MAGNETISM IN SINGLE-CRYSTALLINE CePtSn

H. Nakotte[1], S. Chang[1], M.S. Torikachvili[2], H.N. Bordallo[3], A.H. Lacerda[4] and T. Takabatake[5]

[1]New Mexico State University, Las Cruces NM 88003
[2]San Diego State University, San Diego CA 92182
[3]IPNS, Argonne National Laboratory, Argonne IL 60439
[4]Pulse Field Facility, NHMFL, Los Alamos National Laboratory, Los Alamos NM 87545
[5]Hiroshima University, Higashi Hiroshima 739, Japan

abstract

CePtSn exhibits two antiferromagnetic transitions at low temperatures. We report on magnetoresistance and magnetization studies of single-crystalline CePtSn in magnetic fields up to 18 T. The data were taken to establish the magnetic phase diagrams for CePtSn in fields applied along the principal directions.

CePtSn crystallizes in the orthorhombic ε-TiNiSi structure and has been classified as a 'metallic Kondo compound'. Previous bulk investigations indicated that CePtSn orders antiferromagnetically at $T_N = 7.5$ K, but a second transition is present at $T_M = 5$ K [1].

Previous bulk investigations revealed that the magnetic and transport properties of CePtSn are highly anisotropic, and there has been an attempt to draw tentative magnetic-phase diagrams for CePtSn on the basis of a few specific-heat and magnetization measurements for fields applied along the principal directions. However, these measurements were performed in a quite limited field and temperature range, and we have extended the present investigation in order to establish the phase boundaries of the two antiferromagnetic phases, AF1 (5 K < T < 7.5 K in zero field) and AF2 (T < 5 K). We have performed additional magnetization and magnetoresistance studies on single-crystalline CePtSn using the 20-T superconducting magnet at the Pulse Field Facility, NHMFL, Los Alamos National Laboratory. For both quantities two types of scans were performed: temperature scans at fixed fields and field scans at fixed temperatures.

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For fields applied along the *c* axis, we found that the two magnetic phases are rather insensitive to the application of the field, i.e. there is little effect on resistance up to the highest field applied (18 T). Furthermore, we did not observe anomalies in either the magnetoresistance or the magnetization. For magnetic fields applied along *a* or *b* axes, on the other hand, we observe clear changes upon application of a magnetic field. As an example, field sweeps of the magnetization and magnetoresistance for B//*a* and B//*b* at low temperatures are shown in Fig. 1

For B//*a*, the low-temperature magnetization of CePtSn exhibits a weak S-shaped curvature which extends between 9 and 13 T. Such behavior suggests some spin realignment, and we find that it is reversible. The *a*-axis transition in magnetization is accompanied by a pronounced magnetoresistance effect. At 1.8 K, there is a sharp drop of about 20% in the magnetoresistance at 12.5 T. Noteworthy are also the increase of the magnetoresistance by more than 25% for fields up to about 12 T and a second drop starting around 17.5 T, where there is no visible anomaly in the magnetization data.

The *b*-axis magnetization, on the other hand, exhibits a sharp step-like transition centered around 11 T, which exhibits some weak hysteresis effects. Also in this case, we find that the transition in magnetization causes subsequent effects in the magnetoresistance. However, unlike the *a*-axis magnetoresistance, we find that the resistance increases at the transition field. Furthermore, the *b*-axis magnetoresistance displays some huge irreversible effects at low temperatures. As the magnetic field is raised on a zero-field cooled sample the b-axis magnetoresistance at 1.8 K shows a sharp drop (by more than 30%) at 3.5 T which appears to be irreversible upon field removal. No similar effects are seen in our magnetization studies. However, there has been indications of an additional low-temperature transition in fields above 3 T from previous specific-heat measurements [1].

For B//*a* and B//*b*, we performed a number of field scans at different temperatures, and the critical fields for the two magnetic phases could be determined from the steps in the magnetization and magnetoresistance results. It should be noted, that the previously reported critical fields for the *a*-axis magnetization [1] were determined at the onset of the S-shape, while the clear anomalies in magnetoresistance indicate that one should rather take the values of the center of the S-shape. Similarly, crossing magnetic-phase boundaries causes sudden kinks in the temperature dependencies of the magnetization and magnetoresistance, which allows the determination of the critical temperatures at a certain field. The results of the field and temperature sweeps were taken in an attempt to complete the magnetic phase diagrams of CePtSn for B//*a* and B//*b*. The results are shown in Fig. 2. We find quite different behavior for the two field directions. For B//*a*, the phase AF1 remains stable only up to about 8 T, while for B//*b* it seems to extend to higher fields beyond the phase boundaries of AF2. For B//*a*, there are clear indications of another field-induced phase above 12T at low temperatures, but further high-field studies are needed to establish its exact phase boundaries.

