Progress in High Temperature Superconducting Materials and Superconductivity Mechanism

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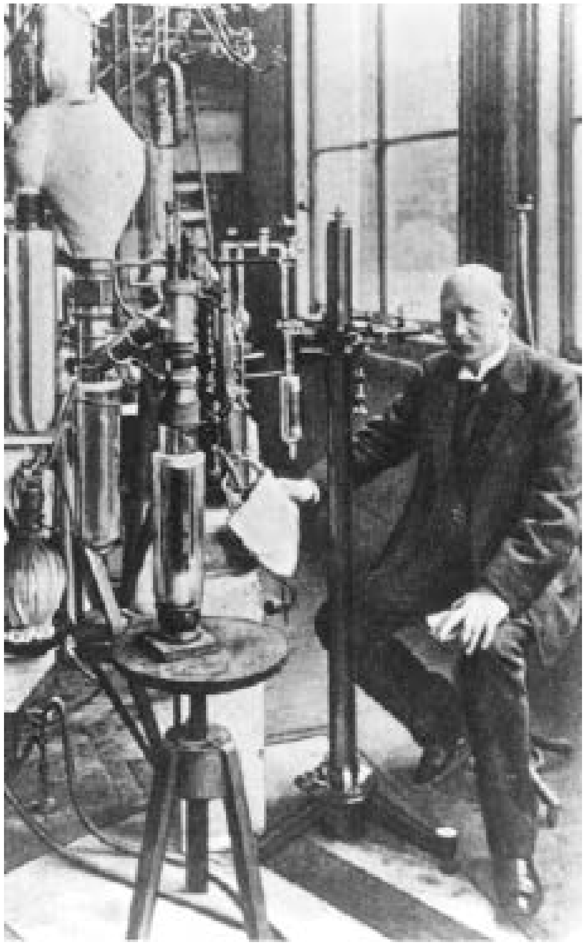
Outline

- Introduction;
- High temperature copper-oxide superconductors;
- Iron-based superconductors;
- Sumary and perspectives.

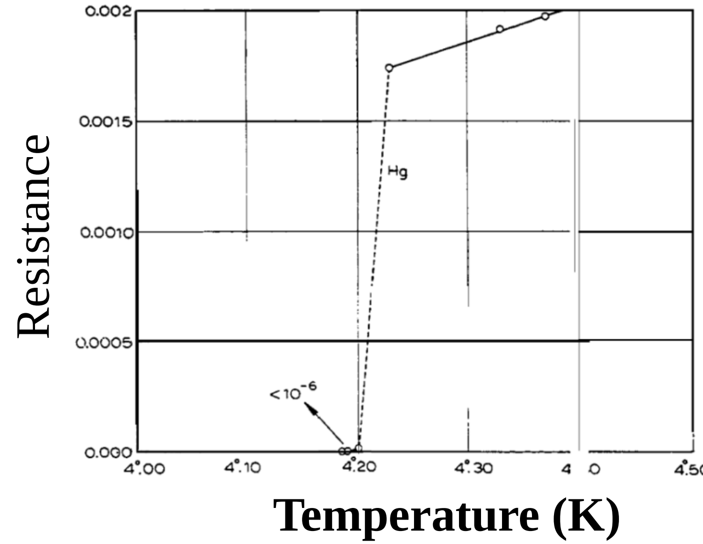
Discovery of Superconductivity (1911)

1908, Liquidation of Helium

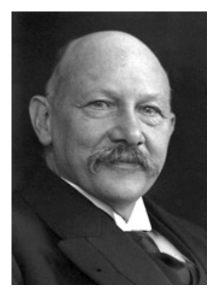


Heike Kamerlingh Onnes
Dutch Physisist
(1853-1926)

1911, Discovery of Superconductivity



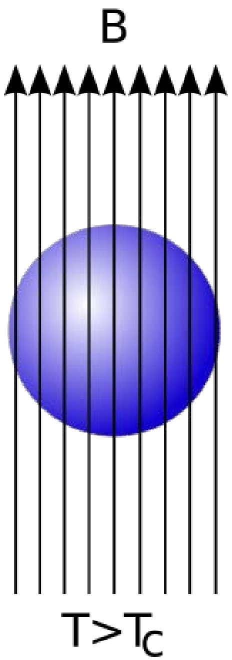
The Nobel Prize in Physics 1913

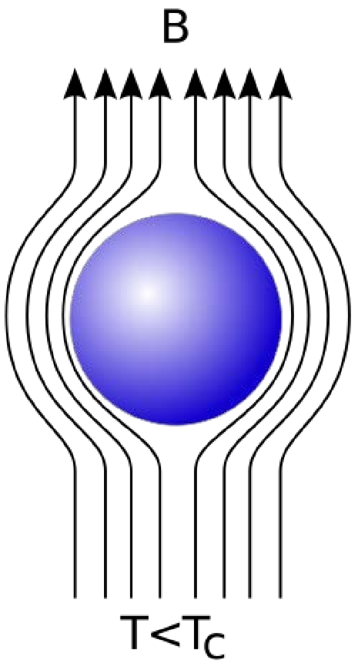


"for his investigations on the properties of matter at low temperatures which led, inter alia, to the production of liquid helium"

Heike Kamerlingh Onnes

Discovery of Meissner-Ochsenfeld Effect (1933)





Expulsion of magnetic field from a superconductor during its transition to the superconducting state

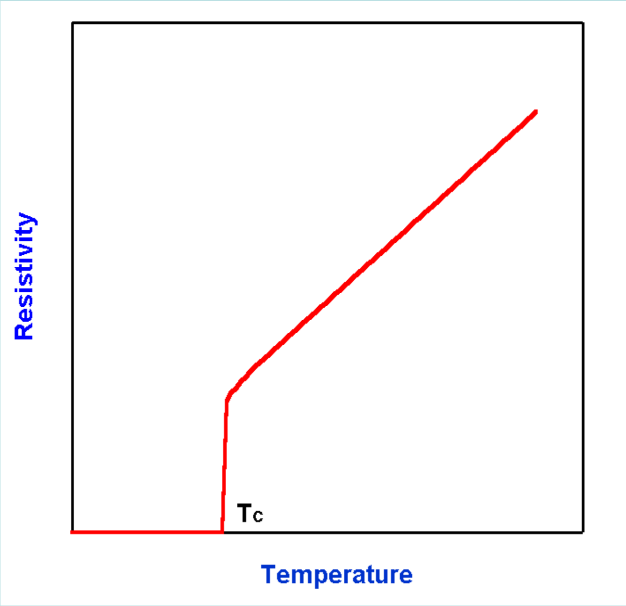
Superconductivity is more than just perfect conductor.

It is a uniquely defining property of the superconductor state.

Walther Meissner
(1882-1974)

Robert Ochsenfeld
(1901-1993)

Two Characteristics of Superconductors



Zero Resistance

Meissner Effect

Potential Applications of Superconductors

Zero Resistance

→**Electrical applications**;

➢Power transmission;

➢High magnetic field generation, NMR, particle collider, fusion;

Meissner Effect

➢Levitation train

Josephson Effect

→**Electronic applications;**

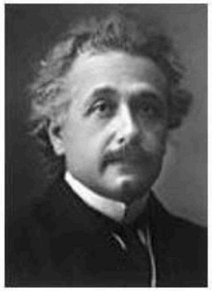
➢SQUID

➢Filters

➢Quantum computing

Superconducting transition temperature is the key.

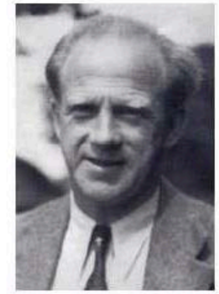
Failed Theories of Superconductivity

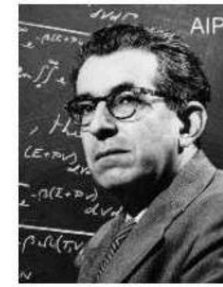

Albert Einstein
(1879-1955)


Niels Bohr
(1885-1962)


Ralph Kronig
(1905-1995)

John Bardeen
(1908-1991)


Werner Heisenberg
(1901-1976)



Fritz London
(1900-1954)


Lev D. Landau
(1908-1968)


Felix Bloch
(1905-1983)

Léon Brillouin
(1889 -1969)


Max Born
(1882-1970)


Herbert Fröhlich
(1905-1991)


Richard Feynman
(1918-1988)

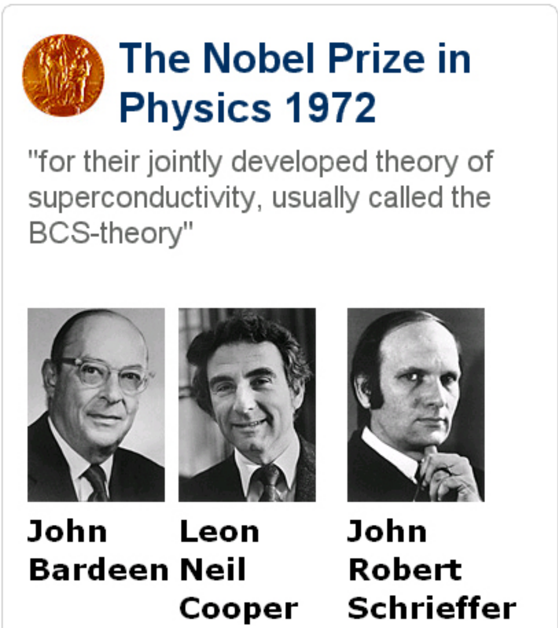
Einstein, Bohr, Landau, Bloch and Brillouin made proposals for microscopic theories of superconductivity prior to experiment by Meissner and Ochsenfeld in 1934.

Between 1941 and the formulation of the BCS theory, attempts to formulate microscopic theories of superconductivity were made by Bardeen, Heisenberg, London, Born, Frohlich and Feynman.

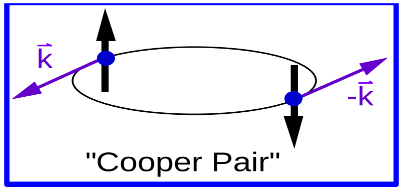
J. Schmalian, Modern Physics Letters B 24 (2010) 2679.

BCS Theory for Conventional Superconductivity (1957)

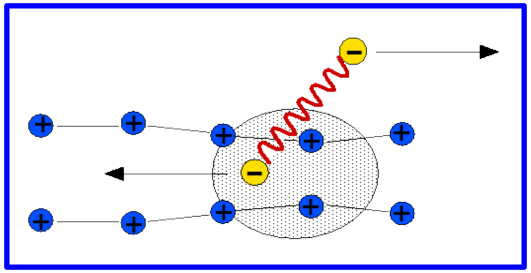
Bardeen, Cooper and Schrieffer (1957)



- **Formation of Cooper pairs;**

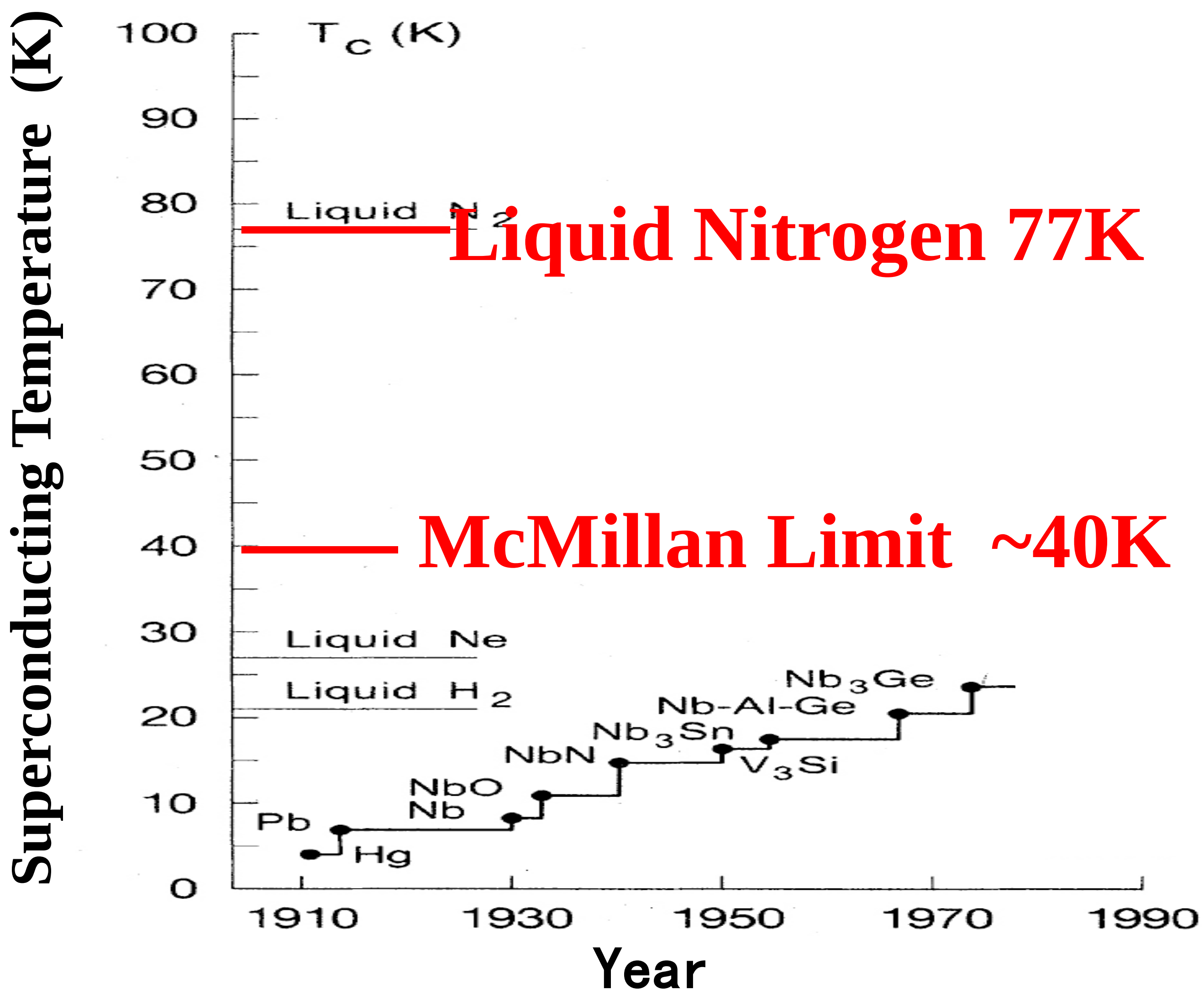


- **The pairing is mediated by phonons (lattice vibrations).**



McMillan Limit: Tc cannot surpass 40 K

Temperature Milestones for Superconductors



The Copper-Oxide Superconductors

Discovery of Superconductivity in Copper-Oxide Compounds

Z. Phys. B – Condensed Matter 64, 189–193 (1986)

Condensed Matter
Zeitschrift für Physik B

Possible High T_c Superconductivity in the Ba–La–Cu–O System

J.G. Bednorz and K.A. Müller
IBM Zürich Research Laboratory, Rüschlikon, Switzerland

Received April 17, 1986

The Nobel Prize in Physics 1987

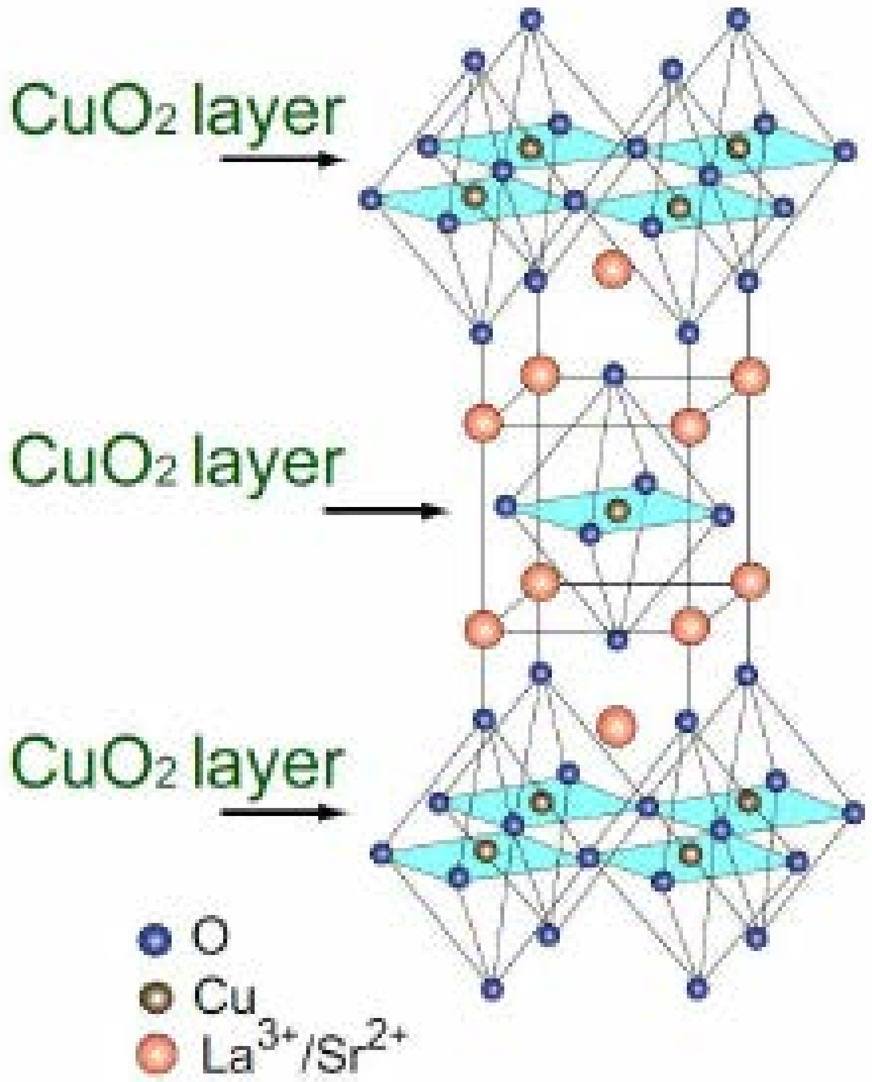
"for their important break-through in the discovery of superconductivity in ceramic materials"

J. Georg Bednorz

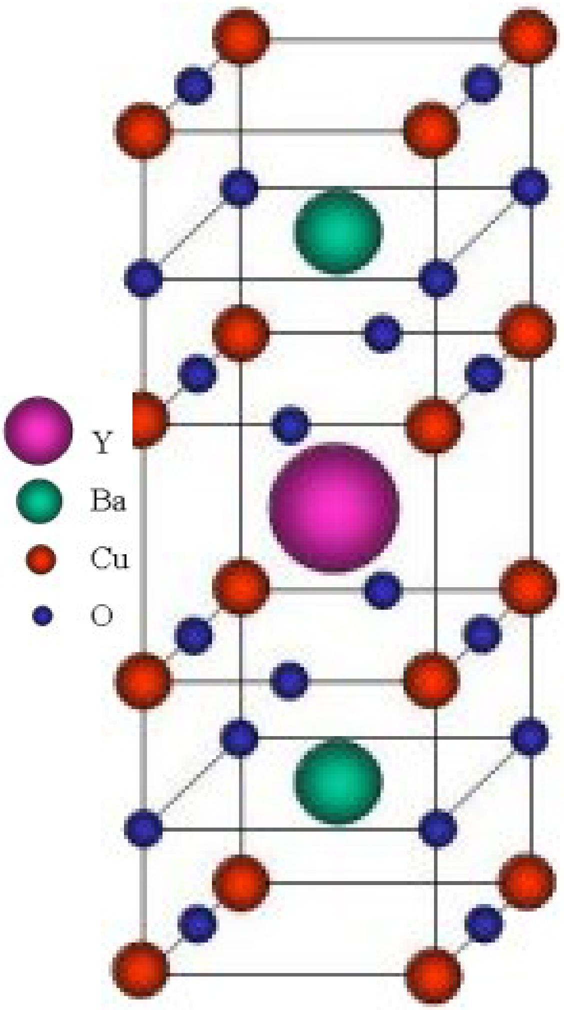
K. Alexander Müller

Metallic, oxygen-deficient compounds in the Ba–La–Cu–O system, with the composition $Ba_xLa_{5-x}Cu_5O_{5(3-y)}$ have been prepared in polycrystalline form. Samples with $x=1$ and 0.75, $y>0$, annealed below 900 °C under reducing conditions, consist of three phases, one of them a perovskite-like mixed-valent copper compound. Upon cooling, the samples show a linear decrease in resistivity, then an approximately logarithmic increase, interpreted as a beginning of localization. Finally an abrupt decrease by up to three orders of magnitude occurs, reminiscent of the onset of percolative superconductivity. The highest onset temperature is observed in the 30 K range. It is markedly reduced by high current densities. Thus, it results partially from the percolative nature, bute possibly also from $2D$ superconducting fluctuations of double perovskite layers of one of the phases present.

