Spin-flop Transition in Finite Antiferromagnetic Superlattices

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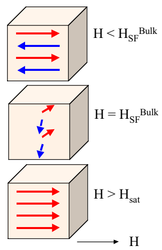
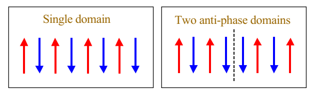
Background

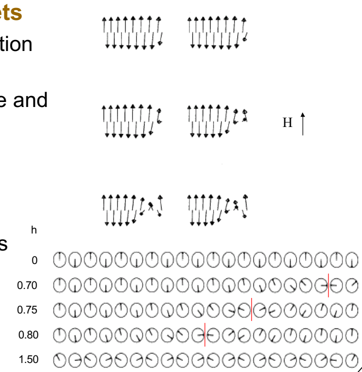
- Interest in the 1st order spin-flop transition in uniaxial bulk antiferromagnets (AFM) originated when it was first predicted by L. Néel in 1936. [1]
  - Reorientation of AFM component perpendicular to easy-axis and applied field
  - Finite magnetization along field
- Bulk spin flop transition experimentally confirmed >30 years later. [2]
- Since then, theoreticians have estimated the effect of the surface in a finite AFM.



Predictions for finite size antiferromagnets

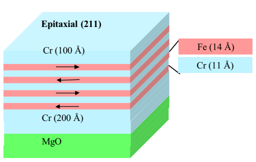
- In a finite AFM there is a surface spin-flop transition at a field below the bulk spin-flop transition. [3]
- Spins near the surface rotate into a flopped state and creating an AF domain wall.
- The wall penetrates through the system until it reaches the center.
- The spin-flopped region expands throughout. [4]
- Wall divides system in two (anti-phase) domains separated by a "discommensuration." [5]

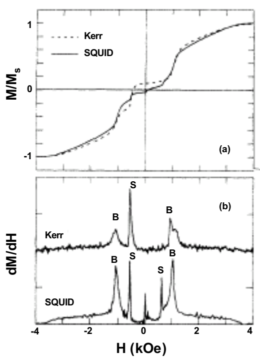




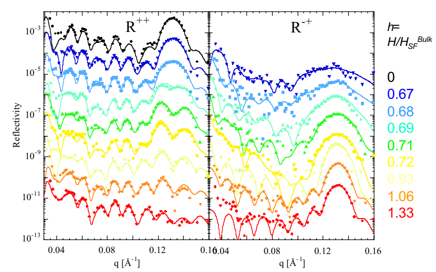
First Experimental Evidence [6]

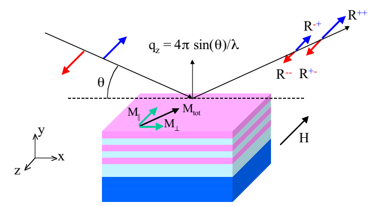
- An Fe/Cr(211) superlattice was used as template for finite uniaxial antiferromagnet
- Comparison between MOKE and SQUID confirmed surface-initiated spin-flop transition [6]



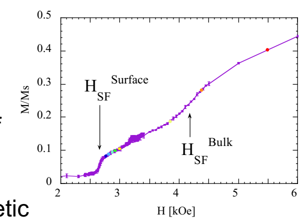


Polarized Neutron Reflectivity Results on a Fe/Cr superlattice

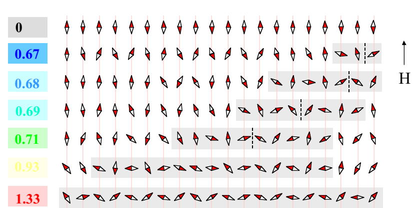


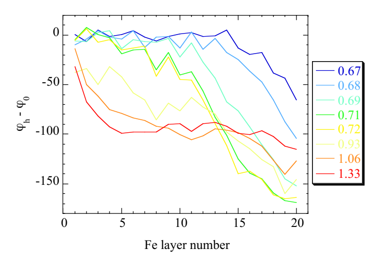


- The spin flip and non-spin flip neutron reflectivities were measured as a function of applied field on POSYI at IPNS.



- After fitting, a detailed picture of the magnetic orientation in each Fe layer was obtained



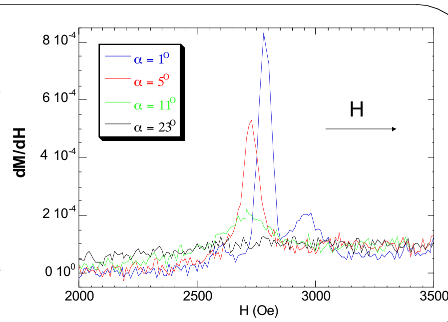


Conclusions

- Basic theoretical description of surface spin-flop transition confirmed experimentally with PNR.
  - Initiation at surface
  - Motion of domain wall into film and expansion
  - Formation of anti-phase domains

Ongoing research:

- Effect of the orientation of the applied field with respect to the easy axis (_) on the (1st order) nature of the SSF transition.
- The influence of the ratio of coupling strength versus anisotropy.
- The SSF transition in a superlattice with perpendicular anisotropy.



References:

[1] L. Néel, Ann. Phys. (Paris) **5** (1936) 232.
[2] For a review see: Y. Shapira and S. Foner, Phys. Rev. B **1** (1970) 3083
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[4] F. Keffer and H. Chow, PRL **31** (1973) 1061
[5] C. Micheletti *et al*., PRB **59** (1999) 6239
[6] R.W. Wang et al. PRL **72** (1994) 920

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