Heat transport in $RbFe_2As_2$ single crystals: Evidence for nodal superconducting gap

Z. Zhang,[1] A. F. Wang,[2] X. C. Hong,[1] J. Zhang,[1] B. Y. Pan,[1] J. Pan,[1] Y. Xu,[1] X. G. Luo,[2,3] X. H. Chen,[2,3] and S. Y. Li[1,3,*]

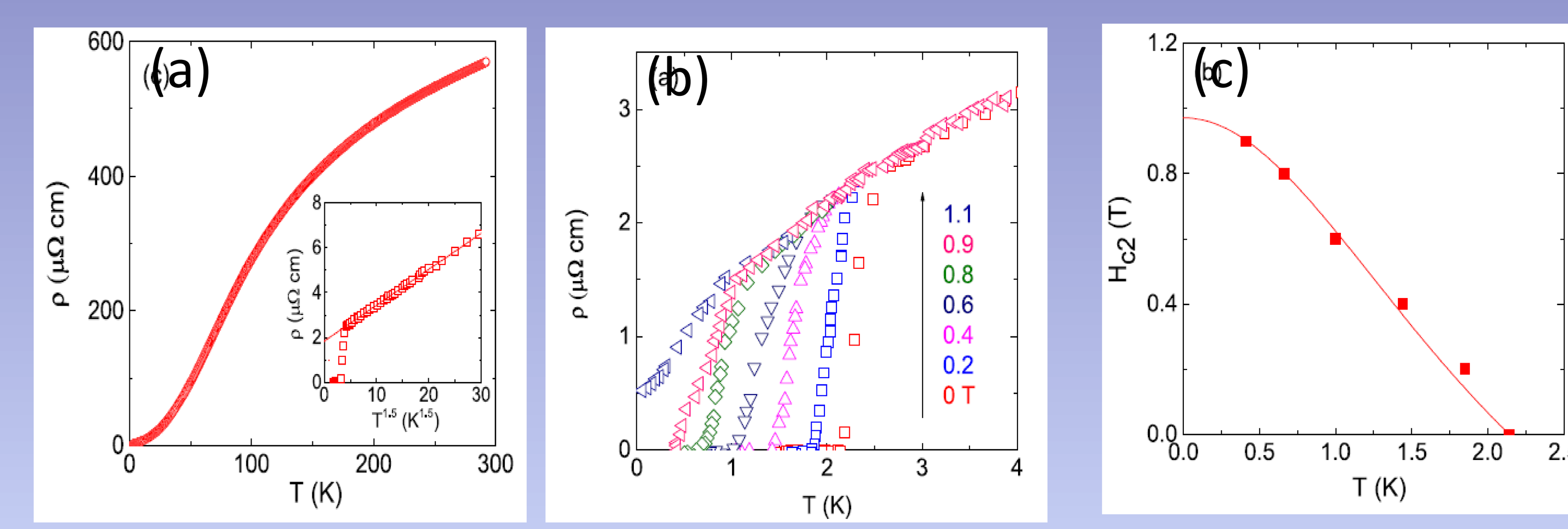
[1]*State Key Laboratory of Surface Physics, Department of Physics, and Laboratory of Advanced Materials, Fudan University, Shanghai 200433, P.R. China*
[2]*Hefei National Laboratory for Physical Science at Microscale and Department of Physics, University of Science and Technology of China, Hefei, Anhui 230026, P.R. China*
[3]*Collaborative Innovation Center of Advanced Microstructures, Nanjing 210093, P.R. China*

