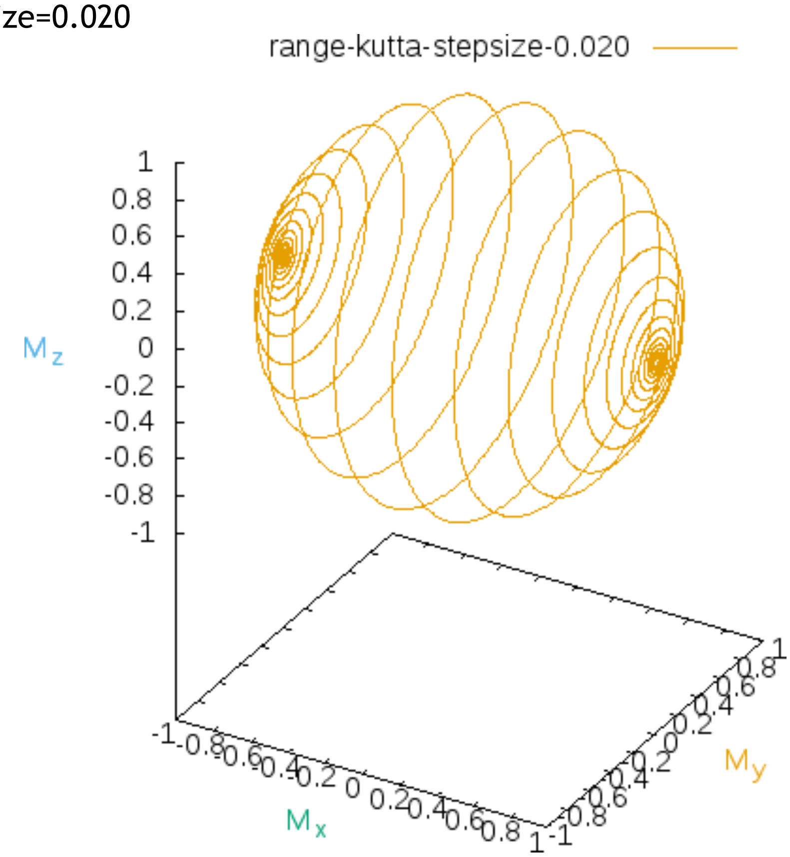
b) For stepsize=0.005



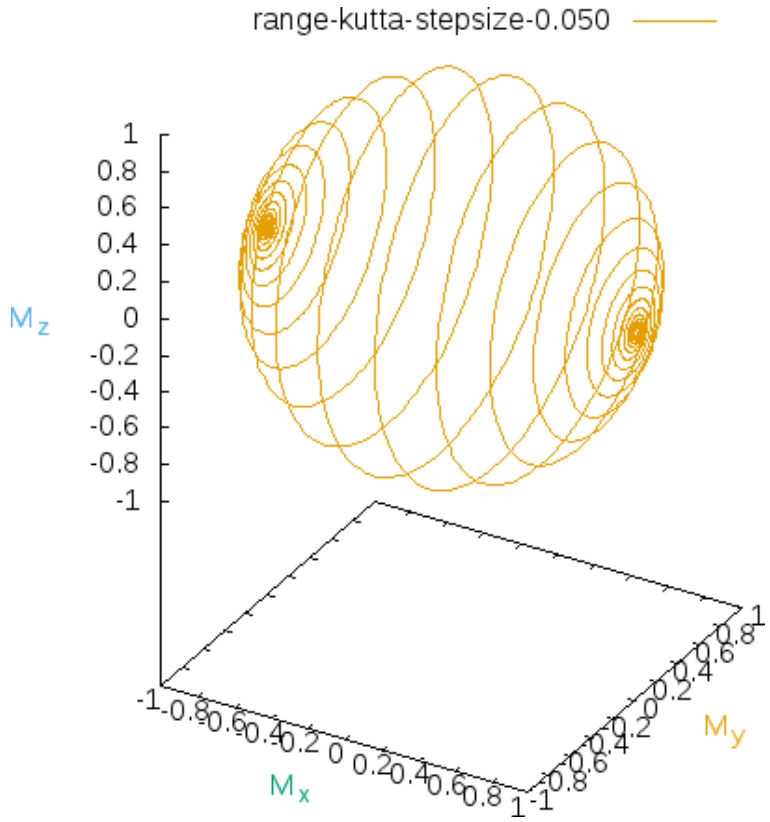
c) For stepsize=0.010



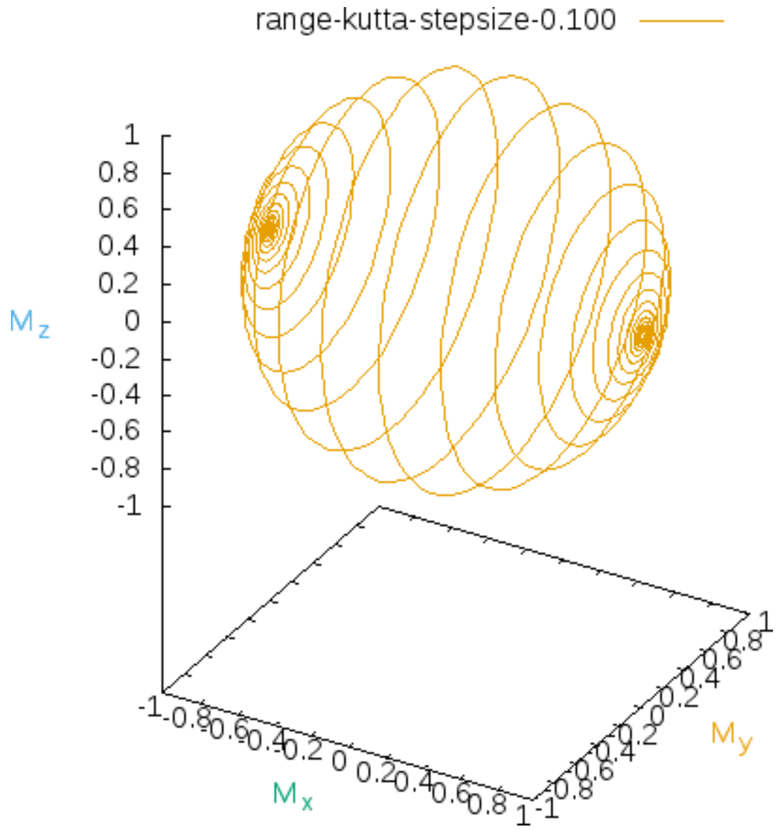
d) For stepsize=0.020



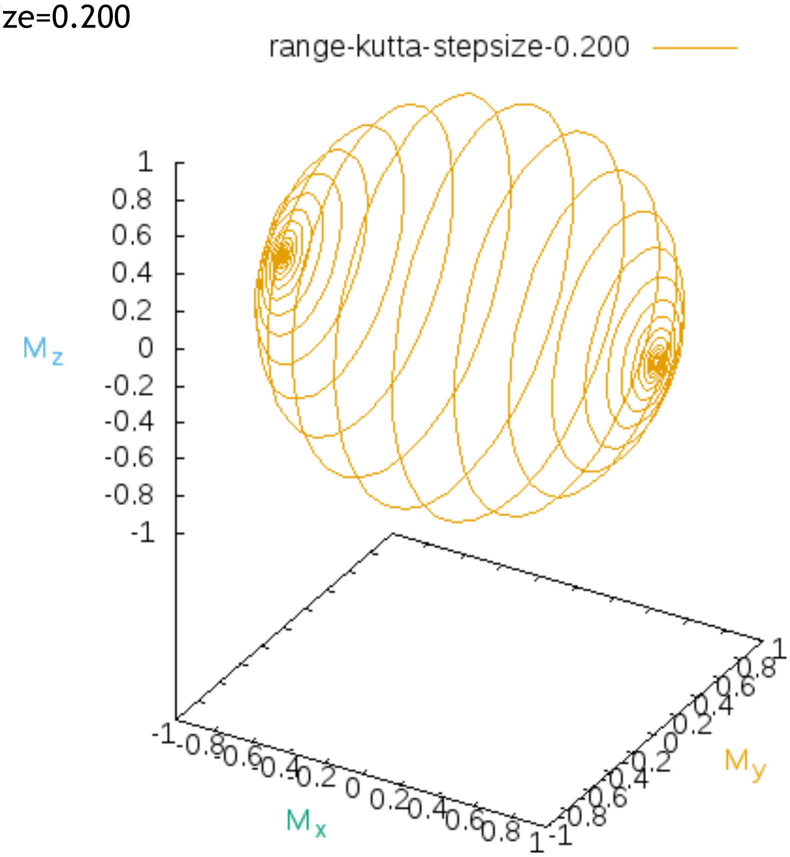
e) For stepsize=0.050



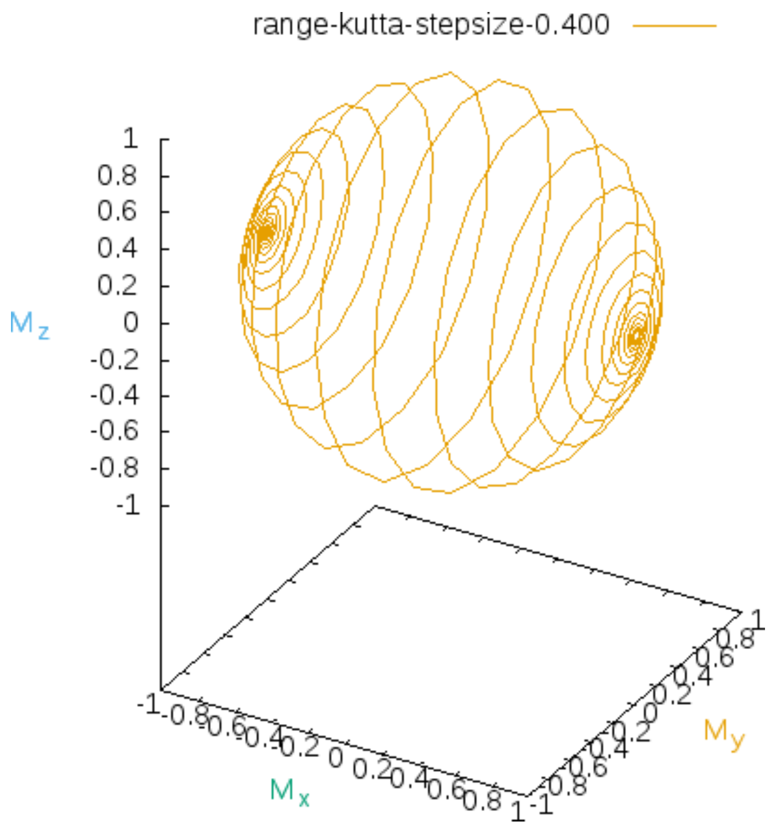
f) For stepsize=0.100



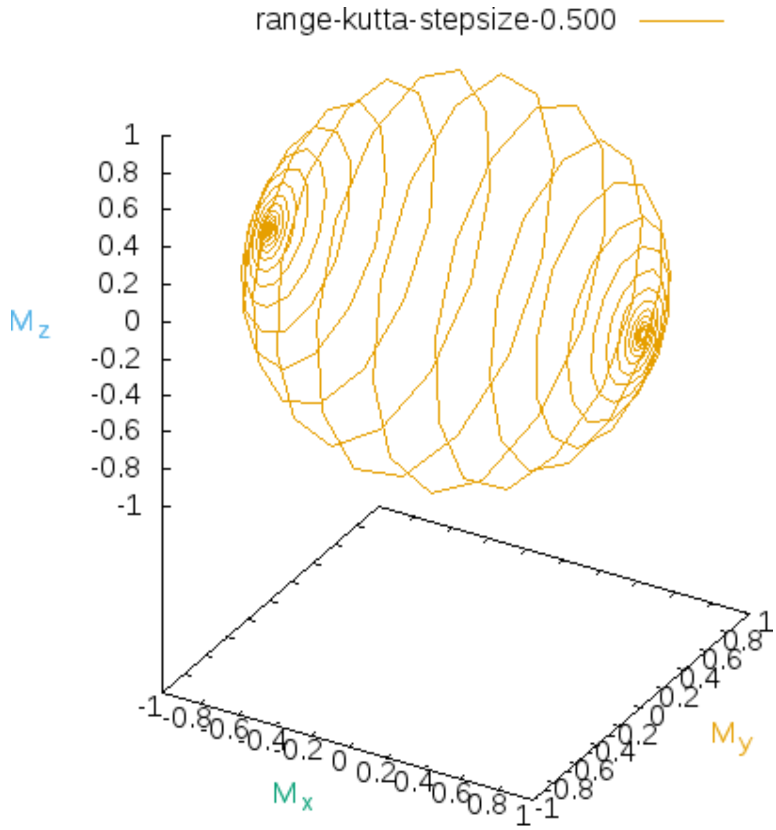
g) For stepsize=0.200



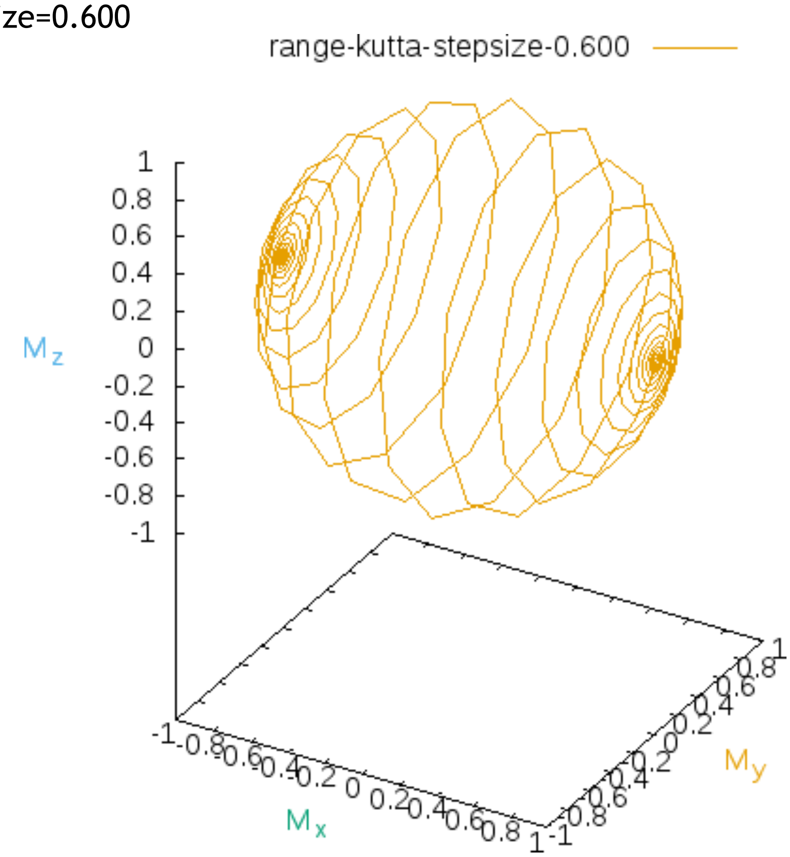
