Scaling laws for the cross–tie wall

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The magnetization of ferromagnetic materials forms complex structures of different dimensionality and on a broad range of length scales: domains, walls of different internal structure, Bloch lines and vortices.

The cross–tie wall is a wall–type (transition layer) which occurs in moderately thin films of ferromagnetic material. The magnetization lies entirely in the film plane and is constant in the direction of the film normal. But curiously, the wall has an internal structure in tangential direction: If one looks closely, the transition layer consists of a periodic arrangement of narrow Néel walls separeted by Bloch lines.

Does the well–accepted micromagnetic model predicts this interesting pattern? Does it at least predict how the distance w between two Bloch lines (hence the period) scales in the material parameters? The material parameters are the exchange length d, the film thickness t and the non–dimensional anisotropy parameter Q. Surprisingly, this question has not been answered in the applied literature. We give the answer

$$\frac{w}{d} \sim \frac{1}{Q}\frac{d}{t},$$

in an appropriate parameter regime. This answer is in qualitative agreement with the experiments. The derivation of this scaling law is based on the rigorous analysis of an interesting cross–over of the energy scaling law for a Néel wall. This is joint work with A. DeSimone, R. V. Kohn and S. Müller