MAGNETOELASTIC INVESTIGATION OF RARE EARTH BASED MATERIALS

M. Doerr, M. Loewenhaupt (University of Technology Dresden, Germany); M. Rotter, A. Lindbaum (University Vienna, Austria); J. Brooks, E. Jobiliong, R. Vasic (FSU)

Introduction

The great interest in magnetostriction is connected to the fundamental importance of the interaction between the electronic and lattice degrees of freedom for superconductivity and magnetism. Many investigations focus on *ferromagnets*, often used in technological magnetostrictive applications. But, from the point of view of fundamental physics *antiferromagnets* may attract even more interest. In contrast to ferromagnets, in antiferromagnets a large variety of magnetic structures exist. This allows to distinguish the different mechanisms of magnetostriction and the interactions responsible for them. The proposed project aims at the investigation of magnetoelastic properties of antiferromagnets based on rare-earth magnetism (4f-systems).

Experimental

A new miniature (outer diameter 22 mm) capacitance dilatometer [1] was used. The advantage of this method is its high resolution. It is possible to measure the longitudinal as well as the transversal components of the magnetostriction tensor, so that the data can be compared well to the results of model calculations including single ion and exchange striction effects. The dilatometer was installed into a 33 T magnet. The field sweeps were done with a ramp rate of 2 T/min at 4.2 K. During extensive setup tests, the noise due to electrical influences and mechanical vibrations could be reduced to about 10^{-6} in dl/l.

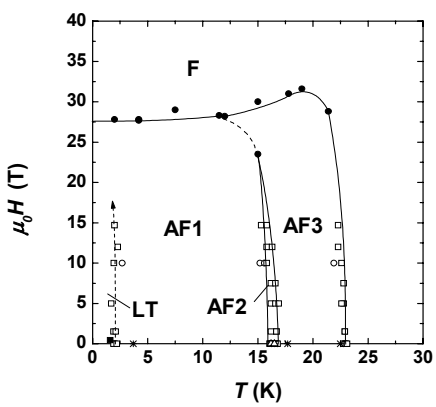

Figure 1: Magnetic phase diagram of $SmCu_2$ [2]

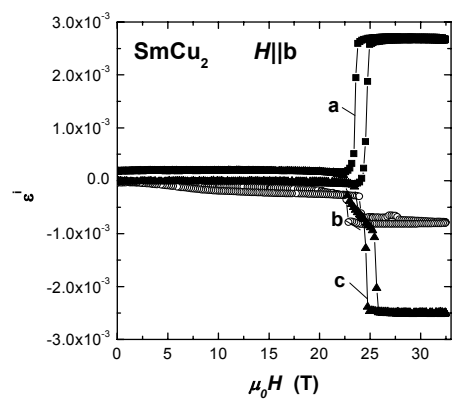

Figure 2: Magnetostriction of $SmCu_2$ in steady high fields along the (easy) *b*-axis

Results and Discussion

Basic magnetoelastic investigations were done at the pure rare elements Sm and Tm, because for both of them no magnetostriction data are available. As examples for rare earth based antiferromagnets some of the orthorhombic RCu_2 (R = Sm, Gd, Tm) compounds were analyzed. Among these, $SmCu_2$ has attracted the most interest (and is discussed here as an example) because of the sign reversal of the anisotropic part of the two ion interaction [2]. The magnetic moment is only 0.5 μ_B/f.u. due to a partial compensation of the orbital and spin moment. The magnetic phase diagram (see fig.1) contains an unconventionally shaped line for the transition into the ferromagnetic state with a critical field of about 27 T at 4.2 K. Our magnetostriction results, which offer steady high field data of $SmCu_2$ for the first time, confirm this transition and show that the lattice is remarkably influenced by this magnetic ordering process. The magnetostriction in fields along the (easy) *b* direction (see fig. 2) is characterized by an expansion of the *a* axis of $\varepsilon_a = +2.7\text{x}10^{-3}$ at 24 T, the *b* and *c* axes contract by ε_b=-0.8x10^{-3} , ε_c=-2.5x10^{-3}. In contrast to these large values, the magnetostriction in fields along the *a* or *c* axis is rather small and does not exceed 10^{-4} up to 33 T. It can be concluded that the capacitive method is a very sensitive tool, also at the highest steady fields. This opens a wide area of magnetoelastic investigations at magnetically ordered samples.

Acknowledgements

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References

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[2] Rotter, M., *et al*., Phys. Rev. B, **64**, 134405-134412 (2001).