$(La,Sr)_2CuO_4$ Superconductors (Tc=40 K)



$YBa_2Cu_3O_{7-\delta}$ Superconductors (Tc~93 K)



VOLUME 58, NUMBER 9 PHYSICAL REVIEW LETTERS 2 MARCH 1987

Superconductivity at 93 K in a New Mixed-Phase Y-Ba-Cu-O Compound System at Ambient Pressure

M. K. Wu, J. R. Ashburn, and C. J. Torng
Department of Physics, University of Alabama, Huntsville, Alabama 35899

and

P. H. Hor, R. L. Meng, L. Gao, Z. J. Huang, Y. Q. Wang, and C. W
Department of Physics and Space Vacuum Epita

(Received 6 February 1987; Revi

A stable and reproducible superconductivity
observed both resistively and magnetically in a
An estimated upper critical field $H_{c2}(0)$ betwee

Alabama and Houston

M. K. Wu

C. W. Chu

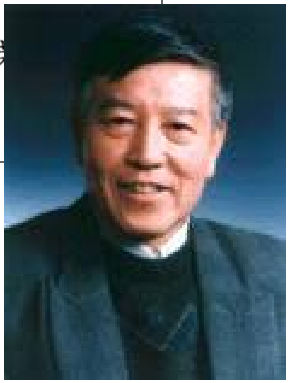
本文 1987 年 2 月 21 日收到.

412 科 学 通 报 1987 年

Ba–Y–Cu 氧化物液氮温区的超导电性

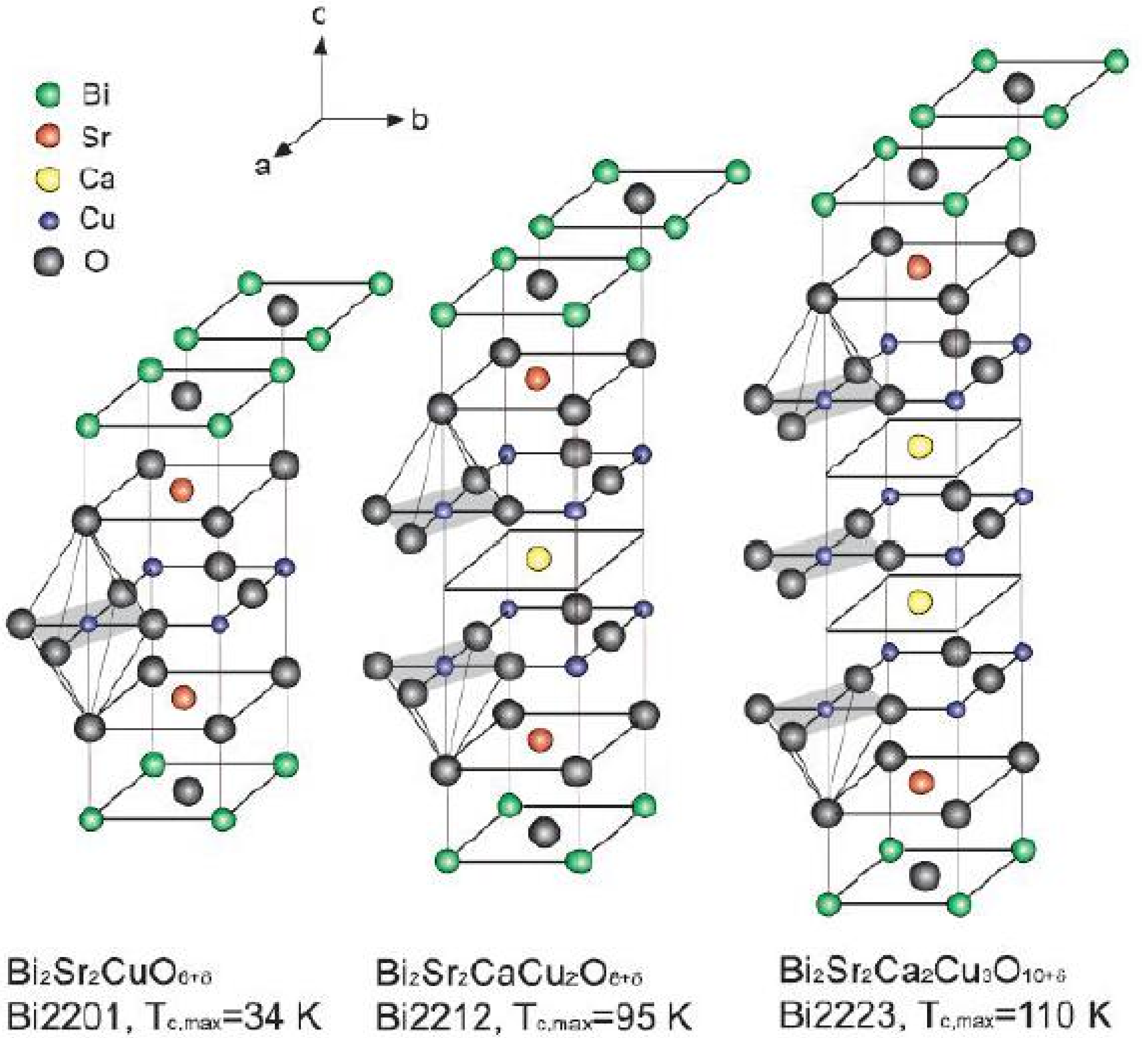
赵忠贤 陈立泉 杨乾声 黄玉珍 陈赓华 唐汝明 刘贵
崔长庚 陈 烈 王连忠 郭树权 李山林 毕建清
(中国科学院物理研究所，北京)

Institute of Physics, CAS, Beijing



Zhongxian Zhao

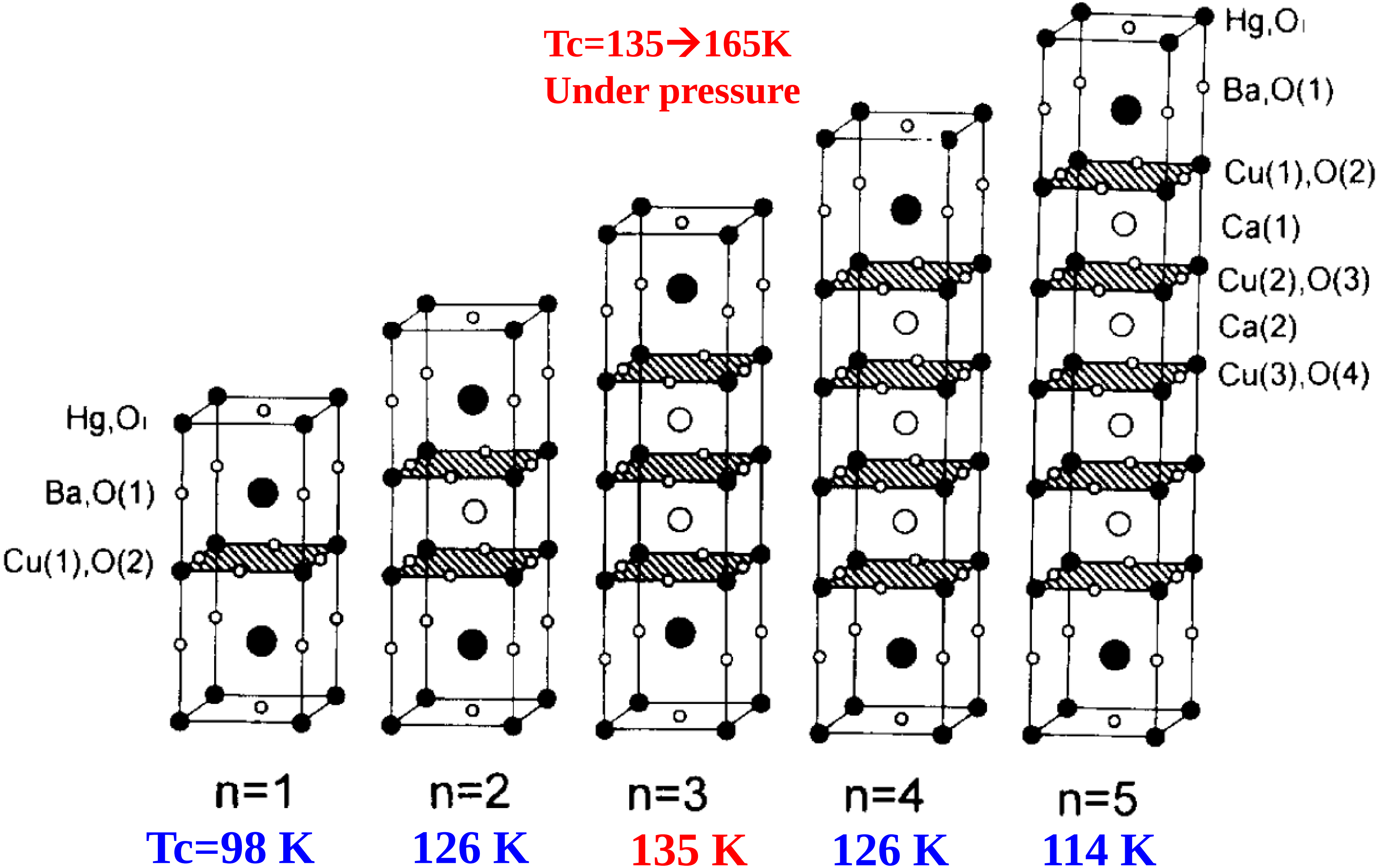
$Bi_2Sr_2Ca_{n-1}Cu_nO_{2n+4}$ Series Superconductors



n=1 (Bi2201) **n=2 (Bi2212)** **n=3 (Bi2223)**

Tc=34 K **Tc=95 K** **Tc=110 K**

$HgBa_2Ca_{n-1}Cu_nO_{2n+2}$ Series Superconductors (1993)



High Temperature Copper-Oxide Superconductors

SYSTEM	*ALIAS*	*COMPOSITION*	*T_C (K)*
La-	214-T	$(La,Sr)_2CuO_{4+\delta}$	40
		$(La,Sr,Ca)_3Cu_2O_6$	58
	214-T'	$(Nd,Ce)_2CuO_{4-\delta}F_\delta$	24
	214-T*	$(Nd,Ce,Sr)_2CuO_4$	35
	123	$YBa_2Cu_3O_{7-\delta}$	92
Y-	124	$YBa_2Cu_4O_8$	80
	247	$Y_2Ba_4Cu_7O_{15}$	95
	2201	$Bi_2Sr_2CuO_6$	10
Bi-	2212	$Bi_2Sr_2CaCu_2O_8$	90
	2223	$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$	110
		$Bi_2Sr_2(Gd,Ce)_2Cu_2O_{10}$	34
	1201	$TlBa_2CuO_5$	60
	1212	$TlBa_2CaCu_2O_{7-\delta}$	103
	1223	$TlBa_2Ca_2Cu_3O_{9+\delta}$	123
	1234	$TlBa_2Ca_3Cu_4O_{11}$	112
Tl-	1245	$TlBa_2Ca_4Cu_5O_{13}$	107
	2201	$Tl_2Ba_2CuO_6$	95
	2212	$Tl_2Ba_2CaCu_2O_8$	118
	2223	$Tl_2Ba_2Ca_2Cu_3O_{10}$	125
	2234	$Tl_2Ba_2Ca_3Cu_4O_{12}$	112
	2245	$Tl_2Ba_2Ca_4Cu_5O_{14}$	105
	1201	$HgBa_2CuO_{4+d}$	98
	1212	$HgBa_2CaCu_2O_6$	126
Hg-	1223	$HgBa_2Ca_2Cu_3O_8$	135
	1234	$HgBa_2Ca_3Cu_4O_{10}$	126
	1245	$HgBa_2Ca_4Cu_5O_{12}$	114
	2201	$HgBa_2CuO_6$	
	2212	$Hg_2Ba_2(Y,Ca)Cu_2O_{7+d}$	
	1201	$(Pb,Cu)(Eu,Ce)_2(Sr,Eu)_2CuO_9$	25
Pb-		$Pb_2(Sr,La)_2Cu_2O_6$	32
		$Pb_2Sr_2YCu_3O_8$	70
		$PbBaYSrCu_3O_8$	50
		$(Cu,CO_2)(Ba,Sr)CuO_{3+\delta}$	
		$(Cu,CO_2)(Ba,Sr)_2CaCu_2O_{5+\delta}$	
		$(Cu,CO_2)(Ba,Sr)_2Ca_2Cu_3O_{7+\delta}$	
		$Ba_2Ca_{n-1}Cu_nO_x$	126
		$(Eu,Ce)_2(Ba,Eu)_2Cu_3O_{10-d}$	43
		$(Tl,Pb)Sr_4Cu(CO_3)O_7$	70
		$(Cu,Pb)Sr_2(Y,Ca)Cu_2O_7$	
		$GaSr_2(Y,Ca)Cu_2O_7$	
		$NdSr_2(Nd,Ce)_2CuO_{10}$	
	Infinite-layer	$(Sr,Nd)CuO_2$	40
		$(Sr,Ca)_{1-x}CuO_2$	110
		$Sr_2CuO_3F_x$	70
		$Sr_3Cu_2O_5$	100
		$(Sr,Ca)_5Cu_4O_{10}$	70
		$(Sr,Na)_2CuO_2(Cl,F)_2$	
		$Sr_3Cu_2O_4Cl_2$	
	Ladder	$(Sr_{0.4}Ca_{13.6})Cu_{24}O_{41}$	10

$(La,Sr)_2CuO_4$

$YBa_2Cu_3O_{7-d}$

$Bi_2Sr_2CaCu_2O_8$

$HgBa_2Ca_2Cu_3O_8$

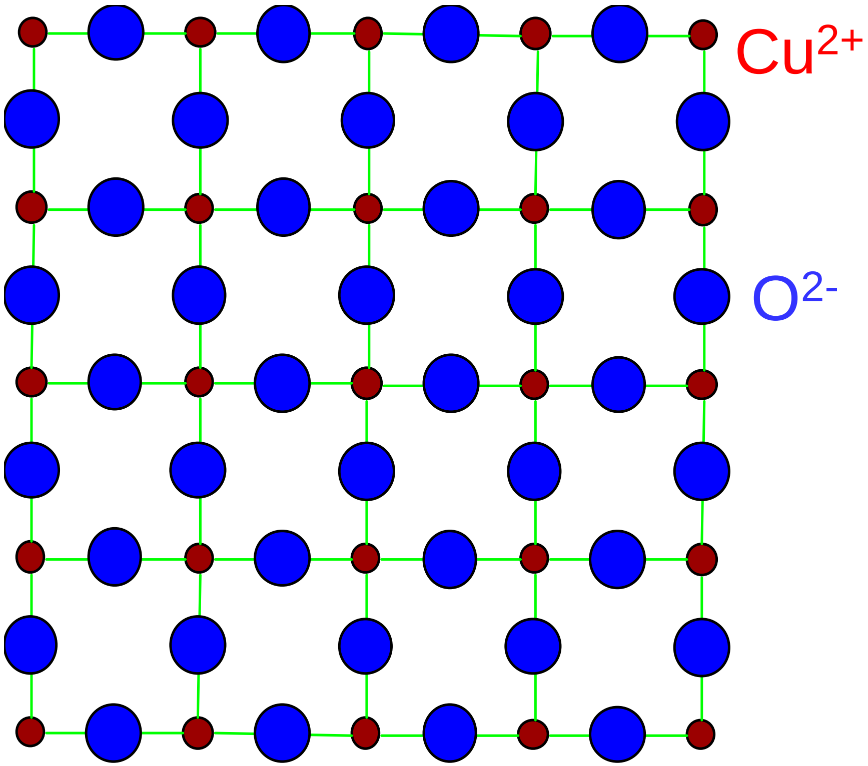
Tc=135 K Ambient

Tc~160 K High pressure

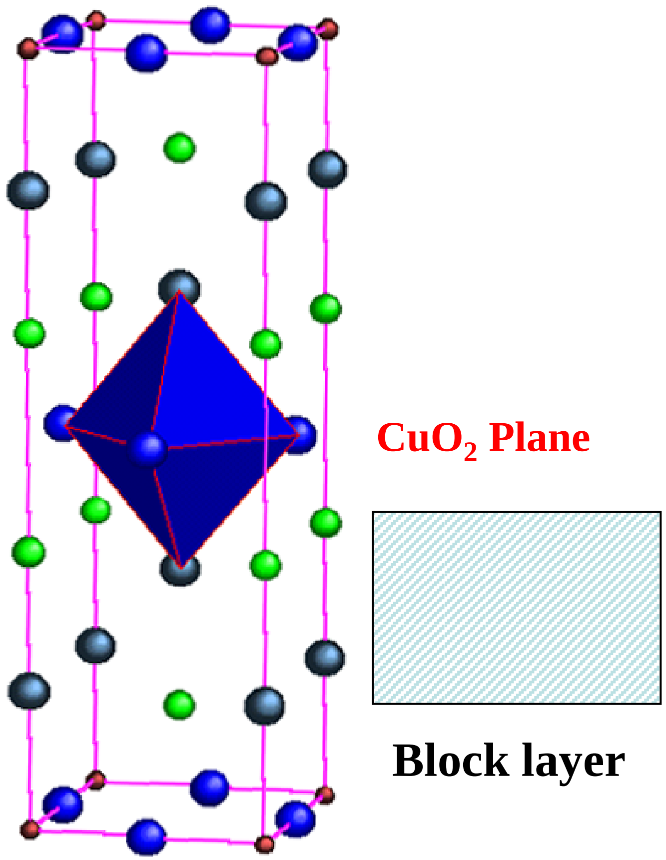
~50 kinds of superconductors

with *distinct* crystal structure

CuO_2 Planes: Common Structural Unit for All Cuprate Superconductors



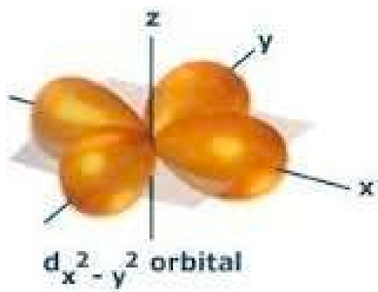
CuO_2 plane



$(La,Sr)_2CuO_4$

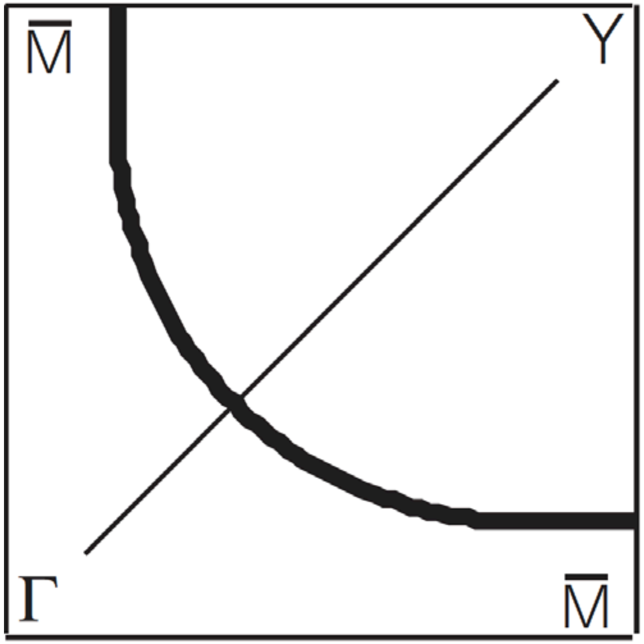
CuO_2 plane is believed to be responsible for high-Tc superconductivity.

