Magnetic behavior of the heavy-fermion system UPd_2Ga_3

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We have synthesized the heavy-fermion compound UPd_2Ga_3, crystallizing in a structure closely related to the hexagonal $PrNi_2Al_3$ lattice. The physical properties show UPd_2Ga_3 to behave very similar to the heavy-fermion superconductor UPd_2Al_3. It orders antiferromagnetically at $T_N = 13$ K, while a large decrease in the electrical resistivity below T_N and electronic specific-heat coefficient $\gamma = 230$ mJ/mol K^2 classify the new compound as a heavy fermion. The magnetic structure is equivalent to that of UPd_2Al_3, although the ordered moment of $0.50(5)\mu_B$ is smaller. No superconductivity has been observed in UPd_2Ga_3 above 50 mK.

I. INTRODUCTION

Heavy-fermion materials are of general interest in present day research due to their unusual and still not fully understood low-temperature properties. Many of these systems order magnetically, and some become superconducting as well. Two of the more recent examples are UPd_2Al_3 and UNi_2Al_3. Both systems crystallize in the hexagonal $PrNi_2Al_3$ structure, show magnetic transitions at 14.5 and 4.6 K, and become superconducting below 2 and 1 K, respectively.[1,2] It has been argued that in UPd_2Al_3 superconductivity and magnetism are carried by different electronic f subsystems of "light" magnetic ($\gamma = 25$ mJ/mol K^2) and "heavy" superconducting character ($\gamma = 115$ mJ/mol K^2).[3,4]

In this contribution we present our results on the allomorphic compound UPd_2Ga_3. We were able to prepare this material in nearly single-phase polycrystalline form and determine its crystal structure. Our measurements of the specific heat, electrical resistivity, magnetoresistivity, magnetic susceptibility, magnetization, and neutron diffraction show UPd_2Ga_3 to order antiferromagnetically at $T_N \simeq 13$ K. No superconductivity was observed down to 50 mK. The zero-temperature extrapolation of the specific heat c_p/T is 230 mJ/mol K^2, thus making UPd_2Ga_3 a moderately heavy-fermion material. The resistivity exhibits a large drop below T_N, which indicates that a very large scattering contribution is removed by a continuous formation of a coherent state and the magnetic ordering.

These and the other physical properties of UPd_2Ga_3 will be compared to those of UPd_2Al_3 in which superconductivity does coexist with magnetism. We will discuss both systems and give arguments for the similarities of the magnetic and disparity of the superconducting properties in terms of the differences of the crystal structures affecting the Fermi surface.

II. METALLURGY AND EXPERIMENTAL TECHNIQUES

Polycrystalline samples of UPd_2Ga_3 have been formed by arc-melting the constituents (with purity U: $3N$, Pd: $5N$, and Ga: $4N$) in stoichiometric ratio under argon atmosphere in a water-cooled copper crucible. The weight loss during melting was less than 0.5%. Subsequently the samples were annealed for one week at 700 °C in high vacuum in a quartz ampule. As-cast and annealed material has been examined by electron-probe microanalysis. This proved that annealing is necessary to obtain a homogeneous sample of the proper stoichiometry. While as-cast samples consist of about 70 vol. % of a phase with the composition $UPd_{2.4}Ga_{3.2}$ and 30 vol. % $UPd_{1.2}Ga_{2.4}$, the annealed samples contain 95% UPd_2Ga_3, 4 vol. % $UPd_{2.6}Ga_{3.4}$, and 1 vol. % UGa_3.

