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Multigap Nodeless Superconductivity in $CsCa_2Fe_4As_4F_2$ Probed by Heat Transport

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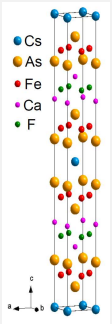
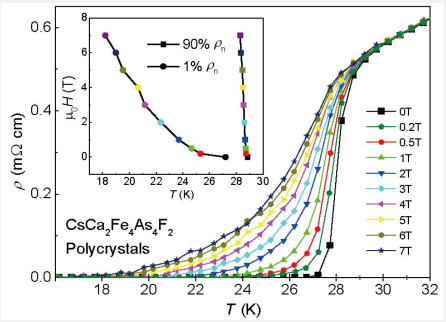
We report the ultralow-temperature thermal conductivity measurements on $CsCa_2Fe_4As_4F_2$ single crystals (T_c = 29.3 K) . Unlike the previous μSR measurements, a negligible residual linear term κ_0/T in zero field and the field dependence of κ_0/T obtained in our work suggest multiple nodeless superconducting gaps in $CsCa_2Fe_4As_4F_2$, rather similar to $CaKFe_4As_4$ or moderately doped $Ba_{1-x}K_xFe_2As_2$, but contrasts to the nodal gap structure indicated by the μSR measurements on $CsCa_2Fe_4As_4F_2$ polycrystals.

Introduction

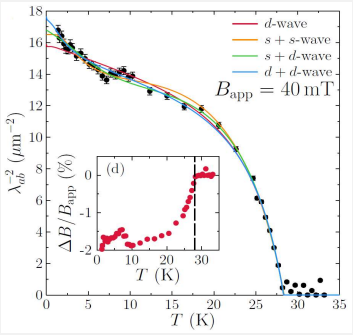
The iron-based superconductors called 12442 family was designed by replacement of the Ca layers in $ACaFe_4As_4$ (A = K, Rb, Cs) with Ca_2F_2 layers and synthesized successfully [1]. A series of μSR measurements on the polycrystalline 12442 compounds $ACa_2Fe_4As_4F_2$ (A = K, Cs) indicated that there are possible nodal gap structures with s + d wave pairing in $KCa_2Fe_4As_4F_2$ and $CsCa_2Fe_4As_4F_2$ [2, 3]. Since the CaF_2 layers are insulating, the 12442 compounds should have the similar charge homogenization appeared in 1144 compounds. Thus, the indication from μSR measurements is striking, which motivates us to investigate the gap structure by measuring the ultralow-temperature thermal conductivity of 12442 single crystals.



Crystal structure of $CsCa_2Fe_4As_4F_2$.

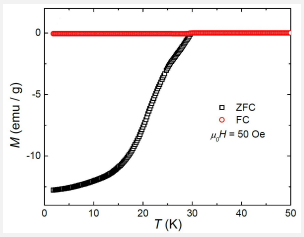


Temperature dependence of electrical resistivity for the $CsCa_2Fe_4As_4F_2$ polycrystalline samples [1].

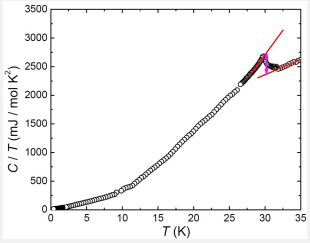


(s + d) – wave superconducting gap structure fits the temperature dependence of the inverse square penetration depth best [2].

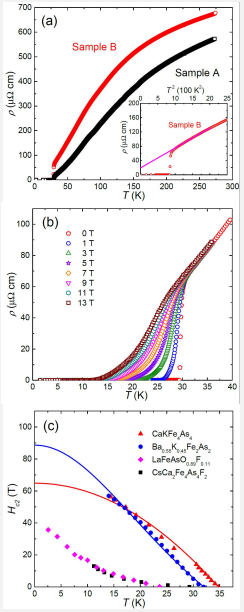
Physical properties of our $CsCa_2Fe_4As_4F_2$ single crystals



The diamagnetic transition occurs at 29.2 K in both zero-field and field cooling process.

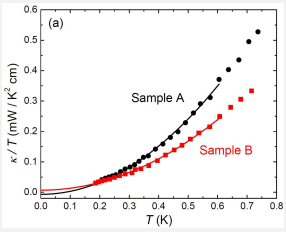


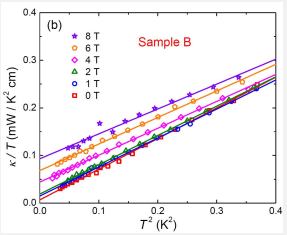
Specific heat anomaly due to the superconducting transition is observed at 30.2 K. The behavior is rather similar to that of $Ba_{0.6}K_{0.4}Fe_2As_2$.

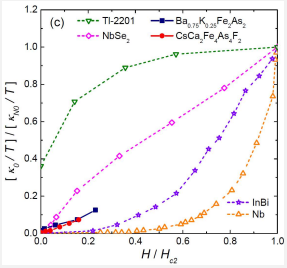


The T_cs of both samples are identically 29.3 K defined by ρ = 0. The superconducting transition broadens significantly with the increase of the magnetic field.

The study of superconducting gaps







- A negligible residual linear term κ_0/T in zero field confirmed by two samples indicates nodeless gap structure.
- The normalized field dependence is somewhat like that of the multigap nodeless superconductor $Ba_{0.75}K_{0.25}Fe_2As_2$.

Conclusions

- A negligible residual linear term κ_0/T in zero field and the field dependence of κ_0/T both suggest multiple nodeless superconducting gaps, similar to the moderately doped Fe-based superconductor $Ba_{0.75}K_{0.25}Fe_2As_2$.
- More experiments are still needed to explain the discrepancy between the results of our work and previous μSR measurements.

References

[1] Z. Wang *et al.*, Sci. China Mater. **60**, 83 (2017).
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[3] M. Smidman *et al.*, Phys. Rev. B **97**, 060509 (2018).

For more details, please refer to Y. Y. Huang *et al.*, Phys. Rev. B **99**, 020502(R) (2019).