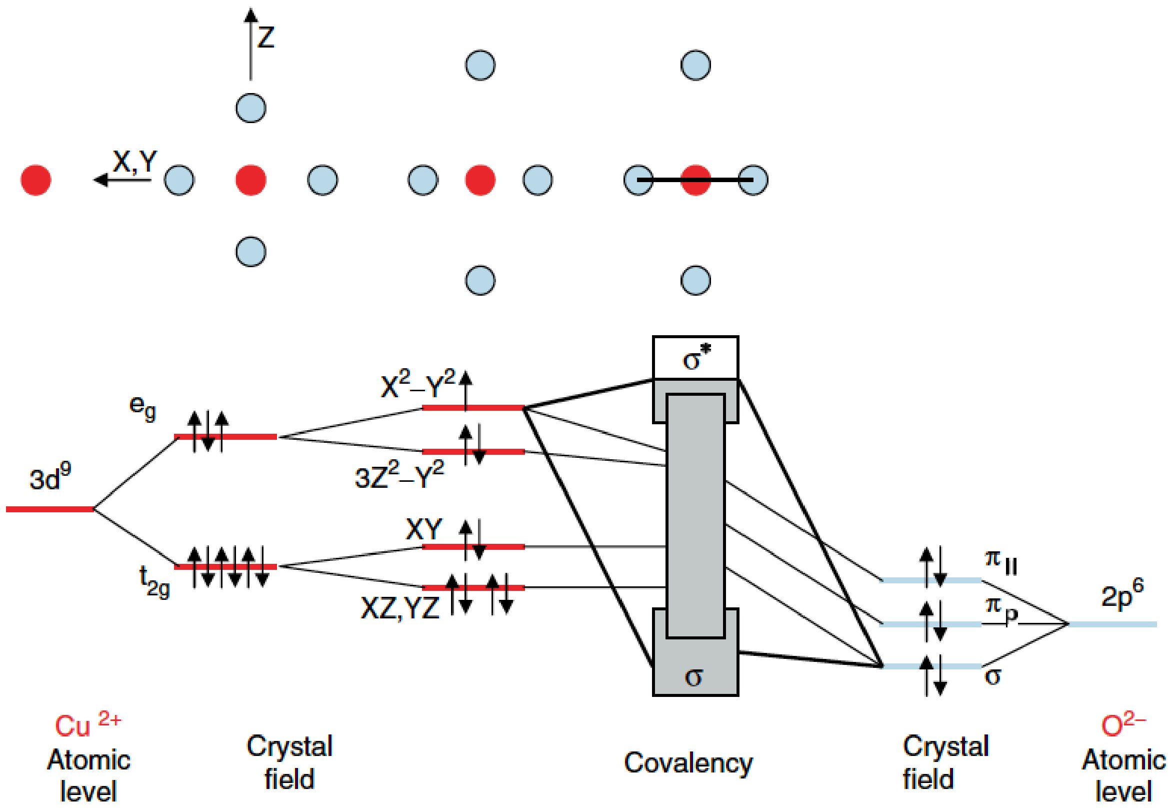
Single-Band from Cu $3dx^2$-y^2 and O 2p Orbitals



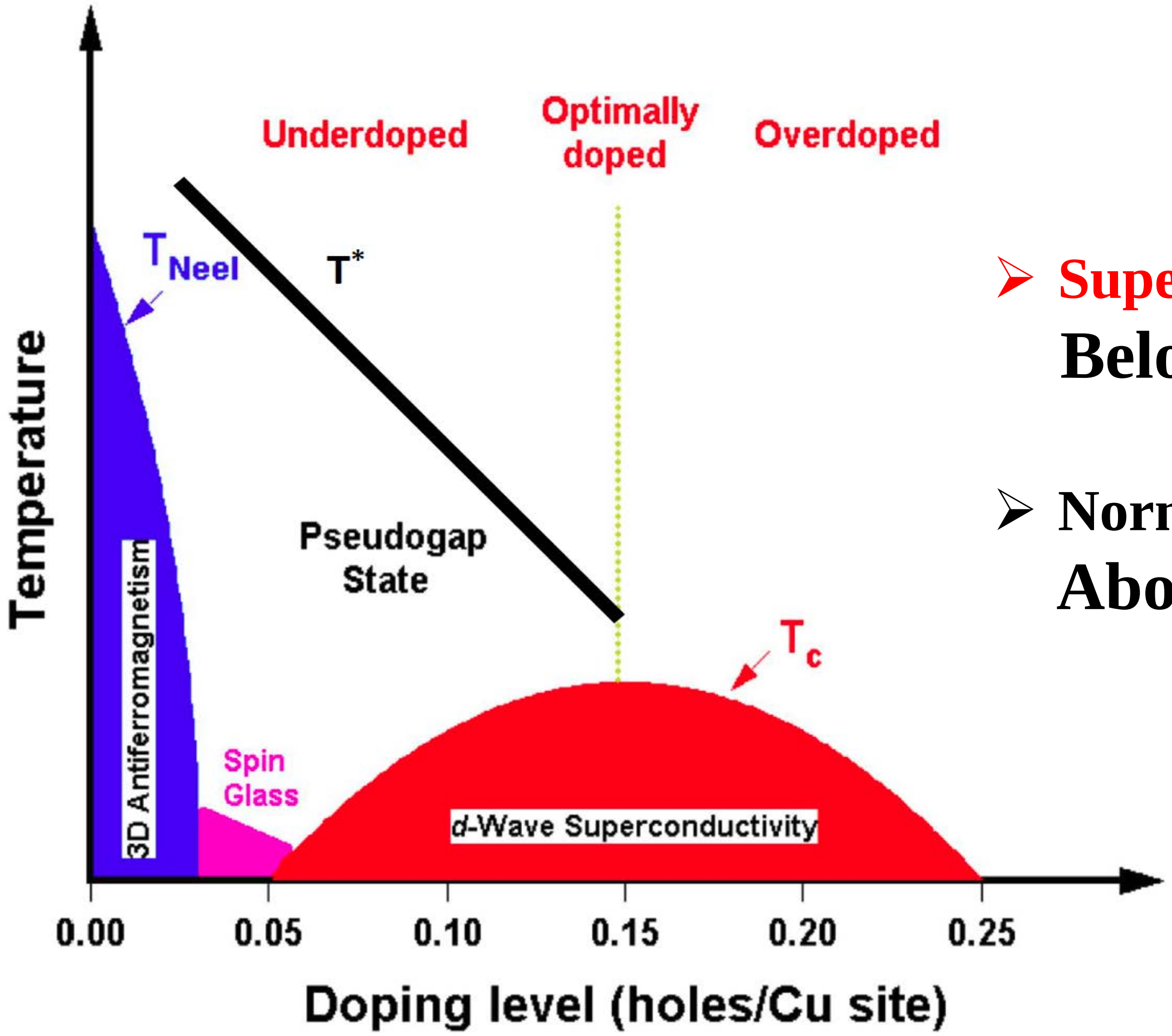
Cu $3dx^2$-y^2

Fermi Surface





Electronic Phase Diagram of Copper-Oxide Superconductors

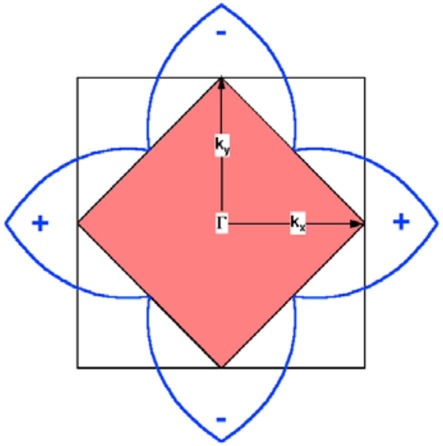


- **Superconducting state**
  Below Tc ;
- **Normal state**
  Above Tc.

Unusual Superconducting Properties of High-Tc Superconductors

(1). Tc is high
(Tc max= 135K for Hg1223
Tc max =160K under pressure);

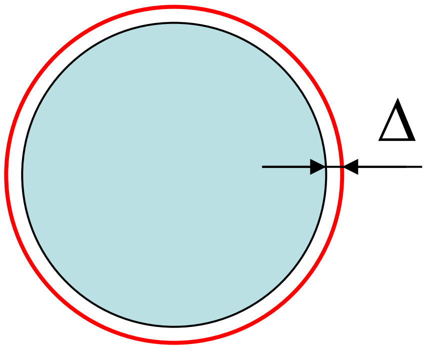
(2). Superconducting gap is anisotropic.
(Electrons are still paired)



d-wave gap

Consequence of BCS Theory:

(1). Tc has a limit (~ 40K);
(2). Superconducting gap is isotropic.



s-wave gap

What is the pairing mechanism
if it is not electron-phonon coupling?

High-Tc Mechanism: A Challenge

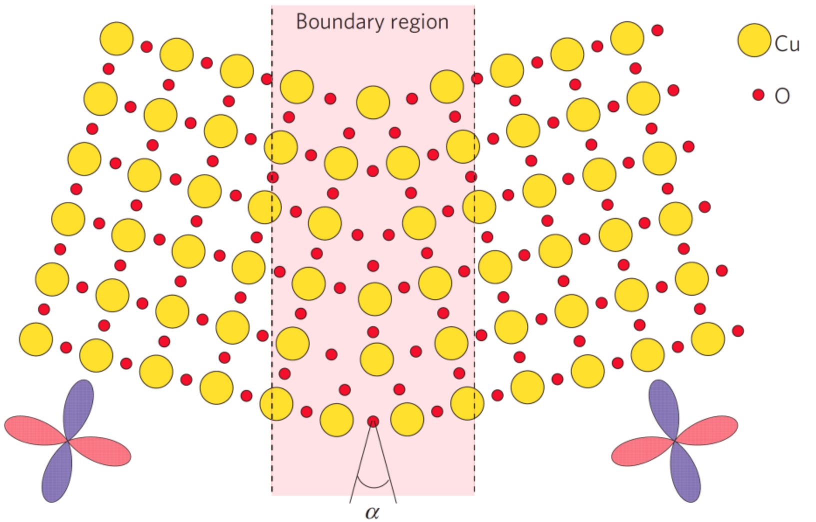
- **Various theories are proposed;**
- **No consensus has been reached.**

RVB: P. W. Anderson*, T. M. Rice, P. Lee, F.-C. Zhang etc.
Spin-Bag: J. R. Schrieffer* etc.
Spin Fluctuations: D. Pines, D. Scalapino and more
Stripes: S. Kivelson etc.
Loop Current: C. M. Varma
Phonon/Polarons: N. Mott*, K. Mueller* etc.
…………….
***:   Nobel prize laureates**

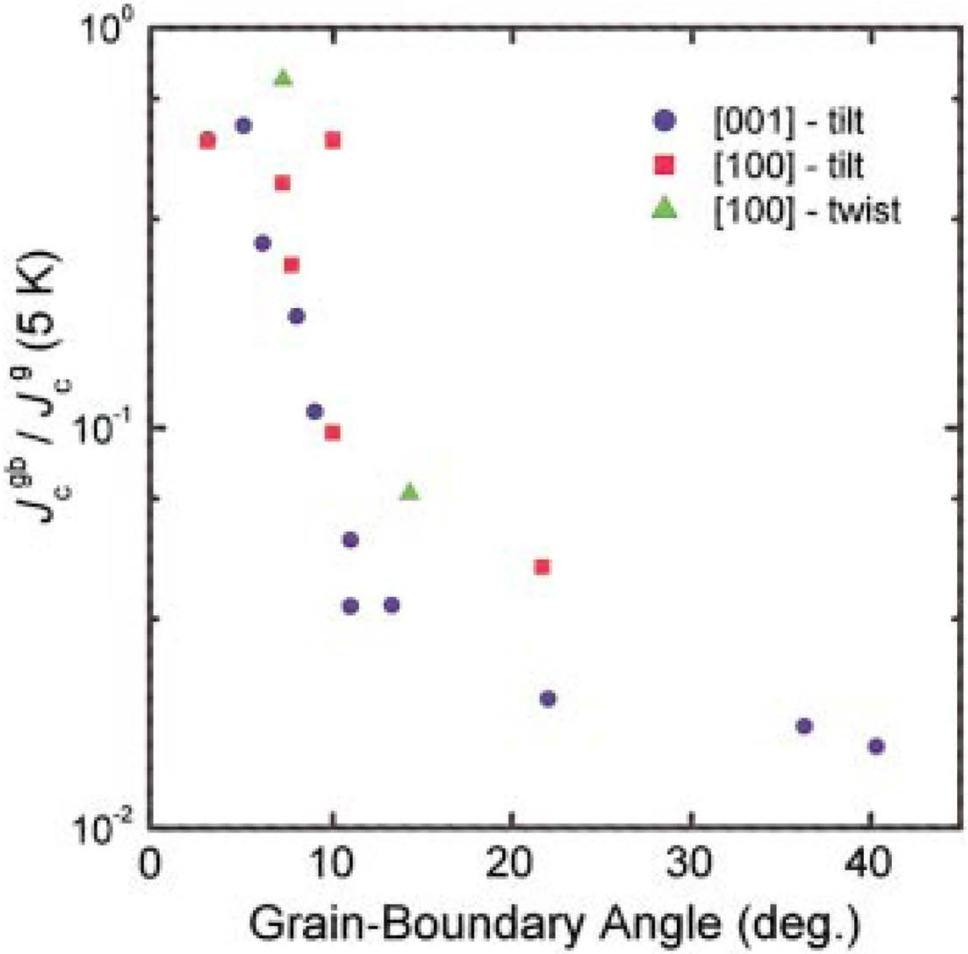
The final solution relies on decisive experiments

d-Wave Gap on Critical Current of Superconductors

YBCO Grain Boundary

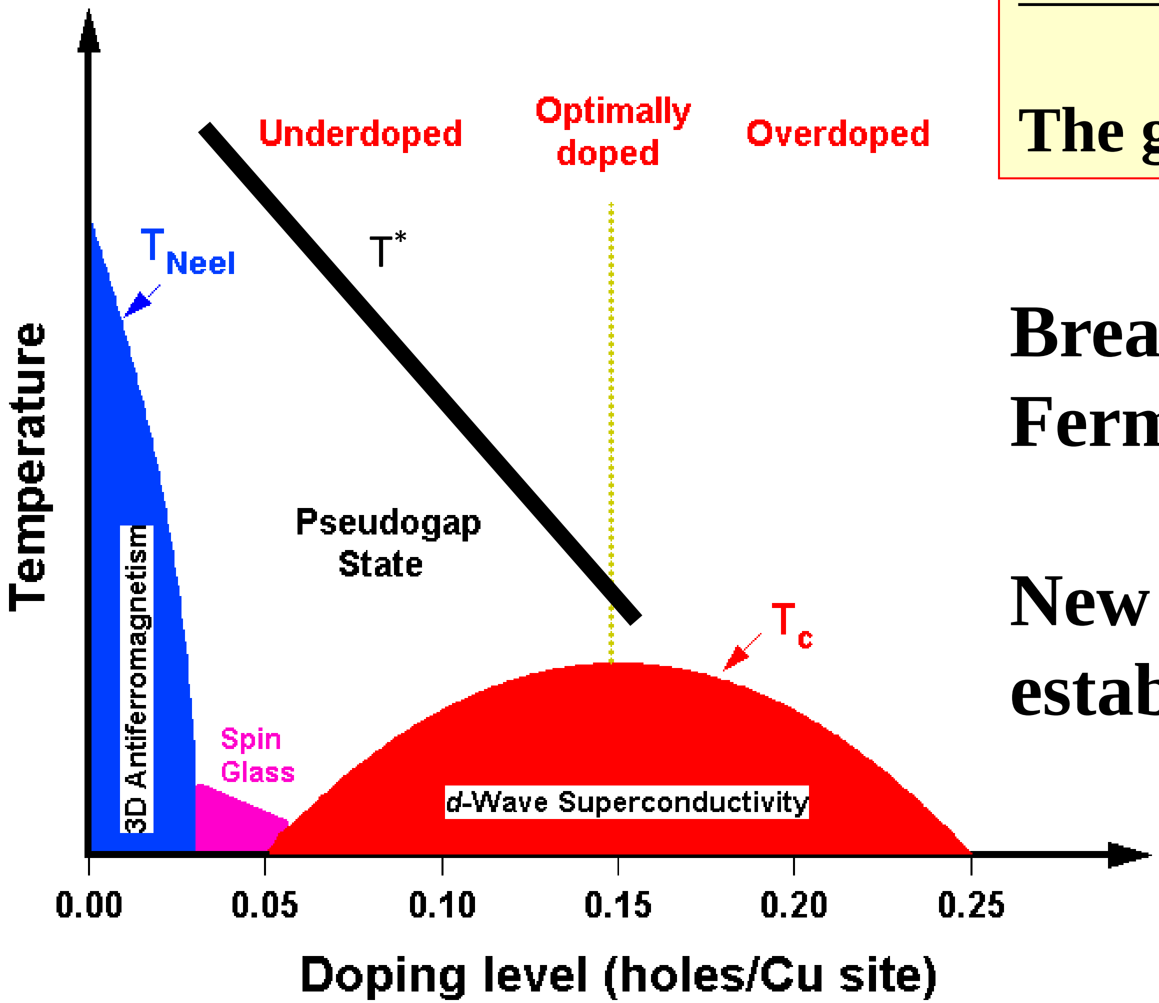


Mismatch angle~5 degrees



D. Dimos et al., Phys. Rev. Lett. 61 (1988) 219;
H. Hilgenkamp and J. Mannhart, Rev. Modern Phys. 74 (2002) 485;
S. Gfraser et al., Nature Physics 6 (2010) 609.

Anomalous Normal State Properties of HTSC--Pseudogap



Pseudogap:

The gap that opens above T_c

Breakdown of Landau Fermi Liquid Theory

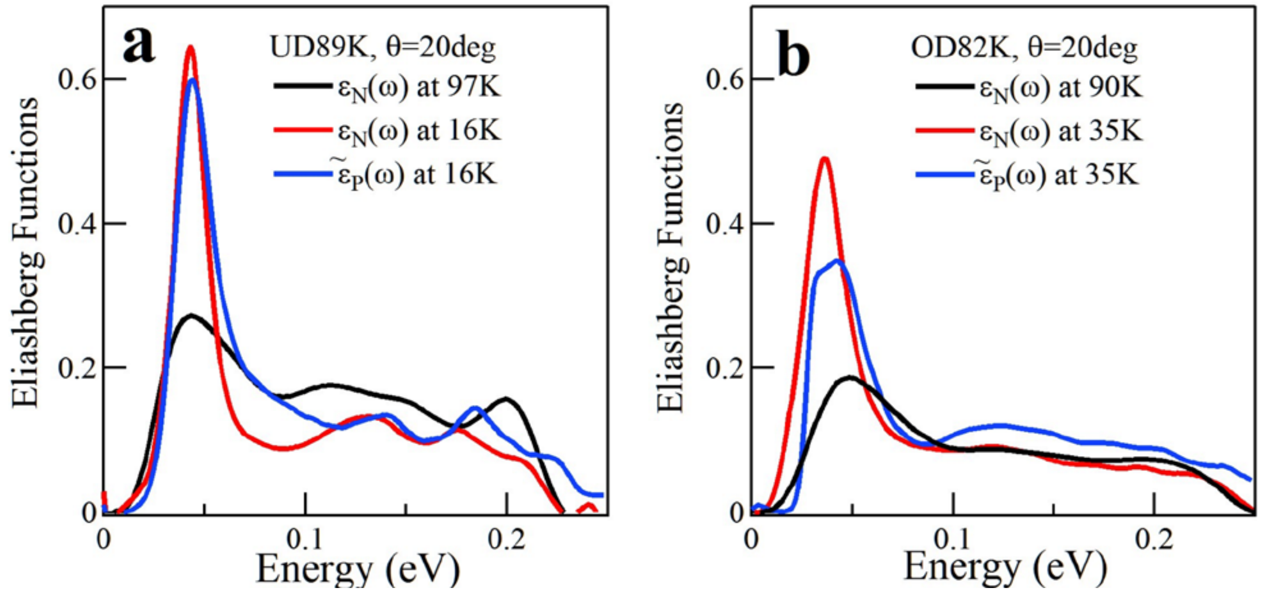
⬇

New theory has to be established.