The crystallographic structure has been determined by a full refinement of combined x-ray and neutron diffraction at room temperature, and refinement of further neutron diffractograms at 4.2, 20, and 150 K. Best agreement between calculated and measured diffraction patterns was achieved by assuming a hexagonal superstructure of the $PrNi_2Al_3$ lattice with the unit cell doubled along the c axis (BaB_2Pt_3 structure). The lattice parameters at room temperature are $a = 5.3015(1)$ Å and $c = 8.5112(3)$ Å. Details of the structure, including the free positional parameters of Pd and Ga are given in Table I. The superstructure is realized by the small displacement of the Ga and Pd atoms. In the

TABLE I. Refined structural parameters of UPd_2Ga_3, space group $P6_3/mmc$ (BaB_2Pt_3 type), from neutron powder diffraction at $T = 290$, 150, and 20 K. The room-temperature refinement is the result of a refinement of combined neutron and x-ray powder diffraction patterns.

	$T = 290$ K	$T = 150$ K	$T = 20$ K
a (Å)	5.3015(1)	5.2904(3)	5.2840(3)
c (Å)	8.5112(3)	8.4834(8)	8.4774(9)
V (Å^3)	207.17(2)	205.63(2)	204.98(2)
x_{Ga} (−)	0.5055(4)	0.5118(7)	0.5106(7)
y_{Ga} (−)	0.0110(8)	0.024(1)	0.021(1)
z_{Pd} (−)	0.0262(2)	0.0185(7)	0.0197(7)
R_p (%)	16.3	17.3	18.6
Ordered moment at 4.2 K: $0.50(5)\mu_B$/U atom			

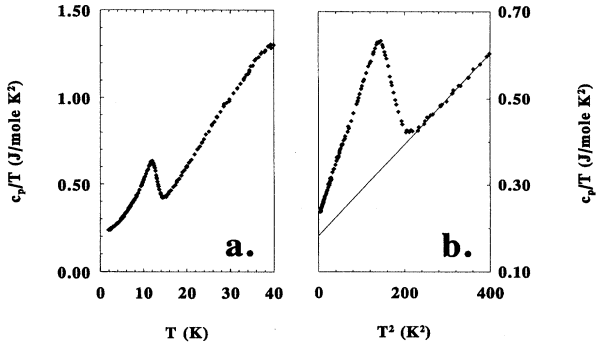

FIG. 1. (a) The specific heat c_p/T vs T of UPd_2Ga_3. (b) The specific heat c_p/T vs T^2. The solid line indicates the influence of CEF contributions on the determination of γ; the extrapolation between 15 and 20 K leads to a lower value of γ than the extrapolation between 1.8 and 10 K.

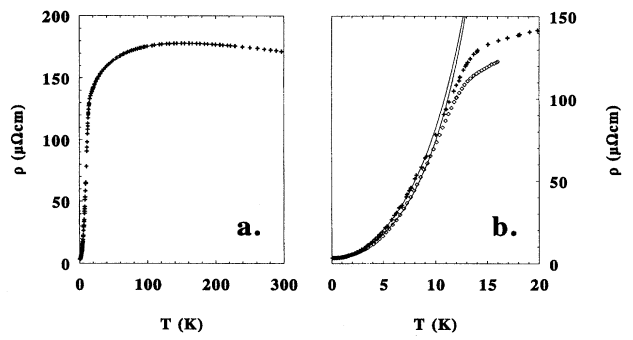

FIG. 2. (a) The overall behavior of the resistivity of UPd_2Ga_3. (b) The low-temperature resistivity ρ of UPd_2Ga_3 in zero field (+) and in a field of 8 T (◇) with the magnetic transition. In the zero-field measurement the resistivity drops by a factor of 40 between 14 and 0.05 K. The solid lines are fits to Eq. (1) with parameters as described in the text.

$PrNi_2Al_3$ lattice the positions of the Ga and Pd atoms would be given by parameter values x_{Ga}, y_{Ga}, and z_{Pd} of 0.5, 0, and 0, respectively. We have not been able to determine the crystallographic structure of the $UPd_{2.6}Ga_{3.4}$ impurity phase. Since we have not excluded the reflections corresponding to this phase, the reliability factors of our refinement are rather poor.

