Quiz II EE1103 (20 marks)

Note : All code should be written in C, properly commented, and plots should be generated using gnuplot. Please create a proper report with all the graphs and your conclusions. Upload a c-file with your code (that compiles and runs and generates output) and a pdf file with your plots and observations.

The Landau-Lifshitz equation governs the dynamics of the a single magnetic moment in the presence of an applied magnetic field. It is given by

$$\frac{d\mathbf{M}}{dt} = -\gamma(\mathbf{M}\times\mathbf{H}) + \alpha\{\mathbf{M}\times(\mathbf{M}\times\mathbf{H})\} \tag{1}$$

We are ignoring all temperature variations. Let us take $\gamma = 1.0$. We have to specify the initial magnetization (which we will call $\mathbf{M}_0$), α and $\mathbf{H}$ to solve this equation. Take the following initial values $\mathbf{M}_0 = (-0.99, 0.00.0)$, $\mathbf{H} = (1, 0.01, 0.0)$ and $\alpha = 0.05$, unless otherwise specified and remember to normalize $\mathbf{M}$ after each time step, so the trajectory falls on a unit circle.

1. Write a solver based on the forward difference method for solving (1). Note that you will have to solve the equation component wise. . Take your simulation domain as t going till 200 time units with a time stepsize of 0.001 units. Plot the trajectory of $\mathbf{M}$ in 3D space (m_x, m_y, m_z). Repeat this exercise for larger and smaller stepsizes and determine the maximum stepsize you can take for a stable solution?

2. Change the above solver so that it is based on a fixed stepsize fourth order Runge-Kutta method. Again plot $\mathbf{M}$ in 3D space and repeat with different stepsizes. What is the maximum stepsize that you can now afford? You could also plot each component of $\mathbf{M}$ versus t.

3. Now consider your Runge-Kutta solver (suggest using RK_{45}). Take α going from 10^{-4} to 1 in a logscale with 10 points in between. Measure the time it takes for the magnetization to switch (i.e. you have $M_x < 0.0$) for each value of α. Generate a plot of the switching time as a function of α. What inferences do you draw from this plot?

4. To simulate a physical system, we must add noise to the simulation. This is done by adding a small kick, in a random direction, after each iteration of the RK solver. The easiest way to do this is to generate three random numbers, from a distribution with mean 0 and variance σ, and add it to the 3 components of the magnetization after every time step. Determine the correlation betwen this simulation and the noise-free simulation, and tabulate this correlation for different values of σ