Introduction

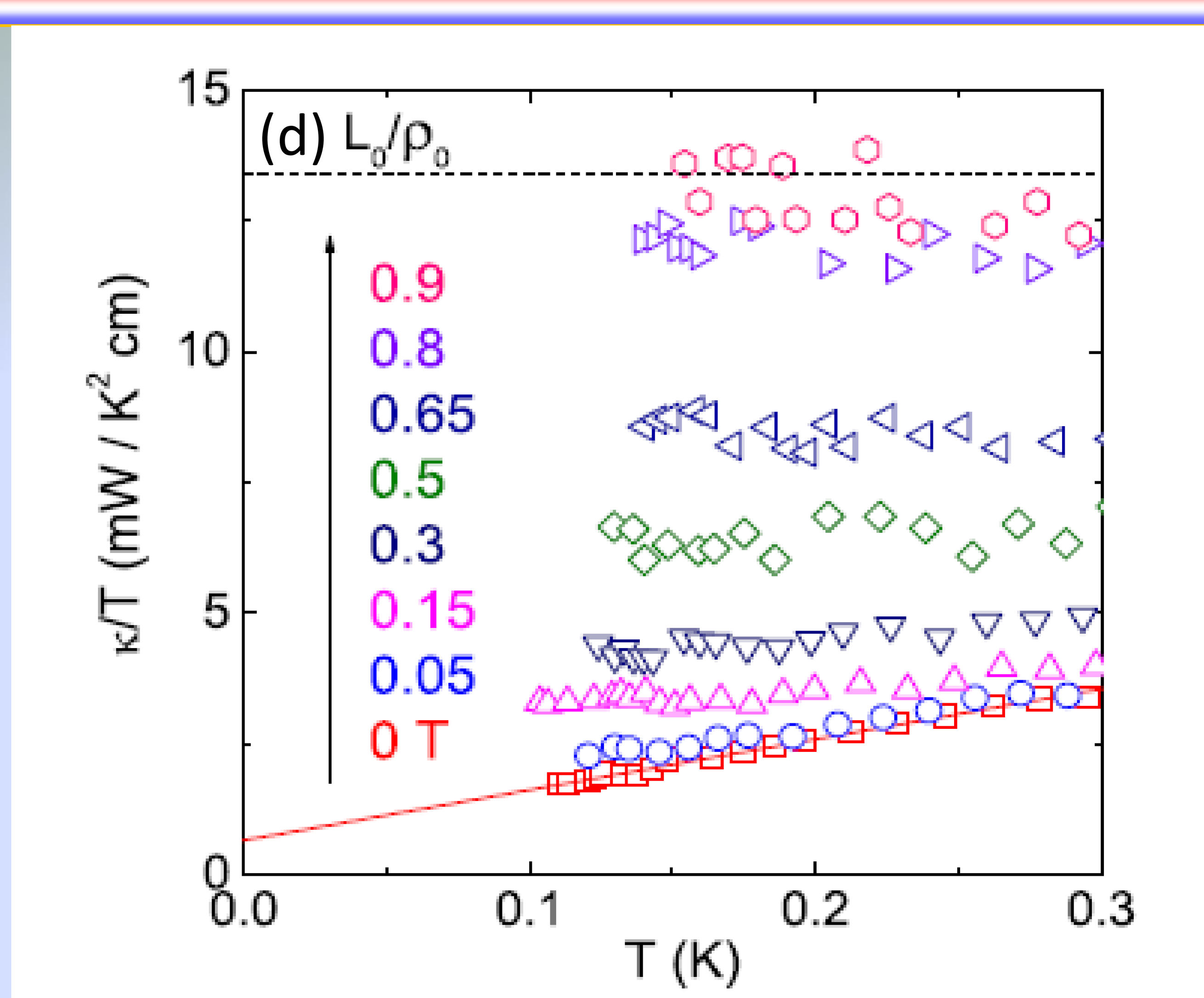
Since KFe_2As_2 was reported to be a nodal superconductor, its superconducting pairing symmetry is under hot debate. The detailed thermal conductivity study provided compelling evidences for a *d*-wave gap in KFe_2As_2, but the low-temperature ARPES measurements clearly showed nodal *s*-wave gap . Recent ARPES and thermal conductivity experiments on highly hole-doped $Ba_{1-x}K_xFe_2As_2$ also support nodal *s*-wave gap .

KFe_2As_2 has two sister compounds, $CsFe_2As_2$ and $RbFe_2As_2$. While muon-spin spectroscopy measurements on $RbFe_2As_2$ polycrystals suggested that $RbFe_2As_2$ is best described by a two-gap *s*-wave model, recent specific heat and thermal conductivity measurements on $CsFe_2As_2$ single crystals provided clear evidences for nodal superconducting gap in $CsFe_2As_2$. To clarify whether the superconducting gap structure of $RbFe_2As_2$ is indeed different from those of KFe_2As_2 and $CsFe_2As_2$, more experiments on $RbFe_2As_2$ single crystals are highly desired.