There are obvious differences in the lattice constants between UPd_2Ga_3 and UPd_2Al_3; for UPd_2Al_3 values of 5.365 Å (a axis) and 4.186 Å (c axis) have been reported.[1] Thus, while half the c axis of UPd_2Ga_3 is nearly 2% longer than that of UPd_2Al_3, the a axis is about 1% shorter. On the one hand, this implies a larger magnetic anisotropy between hexagonal plane and c axis in UPd_2Ga_3 compared to UPd_2Al_3, on the other hand it gives rise to a stronger U-Pd hybridization, since the distance between U and Pd is considerably diminished here (UPd_2Ga_3: 3.069 Å vs UPd_2Al_3: 3.097 Å).

Moreover, the unit-cell volume of the Ga compound is reduced compared to the Al system. While for UPd_2Ga_3 half the volume of the unit cell is $V=103.6$ Å^3, it is $V=104.3$ Å^3 for UPd_2Al_3. Generally, such change of the unit-cell volume can be treated in terms of increasing the hybridization on applying pressure. Although the volume effect is generated by anisotropic lattice parameter changes (i.e., by uniaxial pressure), we can at least estimate the order of magnitude of (hydrostatic) pressure necessary to achieve a similar compression. With the isothermal compressibility $\kappa_T=0.85$ Mbar^{-1} of UPd_2Al_3 this volume difference between the two systems would be equivalent to 10 kbar pressure applied to UPd_2Al_3.[5]

The physical properties of UPd_2Ga_3 have been examined by specific heat c_p, resistivity ρ, susceptibility χ, magnetization M, and neutron diffraction. The specific heat has been determined by a conventional adiabatic technique, at temperatures from 1.8 to 50 K. The resistivity was measured with a four-probe ac technique in zero field from 50 mK to 300 K and in fields up to 8.5 T below 1.5 and 16 K utilizing a four-probe dc technique. For the susceptibility in 0.01 T between 2 and 300 K, a commercial SQUID was employed, while the magnetization was obtained using a FONER magnetometer between 5 and 15 K from 0 to 12 T. Powder neutron-diffraction measurements were performed with the high-resolution 800-wire multidetector on the C2 spectrometer at the NRU reactor of Chalk River Laboratories, using a neutron wave length of 1.5405 Å. The 1-cm^3 sample was mounted in a cylindrical vanadium container with helium exchange gas. Full diffractograms were recorded at temperatures from 4 to 290 K.

III. RESULTS

The specific heat divided by temperature in zero field vs temperature T is plotted in Fig. 1(a). An anomaly (of antiferromagnetic origin, as will be shown below) is clearly visible, the transition temperature is determined by an entropy balance to $T_N=13.3$ K. At higher temperatures the c_p/T vs T curve starts to bend due to contributions of crystalline electric fields (CEF). The CEF contributions prohibit an evaluation of the electronic specific heat γ at temperatures above T_N. Extrapolating c_p/T between 15 and 20 K to $T=0$, as is done by the straight line in Fig. 1(b) (where c_p/T is plotted against T^2), leads to a γ that is lower than that yielded by an extrapolation from below 10 K, thus illustrating the influence of CEF contributions above T_N on the determination of γ. From the low-temperature extrapolation we obtain $\gamma=230$ mJ/mol K^2 indicating that UPd_2Ga_3 belongs to the class of heavy-fermion materials [for comparison the value of UPd_2Al_3: $\gamma=140$ mJ/mol K^2 (Ref. 3)]. We did not correct the specific heat of UPd_2Ga_3 for lattice contributions, since up to now no nonmagnetic allomorph having a superstructure as described above has been found and thus we cannot obtain a reliable correction for the phonons. We remark that, although there are quantitative differences between the specific heat of UPd_2Ga_3 and UPd_2Al_3, the general shape of c_p is quite similar for both systems.