CONDENSED MATTER PHYSICS

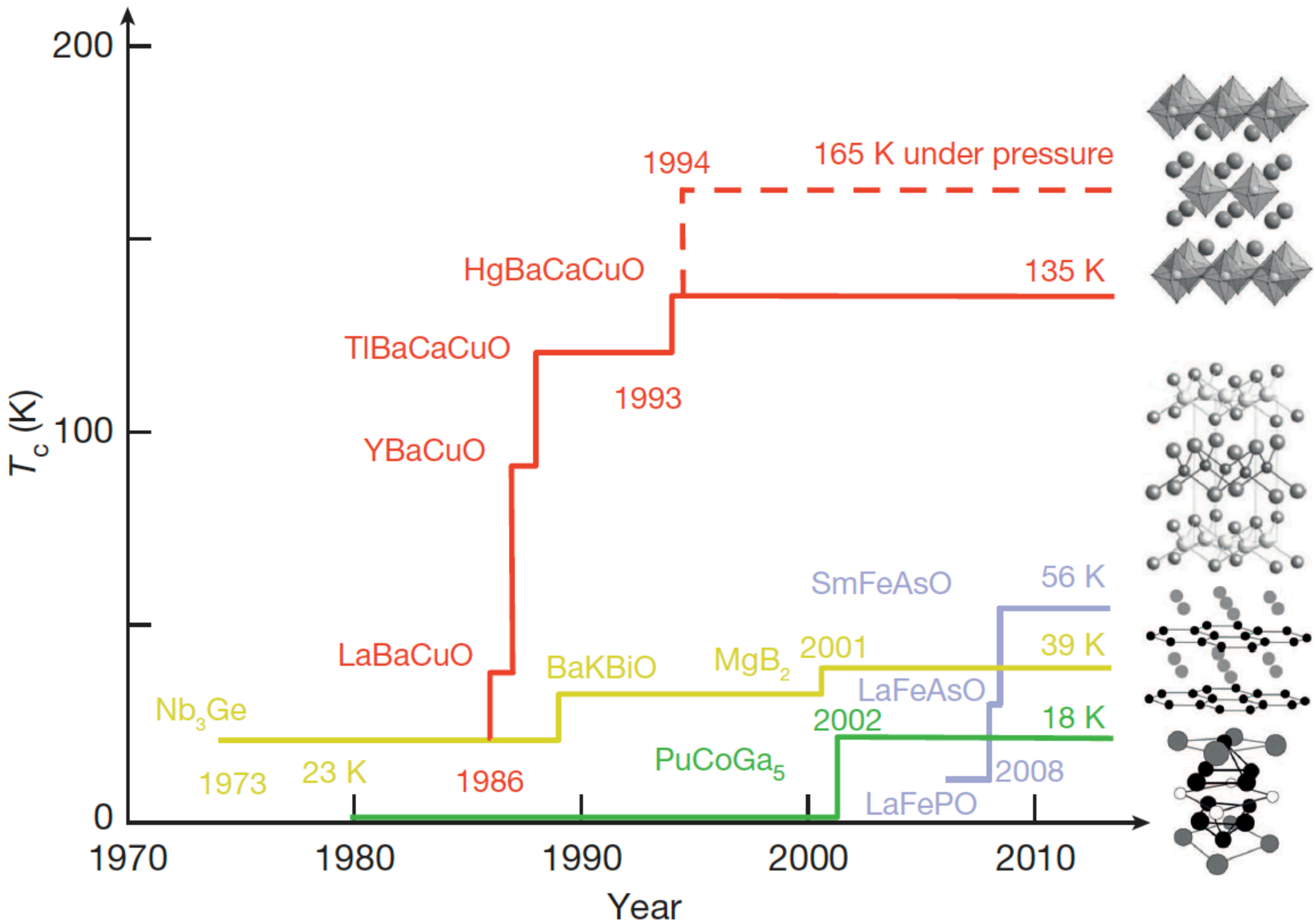
Quantitative determination of pairing interactions for high-temperature superconductivity in cuprates

Jin Mo Bok,[1,2] Jong Ju Bae,[1] Han-Yong Choi,[1,3]* Chandra M. Varma,[4]* Wentao Zhang,[2,5] Junfeng He,[2] Yuxiao Zhang,[2] Li Yu,[2] X. J. Zhou[2,6]*



Science Advances 2, e1501329 (2016)

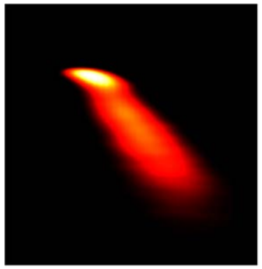
Progress of Tc in Superconductors



B. Keimer et al., Nature 518 (2015) 179.

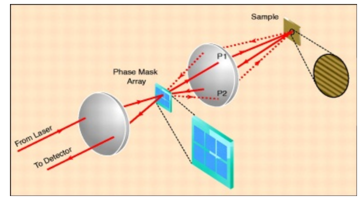
High-Tc Has Changed Landscape of Condensed Matter Physics

ARPES



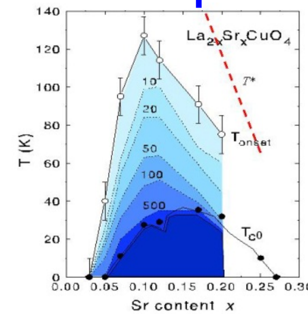
Nature 412(2001)510

Optical



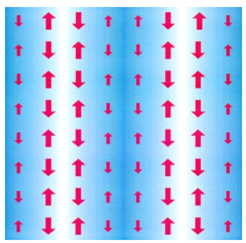
Science 300(2003)1410

Transport



Nature 406(2000)486

Neutron

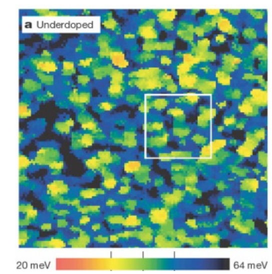


Nature375(1995)561

High Tc Superconductivity

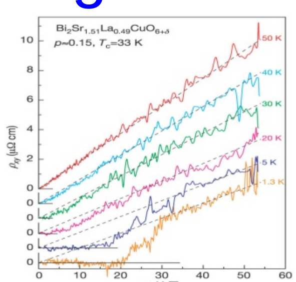
The Nobel Prize in Physics in 1987

STM



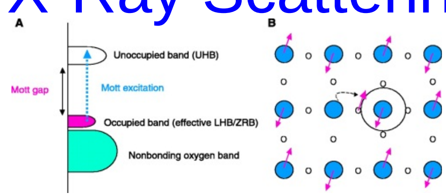
Nature 415(2002)412

High Magnetic Field



Nature 424 (2003)912

X-Ray Scattering

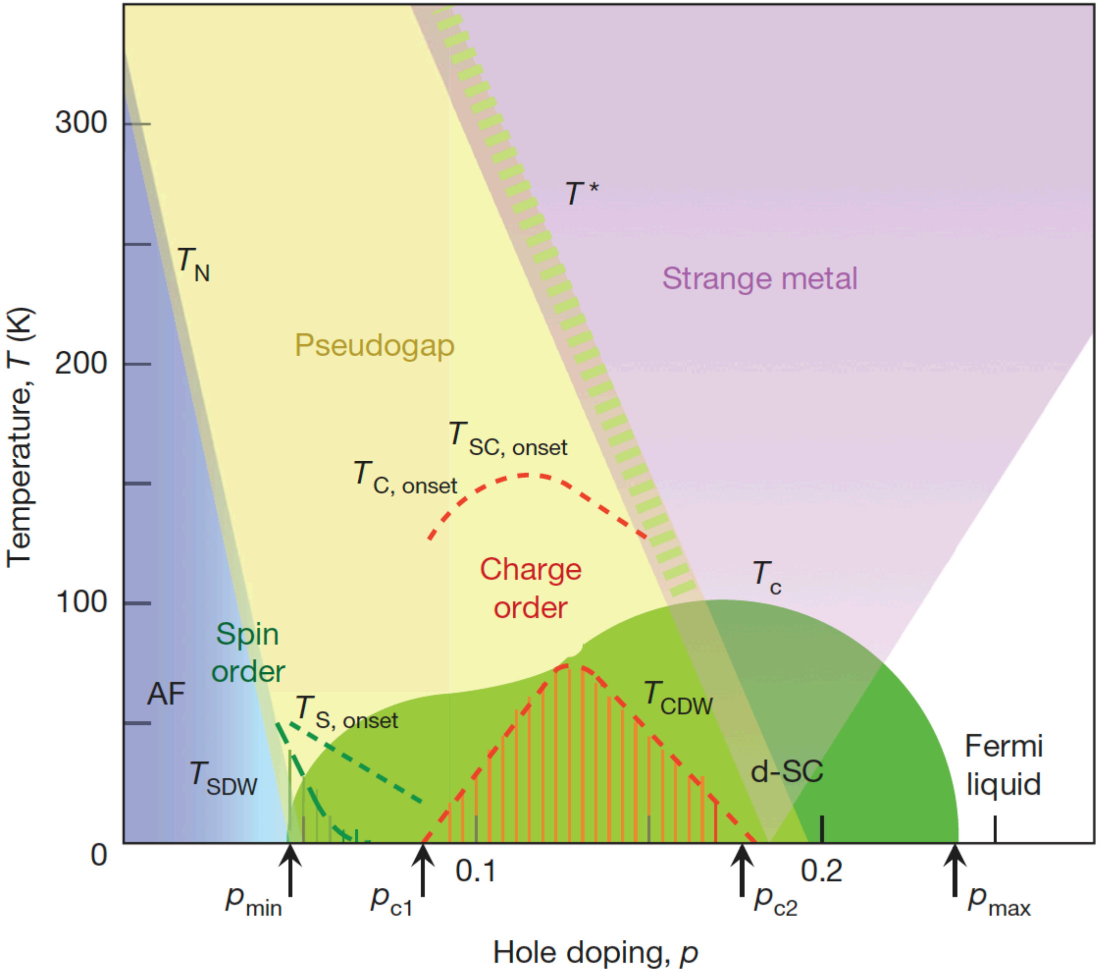


Science 288(2000)1811

High Pressure

Nature 365(1993)323

Rich Physics in Copper-Oxide Superconductors



Various phenomena:

- ➢Superconductivity;
- ➢Charge density wave (CDW);
- ➢Spin density wave (SDW);
- ➢Antiferromagnetism;
- ➢Stripes;
- ➢Pseudogap;
- ➢Metal-insulator transition;
- ➢Insulator-supercond transition;
- ➢Spin glass;
- ➢Quantum phase transition;
- ➢Fermi liquid;
- ➢Non-Fermi liquid;
- ➢Marginal Fermi lquid;
- ➢Strange metal;
- ➢RVB
- ➢Loop current

…………

B. Keimer et al., Nature 518 (2015) 179.

The Iron-Based Superconductors

Discovery of the Iron-Based Superconductors

J|A|C|S
COMMUNICATIONS

Published on Web 02/23/2008

Iron-Based Layered Superconductor $La[O_{1-x}F_x]FeAs$ ($x = 0.05-0.12$) with $T_c = 26$ K

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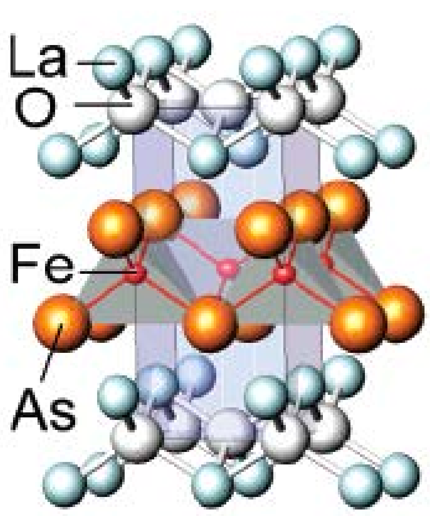
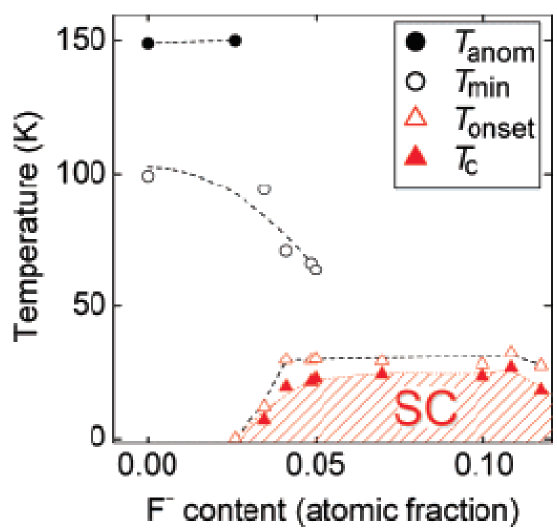
Received January 9, 2008; E-mail: hosono@msl.titech.ac.jp





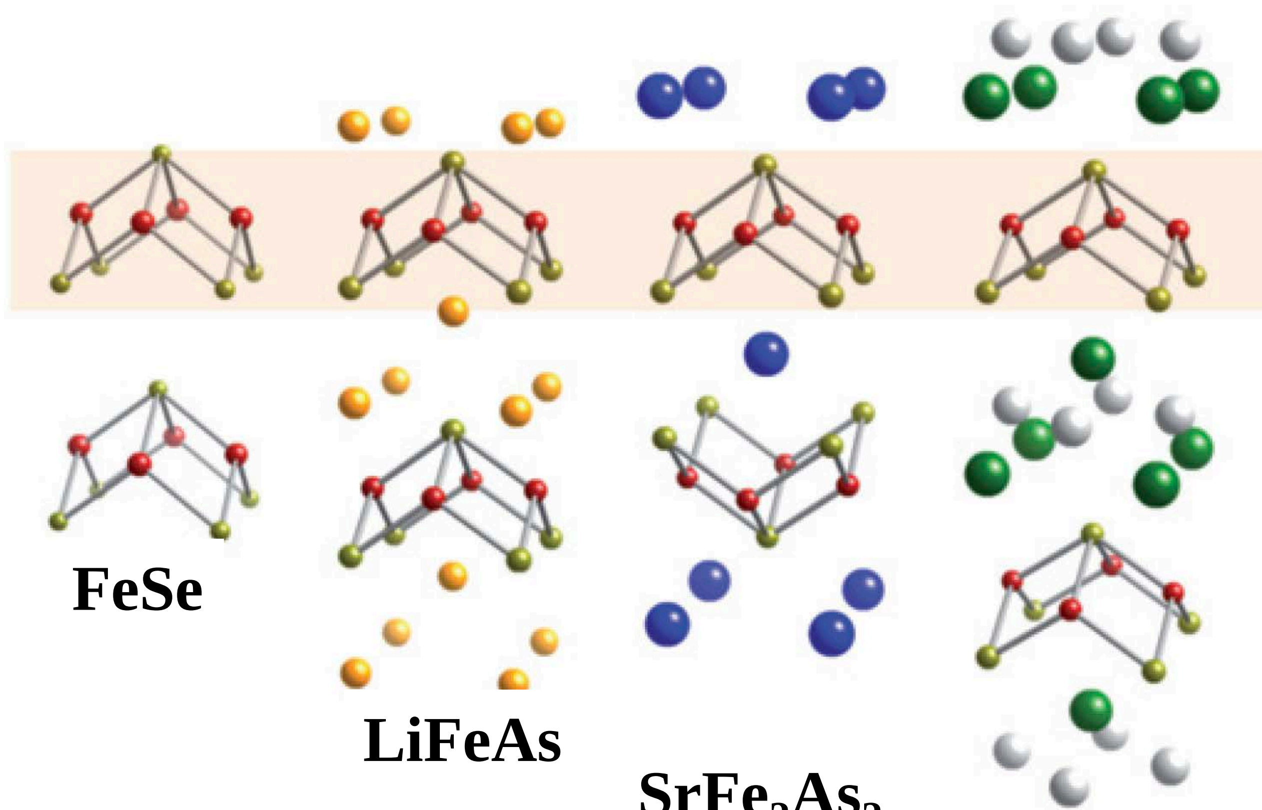
Major Classes of Iron-Based Superconductors

11 Tc~8K

111 Tc~18K

122 Tc~38K

1111 Tc~55K



FeSe

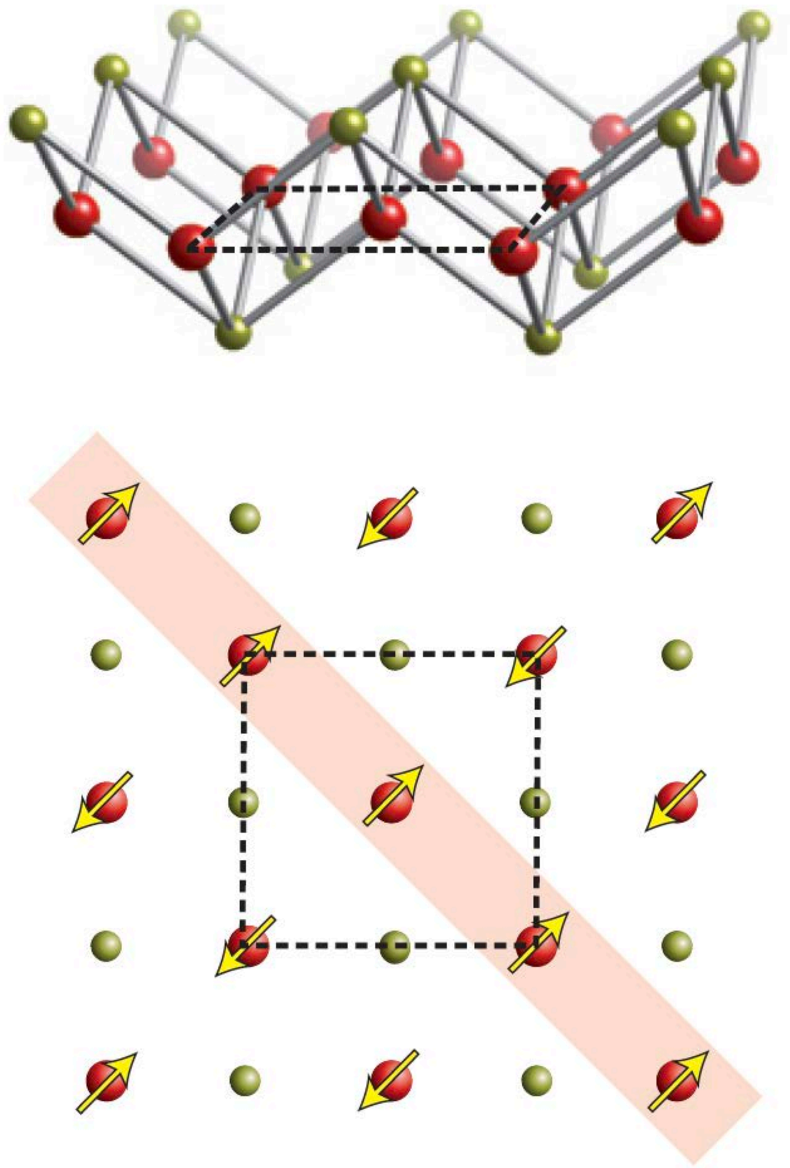
LiFeAs

$SrFe_2As_2$

LaFeAsO/SrFeAsF

J. Paglione and R. L. Greene, Nature Physics 6(2010)645.

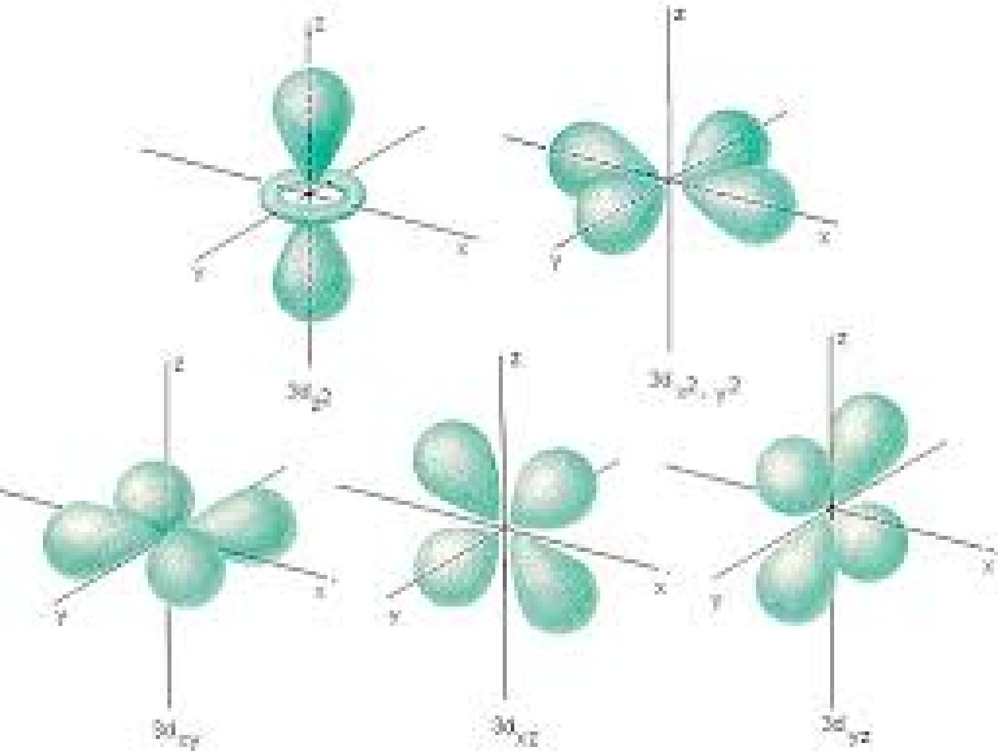
Common Building Blocks of Iron-Based SCs



