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Possible origins of the low-temperature anomaly in $CeRu_2$

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ABSTRACT

The magnetic-field dependence of DC susceptibility and specific heat of polycrystalline $CeRu_2$ has been studied. The superconducting transition temperature (T_c) of the sample is 6.2 K. An extraordinary anomaly was observed at the $T^* \sim 6$ K in the absence of magnetic field (H), and T^* is suppressed slightly with increasing H. Such an anomaly can be most probably attributed to the existence of few amounts of $CeRu_2$ nano-clusters embedded in the bulk or the magnetic ordering of impurity phase Ce_xRu_y. The T^* is actually a superconducting transition, which has a higher critical field than the bulk $CeRu_2$.

1. Introduction

$CeRu_2$ is known as a type II superconductor with $T_c = 6.2$ K [1] and critical field is 6.5 T with the cubic Laves phase structure. The *f* electron is most likely itinerant in $CeRu_2$, in which the valence is fluctuated, contributing to the conduction electrons at low temperatures. The specific heat anomaly was reported and explained to result from the magnetic ordering the excess of β-Ce [2]. We argue that the result is questionable, and thus present different description in this work.

2. Experiments

The polycrystalline $CeRu_2$ was synthesized by the arc melting method. The specific heat $C(T)$ was measured from 0.6 to 10 K under the magnetic fields up to $H = 8$ T with a ^{3}He thermal relaxation calorimeter [3]. The dc magnetization measurements were proformed using a SQUID magnetometer (Model: MPMS–XL, Quantum Design) in the temperature range from 1.8 to 10 K.

3. Results and discussion

The data obtained for the temperature dependence of the specific heat of the $CeRu_2$ sample under different magnetic field are graphically represented in Fig. 1. The superconductivity is totally suppressed at $H = 8$ T, while a field-dependent anomaly appears at $T^* \sim 6$ K. This phenomenon can be also observed in dc magnetic measurements, as depicted in Fig. 2.

We collected the specific heat and the susceptibility data and plotted a T–H phase diagram in Fig. 3. There are two possibilities to explain the origin of the anomaly. First, there are some different phases Ce_xRu_y coexisting with $CeRu_2$, which shows a canted antiferromagnetic transition ∼6 K and thus the T^* sustains under high magnetic fields. An X-ray absorption spectroscopy study with limit resolution might shed light on this issue. Second, the anomaly comes from $CeRu_2$ nano-clusters embedded in the bulk, originated from the disruption of lattice periodicity which have higher H_{c2} [4]. Hence the T^* is a superconducting transition temperature of the

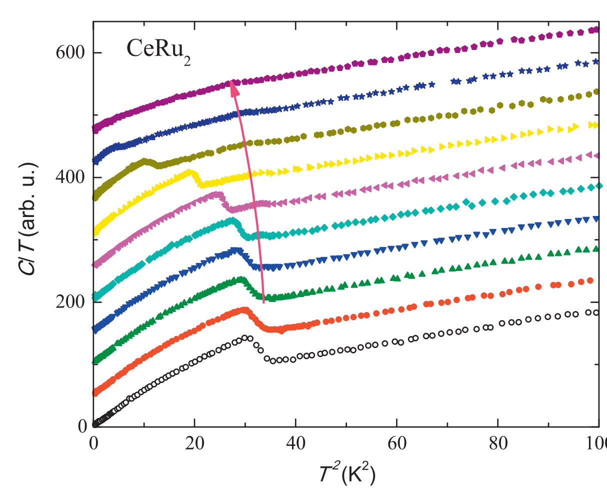

Fig. 1. Specific heat of $CeRu_2$ under 0, 0.1, 0.2, 0.3, 0.5, 1, 2, 4, 6 and 8 T from bottom to top. The data is offset for clarity. The line with an arrow points that T^* is suppressed by field.

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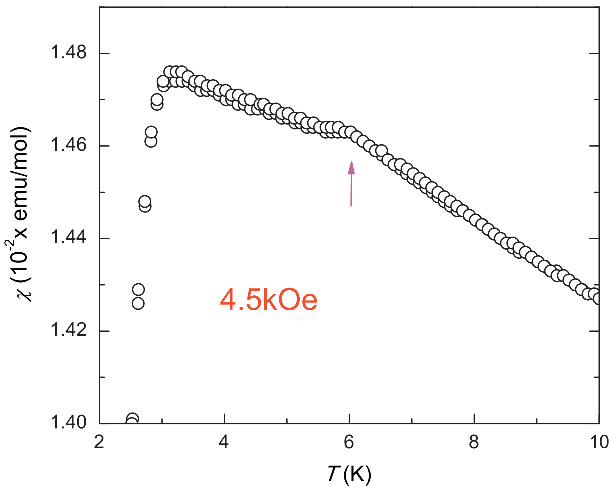

Fig. 2. The dc susceptibility data of $CeRu_2$ under $H = 4.5$kOe. The arrow points the anomaly. The drop around 3.5 K is a superconducting transition.

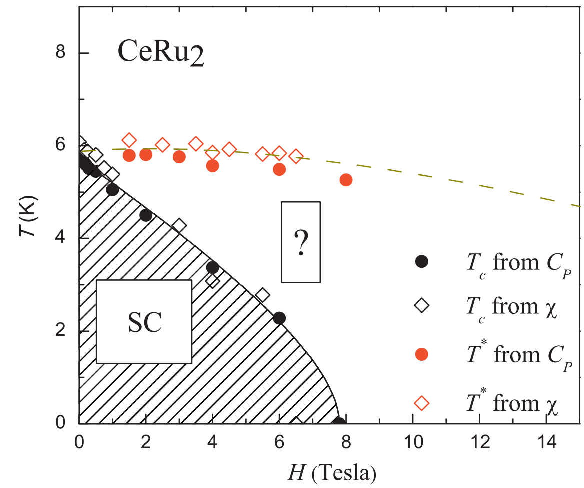

Fig. 3. The T–H phase diagram of $CeRu_2$ separated with a superconducting region (SC) and an unknown region (?).

$CeRu_2$ nano-clusters. Transmission electron microscopy and transport measurements on $CeRu_2$ nano-particles would provide more information on this speculation.

4. Conclusion

The specific heat and the dc susceptibility measurements under magnetic fields on polycrystalline $CeRu_2$ have been performed. The anomaly, which appears at $T^* = 6$ K, may come from the impurity phase Ce_xRu_y or $CeRu_2$ nano-clusters. Further experiments are necessary to realize the exact nature of the anomaly.

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