The resistivity in zero field of UPd_2Ga_3 closely resembles that of UPd_2Al_3 [Fig. 2(a)]. The broad maximum around 150 K with the downturn at lower temperatures is

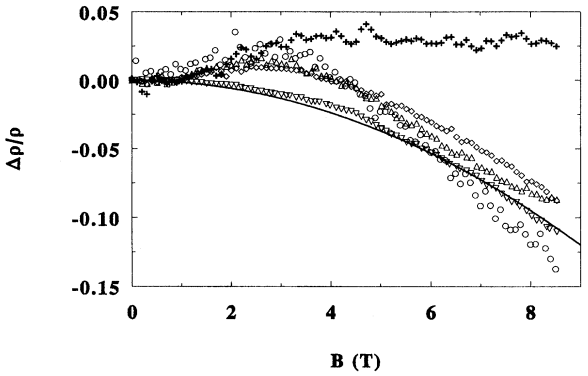

FIG. 3. The normalized magnetoresistivity of UPd_2Ga_3 at 15 K (∇), 12 K ($\diamond$), 8 K ($\triangle$), 5 K ($\bigcirc$), and 1.6 K (+). The solid line indicates a B^2 dependence of the magnetoresistivity of the measurement at 15 K.

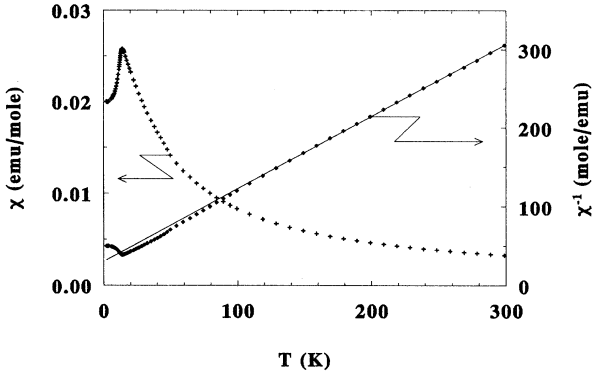

FIG. 4. The susceptibility χ and the inverse susceptibility χ^{-1} of UPd_2Ga_3 plotted against temperature. The solid line indicates a Curie-Weiss fit of the data with $\mu_{\text{eff}}=2.95\mu_B$ and $\Theta_{\text{CW}}=-33$ K.

assigned to the Kondo effect with its reduction due to the low-temperature coherent state and to the depopulation of CEF levels. However, before the coherent state can fully form, magnetic ordering appears. T_N for $B=0$ T is determined to be 13.1 K, defined as the minimum in $d^2\rho/dT^2$, which corresponds to the kink in ρ [Fig. 2(b)]. With magnetic field only a slight decrease of T_N is observed, at 8 T we find a value of 12.3 K.

As in the case of UPd_2Al_3, the zero field resistivity ρ_{ZF} shows a dramatic decrease from just above T_N to lowest temperatures. For UPd_2Ga_3 the resistivity drops by a factor of 40 between 14 and 0.05 K. Dissimilar to UPd_2Al_3, no sign of superconductivity is observed in UPd_2Ga_3 down to lowest attainable temperature (50 mK). Following the approach of Caspary *et al.*[3] we fit ρ_{ZF} below 10 K with a power law

$$\rho(T)=\rho_0+AT^2+bT^5 \tag{1}$$

with $\rho_0=3.37(3)$ $\mu\Omega$ cm, $A=0.663(5)$ $\mu\Omega$ cm K^{-2}, and $b=0.12(1)\times10^{-3}$ $\mu\Omega$ cm K^{-5}. Caspary *et al.*[3] derived fit parameters of $\rho_0=9.2$ $\mu\Omega$ cm, $A=0.26$ $\mu\Omega$ cm K^{-2}, and $b=0.48\times10^{-3}$ $\mu\Omega$ cm K^{-5}, qualitatively illustrating the similarities below T_N of UPd_2Ga_3 and UPd_2Al_3. With our data we can calculate the ratio A/γ^2 yielding a value of 12.5 $\mu\Omega$ cm (mol K/J)^2. This number is in good agreement with that of other heavy-fermion systems [$CeAl_3$: $A/\gamma^2=13.3$ $\mu\Omega$ cm (mol K/J) (Ref. 6)], proving that A is really reflecting the heavy mass of the electrons. We also note that the number A we derived for UPd_2Ga_3 is 2.5 times larger than that one given for UPd_2Al_3, this in good agreement with the difference between the two γ values.

