ND*nano* Undergraduate Research Fellowship (NURF)
2013 Project Summary

1) Student name: Daniel Kestell
2) Faculty mentor name: Gyorgy Csaba
3) Project title: Simulation of the High Frequency Behaviour of Nanomagnets

4) New Skills acquired during research

I learned how to use matlab to create the programs that were used to generate the TCL script files for the simulations and to post process those simulations by using the files returned by the simulation package. These files were used to analyse the resonance and magnetisation of the nanomagnetic dots.

I learned how to simulate nanomagnets using the OOMMF micromagnetic simulation package.

I got experience making a presentation in front of a group

I gained general research skills and knowledge of how to manage the time available correctly.

I learned how to utilise a server, such as that of the Centre for Research Computing, to make simulations less time consuming and more efficient.

5) A practical application/end use of my research:

The research I have done has highlighted some new information that was not realized before, such as, small magnets do not oscillate uniformly throughout but have different oscillation modes based on the frequency of the oscillating field provided.
This information will be useful to the team in the future to determine the cause of the unexplained resonance peaks in some of the simulations and the experiments. These are very interesting as there is some discrepancy between the simulations and the experiments such as the extra peaks which are yet to be fully understood but my research will help the team gain a greater understanding of this.

UNIVERSITY OF NOTRE DAME
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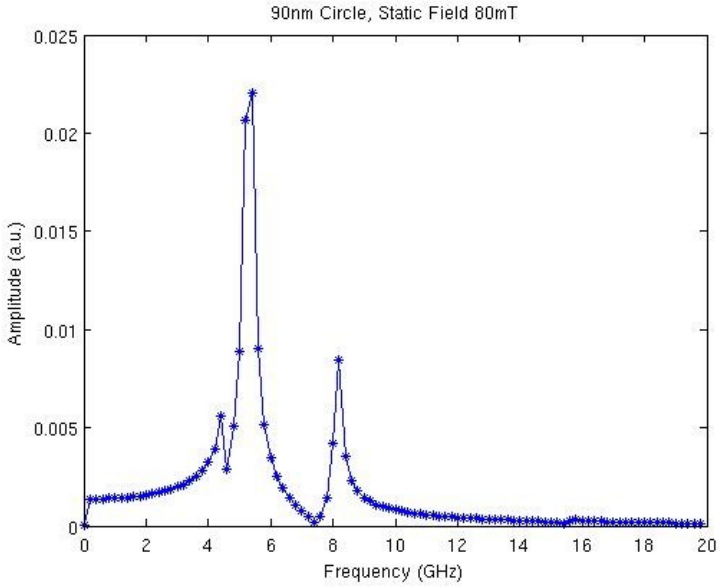
Project Summary:

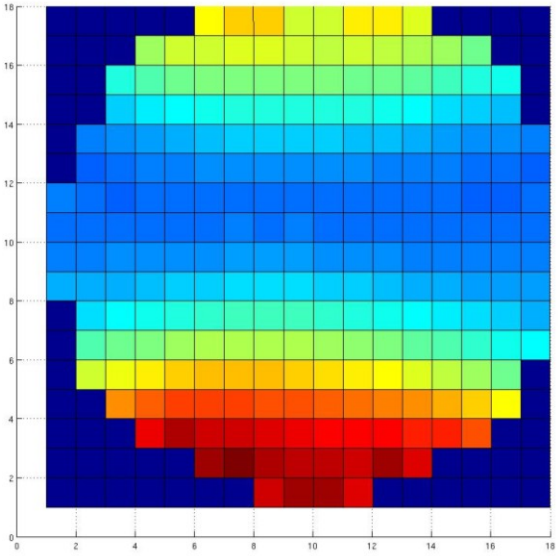
Nanomagnets can be used for logic in computers instead of CMOS transistors. These Nanomagnets could provide lower power consumption than transistors. However, the dynamic switching properties of the nanomagnets are not yet well understood. In this research, the effect of dynamic conditions on the magnets, i.e. the response to an oscillating external field, were investigated by simulation using the OOMMF micromagnetic package. These simulations were directly compared to experiments in some cases where experimental data existed.

The goal of the research was to gain a better understanding of the high frequency behaviour of nanomagnets and to compare the simulations with the experimental data. The effect of simulation parameters, magnet shape and size, coupling strength of magnets were investigated with respect to dynamic conditions. Some of the results for the 150nm Circle simulation and the 90nm circle simulation could be compared with those of the experiments. For most cases, there was a good agreement between the experiments and the simulations, but for larger magnet sizes a lot has yet to be explained. Each of the simulations was generated using a Matlab program that was developed. The resulting data files were of the nanomagnets. An example of the grap

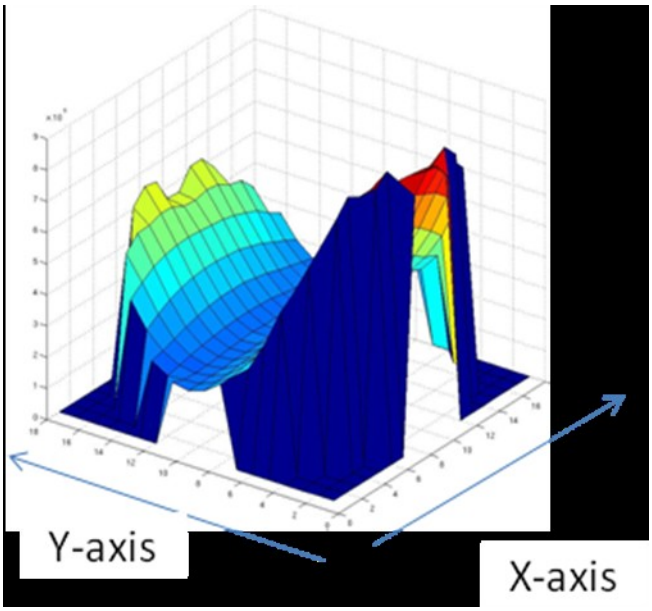


Amplitude vs. Frequency Graph for a 90nm Circular nanomagnet with an external static field of 80mT

A new technique for analysing the internal magnetisation of a nanomagnet was developed. This was used to investigate how the magnets were oscillating. It was found that the nanomagnets do not oscillate uniformly as previously thought but that different portions of a nanomagnet oscillate differently than others, which may be causing some of the unusual peaks that were seen in the simulation. An example of the graphs that were created is shown below.



Pcolor plot of the amount of oscillations in the Nanomagnet



Surface plot of the amount of oscillations in the Nanomagnet

The two graphs above show the same circular nanomagnet, both show where the most oscillation is in the dot. It can be seen that most of the oscillation is at the bottom of the dot and it is not uniform.

Publications (papers/posters/presentations):

- 1 poster for the Undergraduate Research Symposium, which is attached
- 1 Presentation done for Group