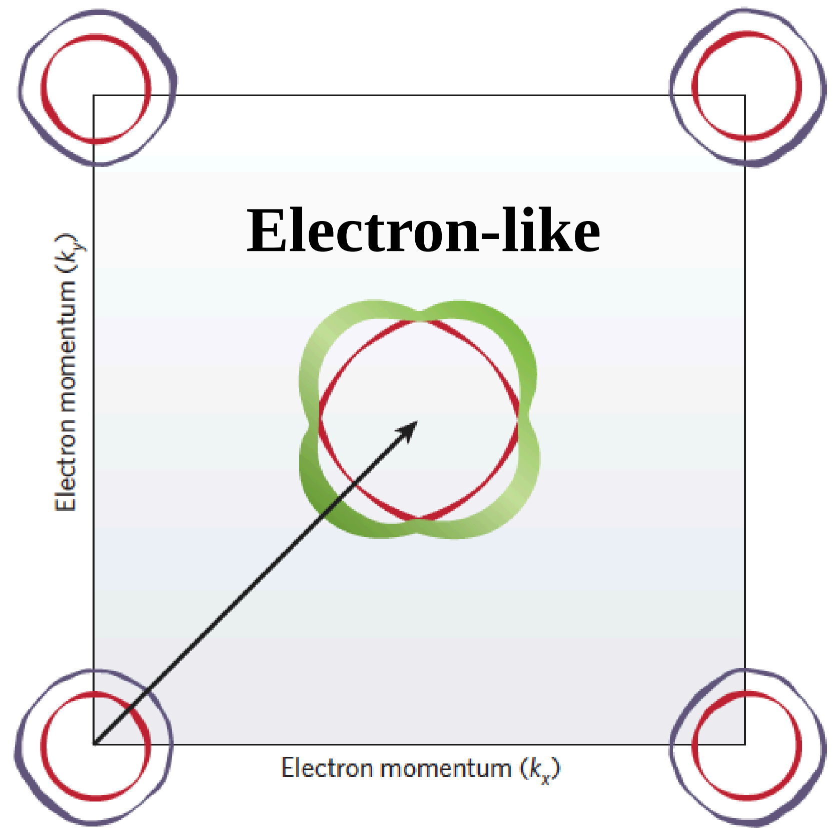
FeAs or FeSe Layers

Multiple Orbitals and Multiple Bands

Five Fe 3*d* orbitals are all involved



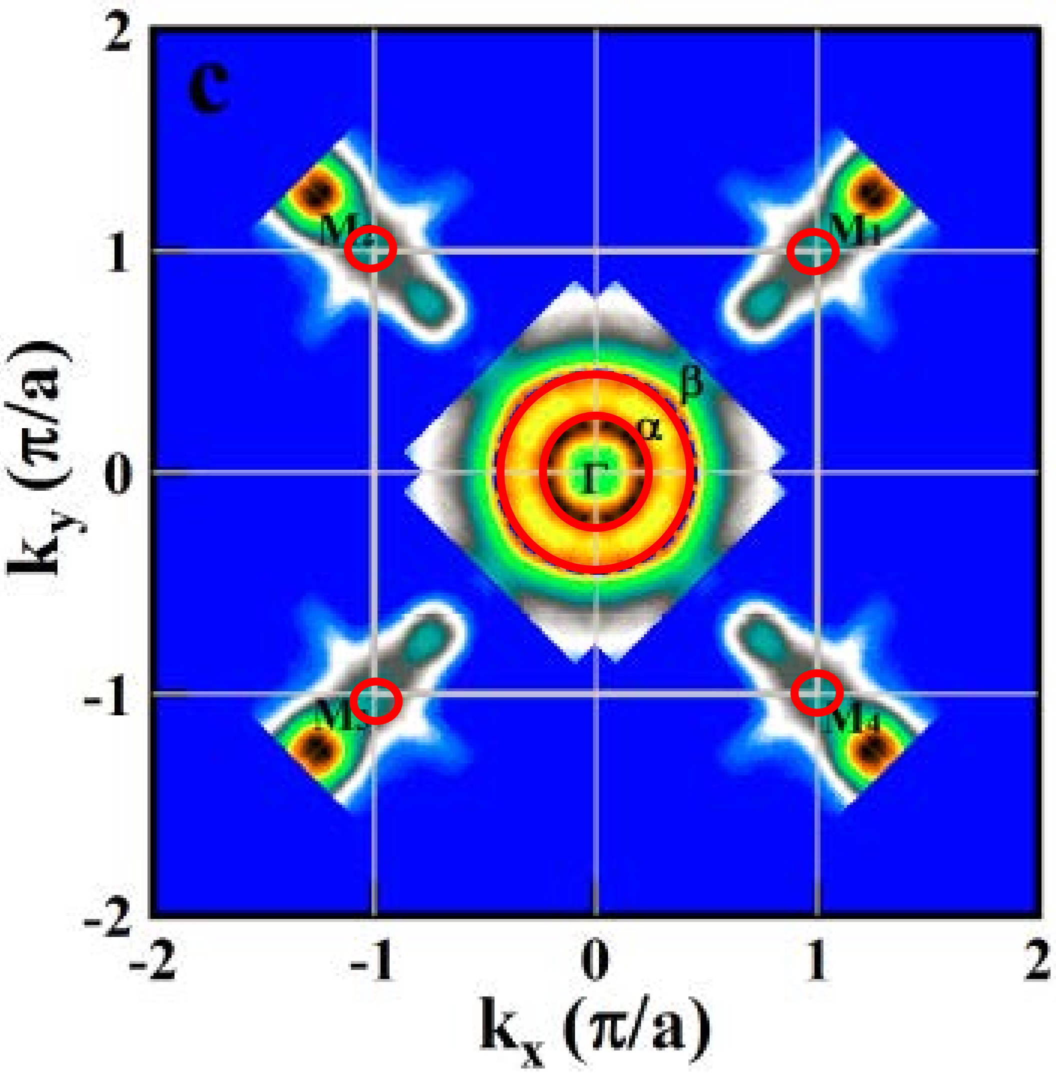
Multiple Fermi surface Sheets are formed



Hole-like

I Mazin, Nature 46 (2010) 183.

Fermi Surface of $(Ba_{0.6}K_{0.4})Fe_2As_2$ (Tc~38K)



Fermi surface at Γ:

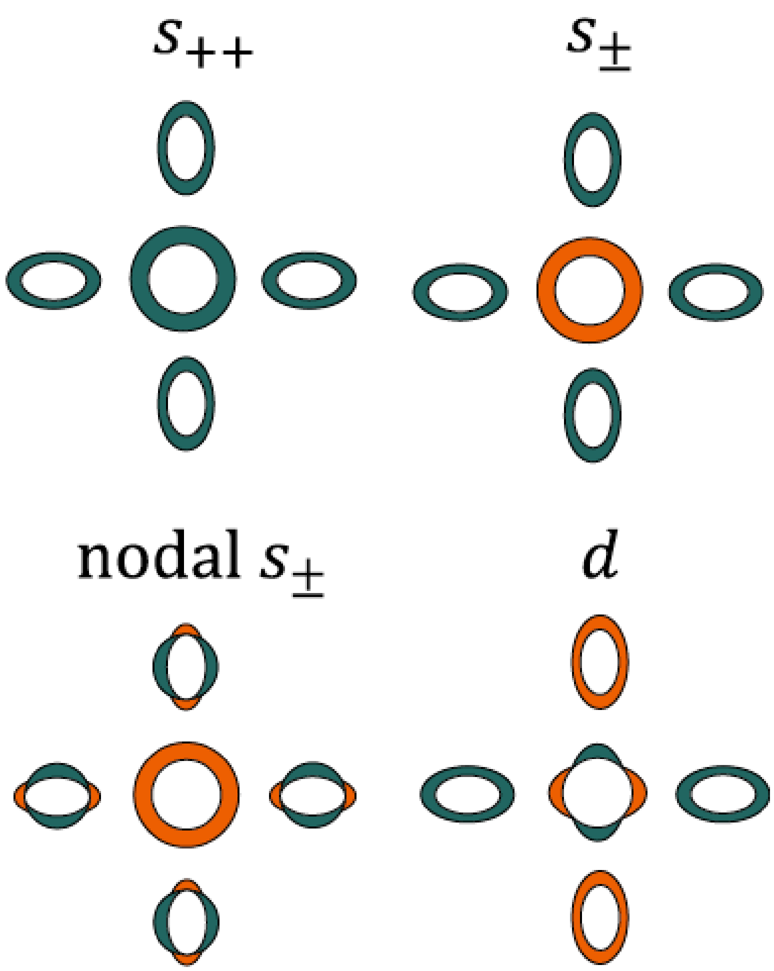
Two large hole-like
Fermi surface sheets;

Fermi surface at M:

One tiny electron pocket
and
Four hole-like lobes

L. Zhou, X. J. Zhou et al., Chin. Phys. Lett. 25(2008) 4402

Superconducting Gap Symmetry of Fe-Based SCs



- **Various gap symmetries are proposed;**
- **No consensus reached yet.**

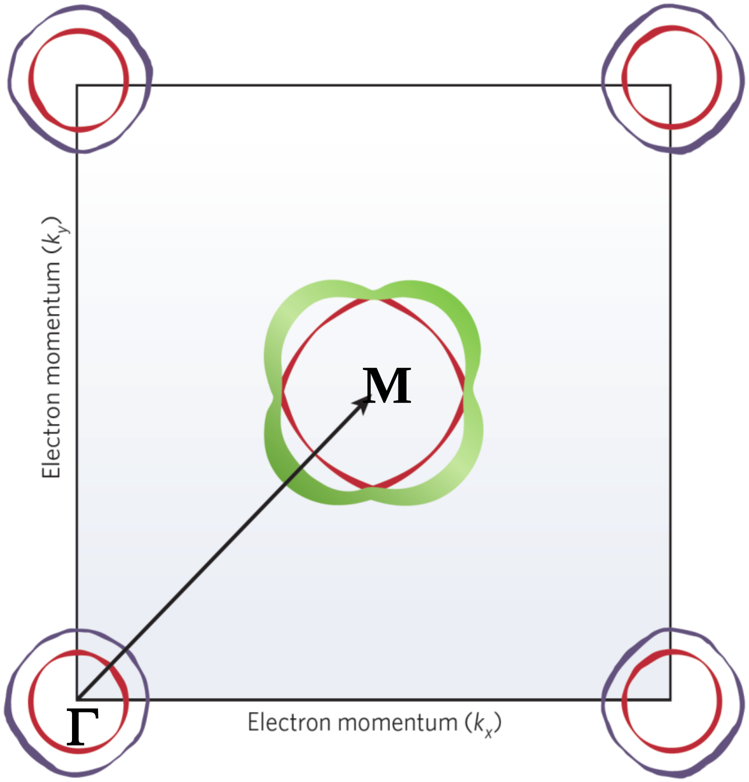
P. J. Hirshfeld et al., Rep. Prog. Phys. 74 (2011) 124508

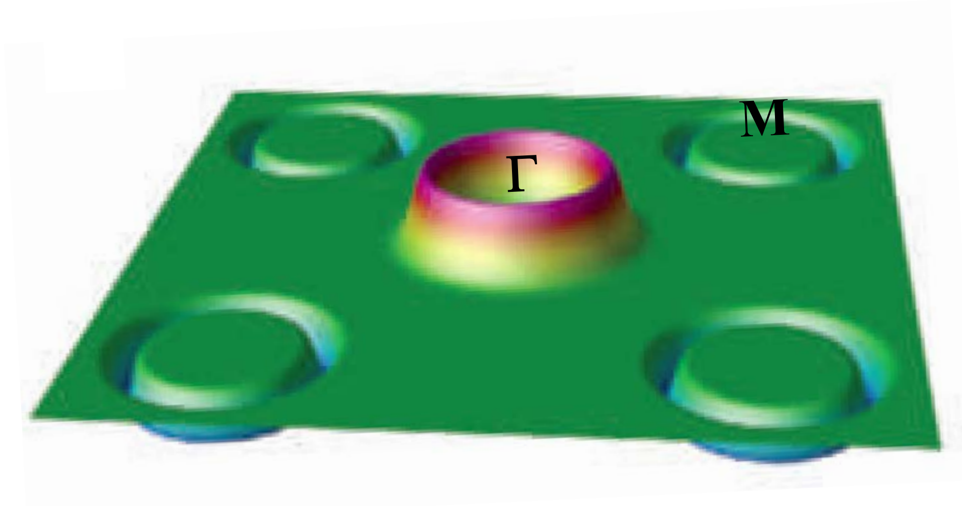
Fermi Surface Nesting Picture

Interband scatterings between hole-like bands near Γ and electron-like bands near M.

→

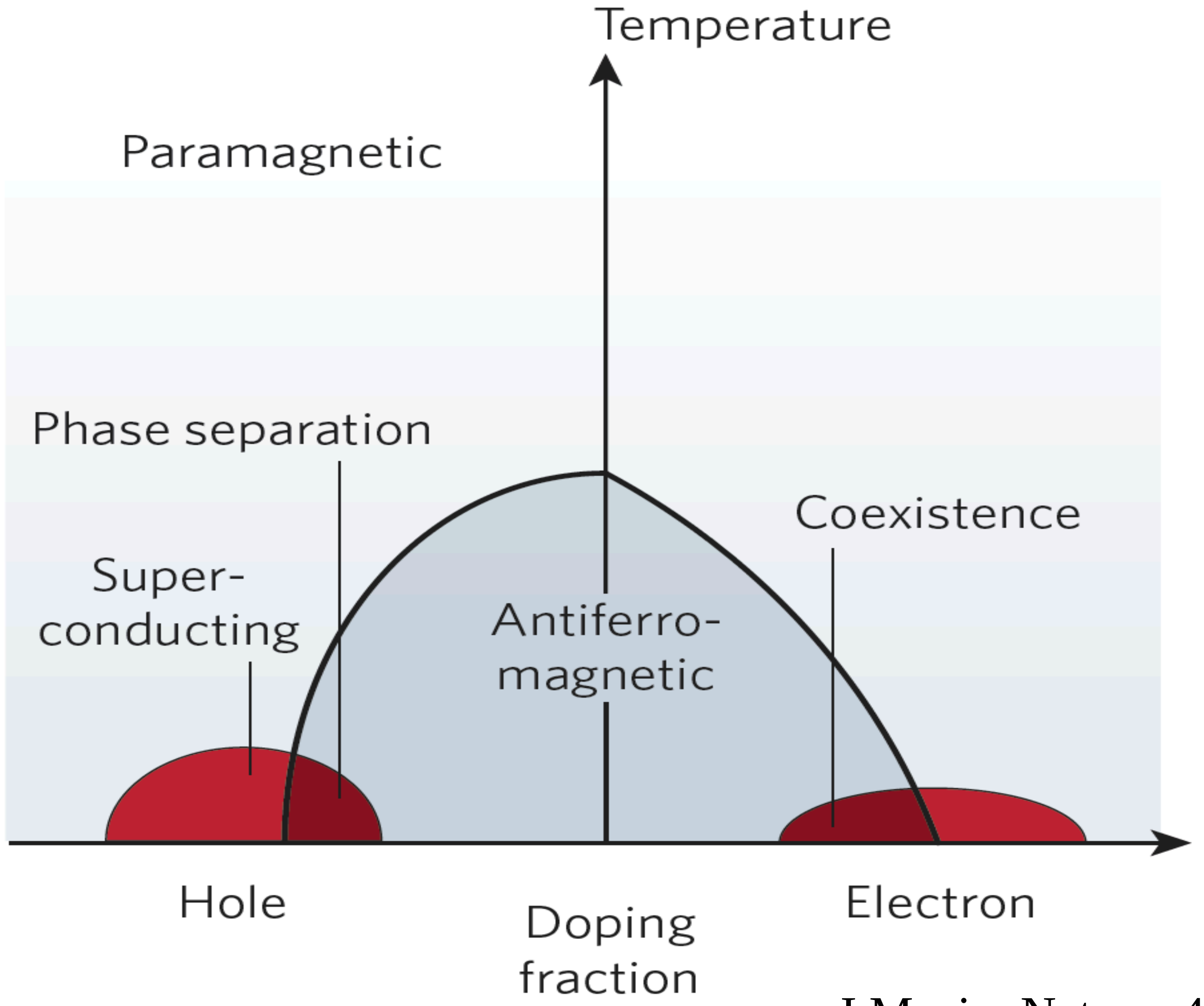
Superconducting order parameter S+ near Γ and S- near M (S±)





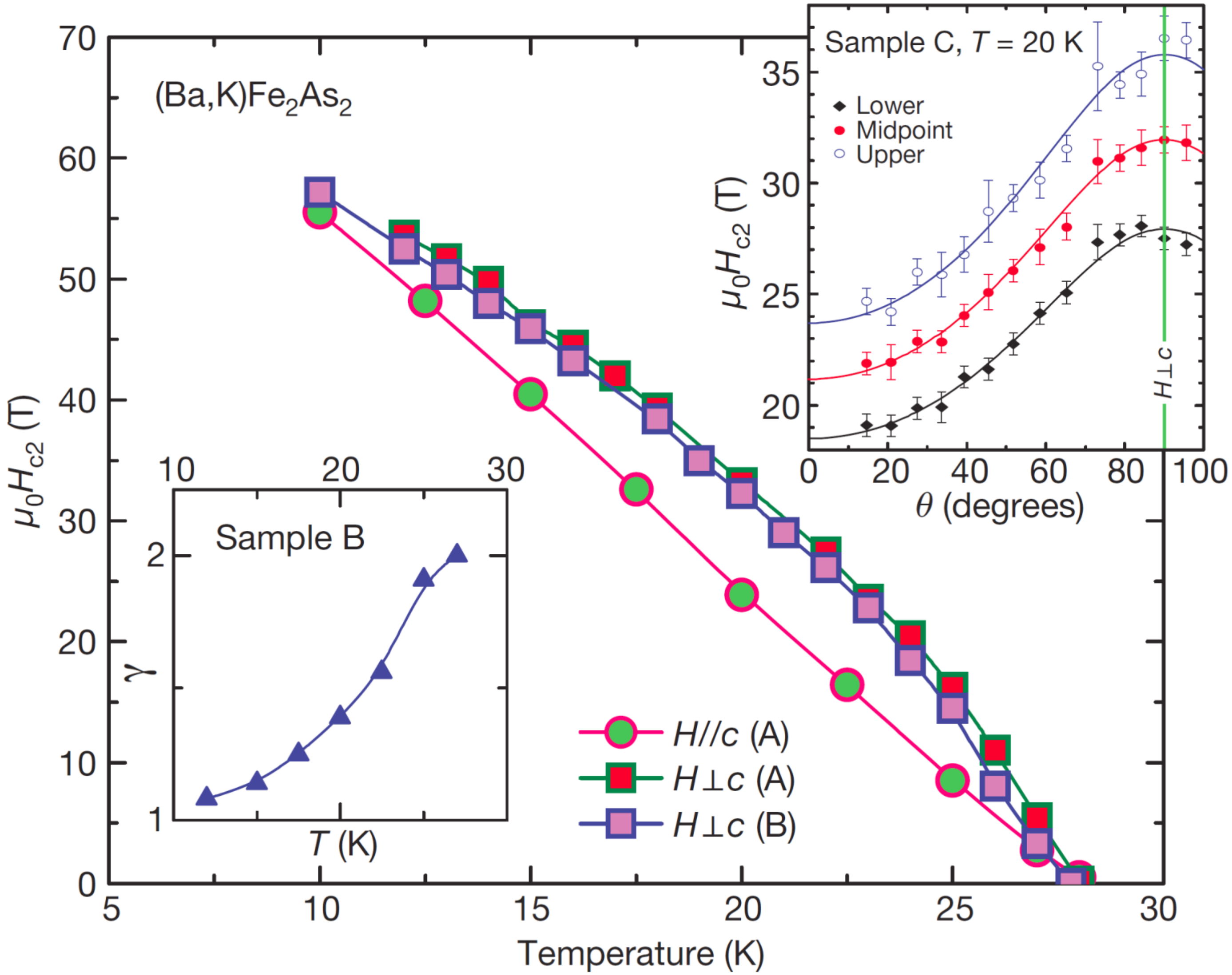
K. Kuroki et al., Phys. Rev. Lett. 101, 087004 (2008);
I. Mazin et al., Phys. Rev. Lett. 101, 057003 (2008);
F. Wang et al., Phys. Rev. Lett. 102, 047005 (2009);
I. Mazin, Nature 464, 183 (2010).

Generic Phase Diagram of the Iron-Based Superconductors



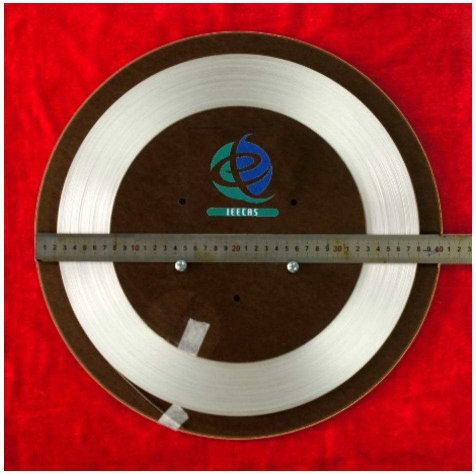
I Mazin, Nature 46 (2010) 183.