The same fit procedure can be performed for the resistivity measured in a magnetic field of 8 T. A best fit of the resistivity below 10 K was obtained using parameters of $\rho_0=3.37(3)$ $\mu\Omega$ cm, $A=0.556(6)$ $\mu\Omega$ cm K^{-2}, and $b=0.15(1)\times10^{-3}$ $\mu\Omega$ cm K^{-5}. From the fit parameters it is obvious that the magnetic field has mainly influenced the T^2 term.

To examine this influence in more detail we performed measurements of the magnetoresistivity in fields up to 8.5 T. In Fig. 3, we show the normalized magnetoresistivity $\Delta\rho/\rho_{\text{ZF}}=[\rho(B)-\rho_{\text{ZF}}]/\rho_{\text{ZF}}$ at different temperatures. Two effects can be distinguished: (i) Above T_N the resistivity decreases with B^2 (the solid line in Fig. 3 indicates a B^2 dependence of the magnetoresistivity at 15 K). (ii) At 1.6 K the resistivity shows, instead of a decrease, a small increase with field. In the intermediate temperature range both effects contribute to the magnetoresistivity leading to a maximum in $\Delta\rho/\rho_{\text{ZF}}$.

The negative $\Delta\rho/\rho_{\text{ZF}}$ at high temperatures can have two sources, either spin disorder scattering is removed by the field or the field is affecting the coherent state. Both effects should be $\propto B^2$, and therefore, we cannot separate the two. On the other hand, the small magnetoresistivity at 1.6 K is entirely due to the field trying to rearrange the antiferromagnetic moments. Hence, the low-temperature magnetoresistivity reveals a complicated interplay between the influence of magnetic field on the coherent state, on the one hand, and on the magnetic moments on the other. We note that the magnetoresistivity of UPd_2Ga_3 resembles qualitatively that one of UPd_2Al_3 determined by de Visser *et al.*[7] for a single crystal with the current and the field oriented along the a axis (i.e., the low resistive axis). The small influence of a magnetic field of 8 T on T_N of UPd_2Ga_3 suggests a phase diagram similar to that of UPd_2Al_3. Taken together the experiments on resistivity and magnetoresistivity indicate that there is a continuous development of the coherent state below T_N and that the very large drop in the electrical resistivity upon antiferromagnetic order is not solely due to the decrease of spin-disorder scattering.

In order to clarify the nature of the magnetic transition we measured the susceptibility χ. In Fig. 4, we plot our data both as χ and χ^{-1} vs T. At high temperatures the susceptibility follows a Curie-Weiss law with an effective moment $\mu_{\text{eff}}=2.95\mu_B$ and $\Theta_{\text{CW}}=-33$ K (by extrapolating χ^{-1} above 100 K as straight line). This effective moment is in agreement with the expected value for either a free U^{3+} or U^{4+} atom. The negative Curie-Weiss temperature, indicative of antiferromagnetic coupling, is in accord with the antifer-

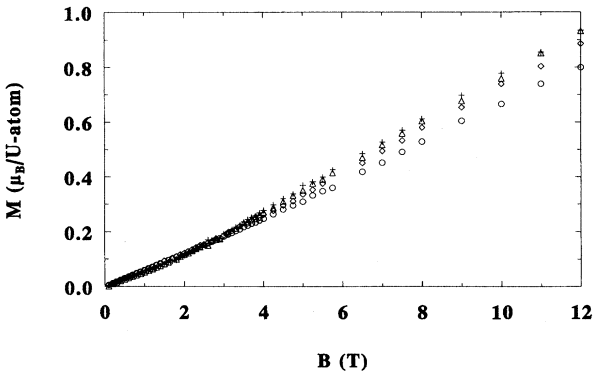

FIG. 5. The magnetization of UPd_2Ga_3 in fields up to 12 T. The measurements have been taken at 15 K (○), 12 K (◇), 8 K (△), and 5 K (+).