In summary, we determined the magnetic phase boundaries of AF1 and AF2 for B//*a* and B//*b*. However, there are additional anomalies in magnetoresistance, and its critical parameters have been marked with a question mark in Fig. 2. The origin of these magnetoresistance anomalies is not clear. One may argue that subtle changes in magnetic structures and/or domain repopluations (not reflected in the magnetization) may be responsible for these effects. However, we argue that another possibility may be alterations of the Fermi surface in CePtSn without changes in the moment configuration. Additional experimental studies are needed to confirm such a picture. Furthermore, some insight may be gained by including magnetic exchange interactions into a theoretical treatment using the crystal-field scheme determined by Divis et al. [2].

References

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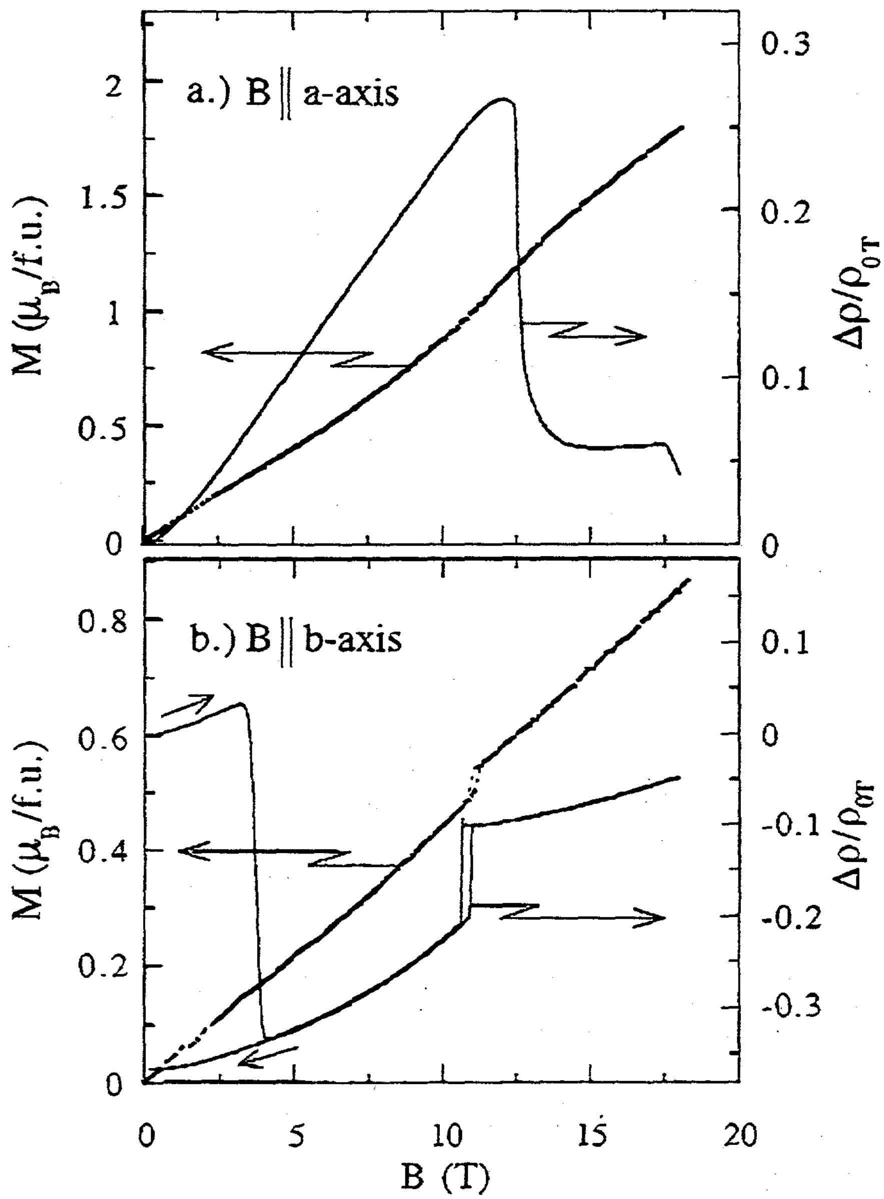
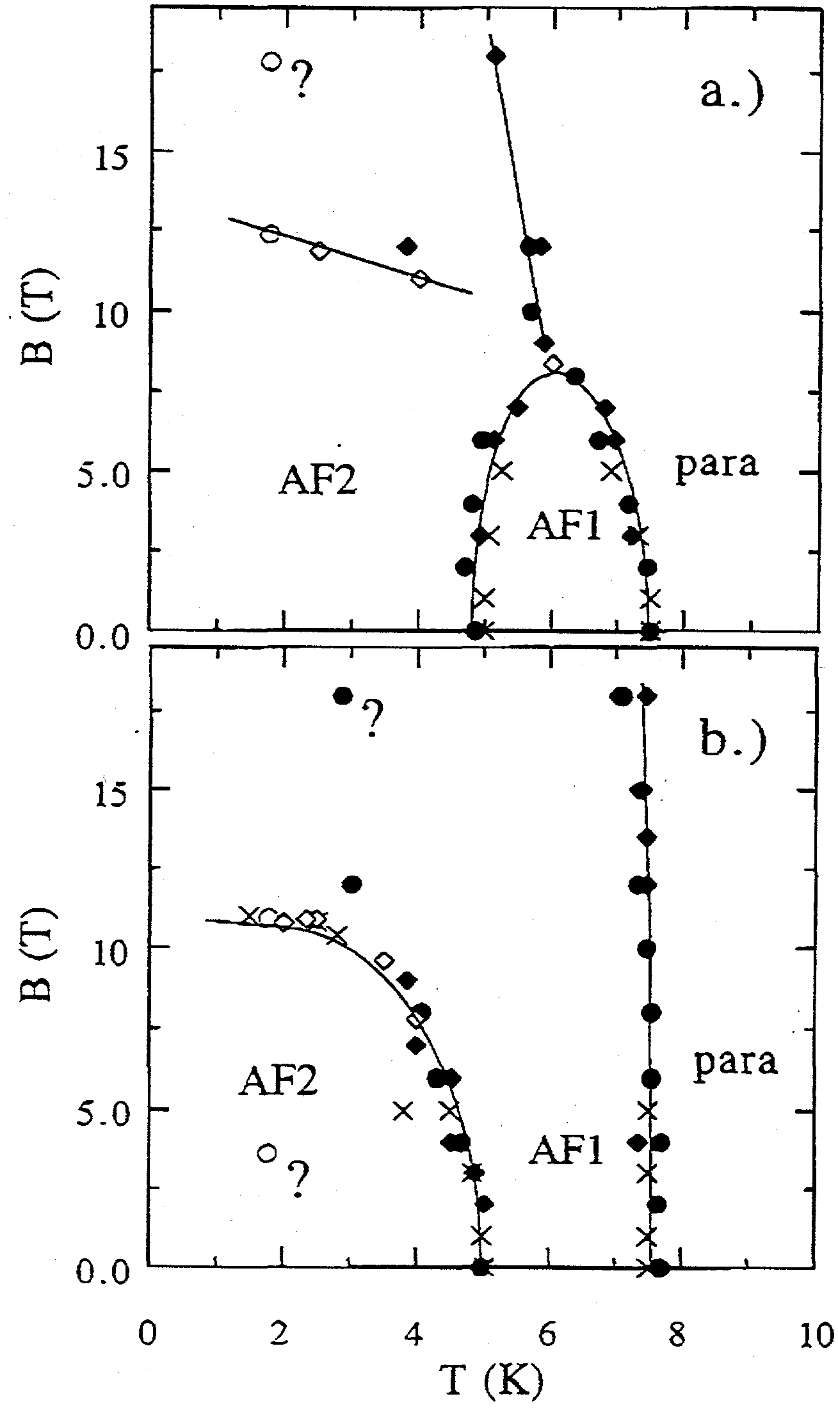
3 **Keywords:** Kondo lattice, antiferromagnetism, magnetic transitions

Figure captions:

Fig. 1: The field dependencies of the magnetization (symbols) and the percentage change of the magnetoresistance (line) of CePtSn for a.) B//*a*-axis and b.) B//*b*-axis. Magnetization data were taken at 2.5 K, magnetoresistance data at 1.8 K.

Fig. 2: Magnetic phase diagrams of CePtSn for a.) B//*a*-axis and b.) B//*b*-axis. The critical values taken from magnetization data are represented by diamonds, the ones from magnetoresistance are represented by circles. Open symbols are taken from field sweeps, solid symbols are taken from temperature sweeps. Previous results from ref. 1 have been included and are represented by crosses. Symbols marked with a question mark are due to anomalies in the magnetoresistance with no similar observation in the magnetization.


a.) B || a-axis
b.) B || b-axis
M (μ_B/f.u.)
$\Delta\rho/\rho_{0T}$
B (T)
0
0.5
1
1.5
2
0.1
0.2
0.3
0.2
0.4
0.6
0.8
-0.3
-0.2
-0.1
5
10
15
20


a.)
b.)
B (T)
T (K)
0.0
5.0
10
15
0
2
4
6
8
10
AF2
AF1
para
?