Magnetization Reversal in Magnetic Nanostructures: Stoner Wohlfahrt Theory Extended to Antiferromagnets

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ABSTRACT

In recent years magnetism at small length scales has been a rapidly growing field in material science as well as in condensed matter physics. Small magnetic particles and artificial thin-film structures based on ferro- or anti-ferromagnetic layers separated by non-magnetic spacers are the basic structural elements for an enormous scope of technical applications in the area of data storage and magnetic sensors found in a variety of everyday products. We start with the N-particle Hamiltonian of the classic anisotropic Dirac-Heisenberg model. The exponentially many locally stable energy minima, which are crucial for hysteresis effects, are determined from the integration of the Landau Lifshitz Gilbert equation. We first study dynamical and static properties only of two interacting magnetic particles subjected to exchange interaction, anisotropy and an external magnetic field. The well-known Stoner Wohlfahrt model for a single magnetic particle is generalized to describe the critical behaviour of two anti-ferromagnetically coupled ferromagnets. The outcoming generalized Stoner "Asteroid" [1] is easily accessible for experimental studies. These partly analytical results can give answers to the problem of finding adequate materials for practical applications such as sensor, storing or recording devices. The problem of multistability for larger numbers of particles or layers turns out to be a highly complex problem within an energy landscape, where we have to deal with exponentially many locally stable energy minima. We show that fractal properties are seen in all physical variables such as the distribution of the magnetic moments, the total magnetizations as well as the total energies of the system [2].

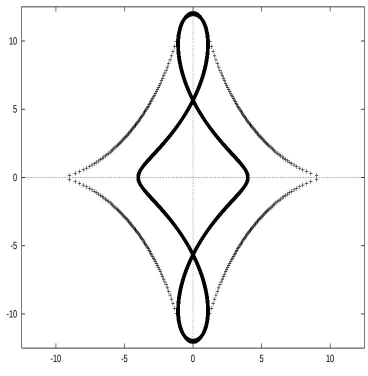

Figure: Generalized Stoner Asteroid for sufficiently strong anisotropy:
The outer critical line specifies the transition from the ferromagnetic to the antiferromagnetic phase

[1] K.E. Kuerten Proceedings of the XXVIII International Conference on Condensed Matter Theories, Kyoto, Nova Science Publishers, N.Y. (2006)

[2] K.E. Kuerten and F.V. Kusmartsev, Phys.Rev.B 73, 014433 (2005)