h) For stepsize=0.400



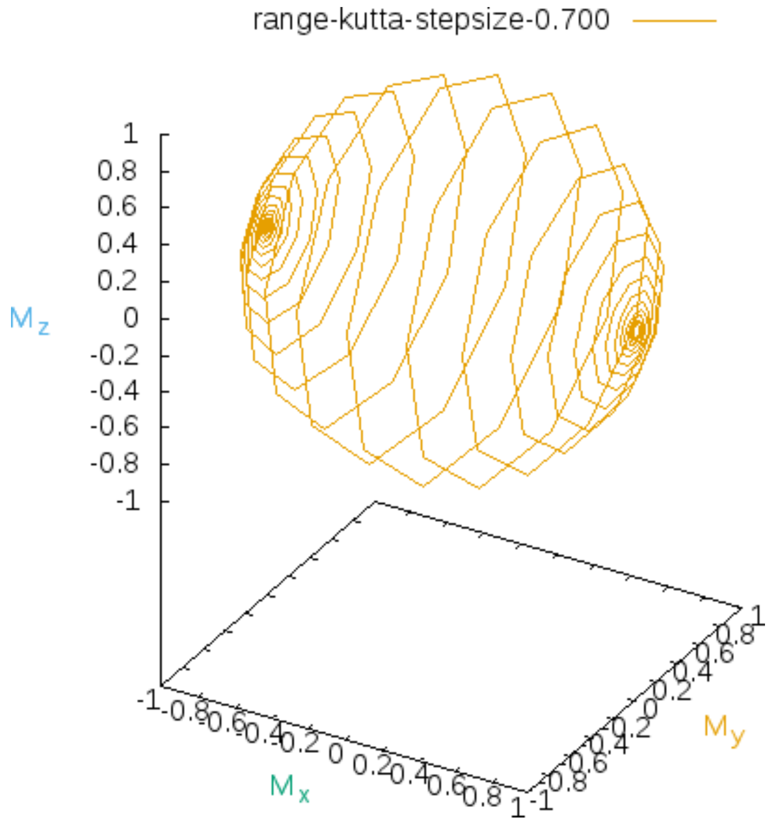
i) For stepsize=0.500



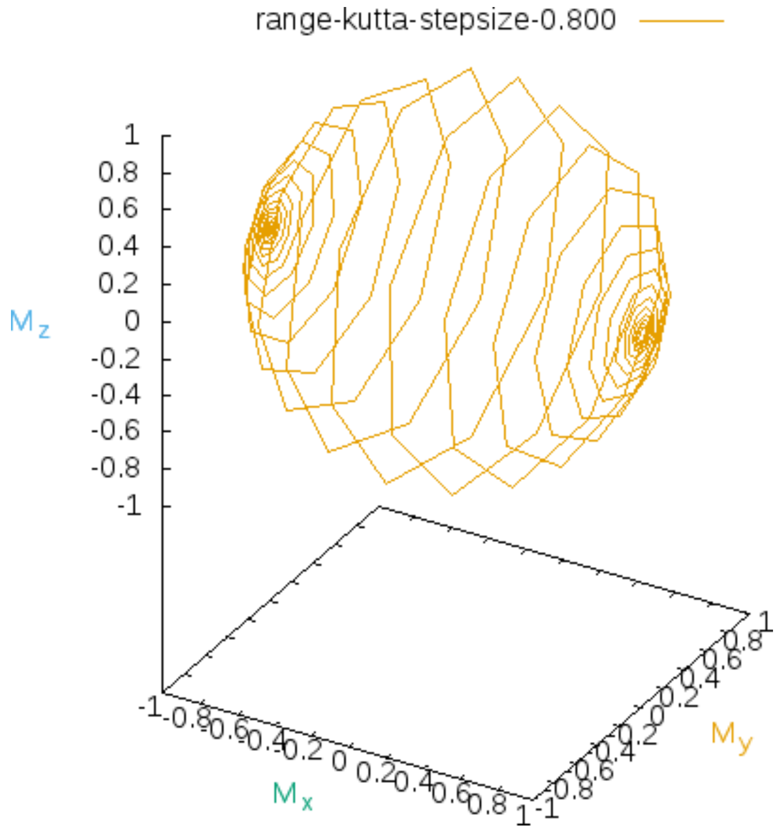
j) For stepsize=0.600



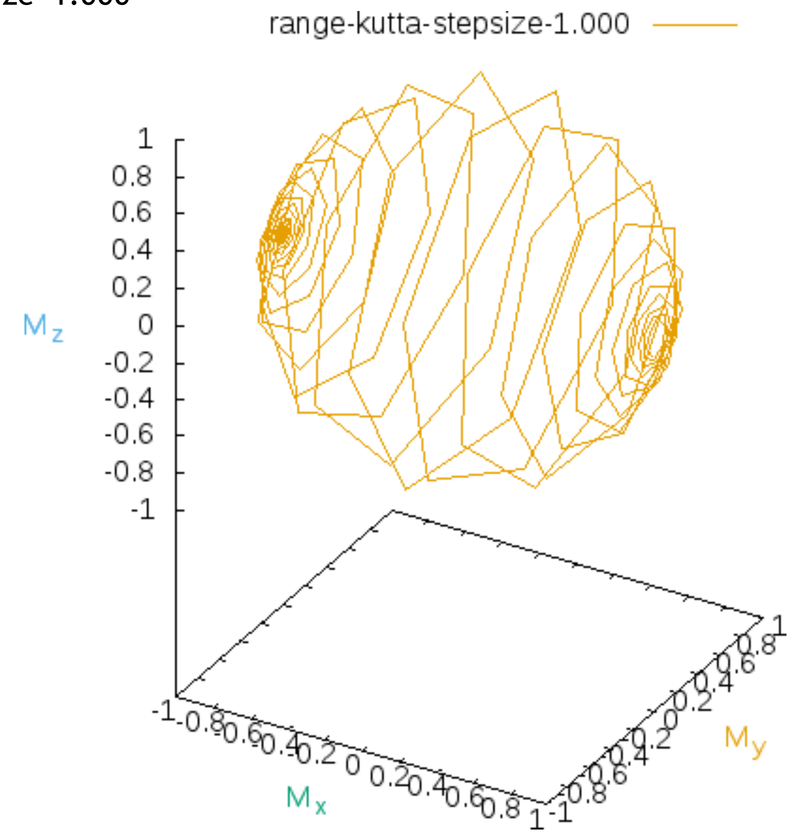
k) For stepsize=0.700



l) For stepsize=0.800



m) For stepsize=1.000

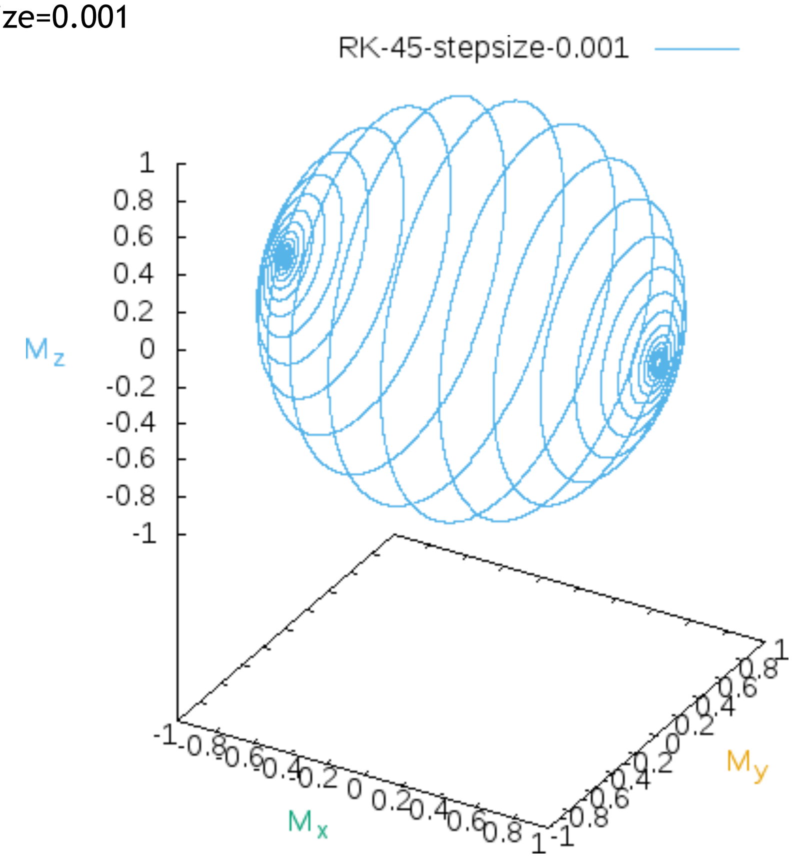


From these graphs we infer that the solutions derived from Runge Kutta are more stable. This is