Magnetic and Fermi Surface Properties of $UTGa_5$ (T : Fe , Co and Pt)

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Abstract

@We succeeded in growing high-quality single crystals of $UTGa_5$ (T : Fe, Co and Pt) by the self-flux method, and measured the de Haas-van Alphen (dHvA) effect. With increasing the number of 3*d*-electrons, from Fe to Pt, the Fermi surface is found to change systematically, indicating cylindrical Fermi surfaces in $UFeGa_5$ and $UPtGa_5$.

Key words: dHvA; Fermi surface; $UPtGa_5$; $UFeGa_5$; $UCoGa_5$

1. Introduction

$UTGa_5$ (T : transition metal) has the $HoCoGa_5$-type tetragonal crystal structure (P4/mmm $\#123D_{4h}^1$)[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].

Namely, the Fermi surface in $UFeGa_5$ is found to consist of a cylindrical but highly corrugated Fermi surface and a lattice-like Fermi surface. On the other hand, $UCoGa_5$ is a semimetal with small electron and hole Fermi surfaces[5]. If one more 3*d*-valence electron is added to $UCoGa_5$, a cylindrical Fermi surface is expected to appear in $UNiGa_5$ and $UPtGa_5$, which is realized in both compounds[2–5].

In the recent de Haas-van Alphen (dHvA) experiment for $UPtGa_5$, detected dHvA branches were not well identified, although the magnetic structure is simple, doubled with respect to the chemical unit cell along [001][6]. we have thus continued in doing the dHvA experiment to clarify the Fermi surface in $UPtGa_5$.

2. Experimental Results and Discussion

Fig. 1 shows the angular dependence of the dHvA frequency F ($=\hbar c S_{\rm F}/2\pi e$), which is proportional to the extremal (maximum or minimum) cross-sectional area of the Fermi surface $S_{\rm F}$. Four kinds of dHvA branches named ε, α_3, $\alpha_1(\alpha_2)$ and γ 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 β and σ 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 γ, we observed the dHvA signal up to θ=75°, where θ 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-

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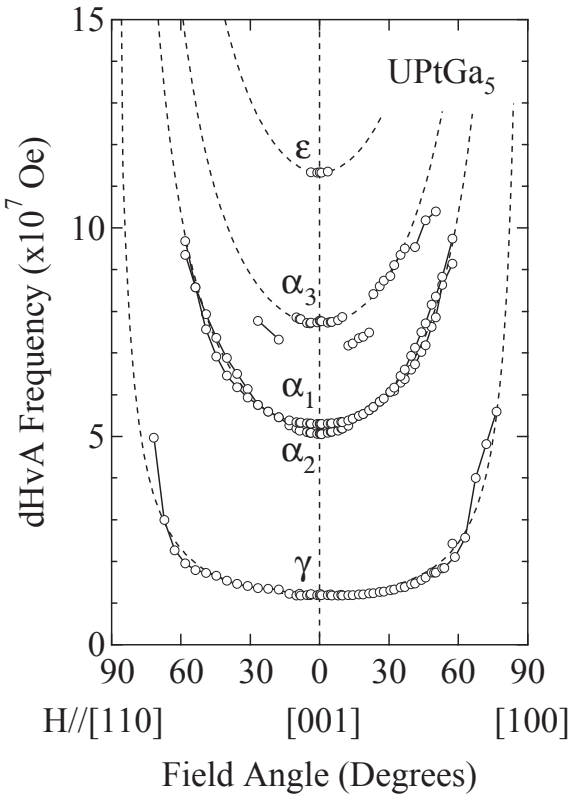

Fig. 1. Angular dependence of the dHvA frequency in $UPtGa_5$.

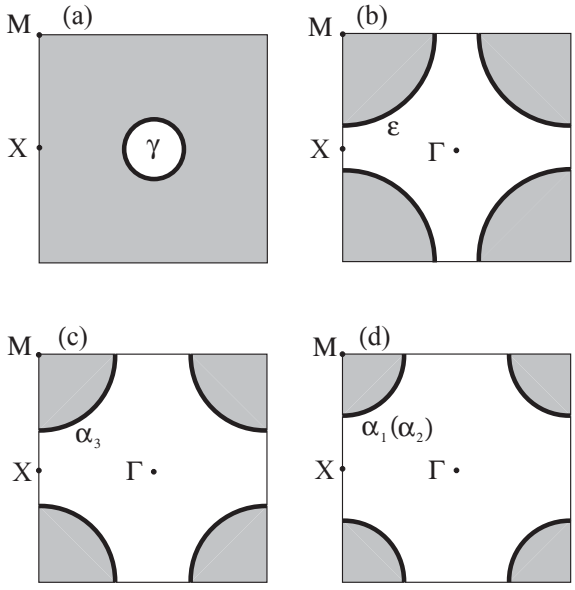

Fig. 2. Cross-sections in the ΓXM plane for each branch in $UPtGa_5$.

face for each branch, as shown in Fig. 2. From the magnetic unit cell, it is clear that this compound is a compensated metal with equal volumes of electron and hole Fermi surfaces[6]. We simply assumed that Fermi surfaces of all the branches are cylindrical. The volume of each Fermi surface is as follows : $V_\gamma = 0.054V_{\rm BZ}$, $V_\varepsilon = 0.512V_{\rm BZ}$, $V_{\alpha_3} = 0.354V_{\rm BZ}$ and $V_{\alpha_1(\alpha_2)} = 0.235V_{\rm BZ}$, where $V_{\rm BZ}$ 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 $2.05V_{\rm BZ}$, indicating the compensated metal. Here branches α_1 and α_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 coefficent $\gamma = 57$ mJ/K^2·mol is consistent with $\gamma = 61$ mJ/K^2·mol obtained from the cyclotron mass, where the cyclotoron mass ($m_c^* = 10$ m_0) for branch γ corresponds to $\gamma_\gamma = 9.3$ mJ/K^2·mol, similarly $\gamma_\varepsilon = 18.6$ mJ/K^2·mol for branch ε ($m_c^* = 20$ m_0), $\gamma_{\alpha_3} = 22.3$ mJ/K^2·mol for branch α_3 ($m_c^* = 24$ m_0) and $\gamma_{\alpha_1(\alpha_2)} = 10.7$ mJ/K^2·mol for branch $\alpha_1(\alpha_2)$ ($m_c^* = 13(10)$ m_0).

It is thus concluded that $UPtGa_5$ is a compensated metal and the Fermi surface consists of four kinds of cylindrical Fermi surfaces.

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