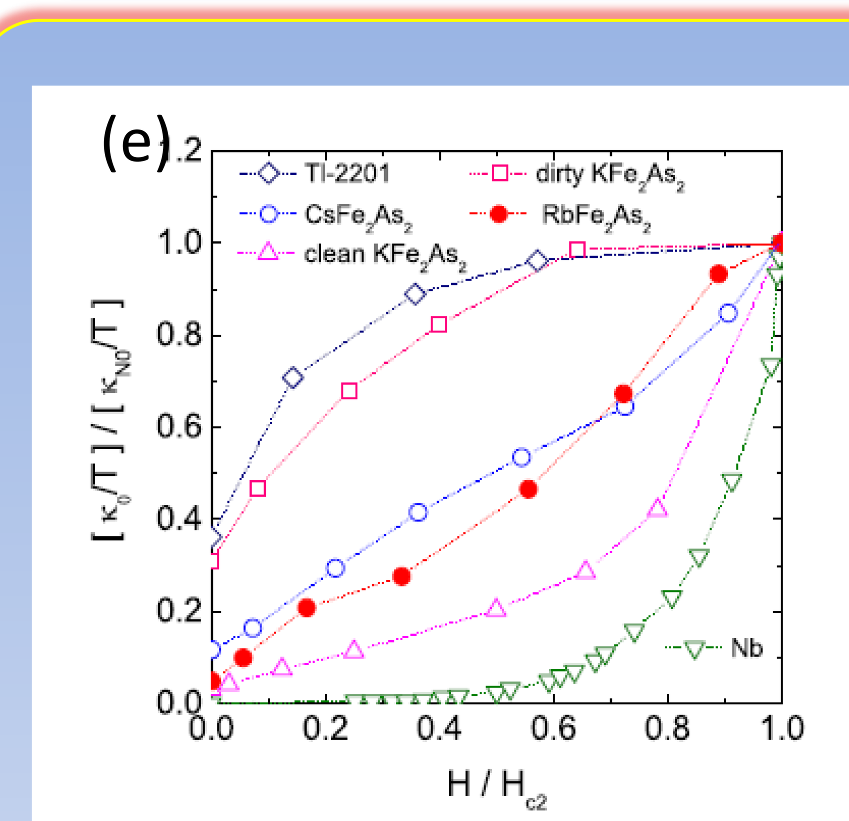
Here, we present the low-temperature thermal conductivity on $RbFe_2As_2$ single crystals.



(a) In-plane resistivity of $RbFe_2As_2$ single crystal in zero field. The data between 2.2 and 9 K can be fitted to $\rho = \rho_0 + AT^{1.5}$, as shown in the inset, which gives ρ_0 = 1.84 μΩ cm.
(b) Low-temperature resistivity of $RbFe_2As_2$ single crystal in magnetic fields up to 1.1 T.
(c) Temperature dependence of the upper critical field $H_{c2}(T)$, defined by ρ = 0 in (b). The solid line is a fit of $H_{c2}(T)$ to the Ginzburg-Landau equation, which gives $H_{c2}(0) \approx 0.97$ T



(d) Low-temperature in-plane thermal conductivity of $RbFe_2As_2$ single crystal in zero and magnetic fields applied along the *c* axis. The solid line is a fit of the zero-field data between 0.1 and 0.3 K to $\kappa/T = a + bT$, giving a residual linear term κ_0/T = 0.65 ± 0.03 mW K^{-2} cm^{-1}. The dashed line is the normal-state Wiedemann-Franz law expectation L_0/ρ_0, with $L0$ the Lorenz number 2.45 ×10−8 W Ω K^{-2} and ρ_0 = 1.84 μΩ cm.



	T_c (K)	ρ_0 (μΩ cm)	γ_N (mJ/mol K^2)	$H_{c2}(0)$ (T)	κ_0/T (mW/K^{2}cm)
KFe_2As_2(clean)	3.8	0.21	94	1.60	3.60
KFe_2As_2(dirty)	2.5	3.32	91	1.25	2.27
$RbFe_2As_2$	2.1	1.84	127	0.97	0.65
$CsFe_2As_2$	1.8	1.80	184	1.40	1.27

(e) Normalized residual linear term κ_0/T of $RbFe_2As_2$ as a function of H/H_{c2}. For comparison, similar data are shown for the clean *s*-wave superconductor Nb, the *d*-wave cuprate superconductor Tl-2201, the dirty and clean KFe_2As_2 and $CsFe_2As_2$.
Table: The superconducting transition temperature T_c, residual resistivity ρ_0, zero-field normal-state Sommerfeld coefficient γ_N, upper critical field $H_{c2}(0)$, and residual linear term κ_0/T of the clean and dirty KFe_2As_2, CsFe2As2, and $RbFe_2As_2$.

Conclusions

A nodal superconducting gap in $RbFe_2As_2$ is strongly suggested by the observation of a significant residual linear term κ_0/T = 0.65 mW K^{-2} cm^{-1} in zero magnetic field.

The (K, Rb, Cs)Fe_2As_2 serial superconductors may have a common nodal gap structure, and the field dependence of κ_0/T seems to evolve with the impurity level.

References

[1] J. K. Dong *et al.*, Phys. Rev. Lett. 04, 087005 (2010).
[2] J.-Ph. Reid *et al.*, Phys. Rev. Lett. 109, 087001(2012).
[3] F. F. Tafti *et al.*, Nat. Phys. 9, 349 (2013).
[4] J K. Okazaki *et al*, Science 337,1314 (2012).
[5] X. C. Hong *et al.*, Phys. Rev. B 86, 224514 (2012).
[6] Z. Shermadini *et al.* Phys. Rev. B 86, 174516 (2012).

Z. Zhang, *et al.* PHYSICAL REVIEW B **91**, 024502 (2015)