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Magnetic Flux Distribution in High T_c SC / FM Multilayers

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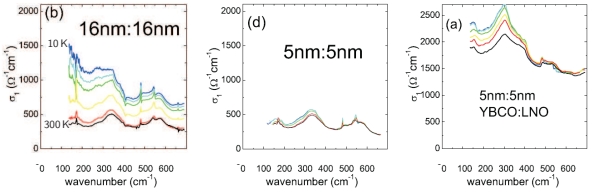
Motivation

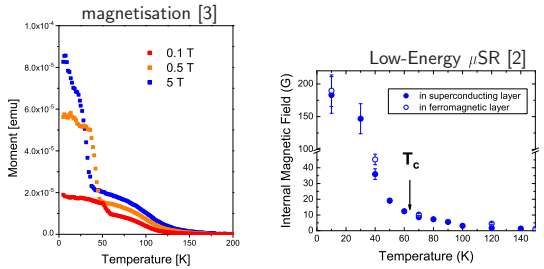
Transport measurements on multilayers of high T_c superconducters and ferromagnets have established that there is a strong interaction between the SC and FM order parameters. Given the metallic properties of the individual materials one would expect that the multilayers also should exhibit a strong metallic response. Instead they exhibit a drastic decrease in the absolute value of σ_1 which corresponds to a significant reduction of the free carrier concentration or of their mobility.



Representative spectra for the real-parts of the in-plane conductivity σ_1 of YBCO/LCMO multilayers obtained by ellipsometry [1].

For the 5:5 nm superlattices, the free carrier response is barely visible. A corresponding suppression of metallicity is not observed in superlattices where LCMO is replaced by the paramagnetic metal $LaNiO_3$.

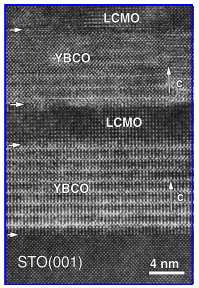
Low-Energy μSR and magnetisation measurements showed an unexpected magnetic behaviour below T_c:



The depth-resolution of these methods (if any) is not sufficient to allocate the increased magnetic flux to certain regions.

Sample

The sample is a multilayer consisting of the high T_c superconductor $YBa_2Cu_3O_{7-\delta}$ (YBCO) and the GMR ferromagnet $La_{1/3}Ca_{2/3}MnO_3$ (LCMO) on a $SrTiO_3$ substrate.
It was grown by LASER ablation by H.-U. Habermeier *et al.* at the MPI Stuttgart.

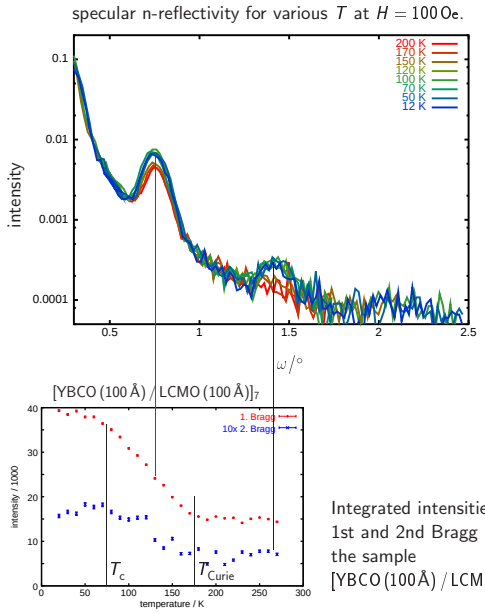


TEM picture of a YBCO / LCMO multilayer

Neutron Reflectometry

Unpolarised neutron-reflectometry with varying temperature and magnetic field strength H.

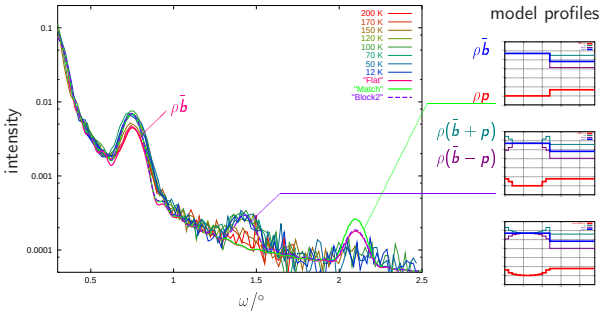
Instrument: Morpheus@SINQ with $\lambda = 4.74$ Å



Integrated intensities of the 1st and 2nd Bragg peak of the sample $[YBCO\,(100\,Å) / LCMO\,(100\,Å)]_7$

Simulations

Computer code: EDXR (P. Mikulík)



Interpretation

increase of the 1st Bragg peak:

→ increased contrast between YBCO and LCMO due to the magnetisation of LCMO below T_{Curie}

appearance of the 2nd Bragg peak:
(which is symmetry forbidden for a thickness ratio 1:1)

→ the magnetic field profile does no longer match the chemical composition

? penetration of **B** some 10 Å into YBCO

To clarify the open points and to reconstruct the profile B_z more measurements are necessary with

→ better peak-to-background ratio,

→ measurements close to the critical angle,

→ polarised neutrons.

References, Acknowledgements

[1] T. Holden *et al.*, cond/mat 0303284 v1 (2003)
[2] C. Bernhard *et al.*, PSI Scientific Report 2002 III, 84
[3] H-U. Habermeier *et al.*, Physica C **364-365**, 298 (2001)

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