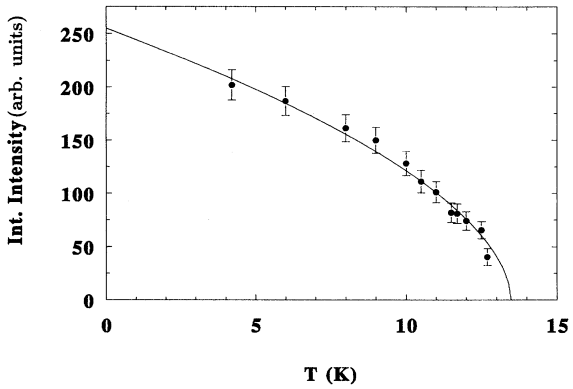

FIG. 6. Integrated intensity vs temperature of the magnetic (001) reflection of UPd_2Ga_3. The solid line denotes a fit to Eq. (2), yielding $\beta=0.28(2)$.

romagnetic peak at $T_N=12.2$ K [determined as maximum in $d(\chi T)/dT$]. The transition temperature derived from the susceptibility is somewhat lower than those extracted from specific heat or resistivity: This is probably due to the relatively broad transition [see the specific heat (Fig. 1)] blurring the exact determination of the transition temperature in the various measurements.

Unlike UPd_2Al_3 there is no pronounced maximum in the susceptibility for UPd_2Ga_3 above T_N, which for the Al compound was attributed to CEF contributions. In UPd_2Ga_3 this maximum is hidden behind the antiferromagnetic transition and is visible here only as small anomaly in χ^{-1}. Qualitatively the susceptibility of UPd_2Ga_3 can be explained within a CEF scheme as proposed by Grauel *et al.*[8] for UPd_2Al_3 but now with a singlet ground state, an excited singlet at about 15 K and a further doublet around 60 K. Especially, we note that the susceptibility for $T\rightarrow 0$, χ_0, being about two times larger for the Ga system than for the Al compound, arises from those low-lying CEF levels. However, without data on the anisotropy of the physical properties, we are unable to obtain more quantitative information about the crystalline electric fields in UPd_2Ga_3.

Further, we measured the magnetization of UPd_2Ga_3 between 5 and 15 K in fields up to 12 T (Fig. 5). The magnetization at 12 T is about $0.8-0.9\mu_B$/U atom and shows no sign of saturation. The absolute values of M for UPd_2Ga_3 are larger than those of UPd_2Al_3 [$\approx 0.3\mu_B$ at 10 T, determined for a single crystal with a $B\|a$ axis (Ref. 9)]. This is a consequence of the smaller CEF splitting in UPd_2Ga_3 compared to UPd_2Al_3. M seems initially linear in B for all temperatures. However, a slight upward curvature begins at lower and lower field as the temperature is reduced. This behavior might arise from domain reorientation processes, as they have been found for UPd_2Al_3 in the same temperature and field range.[8]

