Magnetic Flux Distribution in High $T_c$ SC / FM Multilayers

Motivation

Low-Energy $\mu$SR, magnetisation and ellipsometry measurements on multilayers of high $T_c$ superconductors and ferromagnets showed an unexpected magnetic behaviour below $T_c$ [1,2]:

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

Neutron Reflectometry

Unpolarised neutron-reflectometry was applied to 2 samples with varying temperature and magnetic field strength $H$.

Instrument: TOPSI (Morpheus) with $\lambda = 4.74\ \text{Å}$

Specular n-reflectivity for various $T$ at $H = 100\ \text{Oe}$.

Integrated intensities of the 1st and 2nd Bragg peak of the sample with layer-thickness ratio 1:1.

Samples

The samples are multilayers consisting of the high $T_c$ superconductor YBa$_2$Cu$_3$O$_{6.85}$ (YBCO) and the GMR ferromagnet La$_{1.2}$Ca$_{2.2}$MnO$_3$ (LCMO) on SrTiO$_3$. The samples were grown by LASER ablation by H.-U. Habermeier at the MPI Stuttgart.

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

decay of the intensity for $T < 20\ \text{K}$ for [YBCO (140 Å) / LCMO (70 Å)]:
? a "magnetic roughness" of the order of 50 Å appears

To clarify the open points and to reconstruct the profile $B_z$ more measurements are necessary with
→ better peak-to-background ratio (ADAM@ILL),
→ measurements close to the critical angle (AMOR),
→ polarised neutrons.

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