FORC based interaction strength investigations in permalloy micro arrays

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First-order reversal-curves (FORCs) are a powerful tool to not only get the fingerprint of investigated materials but also distinguish between microscopic interaction and coercivity contributions. However, most real systems usually violate Mayergoyz' congruency property [1] which has to be fulfilled to easily interpret the FORC diagram as a Preisach distribution. It is desirable to get deeper insight into FORC features of systems, which are violating the congruency condition. Finding the fundamental origin for the differences between FORC and Preisach is a challenging task, especially the extraction of physics from the FORC density rather than just getting magnetic fingerprints. To build a congruency violating system, one-dimensional soft-magnetic permalloy micro arrays (see inset in Fig. 1) of length 150 µm have been designed using photolithography. One structure consists of eleven stripes of alternating width (stripe width: 10-50 µm, spacing 10-30 µm). By varying these parameters, we manipulate coercivities and interaction strength. Using a *Durham Magneto Optics NanoMOKE3* [2][3][4] we directly measure the low field spatially resolved switching field distribution (bottom inset in Fig. 1) which clearly shows that the coercivities of the sample is binary and distributed around 1 and 3 Oe. Surprisingly, not only the two expected peaks appear in the FORC density. There is an additional positive-negative peak pair appearing at negative interaction fields. By exactly knowing the system and further conformation using the spatially resolved coercivity, we can exclude that this peak corresponds to any specific component of the structure. Taking a deeper insight reveals that the two peaks are cause by interaction of small and big stripes, more precisely by the interaction field, created by the high coercivity component, which causes the small coercivity component to flip at different fields when aligned parallel or antiparallel to the high coercivity stripes. These peaks would not appear had Mayergoyz' conditions been fulfilled. Plotting the volume of the integrated interaction peak for increasing distance normalized by the integrated FORC density (see Fig. 1 bottom) shows a clear trend to smaller peaks as the interaction goes down with increasing distance. So we can conclude, if we *turn off* the interactions within the system, the Mayergoyz' criteria will be fulfilled and the FORC density would merge with the Preisach distribution.

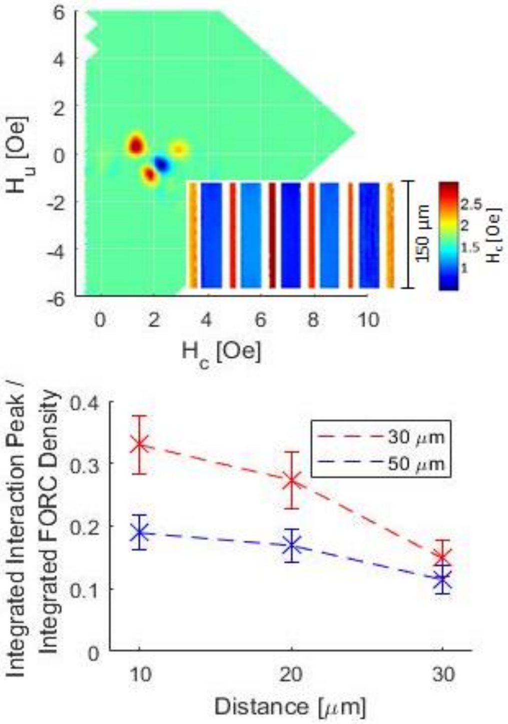

Figure 1: FORC density and measured coercivity distribution (inset). / Normalized interaction peak contribution.

Systematically investigating alternating microarrays using first-order reversal-curves and spatially resolved imaging methods for the switching field, we found that hard and soft magnetic components within one structure lead to extra peaks in the FORC density, which are not caused by specific components. Compared to previous dominated fingerprint FORC interpretations this could be used to extract additional quantitative information not provided by a Preisach distribution.

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