Nearly Isotropic Superconductivity of Fe-Based SCs

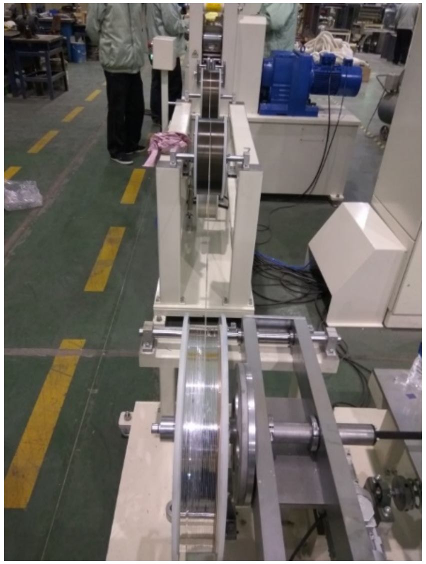


H. Q. Yuan et al., Nature 457 (2009) 565.

The World's First 100 Meter-Class Iron-Based Superconducting Wire

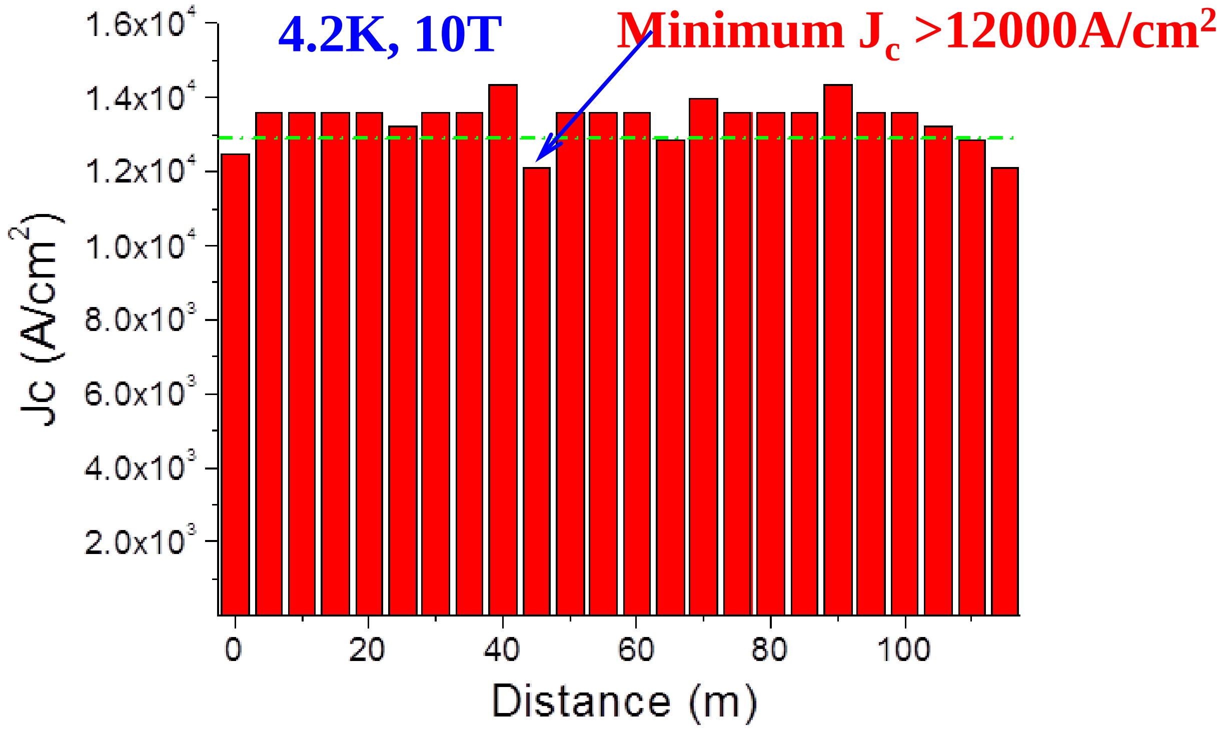


115 m long **7-filamentary** wire



In Aug., 2016

-- Presented at ASC2016, Denver



At 4.2 K, 10 T, transport Jc distribution along the length of the first 100 m long 7-filament Sr122 tape

http://snf.ieeecsc.org/pages/new-paper-and-result-highlights

X. P. Zhang, Y. W. Ma et al., IEEE TAS 27 (2017) 7300705

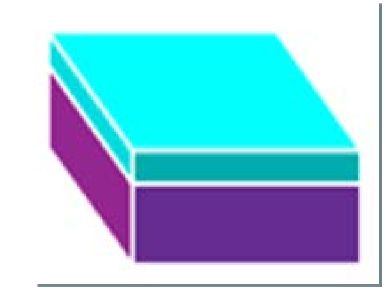
Advantages of Fe-Based Superconductors

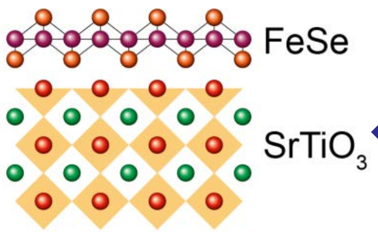
- ◆High transition temperature T_c;
- ◆High critical field H_{c2};
- ◆Nearly isotropic superconductivity;
- ◆More metallic, easier to fabricate.

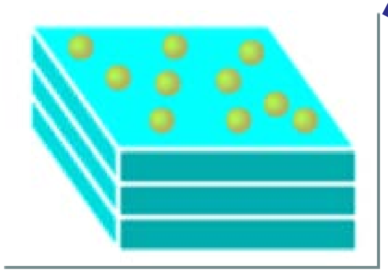
Promising for applications

Latest Development
on
FeSe-Related Superconductors

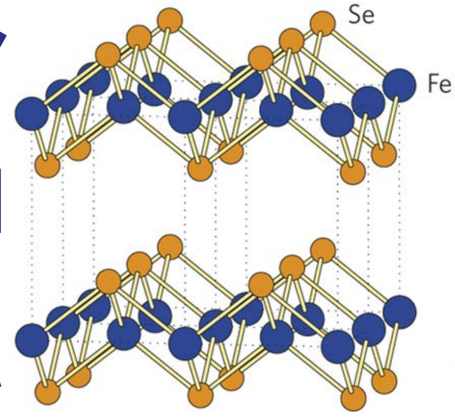
FeSe-Derived Superconductors and Physics

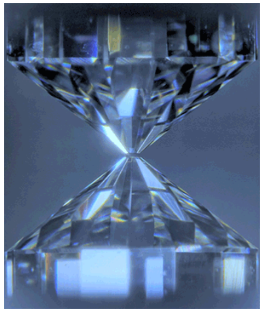


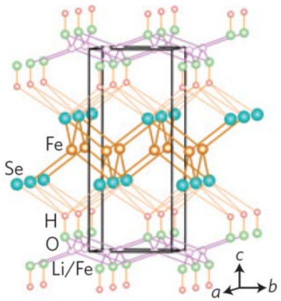


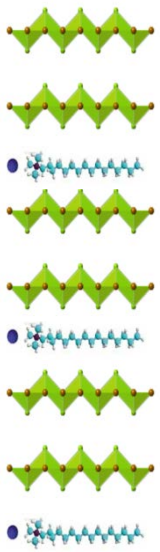


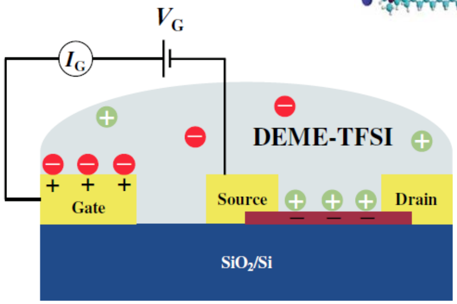
FeSe











FeSe、FeSe Films

$FeSe_xTe_{1-x}$、 $FeSe_{1-x}S_x$

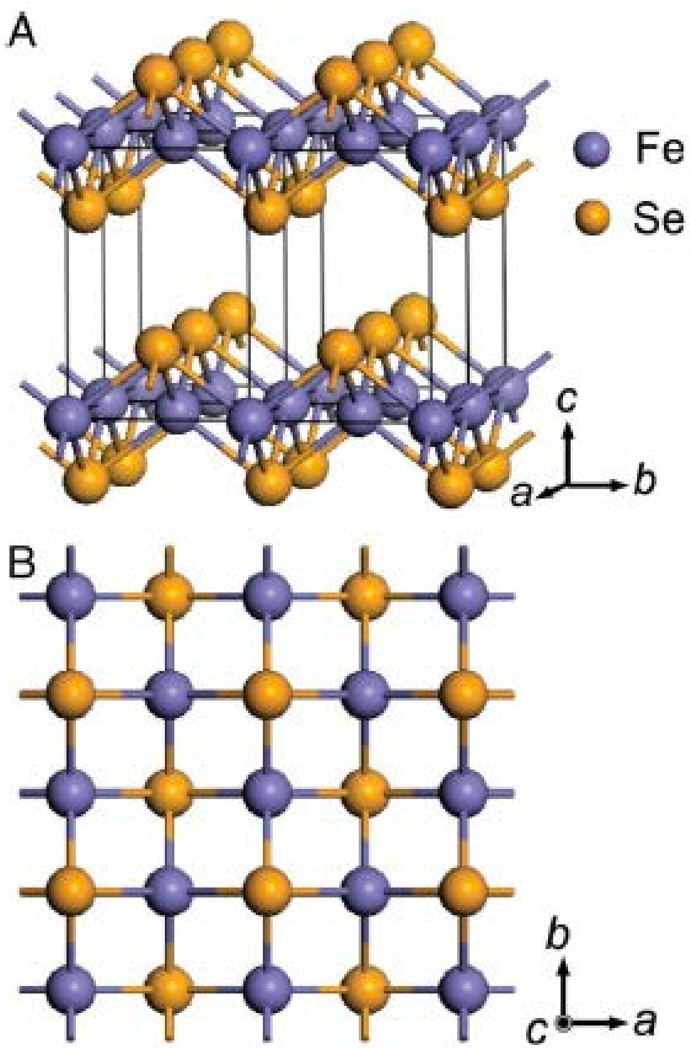
$(Li,K,Na,Rb,Cs)Fe_2Se_2$

(Li,Fe)OHFeSe

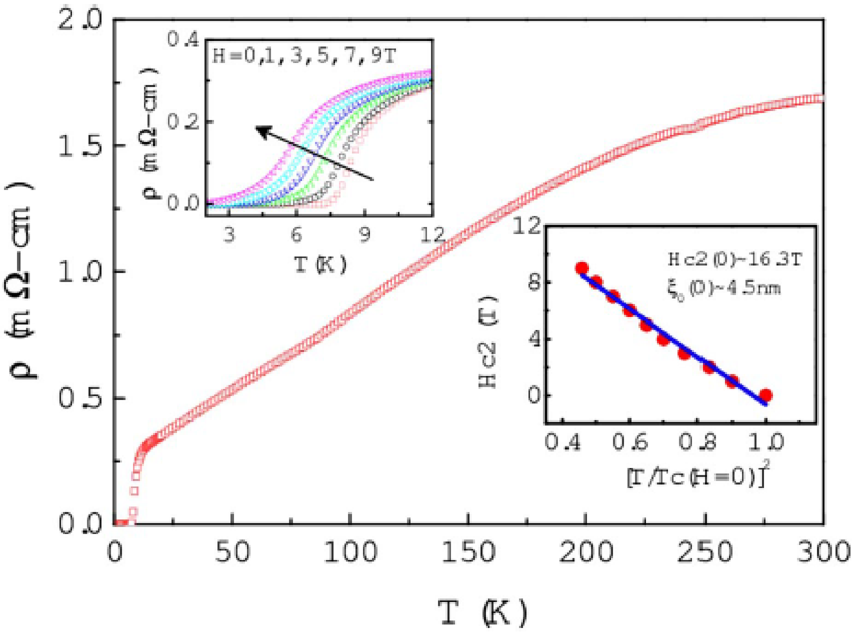
$Li_x(C_6H_{16}N_2)_yFe_{2-z}Se_2$

$FeSe+ (H_2N)C_nH_{2n}(NH_2)$

Discovery of Superconductivity in Bulk FeSe



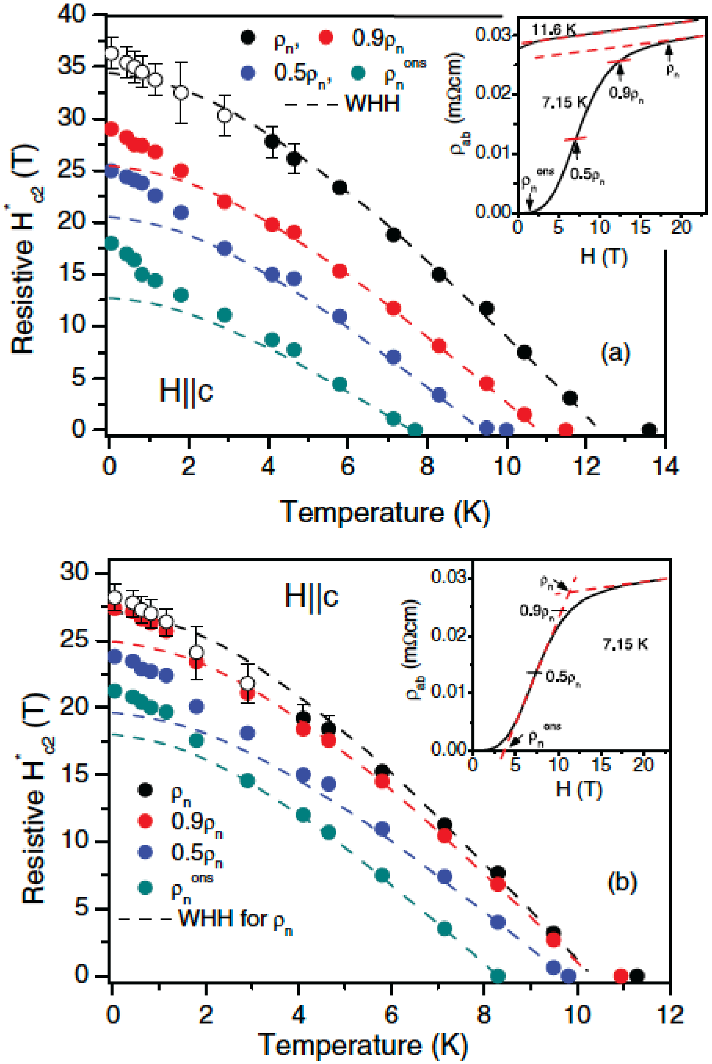
Tc= ~9 K



- **Two elements;**
- **Simplest crystal structure.**

F. C. Hsu, M. K. Wu et al., PNAS 105 (2008) 14262.

Upper Critical Field of Bulk FeSe Superconductor



Bulk FeSe

Tc~10 K

Upper critical field
H_{c2} ~30 Tesla

Conventional Superconductor NbTi

Tc~10 K

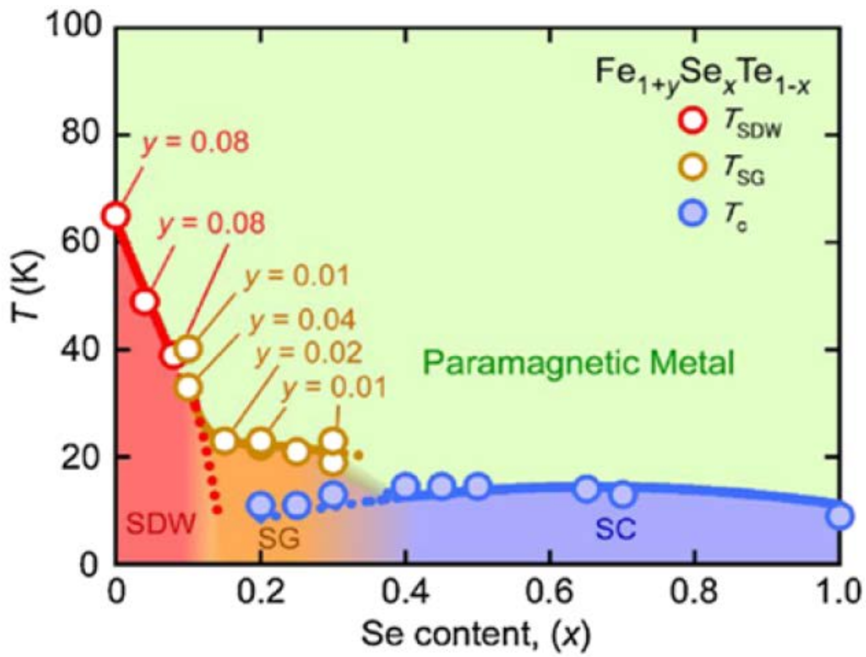
Upper critical field
H_{c2} ~15 Tesla

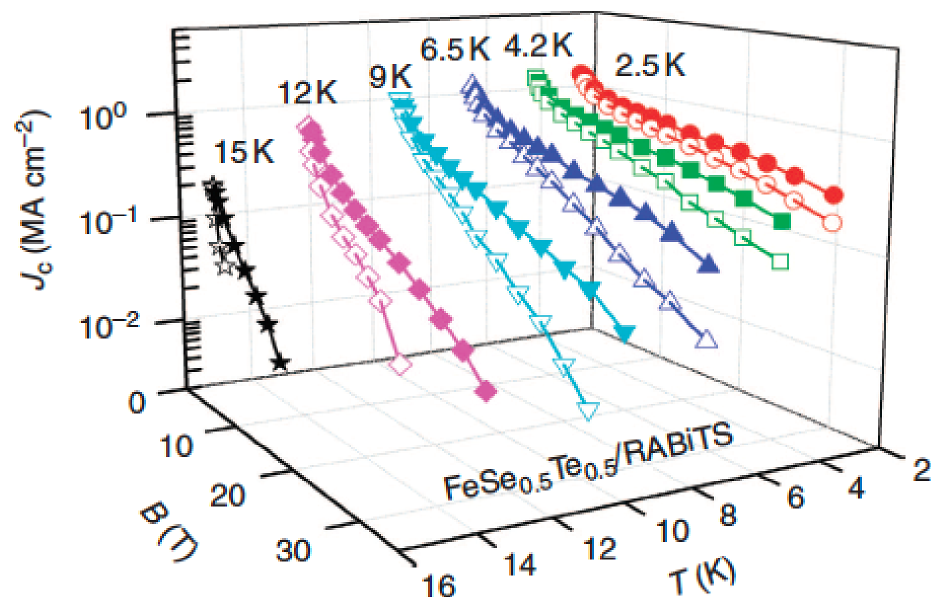
S. I. Vedeneev et al., Phys. Rev. B 87 (2013) 134512

Superconductivity in $Fe(Te_{1-x}Se_x)$ System

Tc~14.5 K

Under 30 T, 4.2K
Jc ~ 1 x 10^5 A/cm^2



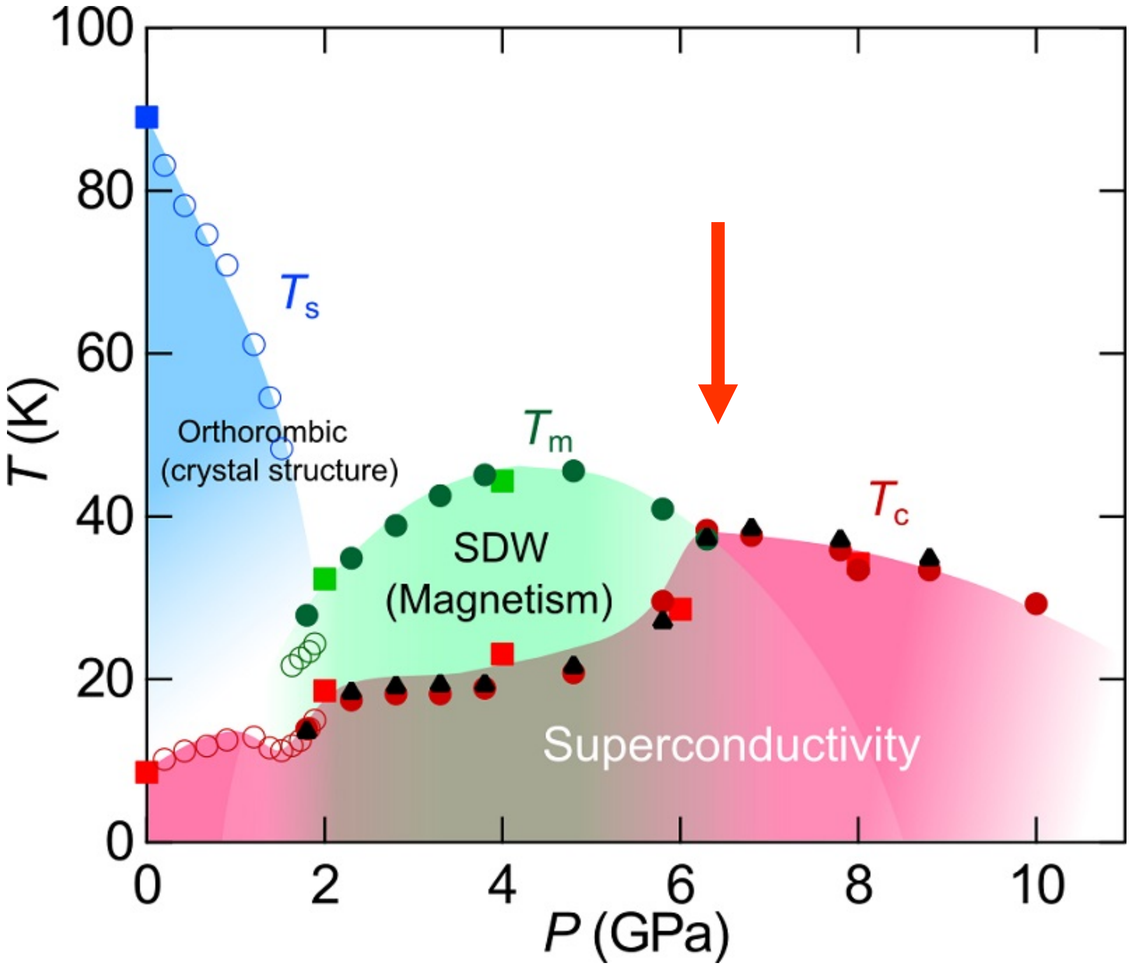


M. H. Fang et al., Phys. Rev. B 78 (2008) 224503;
N. Takayaka et al., J. Phys. Soc. Jpn. 79, 113702(2010)

W. D. Si and Q. Li et al.,
Nature Commun. 4 (2013) 1347

Strong Enhancement of Tc in FeSe under High Pressure

Tc is increased from ~9 K to ~40 K at ~6 GPa.

