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MAGNETORESISTANCE AND MAGNETIC PHASES IN UNi_2Si_2* ‡

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Electrical resistivity was measured on a single crystal of UNi_2Si_2 for T = 4.2 ÷ 140 K in fields up to 8.4 T. Anomalies in the temperature dependence of resistivity in various fields and on isothermal magnetoresistance curves clearly indicate the magnetic phase transitions. From analysis of these effects a magnetic phase diagram is proposed. Relations between the resistance and types of magnetic phases are considered.

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1 Introduction

UNi_2Si_2, which crystallizes in the tetragonal $ThCr_2Si_2$–type structure, attracts much attention owing to a rich magnetic phase diagram. Three magnetic phases appear in zero field in consecutive temperature intervals below T_N = 124 K (Fig. 1) as confirmed by neutron scattering [1, 2], magnetization, transport [3, 4] and thermal expansion [5, 6] measurements on single–crystals. The reported magnetic structures [1, 2] consist of ferromagnetic basal planes of U moments oriented along the c-axis and sinusoidally modulated with a propagation vector $\boldsymbol{q}$ = (0, 0, q). The high–temperature phase (denoted as 1 in Fig.1) is an incommensurate longitudinal spin-density wave (ILSDW) with $\boldsymbol{q}$ = 0.745 (at 110 K). Below 103 K a simple AF-I structure (phase 2) with $\mu_U = 1.6\,\mu_B$ is stabilized. Below 50 K uncompensated AF structure (phase 3) with the + + – stacking along c (q = 2/3) exists. The transitions (the lower two are of first order type) are accompanied by anomalies in transport and magnetoelastic properties. Some versions of the magnetic phase diagram have been proposed from neutron diffraction [7] and thermal expansion [5, 6] studies in fields parallel to c. Owing to strong uniaxial anisotropy in UNi_2Si_2 no field effect is found for $B \perp c$. Here we report on our resistivity study in magnetic fields (B) up to 8.4 T.

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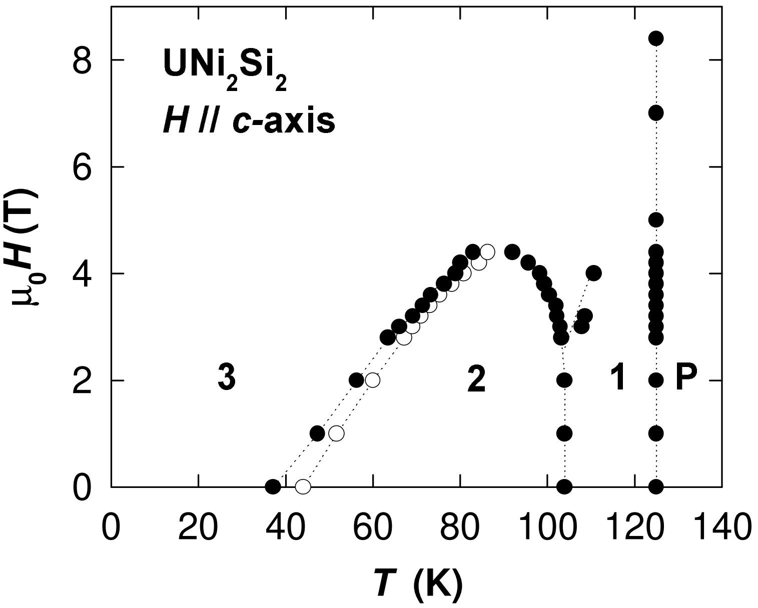

Fig. 1.: Magnetic phase diagram of UNi_2Si_2 in fields parallel to the c–axis. P - paramagnetic phase, 1 - ILSDW with $\boldsymbol{q}$ = (0,0,q), 2 - AF-I structure, 3 - uncompensated AF structure with $\boldsymbol{q}$ = (0,0,2/3). The dotted lines are guides for the eye. For further details see text.

2 Experimental results and discussion

The UNi_2Si_2 single crystal has been grown by Czochralski method in a tri-arc furnace. Electrical resistivity ρ with current along c was measured using standart AC four probe method. Various fields up to 8.4 T were applied also along c. The temperature range 4.2 $\div$ 140 K was selected to cover all the magnetic phase transitions. Results are in Fig.2.

