Magnetic and Fermi Surface Properties of UTGa$_5$ (T: Fe, Co and Pt)

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1. Introduction

UTGa$_5$ (T: transition metal) has the HoCoGa$_5$-type tetragonal crystal structure (P4/mmm $\#123D_{4h}$)[1]. Uniaxially distorted AuCu$_3$-type layers of UGa$_3$ and TGa$_2$ are stacked sequentially along the [001] direction (c-axis). The corresponding Brillouin zone becomes flat along [001], reflecting a large $c$-value. This characteristic feature brings about the quasi-two dimensional Fermi surface. In fact, we found recently cylindrical Fermi surface in a paramagnet UFeGa$_5$ and antiferromagnets UNiGa$_5$ and UPtGa$_5$[2–4].

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2. Experimental Results and Discussion

Fig. 1 shows the angular dependence of the dHvA frequency $F (=\hbar c S_{F}/2\pi e)$, which is proportional to the extremal (maximum or minimum) cross-sectional area of the Fermi surface $S_F$. Four kinds of dHvA branches named $\varepsilon$, $\alpha_3$, $\alpha_1(\alpha_2)$ and $\gamma$ were detected. Broken lines in Fig. 1 show the $1/\cos\theta$-dependence, which is expected for cylindrical Fermi surfaces.

In the previous paper, another branches named $\beta$ and $\sigma$ were adopted[4]. They are found to be due to second harmonic and sum of two fundamental branches, and then omitted in Fig. 1. For branch $\gamma$, we observed the dHvA signal up to $\theta=75^\circ$, where $\theta$ is a tilted field angle from [001] to [100] or [110]. This Fermi surface is thus found to be cylindrical.

From these dHvA results, we propose the Fermi sur-
Fig. 1. Angular dependence of the dHvA frequency in UPtGa.

Fig. 2. Cross-sections in the ΓXM plane for each branch in UPtGa.

The magnetic unit cell, it is clear that this compound is a compensated metal with equal volumes of electron and hole Fermi surfaces. We simply assumed that Fermi surfaces of all the branches are cylindrical. The volume of each Fermi surface is as follows: $V_\gamma = 0.054V_{\text{BZ}}$, $V_\varepsilon = 0.512V_{\text{BZ}}$, $V_{\alpha_3} = 0.354V_{\text{BZ}}$ and $V_{\alpha_1(\alpha_2)} = 0.235V_{\text{BZ}}$, where $V_{\text{BZ}}$ is the volume of the Brillouin zone based on the magnetic unit cell. The total volume for electrons, which are shown by gray areas in Fig. 2, is 2.05$V_{\text{BZ}}$, indicating the compensated metal. Here branches $\alpha_1$ and $\alpha_2$ correspond to the maximum and minimum cross-sectional areas of a cylindrical Fermi surface with convex and concave, respectively. Moreover, the electronic specific heat coefficient $\gamma = 57 \text{ mJ/K}^2\cdot\text{mol}$ is consistent with $\gamma = 61 \text{ mJ/K}^2\cdot\text{mol}$ obtained from the cyclotron mass, where the cyclotron mass ($m^*_c = 10m_0$) for branch $\gamma$ corresponds to $\gamma = 9.3 \text{ mJ/K}^2\cdot\text{mol}$, similarly $\gamma = 18.6 \text{ mJ/K}^2\cdot\text{mol}$ for branch $\varepsilon$ ($m^*_c = 20m_0$), $\gamma = 22.3 \text{ mJ/K}^2\cdot\text{mol}$ for branch $\alpha_3$ ($m^*_c = 24m_0$) and $\gamma = 10.7 \text{ mJ/K}^2\cdot\text{mol}$ for branch $\alpha_1(\alpha_2)$ ($m^*_c = 13(10)m_0$).

It is thus concluded that UPtGa is a compensated metal and the Fermi surface consists of four kinds of cylindrical Fermi surfaces.

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References