MAGNETOSTATICS IN NANOSTRUCTURED ARRAYS: BEYOND THE DIPOLAR APPROXIMATION

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For magnetic storage and memory devices it is very important to understand the combined effect of reducing magnetic element sizes and stacking them into arrays. In fact, on reducing dimensions to the nanoscale, the superparamagnetic limit is reached for ferromagnetic materials. At this limit, thermal fluctuations overcome anisotropy. Different approaches to beat this limit involve an increase in the anisotropy, either intrinsic or shape (magnetostatic), or coupling the magnetization to another media like an antiferromagnetic material **[1]** or like in antiferromagnetic coupled media (AFC). Our approach tries to understand and isolate pure magnetostatic effects that would be very demanding to model by micromagnetic calculations in nanostructured arrays.

In this work, the magnetostatic interactions for an array of ferromagnetic elements in the nanoscale is studied. The size of the elements is down to a maximum of 100 nm, while the thickness of the elements is about 5 nm. We use a magnetic potential proposed by Craik **[2]** for magnetic poles surfaces, assuming a uniform magnetization distribution, in order to take into account short range effects, i.e., in order to go beyond the dipolar approximation **[3]**.

Thus, an analytical expression for the magnetostatic energy of an array (**Fig. 1**) is provided for different cases: isolated elements, considering interactions with first neighbours only, considering *k* nearest neighbours interaction and considering interaction with the whole lattice, etc. These expressions can be used, for instance, to analyse the magnetostatic energy as a function of the inter-element separation (**Fig. 2**) or as a function of the angle of the magnetization with respect to the tile edge. For each case, different element and array shapes are considered.

References:

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[3] E. Tsymbal, Appl. Phys. Lett., Vol 77, No. 17 (2000)
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Figures:

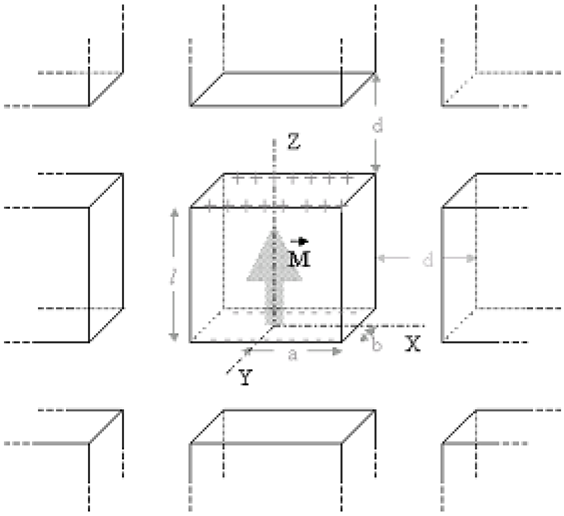

Fig.1: Problem conditions: The magnetization lays parallel to the tile edge, creating two magnetic poles surfaces of area 2a×2b. Tiles are separated a distance d both in the X and Z directions.

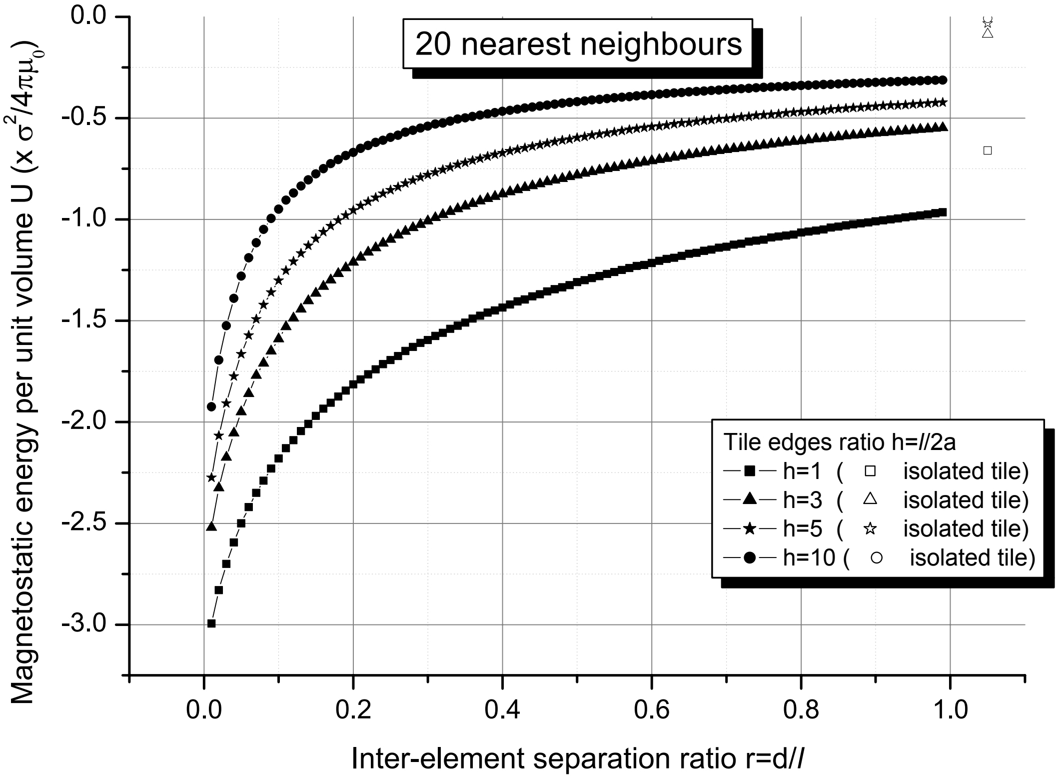

Fig.2: Magnetostatic energy per unit volume vs. inter-element separation ratio for different tile edges ratio considering inter-tile interactions up to 20 nearest neighbours. In Co, for example, $\sigma^2/4\pi\mu_0 \approx 2\cdot10^5$ J/m. For comparation purposes, the magnetostatic energy of an array of isolated elements, i.e., infinite separations, is also displayed.

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