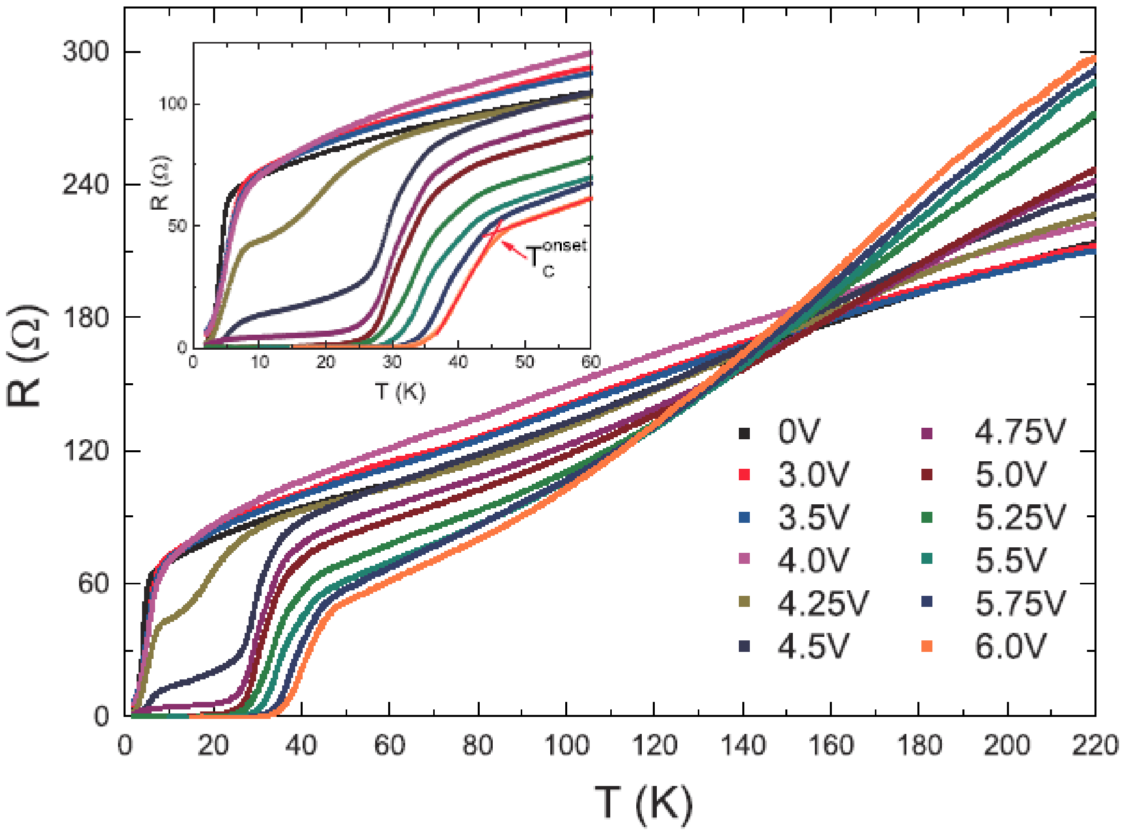


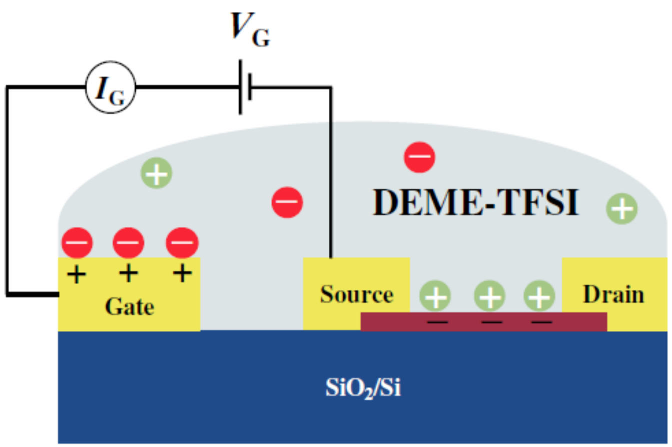
S. Medvedev et al., Nature Materials 8 (2009) 630.

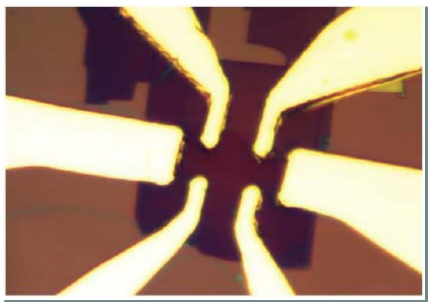
J. P. Sun, J. G. Cheng et al., Nature Communications 7 (2016) 12146;

Enhancement of Tc in FeSe through Gating

Tc is increased from ~9 K to 35~48 K by gating
Gating → Electron doping







B. Lei, X. H. Chen et al., Phys. Rev. Lett. 116 (2016) 077002 (2016);
K. Hanzawa, H. Hosono et al.,PNAS 113 (2016) 3986.

Possible High Tc in Single-Layer FeSe Film on $SrTiO_3$

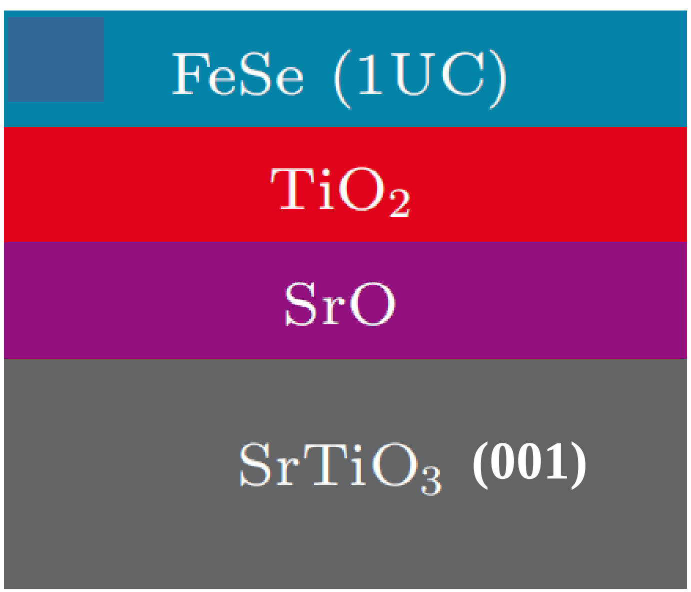
CHIN. PHYS. LETT. Vol. 29, No. 3 (2012) 037402

Interface-Induced High-Temperature Superconductivity in Single Unit-Cell FeSe Films on $SrTiO_3$ *

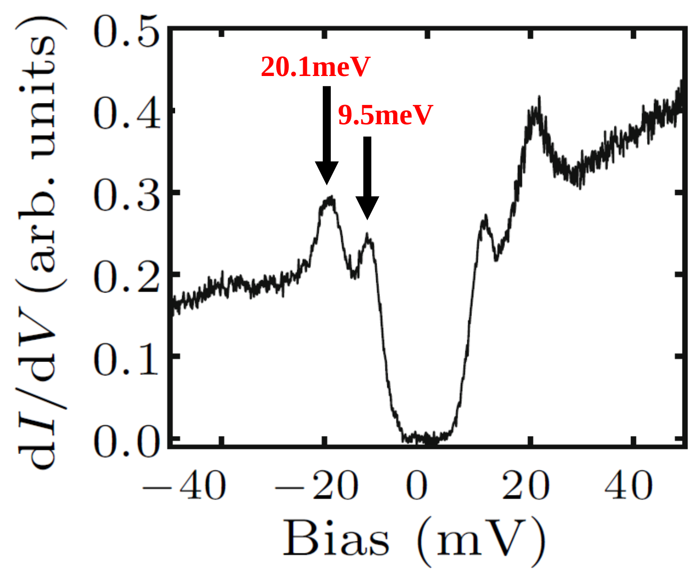
WANG Qing-Yan(王庆艳)[1,2†], LI Zhi(李志)[2†], ZHANG Wen-Hao(张文号)[1†], ZHANG Zuo-Cheng(张祚成)[1†], ZHANG Jin-Song(张金松)[1], LI Wei(李渭)[1], DING Hao(丁浩)[1], OU Yun-Bo(欧云波)[2], DENG Peng(邓鹏)[1], CHANG Kai(常凯)[1], WEN Jing(文竞)[1], SONG CanLi(宋灿立)[1], HE Ke(何珂)[2], JIA Jin-Feng(贾金锋)[1], JI Shuai-Hua(季帅华)[1], WANG Ya-Yu(王亚愚)[1], WANG Li-Li(王立莉)[2], CHEN Xi(陈曦)[1], MA Xu-Cun(马旭村)[2**], XUE Qi-Kun(薛其坤)[1**]

[1] *State Key Lab of Low-Dimensional Quantum Physics, Department of Physics, Tsinghua University, Beijing 100084*
[2] *Institute of Physics, Chinese Academy of Sciences, Beijing 100190*

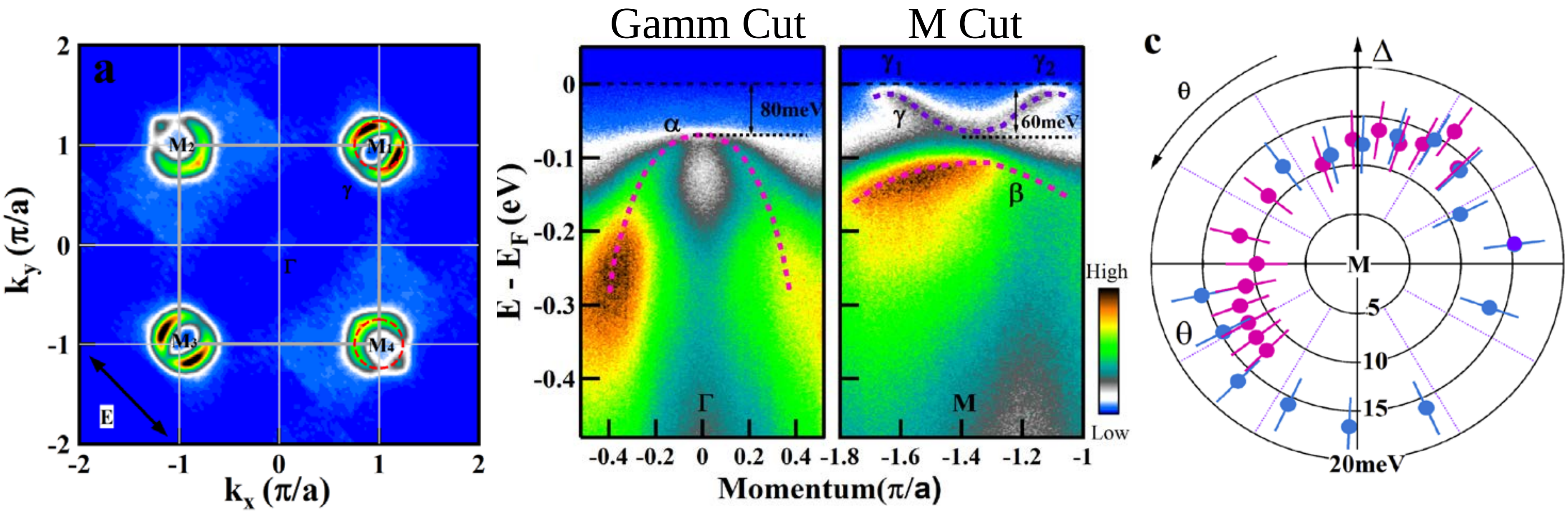
(Received 1 February 2012 and accepted by ZHU Bang-Fen)



$FeSe/SrTiO_3$, Tc ~ 80 K?



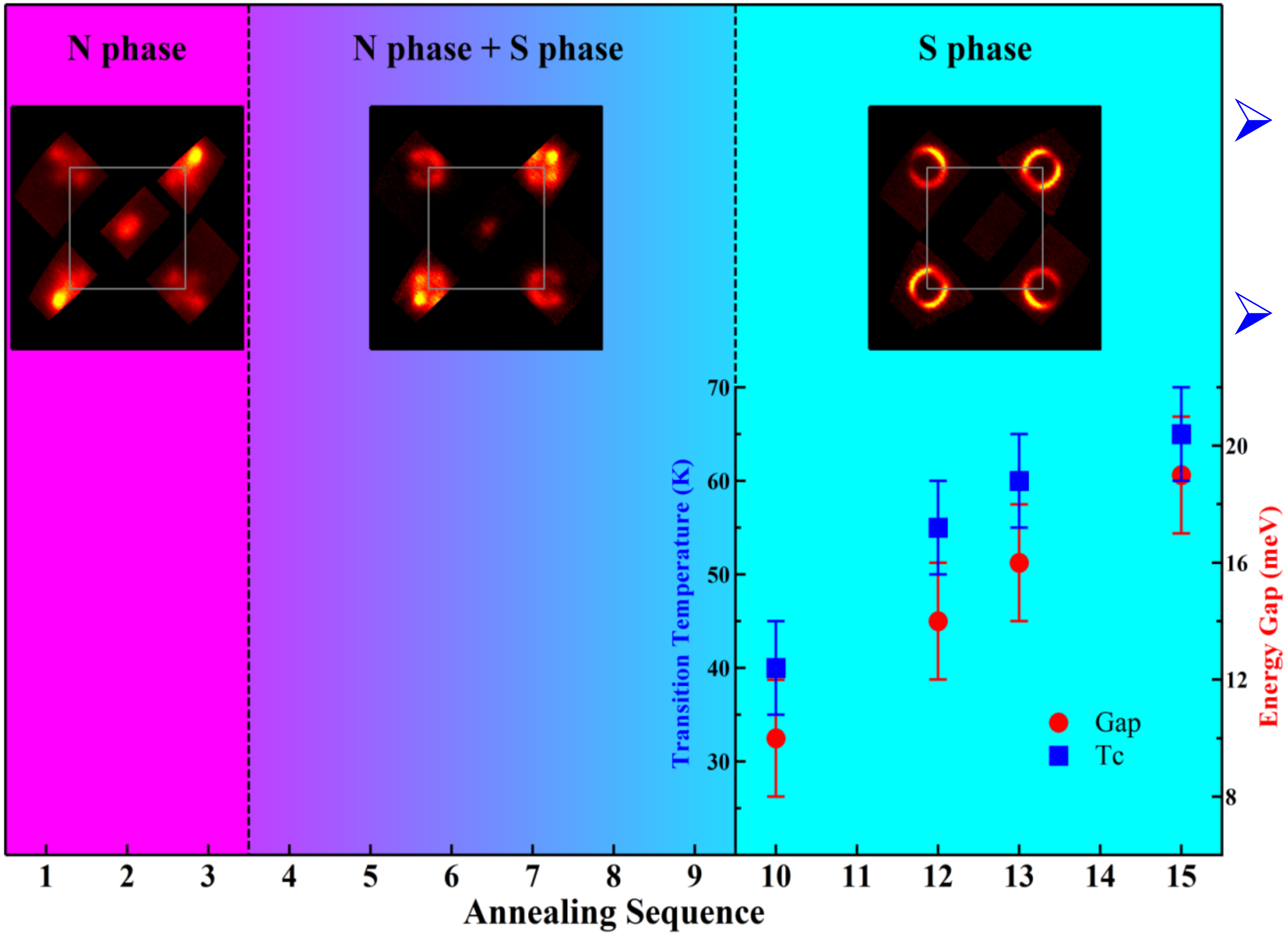
Distinct Electronic Structure of Superconducting Single-Layer $FeSe/SrTiO_3$ Films



- Distinct electronic structure: no Fermi surface near Γ, only electron-like Fermi surface near M;
- Nearly isotropic superconducting gap without nodes.

D. F. Liu , W. H. Zhao, D. X. Mou, J. F. He, X. C. Ma, Q. K. Xue, X. J. Zhou et al., Nature Communications 3, 931 (2012)

Phase Diagram and Indication of Tc~65K in Single-Layer $FeSe/SrTiO_3$ Films



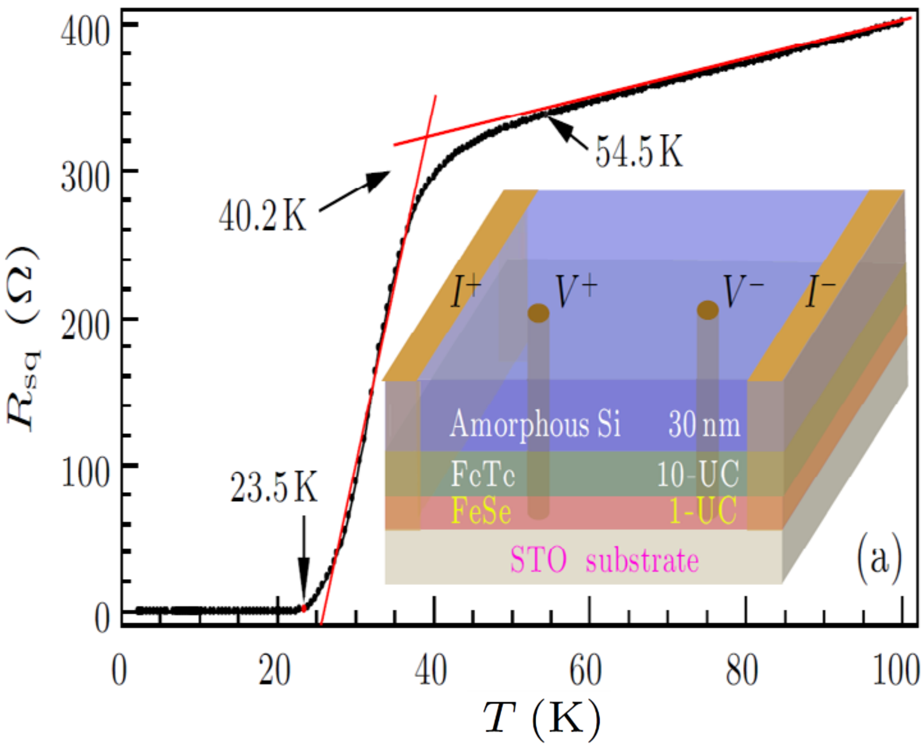
- **Two phases:**
  N phase and S phase;
- **Highest Tc~65 K**
  Gap~19 meV

2Δ/kTc = 6~7

S. L. He, J. F. He, W. H. Zhao, L. Zhao, X. C. Ma, Q. K. Xue, X. J. Zhou et al., Nature Materials 12, 605 (2013)

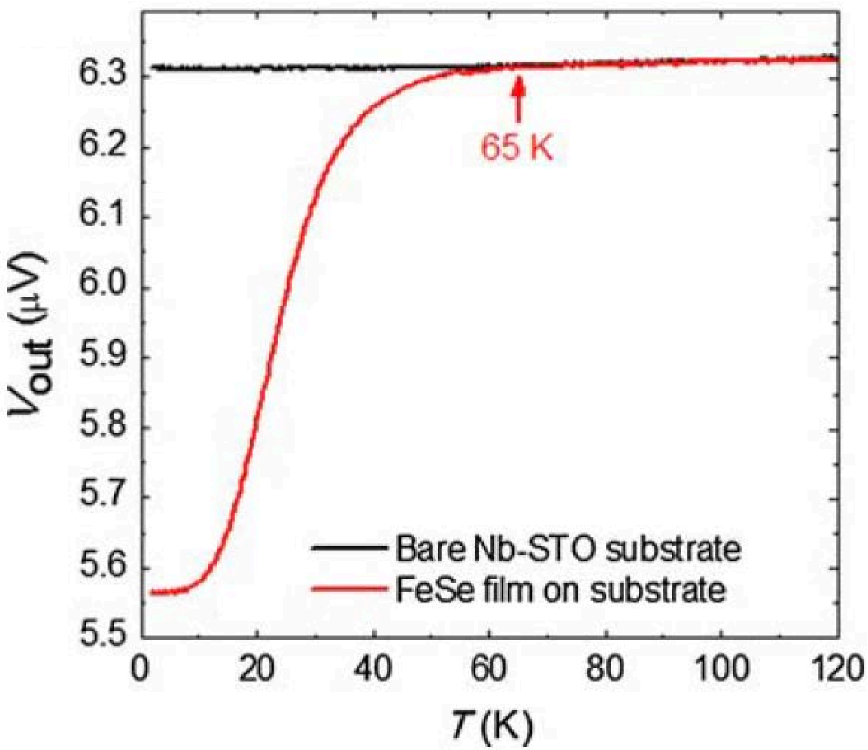
Well-accepted Tc~65 K in Single-Layer FeSe/$SrTiO_3$ Films

