Memory properties in a 3D micromagnetic model for ferromagnetic samples

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I. Introduction

Hysteresis modelling describes the transition curves corresponding with any change of the magnetic applied field. General features in the magnetization process are observed, known as Madelung's rules. Two major properties are the *return-point-memory* and the *wiping-out-property*[1]. Scalar macroscopic magnetic hysteresis models incorporate these rules. Here we show that the three dimensional micromagnetic model for large, bulk like samples presented in [2] incorporates Madelung's rules.

II. Numerical verification in the micromagnetic model

To evaluate the magnetic memory behavior, an iron sample with dimensions of $0.48\,\mu m \times 0.96\,\mu m \times 0.48\,\mu m$ consisting of two grains is simulated. Microscopic stresses are added to simulate grain boundary stresses. The sample is divided in cubical finite difference (FD) cells of $7.5\,nm$. In each cell, a magnetic dipole is defined. The evolution of the applied field is shown in Fig. 1. In Fig. 2, the magnetization

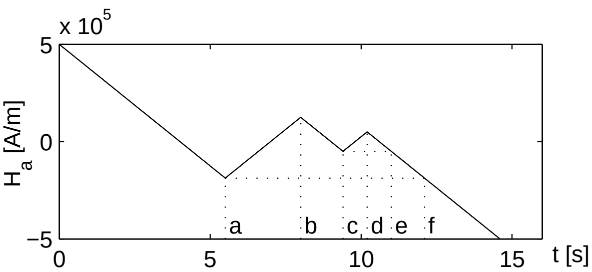

Fig. 1. Evolution of the applied field along the longest edge of the sample

states in a plane parallel with the applied field at time points c and e are shown. The states are identical. This is also shown in Table I where the differences between the magnetization states depicted in Fig. 1 are shown. Here, the difference $\Delta(A \leftrightarrow B)$ between two magnetic states A and B is defined as the mean angle (in degrees) between the magnetic dipoles in corresponding FD cells of state A and B.

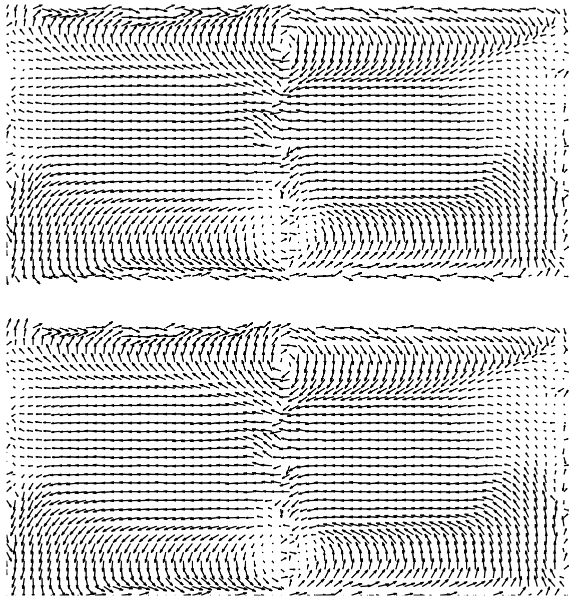

Fig. 2. Magnetic states in a plane parallel with the applied field, in time points c (top) and e (bottom), cfr Fig. 1

TABLE I
DIFFERENCE IN MAGNETIZATION STATE [DEGREES]

$\Delta(a \leftrightarrow f)$	4.33	$\Delta(c \leftrightarrow e)$	2.94
$\Delta(a \leftrightarrow b)$	77.73	$\Delta(c \leftrightarrow d)$	20.22

III. Conclusions

Since the differences $\Delta(a \leftrightarrow f)$ and $\Delta(c \leftrightarrow e)$ are smaller then computational errors [2] while the other states b and d differ substantially one concludes that (1) minor hysteretic loops are closed (*return-point-memory*) (2) the closed minor loops are completely erased from the memory (*wiping-out-property*) and (3) the magnetic state at the start of a minor loop is recovered exactly when this loop is closed.

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ABSTRACT BOOK