understood from observing that the graphs give stable solutions even for large stepsizes that the forward difference method was unable to achieve.
When we solve using the fourth order Runge Kutta method, we get stable solutions for stepsizes less than 0.400.

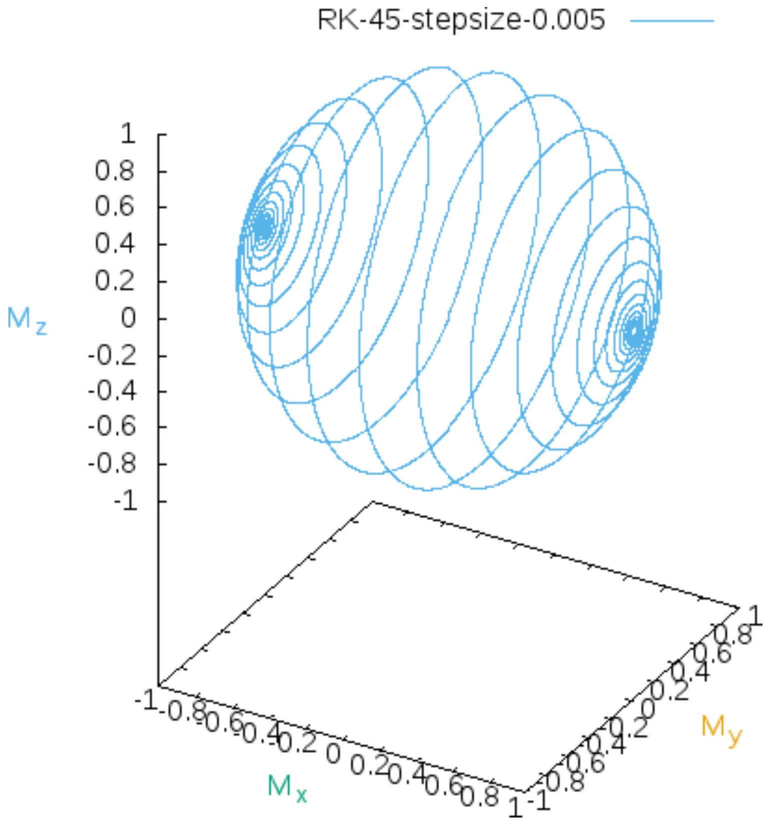
Using RK45

By solving the differential equation using RK45 method for different stepsizes, we get the following graphs