For B = 0, the transition 1→2 (2→3) is reflected in a sudden resistivity drop (increase) at $T_{1\rightarrow 2}$ ($T_{2\rightarrow 3}$), the latter one showing a large hysteresis. In increasing magnetic field $T_{2\rightarrow 3}$ decreases rapidly. $T_{1\rightarrow 2}$ is field independent up to approx. 3 T (see Figs. 1 and 2). Above 3 T, the transition splits into two second–order transitions (at $T_{1\rightarrow 3}$ and $T_{3\rightarrow 2}$) and the phase 3 appears between 1 and 2 in a temperature range, which is expanding with further increasing field. This leads to suppression of the AF-I phase above 4.4 T. The ordering temperature T_{N} and also $T_{1\rightarrow 3}$ can be identified only by anomalies in the second derivative of the resistivity. T_{N} is almost field independent, whereas $T_{1\rightarrow 3}$ slowly increases with increasing field. Above 4 T, however, the latter anomaly cannot be unambiguously indicated due to larger data scatter. Therefore we cannot confirm suppression of ILSDW above 6 T proposed in [6]. The magnetoresistance curves ρ vs. B measured above 40 K exhibit visible anomalies around fields of phase transitions. Inspection of resistivity changes across the all magnetic-phase transitions in UNi_2Si_2 allows to conclude that: (a) the transition between paramagnetic state and ILSDW causes a change detectable only in $\partial^2\rho/\partial T^2$ vs. T, (b) the resistivity increases with increasing size of the magnetic unit cell in the

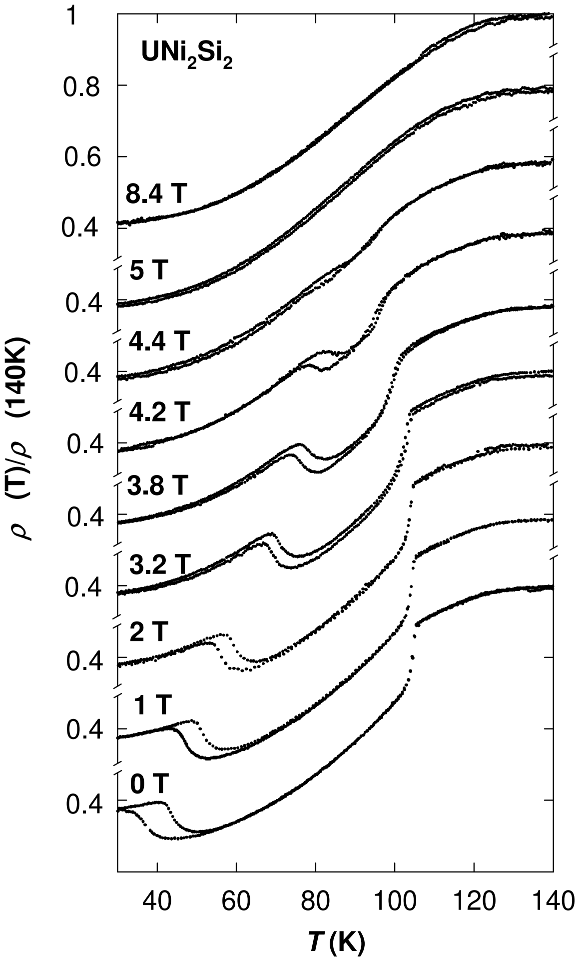

Fig. 2. Temperature dependence of the electrical resistivity (for current along c) in several magnetic fields applied along c.

current direction. Analogous results frequently observed [8] at metamagnetic transitions can be attributed to reconstruction of Fermi surface including formation of gaps due to different periodicity of magnetic and crystallographic structure [8].

In conclusion, we have observed effects of magnetic phase transitions in UNi_2Si_2 on the resistivity in magnetic fields up to 8.4 T and proposed a B-T diagram, which confirms results obtained by other methods. The observed variations of resistivity can be correlated with changes of magnetic periodicity across the magnetic phase transitions.

References

[1] H. Lin, L. Rebelsky, M.F. Collins, J.D. Garrett, W.J.L. Buyers: *Phys. Rev.* **B43** (1991) 3232

[2] L. Rebelsky, H. Lin, M.F. Collins, J.D. Garrett, W.J.L. Buyers, M.W. McElfresh, M.S. Torikachvili: *J. Appl. Phys.* **69** (1991) 4807

[3] Y.B. Ning, J.D. Garrett, W.R. Datars: *Phys. Rev.* **B42** (1990) 8780

[4] Y.B. Ning, V.V. Gridin, C.V. Stager, W.R. Datars, A.LeR. Dawson, D.H. Ryan: *J. Phys.: Condens. Matter* **3** (1991) 4399

[5] F. Honda, G. Oomi, T. Kagayama, A.V. Andreev, V. Sechovský, L. Havela, M.I. Bartashevich, T. Goto, A.A. Menovsky: *J. Magn. Magn. Mater.* **177-181** (1998) 49

[6] S.W. Zochovski, S.A. Creeger, M.F. Collins: *J. Magn. Magn. Mater.* **140-144** (1995) 1399

[7] L. Rebelsky, H. Lin, M.W. McElfresh, M.F. Collins, J.D. Garrett, W.J.L. Buyers, M.S. Torikachvili: *Physica* **B180-181** (1995) 43

[8] V. Sechovský, L. Havela, H. Nakotte, E. Brück: *IEEE Magnetics* **32** (1996) 4687