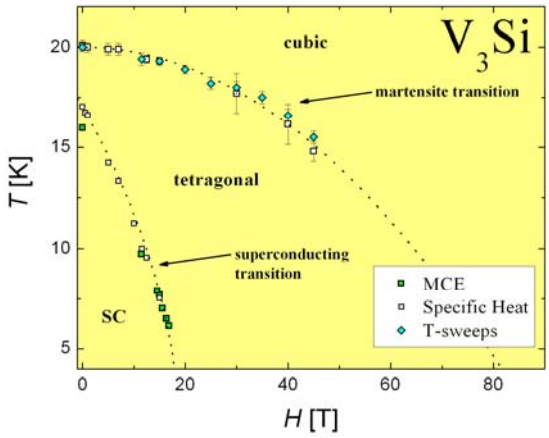
ELECTRONS AND MARTENSITES: EXPLORING THE MARTENSITIC PHASE DIAGRAM WITH MAGNETIC FIELDS

P.A. Goddard (Oxford University / LANL); A.V. Silhanek, J.C. Lashley, J. Singleton, N. Harrison, J.L. Smith (LANL); A. Planes (Barcelona University); A.P. Ramirez (Lucent)

The study of the martensite transition is by no means a new field of research. Its importance in the hardening of steel and its role in the shape memory effect has meant that a great deal of time and effort has been expended in its characterization. Despite this, a true consensus on the underlying microscopic origin of the transition has not yet been reached. At least two electronic mechanisms have been proposed, the band Jahn-Teller effect [1] and a Peierls-like nesting instability [2] each with some degree of experimental support [3, 4]. Recently workers at the NHMFL, Los Alamos observed a Fermi reconstruction associated with the shape memory transition at 67 K in the stoichiometric alloy AuZn using the de Haas-van Alphen (dHvA) effect [5]. That the dHvA oscillations were seen up to the transition temperature and beyond was remarkable - alloys often suffer from inherent disorder, and the martensite phase by its very nature consists of a microstructure of domains. Both of these considerations would lead to the expectation that quantum oscillations would be significantly suppressed in this material.

In the hope of observing further dHvA oscillations we have measured the magnetization of single crystals of the martensitic materials HfV_2, $Au_{0.52}Zn_{0.48}$, V_3Si and polycrystalline NiTi in fields up to 65 T and temperatures as low as 500 mK using the inductive-coil technique at the NHMFL, Los Alamos. No dHvA oscillations were observed in any of the materials other than V_3Si; in this case the oscillations were only visible below about 2 K and were in concordance with previous reports [6]. The negative results can be explained in a number of ways; the samples used may well have a high degree of disorder, the microstructural domains in the martensite phase may be so small as to impede the orbital motion of the quasiparticles in the fields used in this study, or the mass of the quasiparticles (in combination with the disorder) could possibly be large enough to suppress the oscillations at these temperatures.

A slight decrease of the martensite transition temperature with applied magnetic field in the superconductor V_3Si has been previously reported in fields up to 14 T [7]. The fact that a magnetic field can couple to this transition is strong evidence for the role of electrons, and a study of the field and temperature dependence of the martensitic phase boundary could reveal how the electronic system forces the structural transformation. To this end we have made measurements of the heat capacity and the magnetocaloric effect on single crystals of V_3Si in fields up to 45 T at the NHMFL, Tallahassee. In addition, the superconducting and martensite transitions were clearly observable as small anomalous changes in the sample temperature as the bath temperature was swept. The phase diagram arising from these measurements is shown below, and a detailed analysis is underway to ascertain whether it is compatible with the Jahn-Teller effect that is proposed in these A15 materials [1].



[1] J. Labbe, *et al.*, J. Phys (Paris), **27**, 153, (1966).
[2] G.-L. Zhao, *et al.*, Phys. Rev. B., **40**, 7999 (1989).
[3] P.J. Brown, *et al.*, J. Phys C.M., **11**, 4715, (1999).
[4] R.D. McDonald, *et al.*, J. Phys. C.M., **17**, L69 (2005).
[5] P.A. Goddard, *et al.*, Phys. Rev. Lett., **94**, 116401 (2005).
[6] Terashima, *et al.*, Physica B, **294**, 393, (2001).
[7] J. Sebek, *et al.*, Czech J. Phys., **52**, 291, (2002).