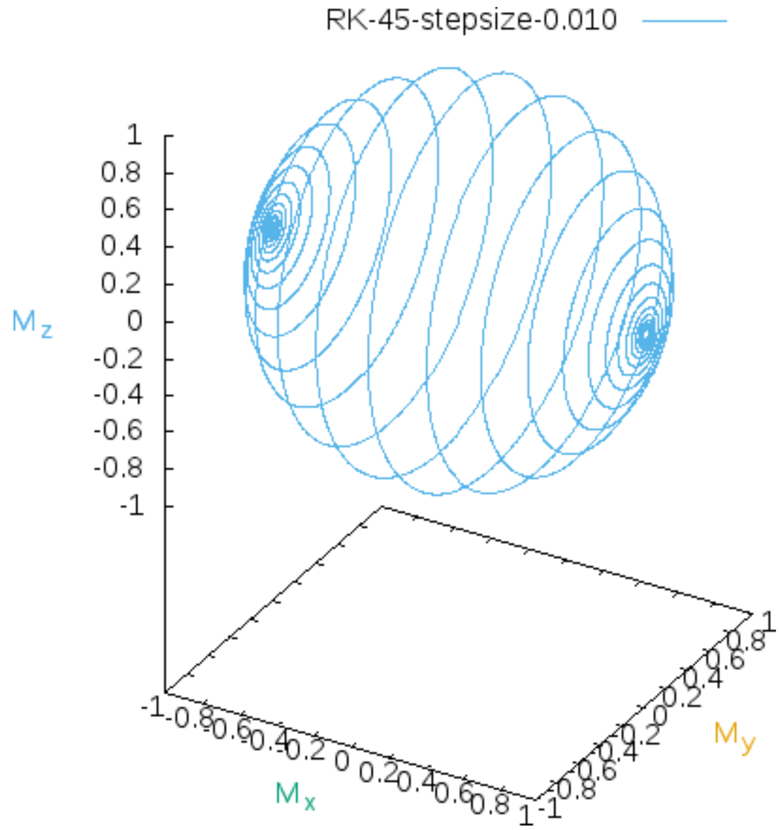
a) For stepsize=0.001



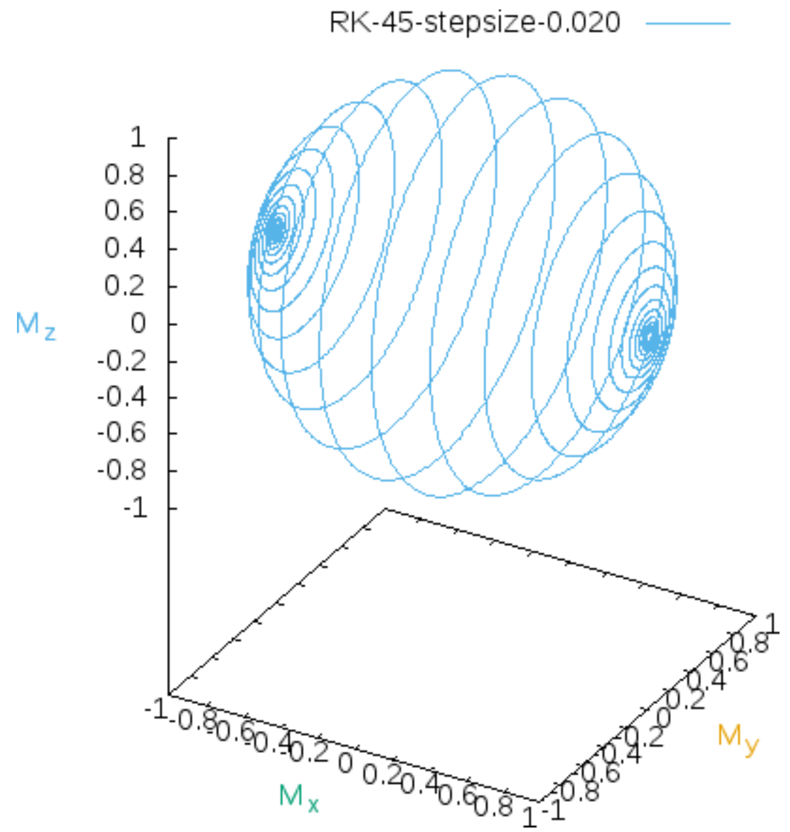
b) For stepsize=0.005



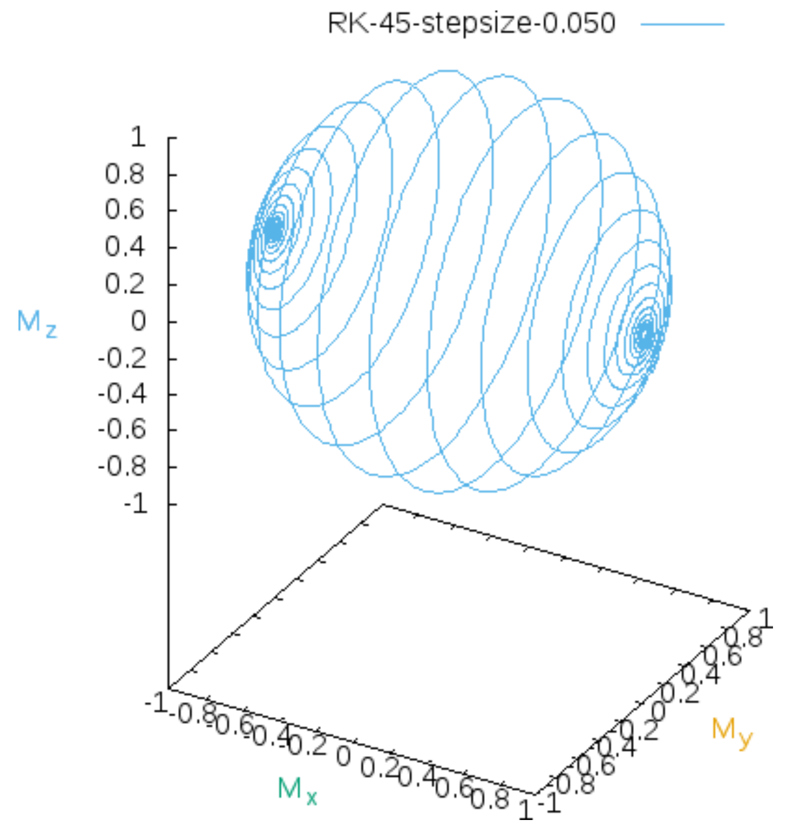
c) For stepsize=0.010



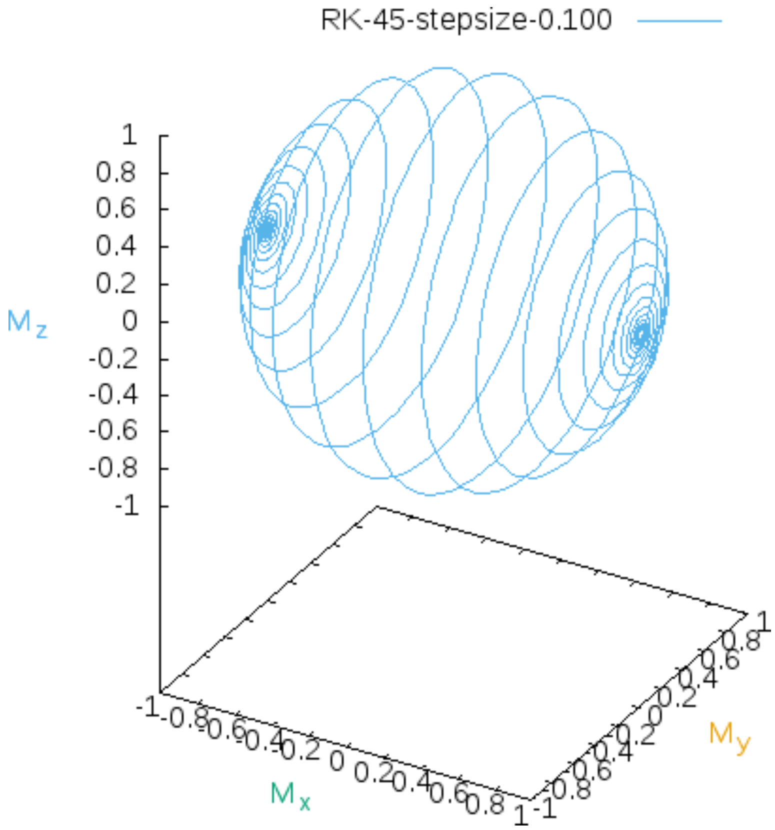
d) For stepsize=0.020



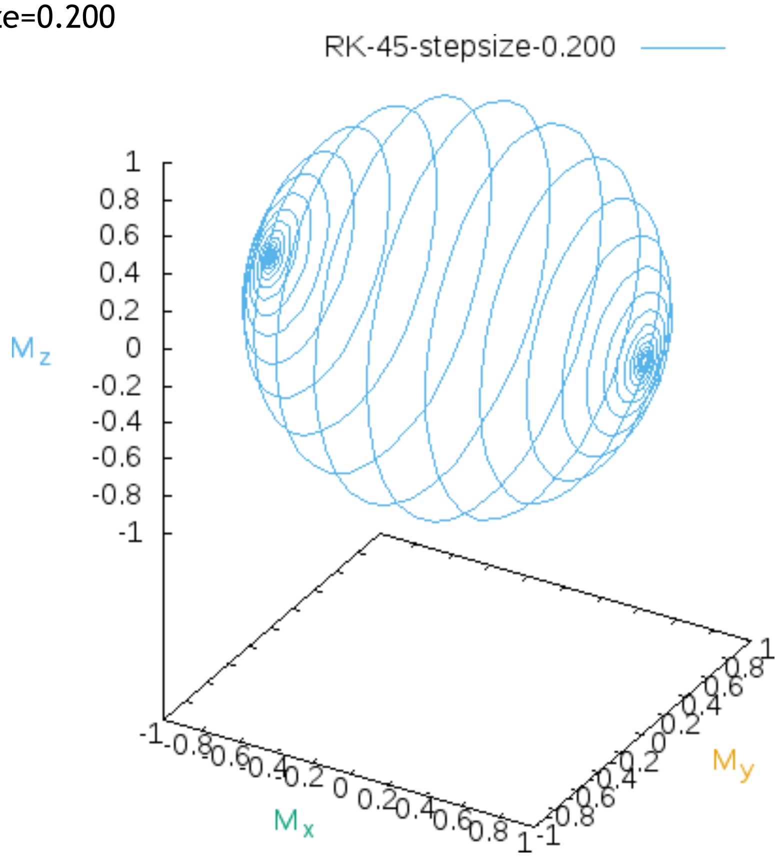
e) For stepsize=0.050



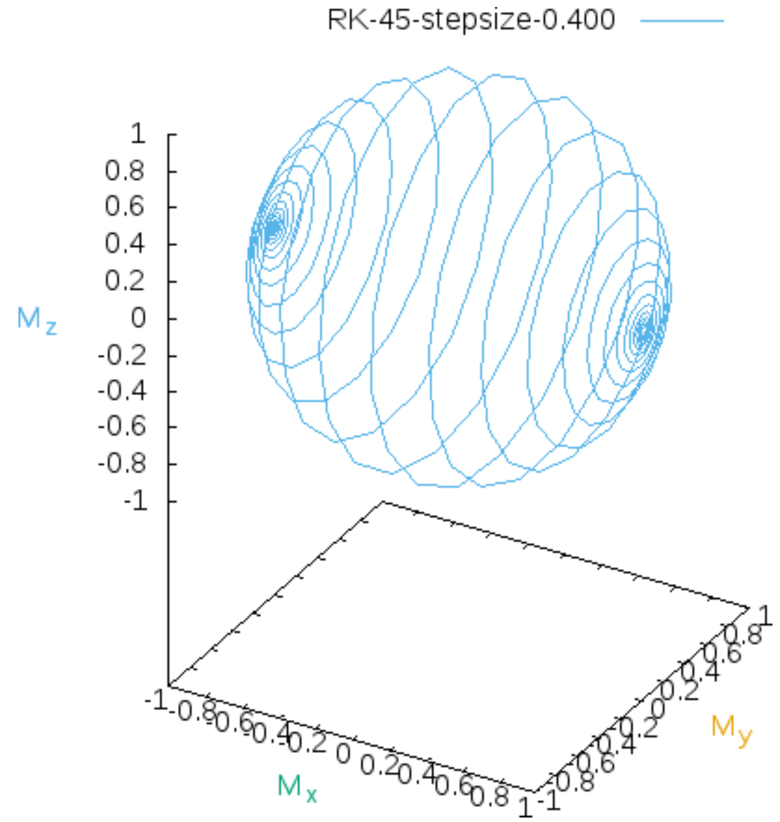
f) For stepsize=0.100



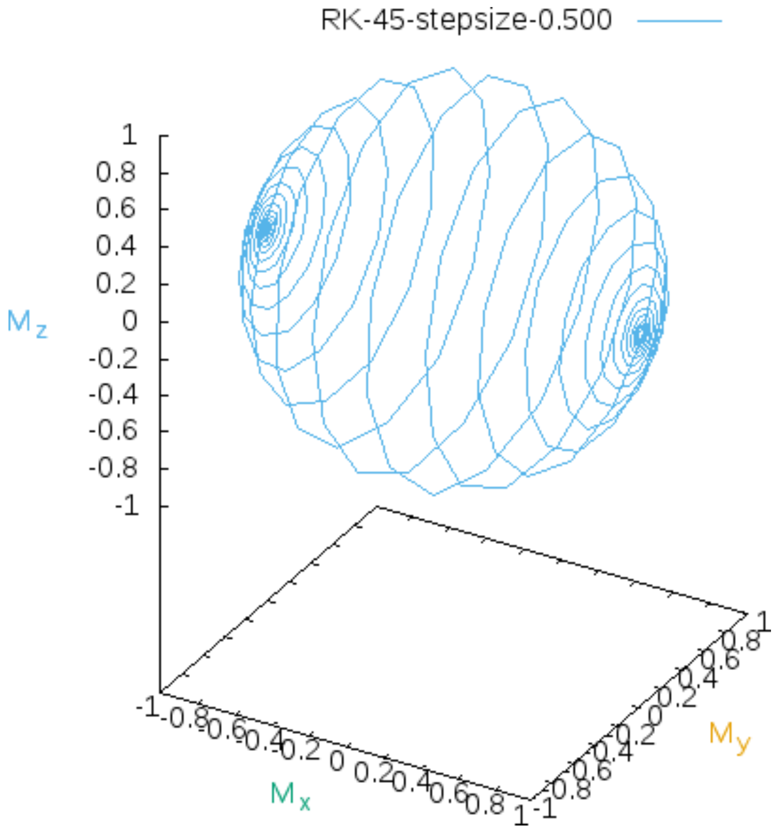
g) For stepsize=0.200



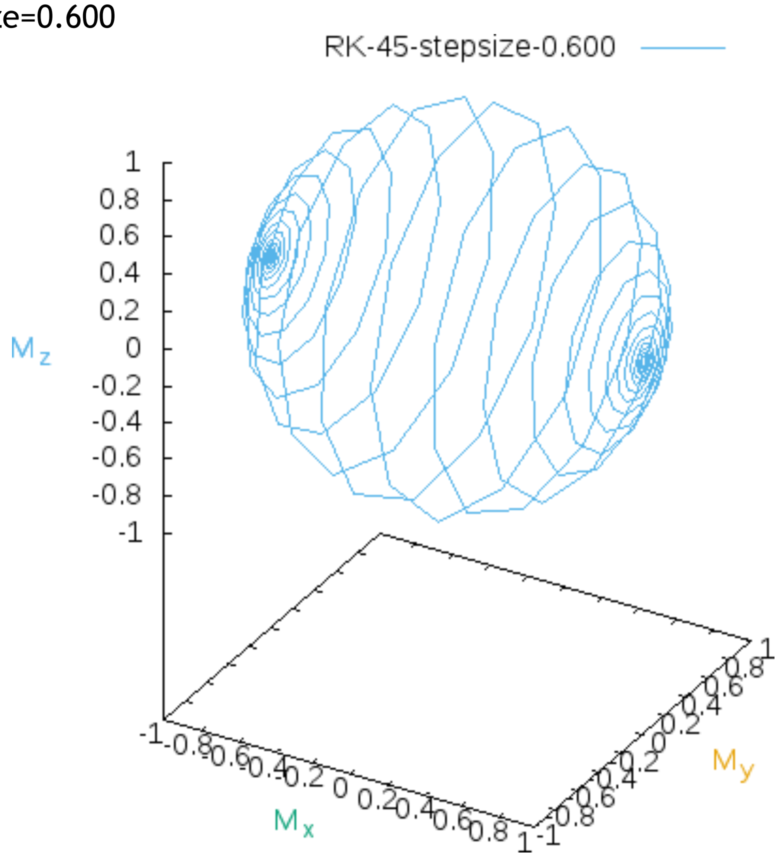
h) For stepsize=0.400