In order to determine the magnetic structure of UPd_2Ga_3, we performed a neutron-diffraction study.[10] Full diffractograms were recorded from $2\theta=5°-85°$ at temperatures from 4.2–20 K. In the difference spectrum of I(4.2 K)–I(20 K) four extra reflections are observed, which are indexed as the (001), (101), (111), and (103) reflections of a magnetic unit cell equal to the nuclear unit cell, $a_{magn}=a_{nucl}=5.286$ Å and $c_{magn}=c_{nucl}=8.474$ Å. The ordering wave vector is (001), implying that ferromagnetic planes are stacked antiferromagnetically along the c axis. The integrated intensities of these magnetic reflections closely agree with those calculated for an ordered structure in which uranium moments are restricted to the basal plane. The orientation of the moment in the basal plane cannot be determined from our powder experiment. This magnetic structure is the same as that of UPd_2Al_3.[11] The ordered moment at 4.2 K is evaluated from a comparison of the integrated intensities of the (001) and (101) magnetic reflections with the nuclear (200) and (202) reflections, using the reported uranium form factor.[12] This procedure yields $\mu_{ord}(4.2\text{ K})=0.50(5)\mu_B$/U atom, well above the detection limit of our powder-diffraction experiment, which is about $0.15\mu_B$. The small U moment explains the absence in the difference spectrum of the other reflections of this magnetic structure. Figure 6 displays the temperature evolution of the integrated intensity of the (001) magnetic reflection. The temperature dependence can be nicely described by the expression

$$I=A\left(\frac{T_N-T}{T_N}\right)^{2\beta}, \tag{2}$$

where β is the critical exponent for the ordering and A a scaling factor. We find $T_N=13.4(2)$ K and $\beta=0.28(2)$. This value is suggestive of conventional 3D XY ordering for UPd_2Ga_3.

The ordered moment μ_{ord} being considerably smaller than the moment of UPd_2Al_3 ($0.85\mu_B$) is in agreement with the observation of the higher effective masses in UPd_2Ga_3 (higher density of states at the Fermi level), since stronger screening is to be expected. Also, a smaller ordered moment is expected from the differences of the crystal structures between the two systems, because, as remarked, in UPd_2Ga_3 the U-Pd distance is smaller than in the Al allomorph leading to a stronger hybridization of the moments. However, one would expect that with a substantially smaller moment also the transition temperature T_N should be correspondingly re-

duced. This, obviously, is not the case. We remark that this rule of the dependence of T_N on the ordered magnetic moment is broken for several heavy-fermion compounds. For instance, URu_2Si_2 has an even higher T_N than UPd_2Al_3, but the ordered magnetic moment is only $0.03\mu_B$.[13]

IV. CONCLUSIONS

We have presented a study of the metallurgical and physical properties of the new heavy-fermion compound UPd_2Ga_3. This compound crystallizes in the BaB_2Pt_3 structure, a superstructure of the $PrNi_2Al_3$ type. With respect to the heavy-fermion superconductor UPd_2Al_3 the major differences are that (*a*) the volume of the unit cell is decreased, (*b*) the lattice constants change anisotropically, and (*c*) the superstructure causes a doubling of the unit cell along the c axis and slight modifications of the local site symmetry of the U atom.

The bulk properties show that UPd_2Ga_3 is a heavy-fermion system with an antiferromagnetic phase transition at $T_N \simeq 13$ K, while it is not superconducting above 50 mK. The appearance of the magnetic transition in the bulk properties of UPd_2Ga_3 resembles qualitatively that in UPd_2Al_3. The quantitative differences can be accounted for by the larger effective mass of the electrons and a smaller CEF splitting in case of UPd_2Ga_3. Further, the magnetic structures of UPd_2Ga_3 and UPd_2Al_3 are identical.

