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CRITICAL SCATTERING OF UNiGa* ‡

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The hexagonal intermetallic compound UNiGa adopts the ZrNiAl structure type, orders antiferromagnetically below 39 K and exhibits several AF phases with lowering temperature. Within narrow temperature range 34 K - 39 K there exist four magnetic phase transitions in zero magnetic field. In all these phases the magnetic structure is highly anisotropic with magnetic moment parallel to the *c*–axis. The phase just below T_N is an incommensurate antiferromagnetic structure characterised by propagation vector **q** = (0, 0, q_z), where q_z is in the range 0.36 - 0.37. We present results of magnetic critical scattering study on a UNiGa single crystal. The intensity of critical scattering drops rapidly within a very narow temperature range above T_N.

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1 Introduction

One of the most thoroughly studied compounds of the UTX-stoichiometry (T = transition metal, X = p-metal) is UNiGa which adopts the hexagonal ZrNiAl-type structure. It orders antiferromagnetically below 40 K and exhibits a complex magnetic phase diagram, namely in the vicinity of the Néel temperature [1, 2]. Similar to other hexagonal UTX, UNiGa displays strong uniaxial anisotropy with magnetic moment parallel to the *c*–axis. The magnetic structure of UNiGa consists of ferromagnetic basal planes antiferromagnetically coupled along the *c*–axis [1, 3]. The huge uniaxial magnetocrystalline anisotropy, amounting to several hundreds of Kelvins, persists till high temperatures in paramagnetic range as was documented by various experiments on available single-crystals [4].

In this paper we present the results of the elastic neutron diffuse-scattering experiment on a high-quality single crystal of UNiGa. The experiment was motivated by the anomalous temperature dependence of the electrical resistivity (see Fig. 1(a)) [5]. Similar to the magnetic properties,

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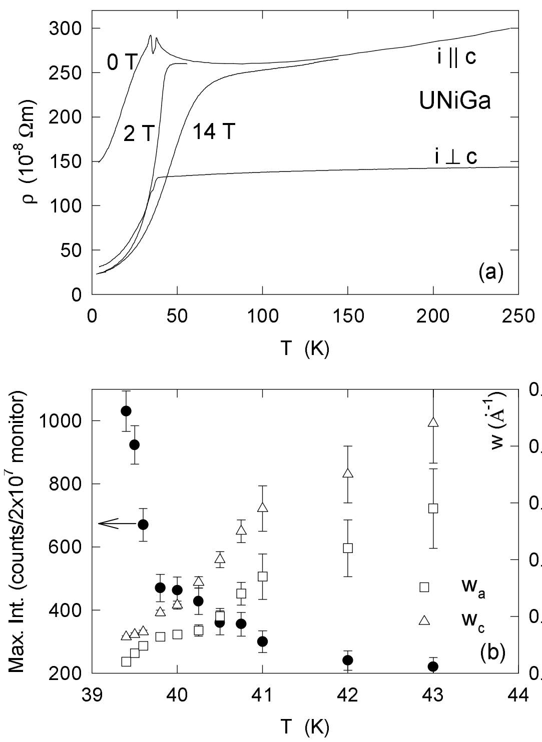

Fig.1.: (a) The temperature dependences of the electrical resistivity of the UNiGa single crystal measured parallel and perpendicular to the *c*–axis. The parallel dependence in zero field is compared with the measurements in B = 2 and 14 T applied along the *c*–axis. (b) The temperature dependences of the maximum critical scattering intensity (•) and of the width of the diffuse peak (□,△) along the a and *c*–axis, respectively.

also the transport properties are highly anisotropic. The basal-plane resistivity is nearly constant above the Néel temperature, resembling the behaviour of a ferromagnetic material. The resistivity measured along the c-axis, however, exhibits an upturn below 80 K, which becomes gradually steeper by approaching the Néel temperature. This upturn in resistivity persists also in relatively strong magnetic fields applied along the *c*–axis, for the complete removal of this feature B = 14 T was necessary. A possible source of this behaviour can be connected with strong antiferromagnetic correlations above the Néel temperature.

2 Experimental

The elastic neutron diffuse-scattering experiment was performed on the E6 focusing diffractometer with a 20^o banana-type multidetector at BER II reactor, HMI, Berlin, with the neutron wavelength λ = 2.404 A . The single crystal of UNiGa was mounted with the *a*-*c* plane as a scattering plane, allowing us to study the anisotropy of the critical scattering. The diffuse scattering was measured at the position of the strongest incommensurate antiferromagnetic reflection **q** = (2 0 0.36). As expected, there was no trace of magnetic intensity at **q** = (0 0 0.36), confirming parallel alignment of magnetic moments to the *c*–axis also above the Néel temperature. At all temperatures the critical scattering is centered at **q** = (2 0 0.36).

3 Results and discussion

As can be seen from Fig. 1(b), the intensity of diffuse scattering rapidly drops down with increasing temperature. Even with extremely long counting times we were able to follow the intensity within only few Kelvins above the Néel temperature. At higher temperatures the intensity was unseparable from the increased background. This surprising result is somewhat contradictory to the pronounced effect on the c-axis resistivity. A possible explanation of this discrepancy, strongly supported by the μSR experiment [6], is the existence of fast antiferromagnetic fluctuations along the *c*–axis, strongly damped just above the Néel temperature. The observed anisotropy of the width of the critical scattering is also supporting this hypothesis (see Fig. 1(b)). The correlation length in the real space (represented by the reciprocal of the peak width) ξ_a is about twice as large as ξ_c (at T = 41 K ξ_a= (5.9 $\pm$ 0.1)nm, ξ_c = (3.4 $\pm$ 0.1)nm).

The assumption (similar to the ordered state) of the ferromagnetic correlations within the basal plane and rapidly fluctuating antiferromagnetic correlations along the *c*–axis is in agreement with the observed correlation length and can also explain the different temperature dependence of electrical resistivity parallel and perpendicular to the *c*–axis as the electron scattering is much more sensitive to fast antiferromagnetic fluctuations.

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