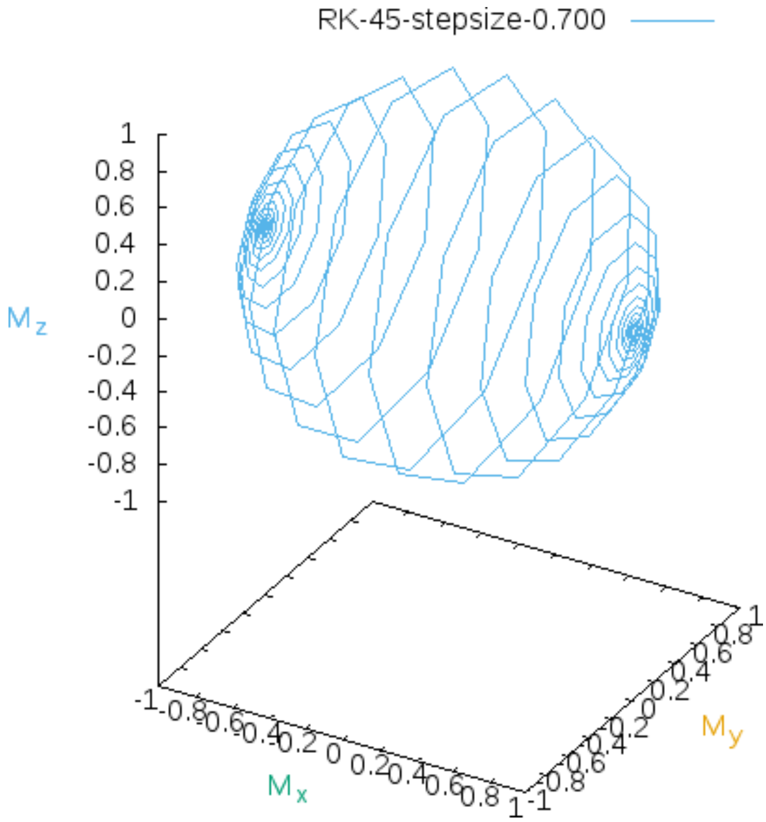
i) For stepsize=0.500



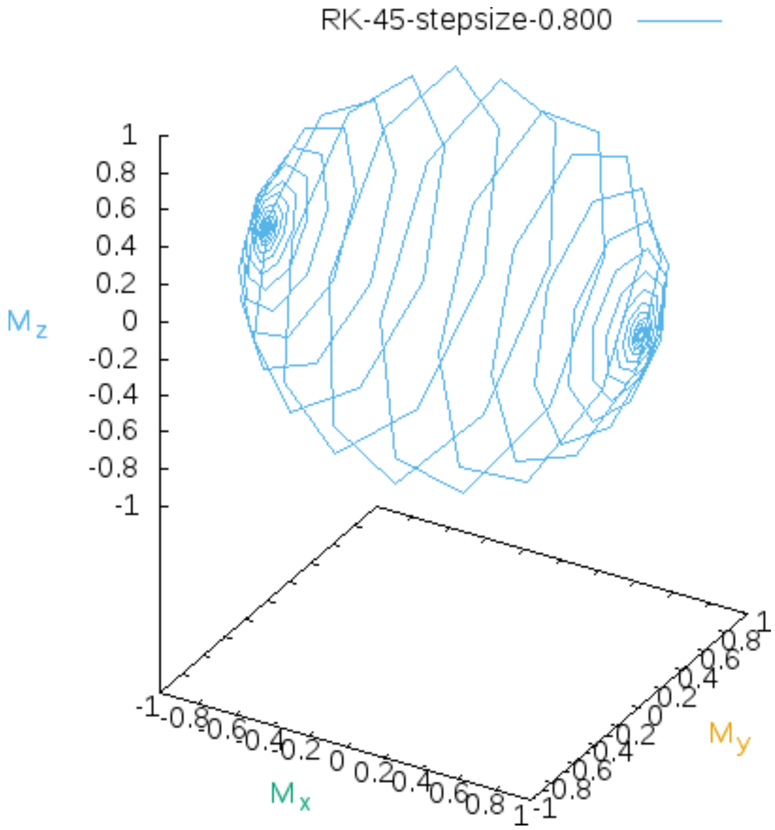
j) For stepsize=0.600



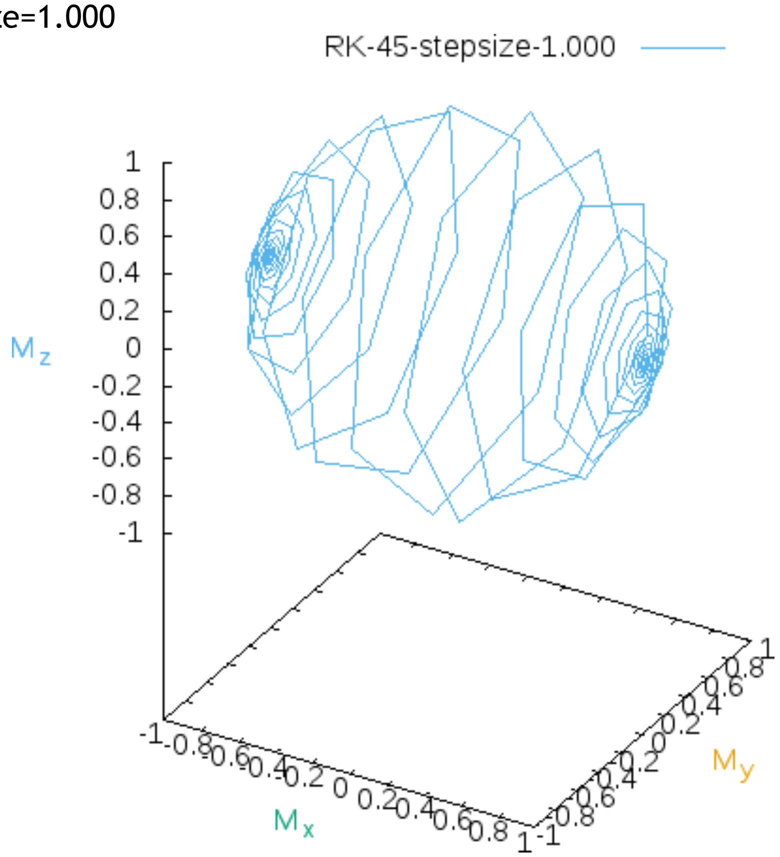
k) For stepsize=0.700



l) For stepsize=0.800



m) For stepsize=1.000



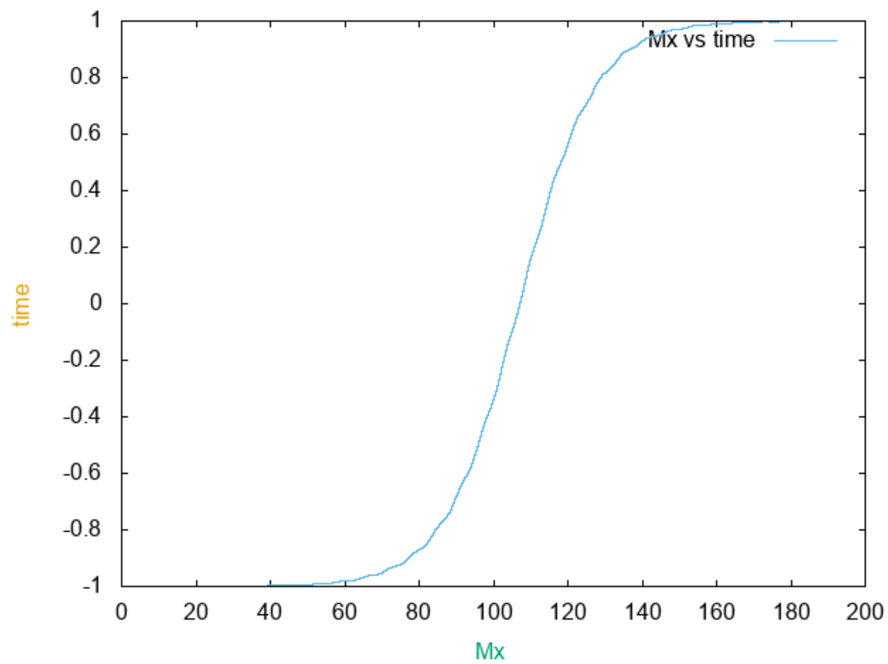
From these graphs we infer that RK45 gives more stable solutions. It gives better plots tan the fourth order Range Kutta.

When we solve using the RK45 method, we get stable solutions for stepsizes less than 0.500.

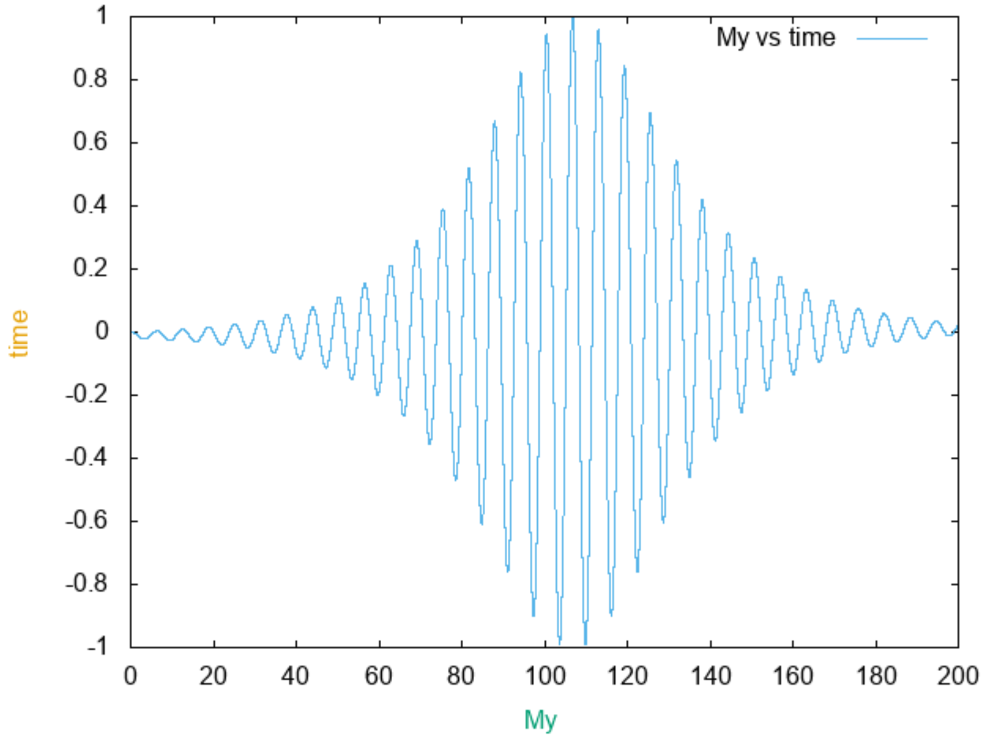
