Low-field magnetic relaxation effects in noncentrosymmetric $CePt_3Si$

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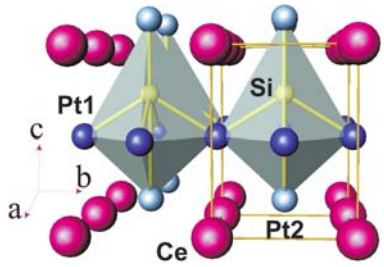
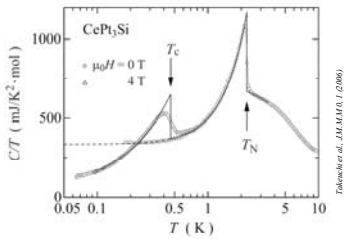
$CePt_3Si$- heavy fermion SC with noncentrosymmetric crystal structure





Structure

•Space group P4mm

a=b=0.4072 nm

c=0.5442 nm

c/a=1.34

Magnetism

Antiferromagnetic order sets in below T_n=2.2 K.

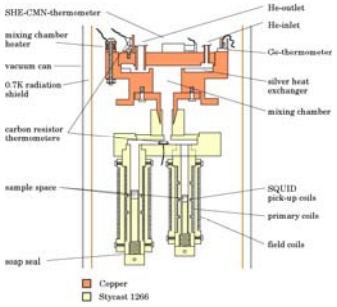
Unconventional Superconductivity

Superconducting phase transition discovered by Bauer et al. in polycrystalline samples at Tc=0.75 K [1].

- For single crystals Tc=0.45K [2].
- Clean limit superconductor l_n/ξ_0=8.
- B_{c2}=4-5T, well above the Clogston limit B_p=1.1 T.
- Broken inversion symmetry due to the absence of the mirror place **c↔-c** => antisymmetric spin-orbit coupling which allows for a mixing of singlet and triplet Cooper-pairing.
- Thermal conductivity and penetration law reveal power laws suggesting lines of nodes in the SC gap.

Experiment; Low temperature SQUID magnetometer

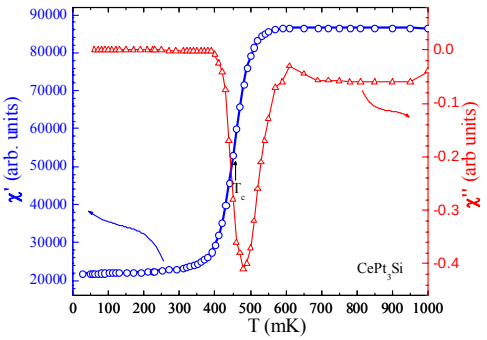
Mixing Chamber:



- **Types of measurements with this setup:**
  - ac susceptibility in very low fields ≈ 1 mOe;
  - remanent magnetization;
  - flux creep.
- Upper magnetic field 2000 Oe;
- Temperatures down to 30 mK with rotary mixture pump;

A $CePt_3Si$ single crystal with mass m=140.01 mg is used in both, susceptibility and flux dynamic investigations.

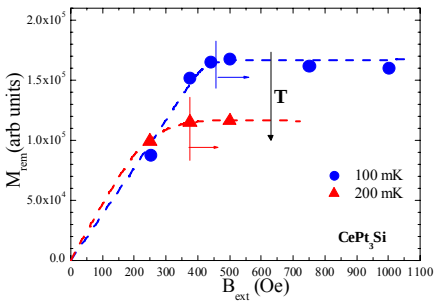
Low temperature AC susceptibility

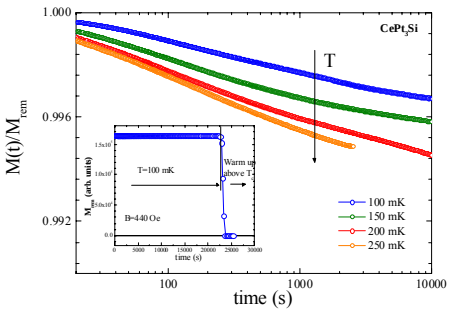


- ac susceptibility with ac field of 1.3 mOe at 500 Hz, field perpendicular to the c-axis.
- clear signature of the superconducting phase transition in both χ' and χ'' T_c= 450 mk.
- Transition width 0.1 K.

T_c is different from the 750 mK obtained previously on polycrystalline samples but in good agreement with the specific heat result obtained on singlecrystals.

Relaxation measurements

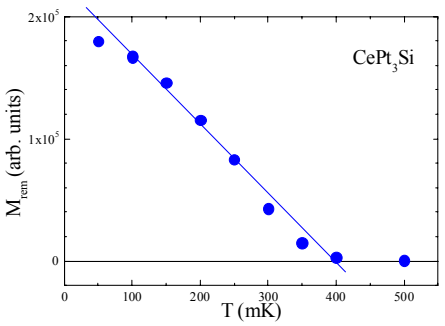




- At fixed temperature the remanent magnetization is measured as function of the external cycling field.
- M_{rem} saturates above a Bean critical field B_c which decreases upon increasing the temperature.
- B_c=500 Oe determined at the lowest temperature is used for the relaxation measurement at all higher T.

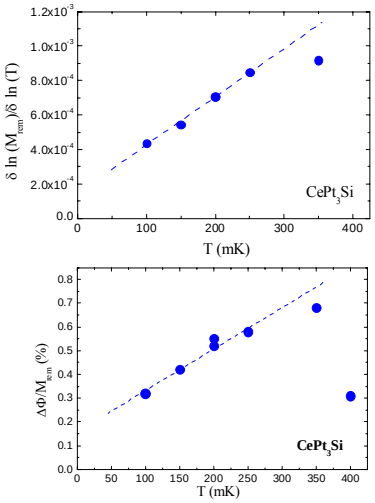
- At fixed T the remanent magnetization of the sample is measured and than the sample is heated up above T_c and all the field is expelled out of the sample (inset).
- The creep rate increases upon increasing temperature.
- The decay show clear logarithmic time dependence as expected from the Kim-Anderson theory.

Remanent magnetization



- M_{rem} decreases linearly upon increasing temperature.
- $CePt_3Si$ shows a smaller critical current than observed in UBe_{13}.
- M_{rem} reaches 0 at 410 mK consistent with the susceptibility data.

Discussion



- The creep data where measured from 10 to 10000 s.
- Relaxation rate increases follows roughly a T-linear Kim-Anderson law (upper figure).
- $\Delta\Phi/M_{rem}$ well below 1% at all temperatures, where $\Delta\Phi$ is the flux expelled from the sample between 10 and 10000s.
- Creep rates are very low, lower than in any other superconductor → is this due to very high critical currents?
- At T=0.3K, $CePt_3Si$ has a critical current a factor of tree smaller than the one observed in UBe_{13}. Nevertheless the flux creep is almost two order of magnitude smaller in $CePt_3Si$. This is an indication that the low relaxation rate in $CePt_3Si$ hints to possible new vortex physics caused probably by the special crystal structure.

Summary:

- Susceptibility Tc=0.450 mK in good agreement with specific heat measurements
- M_{rem} decreases linearly and reaches 0 at 0.41 K.
- The lower creep rates observed in a superconductor caused not by high critical currents.

Outlook:

Further measurements on the structure related $LaPt_3Si$ (T_c=0 K).

References:

[1] E. Bauer et al., Phys.Rev. Lett. **92**, 027003 (2004).
[2] Takeuchi et al., J.Mag. Mag.Matt. **0**, 1 (2006).