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Energy and Length Scales in the Exchange Bias Problem[1]

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Exchange bias phenomenon in antiferromagnet/ferromagnet (AF/F) systems has been studied for over fifty years, however a quantitative theory of exchange bias is still lacking. Although main theoretical ideas necessary for a comprehensive exchange bias theory appear to be in place, reliable quantitative predictions of exchange anisotropy based on the properties of the ferromagnet and the antiferromagnet cannot be made at present. One reason for the difficulty of understanding of exchange bias is the wide range of qualitatively different magnetic behaviors exhibited by different exchange bias systems. In this talk I will argue that the wide range of magnetic behaviors exhibited by exchange bias systems results from the large number of energy and length scales in the exchange bias problem. Different hierarchies of energy and length scales can give rise to qualitatively different magnetic properties of exchange bias systems. Therefore, a classification scheme of exchange bias systems based on the hierarchy of the relevant energy and length scales would greatly facilitate the progress towards the comprehensive understanding of the exchange bias effect. In this talk I will discuss existing theoretical predictions for the magnitude and symmetry of exchange anisotropy in AF/F systems belonging to different energy and length scale hierarchy classes. These predictions will be compared to our experimental data on exchange anisotropy in Fe/MnF_2, Fe/FeF_2 and Co/CoO systems belonging to three different classes. I will also analyze exchange anisotropy data for other exchange bias systems reported in the exchange bias literature in the context of the energy and length scale hierarchy classification. The degree of success of the proposed classification scheme of exchange bias systems for analysis of the experimental data will be discussed.

[1]In collaboration with D. Dahlberg, T. Gredig, I. K. Schuller, C. Leighton and J. Nogues.