For stepsize values beyond the maximum stepsize for which the method gives stable solution, the plot becomes increasingly distorted.

3. Plot of Mx, My, Mz `vs time

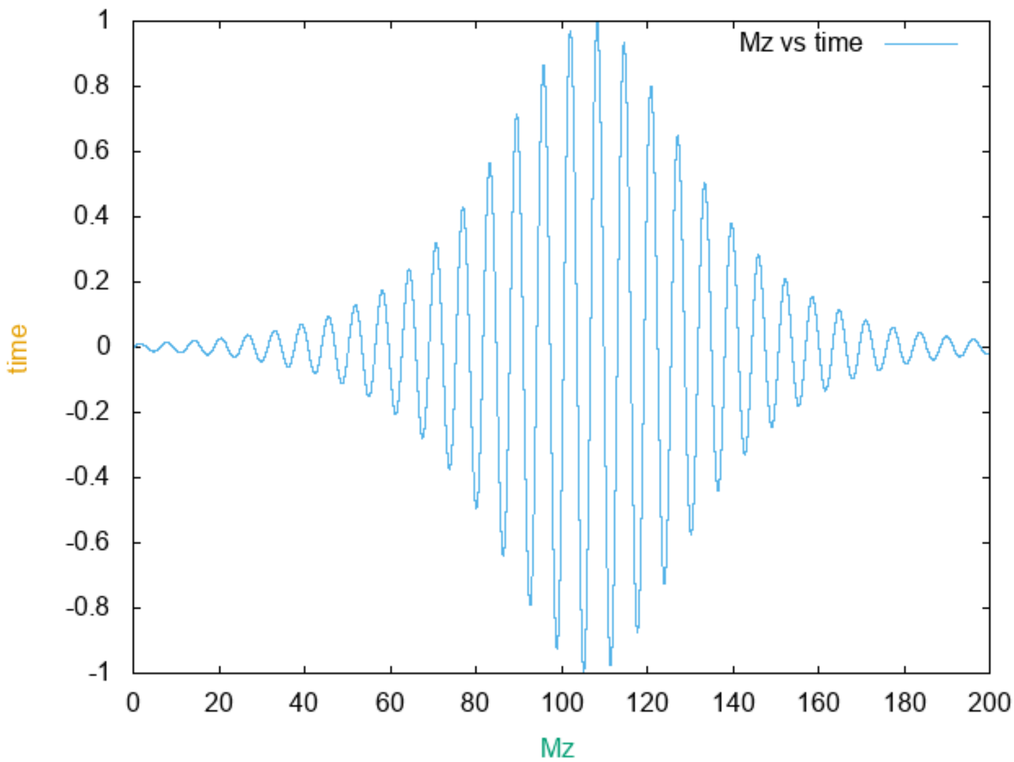
a) Mx vs Time



b) My vs Time

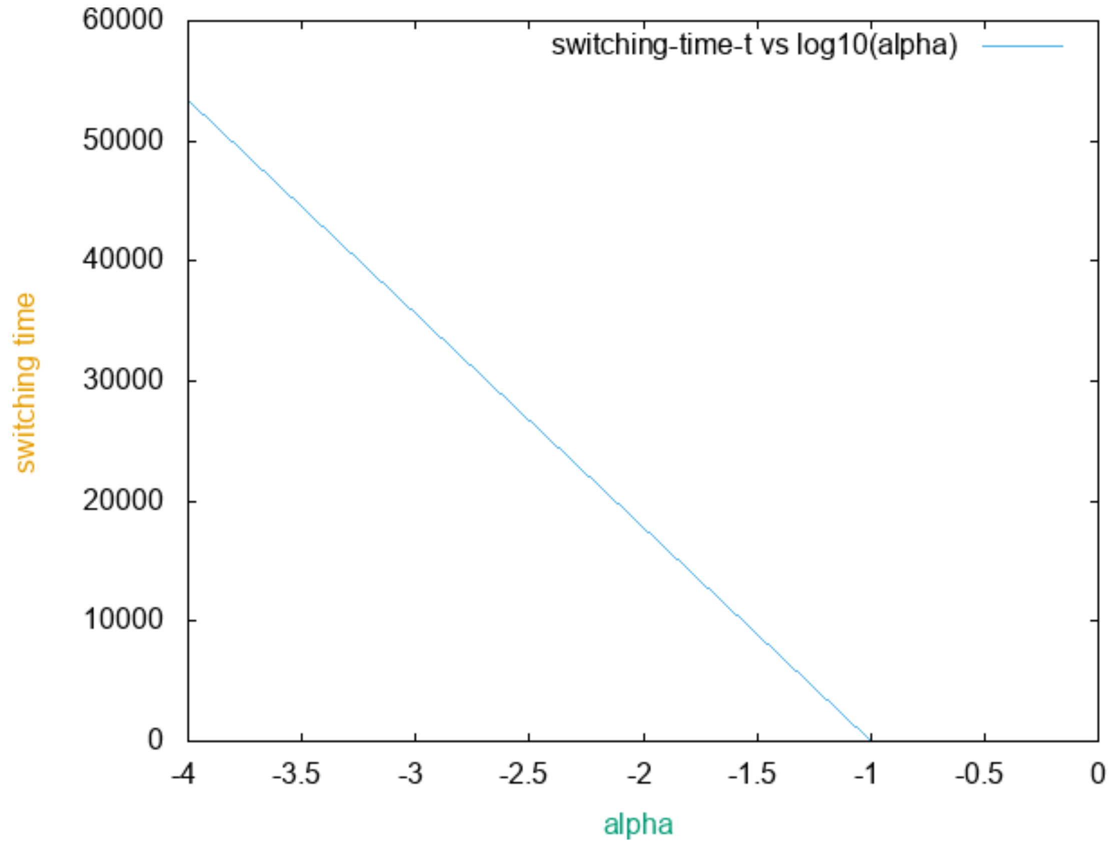


c) Mz vs Time



3. Switching time as a function of alpha

Switching time is given by the time at which magnetisation switches (here, value of Mx to change sign). This varies for different values of alpha. Given below is the plot of switching time t vs log alpha (log to the base 10).

