UNDERSTANDING THE ROLE OF THERMAL FLUCTUATIONS ON THE FIDELITY OF MAGNETIC RECORDING IN ROCKS AND METEORITES.

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When igneous rocks such as lava cool in the Earth's field the magnetic minerals within acquire a thermally activated magnetisation, which on cooling to ambient temperatures is commonly stable on geological timescales. It is this ability to record meta-stable magnetisations that forms the basis of palaeomagnetism, which has been influential in many areas of Earth and Planetary Sciences in particular the unravelling of plate tectonics and Solar Nebular formation.

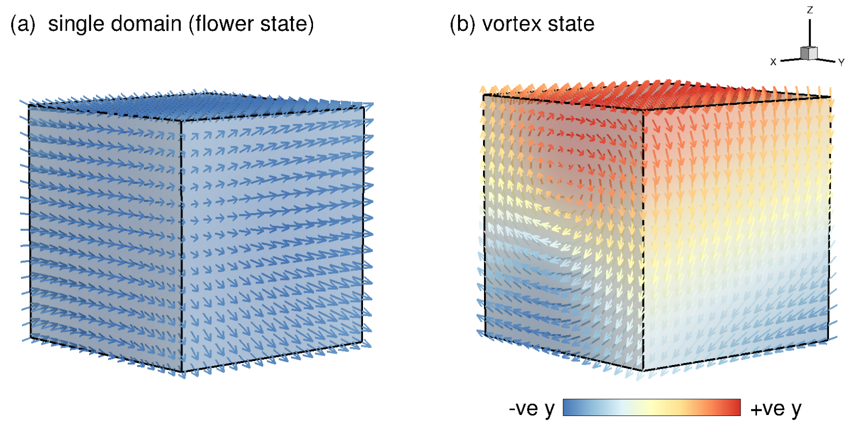

Figure 1. *Micromagnetic solutions for metallic iron particles: a) a small grain with a uniform (single domain or 'flower state') magnetisation, and b) a slightly larger particle showing a non-uniform vortex structure. From Muxworthy and Williams (2015).*

There are tried and tested models of how the smallest magnetic grains (which have uniform magnetic structures (Fig. 1a)) acquire such thermally activated magnetisations; however, our understanding of how larger grains that display non-uniform magnetisations ('vortex', Fig 1b), which are very common in nature, is largely phenomenological. The behaviour of these larger grains is very different to the smaller ones, as their non-uniform magnetic structures behave non-linearly. Previous attempts have been made to model this magnetic acquisition behaviour using numerical Monte Carlo simulations (Thomson *et al.*, 1994), however, in the last 20 years, there have been significant advances in both numerical modelling techniques and algorithms, in addition to very large advances in available computing facilities (Nagy et al, 2017). We are now in a position to develop more advanced thermal fluctuation models, and to apply these models to actual geophysical problems.

It is proposed that the student will develop and implement a thermal fluctuation algorithm (stochastic integration), which will be incorporated into a state-of-the-art existing finite-element (FEM) numerical micromagnetic model developed by a recent PhD student of the two supervisors (Nagy et al, 2017). The student will then numerically investigate thermally activated magnetic-acquisition processes in iron oxide grains, to assess the fidelity of their recording capabilities. Knowledge of computer programming and/or mathematics/physics would be beneficial.

Muxworthy, A.R. and W. Williams (2015). Critical single-domain grain sizes in elongated iron particles: implications for meteoritic and lunar magnetism, Geophys. J. Int., 202, 578-583,

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Thomson, L. C., R. J. Enkin, and W. Williams (1994), Simulated annealing of three dimensional micromagnetic structures and simulated thermoremanent magnetization, J. Geophys. Res., 99, 603-606.

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