(*a*) The decrease of the unit-cell volume of UPd_2Ga_3. To a first approximation this can be viewed as hydrostatic pressure applied to UPd_2Al_3. The decrease of the unit-cell volume of nearly 1% corresponds to a pressure of about 10 kbar. Pressure experiments on UPd_2Al_3 revealed only negligible pressure dependences of the transition temperatures T_N and T_c in this pressure regime.[3,5] Therefore, something more is needed to explain the loss of superconductivity in UPd_2Ga_3 than simple chemical pressure as, for example, Fermi-surface effects. Here, band-structure calculations of UPd_2Ga_3 would give valuable information especially if compared to those for UPd_2Al_3.[14]

(*b*) The anisotropic change of lattice parameters or the increasing U-Pd hybridization. This feature can nicely account for the differences of the magnetic behavior of the two systems. A stronger U-Pd hybridization explains the larger γ and the smaller ordered magnetic moment μ_{ord}. The comparatively small decrease of T_N (with respect to the larger decrease of μ_{ord}) can qualitatively be interpreted within the model put forth by Mentink *et al.*[15] for $CePd_2Al_3$. These authors proposed that in the hexagonal 123-compounds magnetism is governed by an interplay of the in-plane ferromagnetic coupling and the interplane antiferromagnetic interaction. Within their model the antiferromagnetic transition temperature T_N is then determined by the interplane exchange parameter J_z and the spin value of the basal plane magnetic moment, $S(S+1)$. Comparing now the Al system with the Ga homologue, the spin value S of UPd_2Ga_3 is lowered, while J_z is increased due to the larger Ga atom creating a larger $f-s,p$ overlap. Accordingly, T_N depends on two competing effects, and, in our case, is only slightly lowered. We remark that a similar dependence of J_z on the $f-s,p$ overlap has been observed in $CePd_2Al_3$ and $CePd_2Ga_3$.[15,16]

However, although the magnetic behavior of UPd_2Ga_3 can be fairly well explained within such models, the complete absence of superconductivity is far from evident within these models. At present we can only speculate about a possible connection between the anisotropy-hybridization changes in UPd_2Ga_3 and the $2-f$ subsystem model.[3,4] It is striking that in UPd_2Ga_3 as in UPd_2Al_3 the magnetic behavior seems essentially independent of the absence or presence of superconductivity. For now, at best, we can only propose an experimental test for the role of the U-Pd hybridization. The test would be an uniaxial pressure experiment on UPd_2Al_3 with the pressure applied along the c axis.

In our model, described above, T_N is dependent on J_z and S. Uniaxial pressure along the c axis should increase both J_z (since the $f-s,p$ overlap gets stronger) and S (since the U-Pd hybridization becomes weaker). Hence, T_N would increase with uniaxial pressure along the c axis for UPd_2Al_3. The role of the hybridization change on the superconductivity should also be reflected in the uniaxial pressure dependence of T_c. If the U-Pd distance is critical for the suppression of superconductivity in UPd_2Ga_3, then T_c of UPd_2Al_3 should be independent of or even increase with uniaxial pressure applied to the c axis.

(*c*) The crystallographic superstructure and the increase of atomic weight by the substitution of Ga for Al. The crystallographic superstructure might affect the physical properties of UPd_2Ga_3 by two different ways. First, it will slightly change the local site symmetry of the U atoms, and accordingly modify the Fermi surface. Unfortunately, from our data we cannot assess the importance of the local site symmetry for the physical properties of UPd_2Ga_3. Second, the phonon spectrum might possibly be changed by the superstructure, and there will surely be an influence on the phonons by the substitution of Ga for Al, since Ga is about 2.5 times heavier than Al. This, of course, implies a simple BCS picture for superconductivity in UPd_2Al_3 and superconductivity in UPd_2Ga_3 would be destroyed by modifying the phonon spectrum.

In conclusion, based upon our experimental data, we believe a picture using the U-Pd hybridization and the interplane exchange mediated by the Ga or Al atoms can give a reasonable description of the magnetic behavior in these two materials. However, as far as the superconductivity is concerned we have been unable to determine the key parameter for its suppression in UPd_2Ga_3. It is quite possible that all effects mentioned above play a collective role. At any rate, we propose a uniaxial pressure experiment in UPd_2Al_3 which would shed more light on the anisotropy-hybridization situation. Finally the band structure of UPd_2Ga_3 should be calculated and compared with UPd_2Al_3.

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