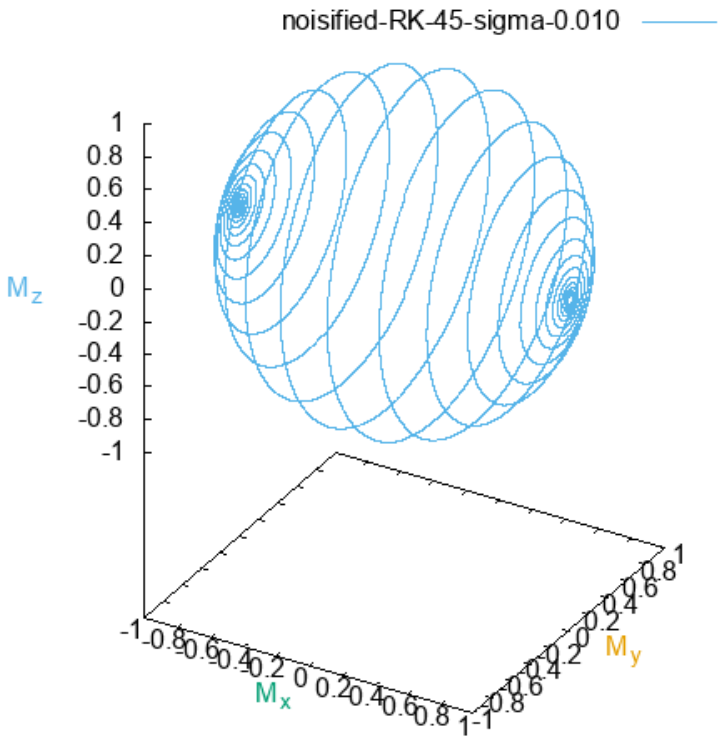


We get the plot to be straight line with a negative slope. Thus we observe that switching time is a logarithmic function of alpha and that as alpha increases, switching time decreases.

4. Adding Noise to the simulation

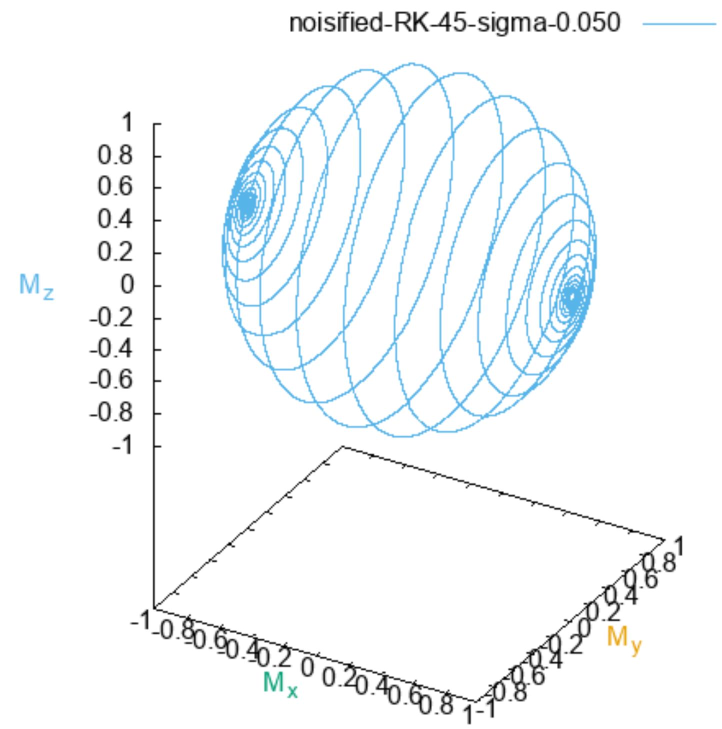
To add noise to the simulation, we add a small kick in a random direction, after each iteration in the RK solver. Here, we create three random numbers with mean 0 and variance sigma and add it to each component of magnetisation after each time step. We plot the trajectory of M after addition of noise for different values of sigma.

a) For sigma=0.010



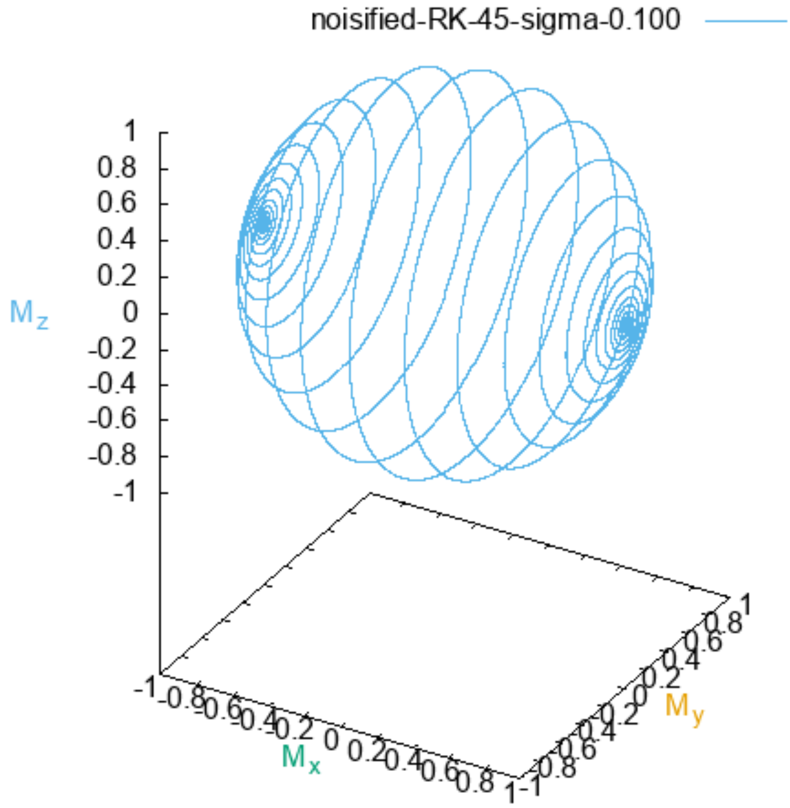
Root mean square error=0.0.025537
Correlation=0.999481

b) For sigma=0.050



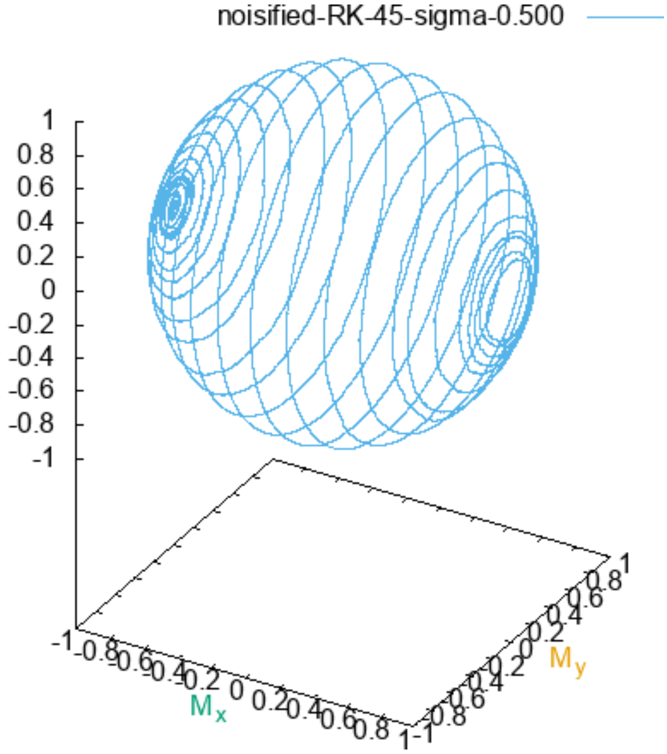
Root mean square error=0.029939
Correlation=0.999370

c) For sigma=0.100



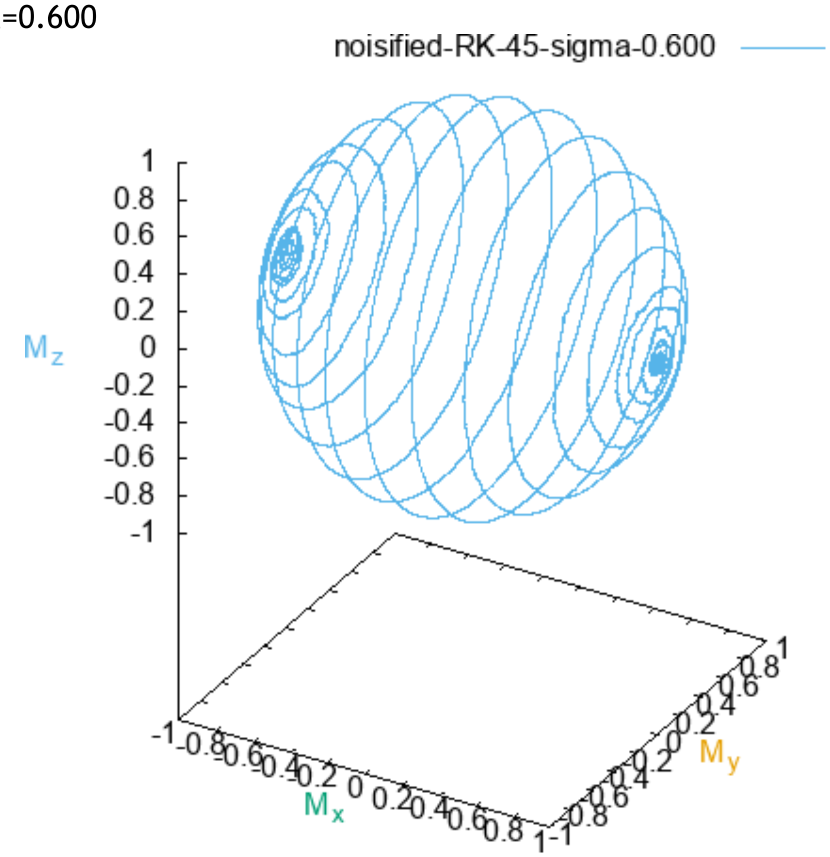
Root mean square error=0.183303
Correlation=0.982625

d) For sigma=0.500



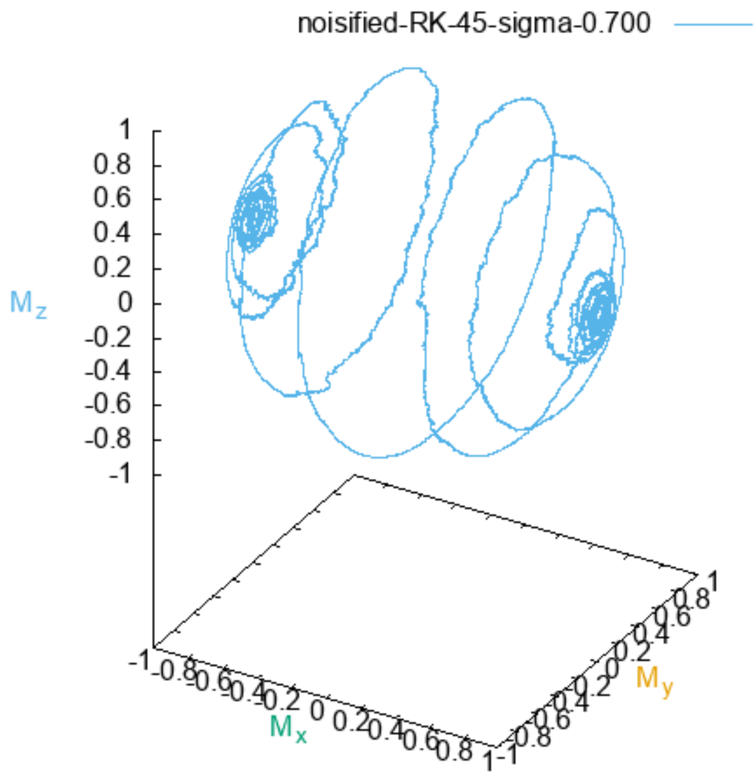
Root mean square error=0.5611711
Correlation=0.851146

e) For sigma=0.600



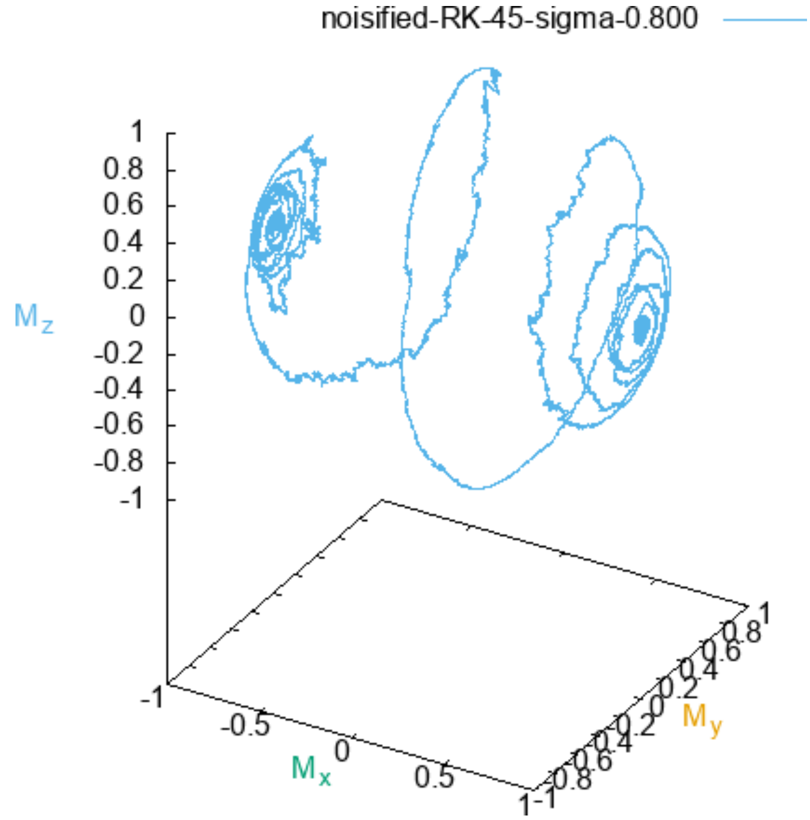
Root mean square error=0.564310
Correlation=0.853856

f) For sigma=0.700



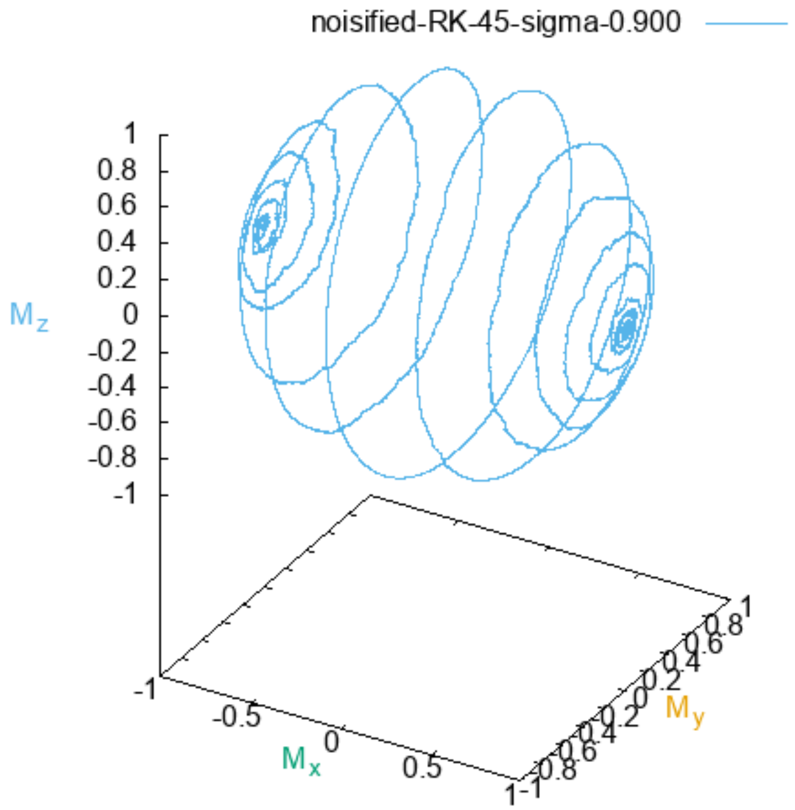
Root mean square error=0.809862
Correlation=0.771393

g) For sigma=0.800



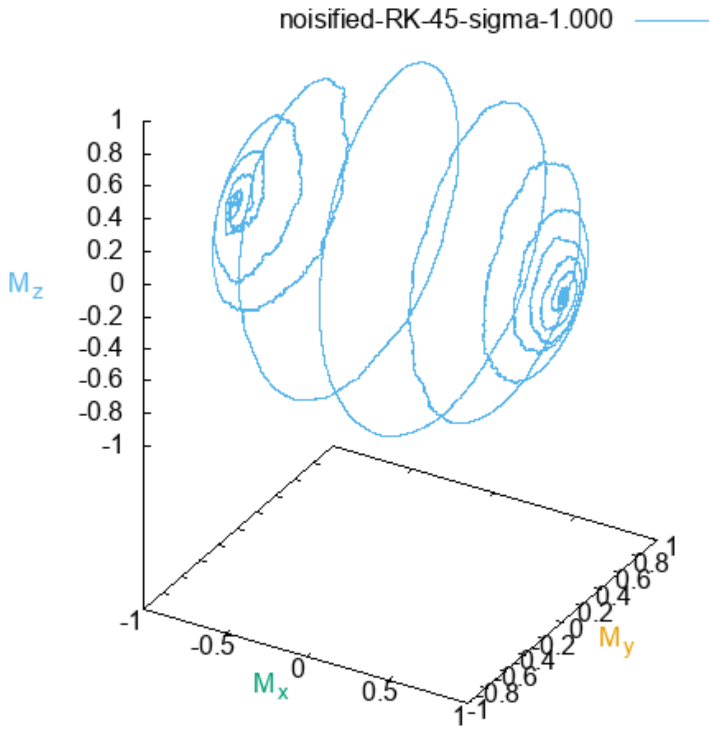
Root mean square error=0.906756
Correlation=0.685760

h) For sigma=0.900



Root mean square error=0.906756
Correlation=0.570970

i) For sigma=1.000



Root mean square error=1.1466911
Correlation=0.530152

The random numbers to create noise to the simulation are generated from a uniform distribution transformed to a normal distribution using Box Muller transformation. We observe that on an average, the plots get increasingly distorted for increasing values of standard deviation, though this nature is slightly contradicted as seen in the case of sigma=0.8 and sigma=1, but the root mean square error increases with increase in sigma.

We also observe that correlation decreases (with a value close to 1 for smaller values of sigma, i.e, for less value of noise added) with increase in standard deviation as the the plot distorts more with increase in standard deviation, the ideal case being correlation=1 which occurs when no noise is added.

We observe the distortion of the trajectory of M in these plots when we compare this with the one we got for stepsize=0.001 in RK45 solver due to the noise added to the simulation.

TABLE OF SIGMA VS CORRELATION FOR MEAN = 0

SIGMA	CORRELATION
0.01	0.999481
0.05	0.999370
0.1	0.982625
0.5	0.851146
0.6	0.853856
0.7	0.771393
0.8	0.685760
0.9	0.570970
1.0	0.530152