Resistivity



W. H. Zhang, J. Wang, Q. K. Xue et al., Chinese Physics Letters 31 (2014) 017401.

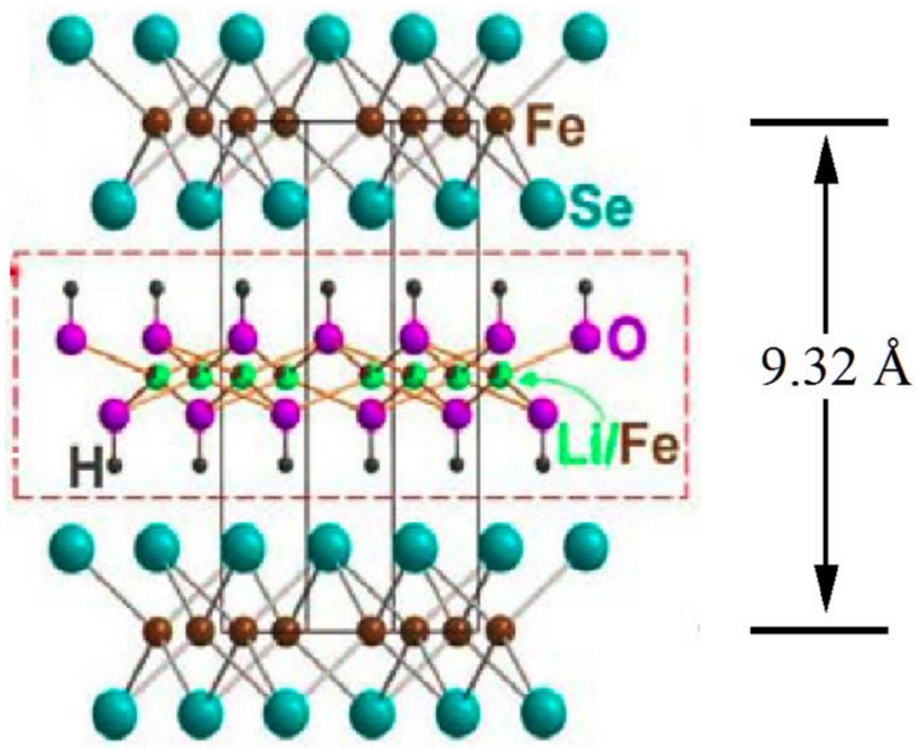
Magnetic measurements



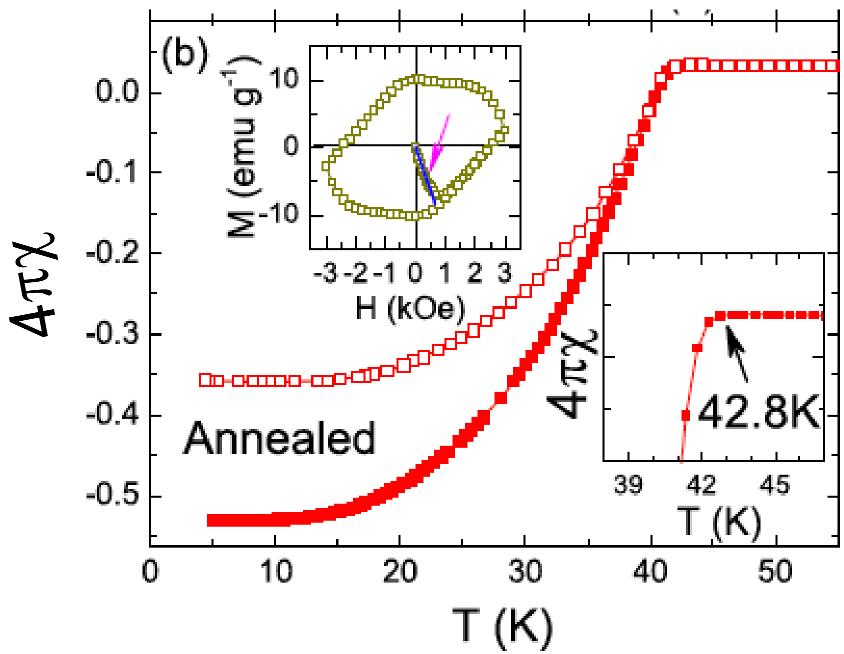
Z. Zhang, Y. Y. Wang et al., Science Bulletin 60 (2015) 1301.

Discovery of (Li,Fe)OHFeSe Superconductor with a Tc~42 K

Bulk, Single-phase



Magnetic measurements



X. F. Lu, X. H. Chen et al., Phys. Rev. B 89 (2013) 020507 (R).
X. F. Lu, X. H. Chen et al., Nature Mater. 14 (2015) 325.
U. Pachmayr, D. Johrendt, et al. Angew. Chem. Int. Edit. 54, 293 (2015).
X. L. Dong, Z. X. Zhao et al., J. Am. Chem. Soc. 137, 66 (2015).

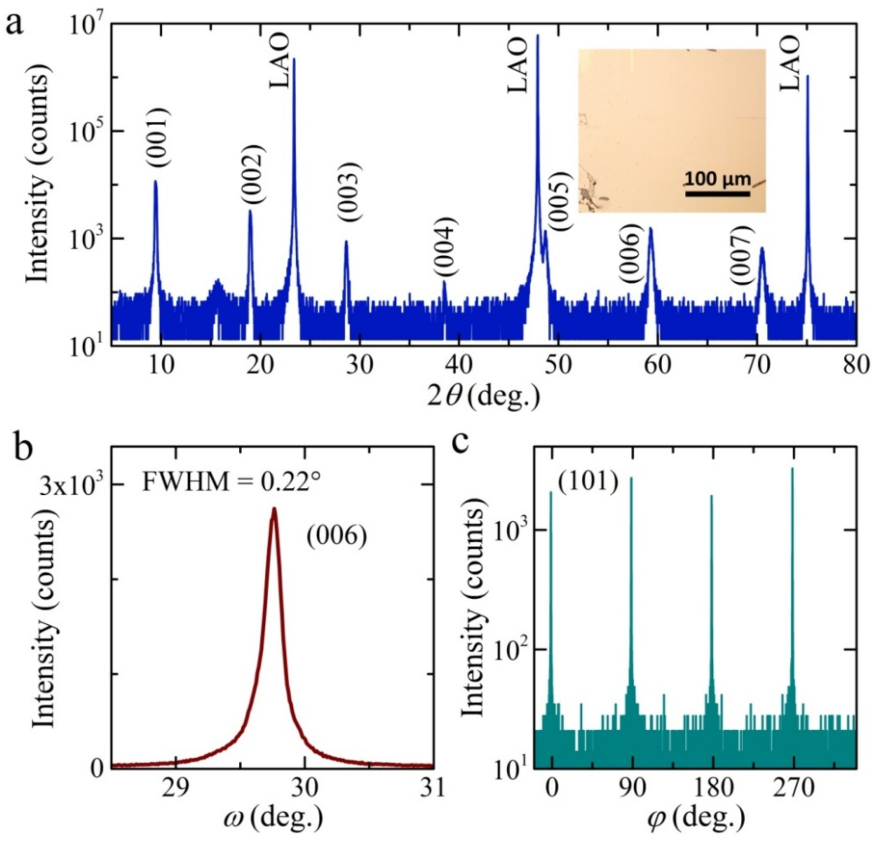
Performance of 11111 Thin Films

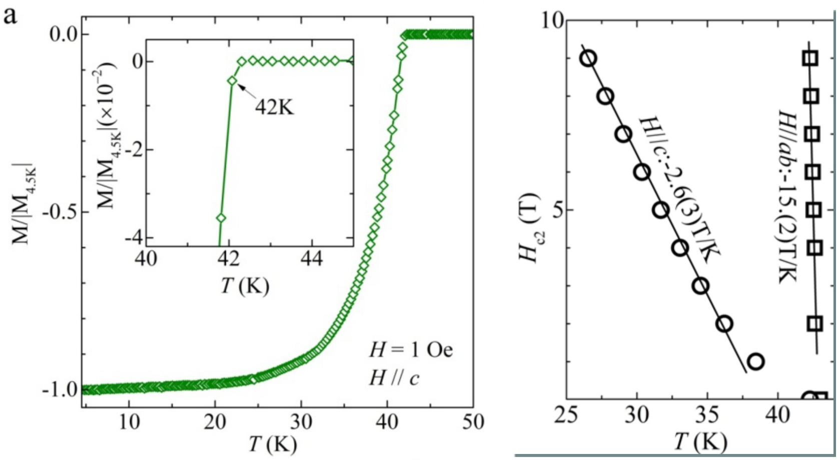
1、High critical temperature: Tc = 42.4 K;

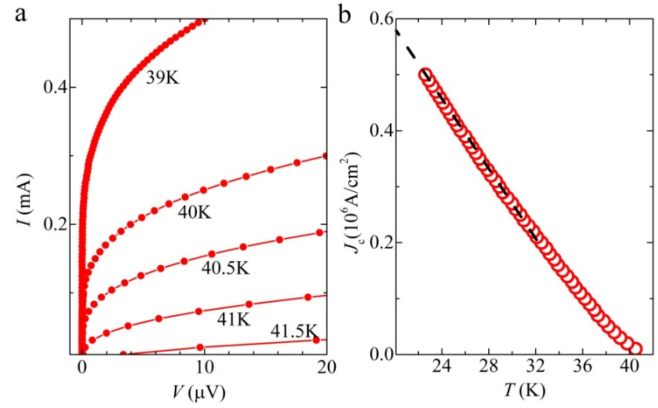
2、High critical field: $H_{c2}^{c}(0)$ ~79.5 T; $H_{c2}^{ab}(0)$ ~ 443 T

3、High critical current: 5 x 10^5 A/cm^2 at ~20K

Superconducting cavities?



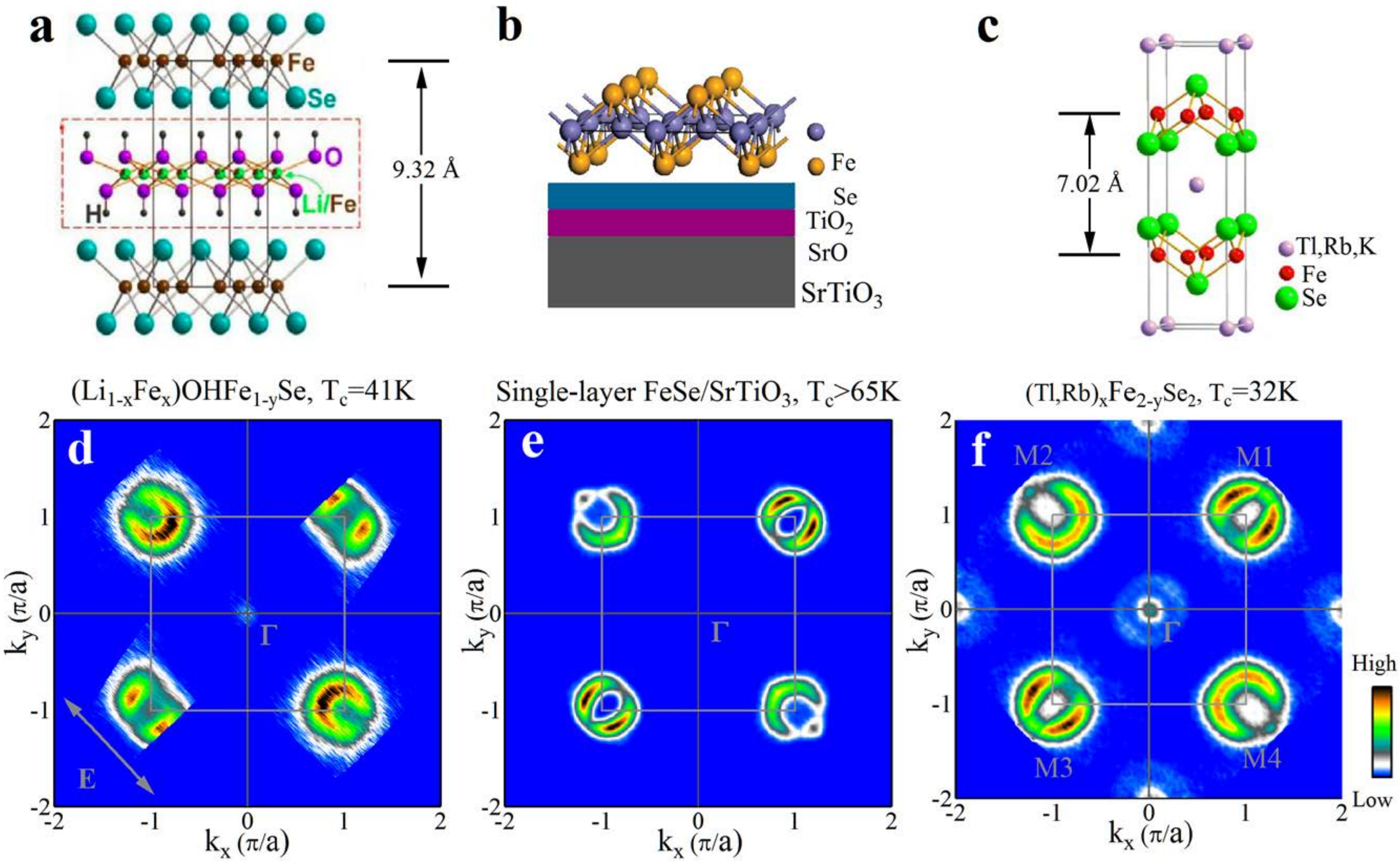




Y.L. Huang, X. L. Dong, K. Jin, Z. X. Zhao et al., Chin. Phys. Lett. 34 (2017) 077404

Progress
in Physics Study
of the Iron-Based Superconductors

Distinct Fermi Surface Topology in FeSe-Related Superconductors



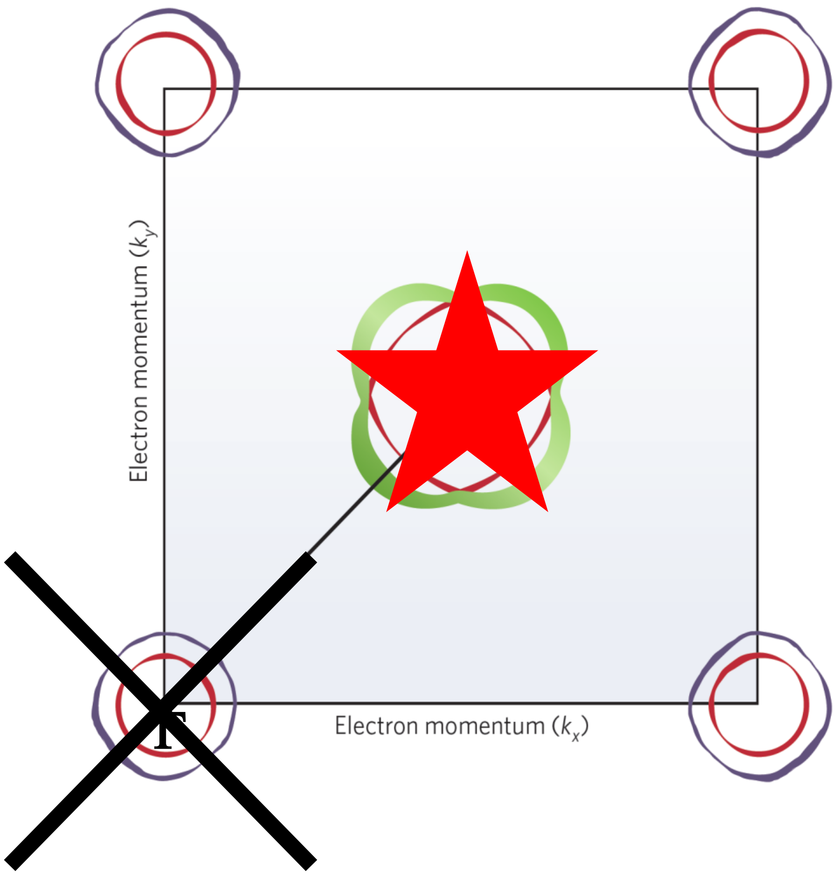
Lin Zhao and X. J. Zhou et al., Nature Communications 7, 10608 (2016)

D. F. Liu , X. J. Zhou et al., Nature Communications 3, 931 (2012).

D. X. Mou and X. J. Zhou et al., Phys. Rev. Lett. 106, 107001 (2011)

Implications on Superconductivity Mechanism

--Rules out Fermi Surface Nesting Picture

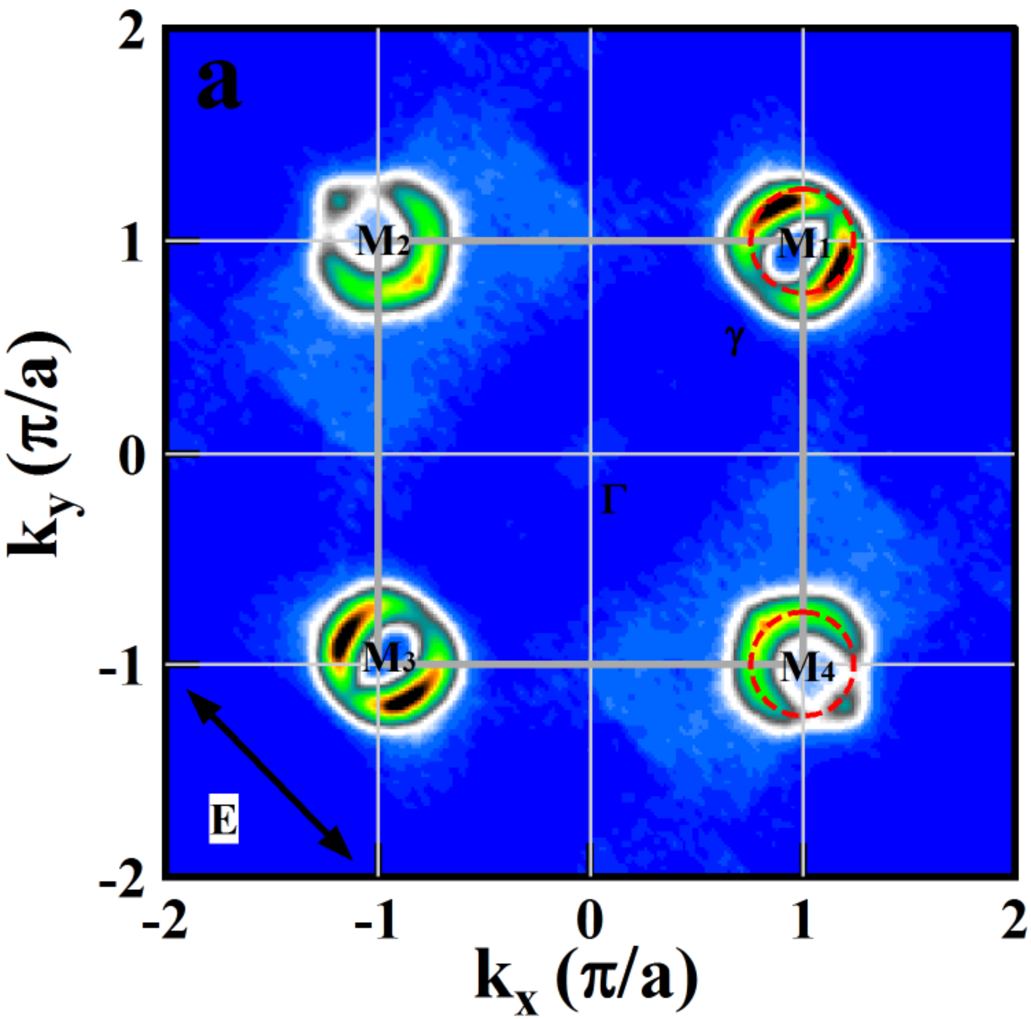


If Fermi surface topology is critical, then

Hole-Like Fermi Surface near Γ is NOT necessary for superconductivity;

Electron-Like Fermi Surface near M is crucial.

Key Ingredients for Superconductivity in Iron-Based Superconductors



1), Simple electronic structure;

2). Record high Tc~65K;

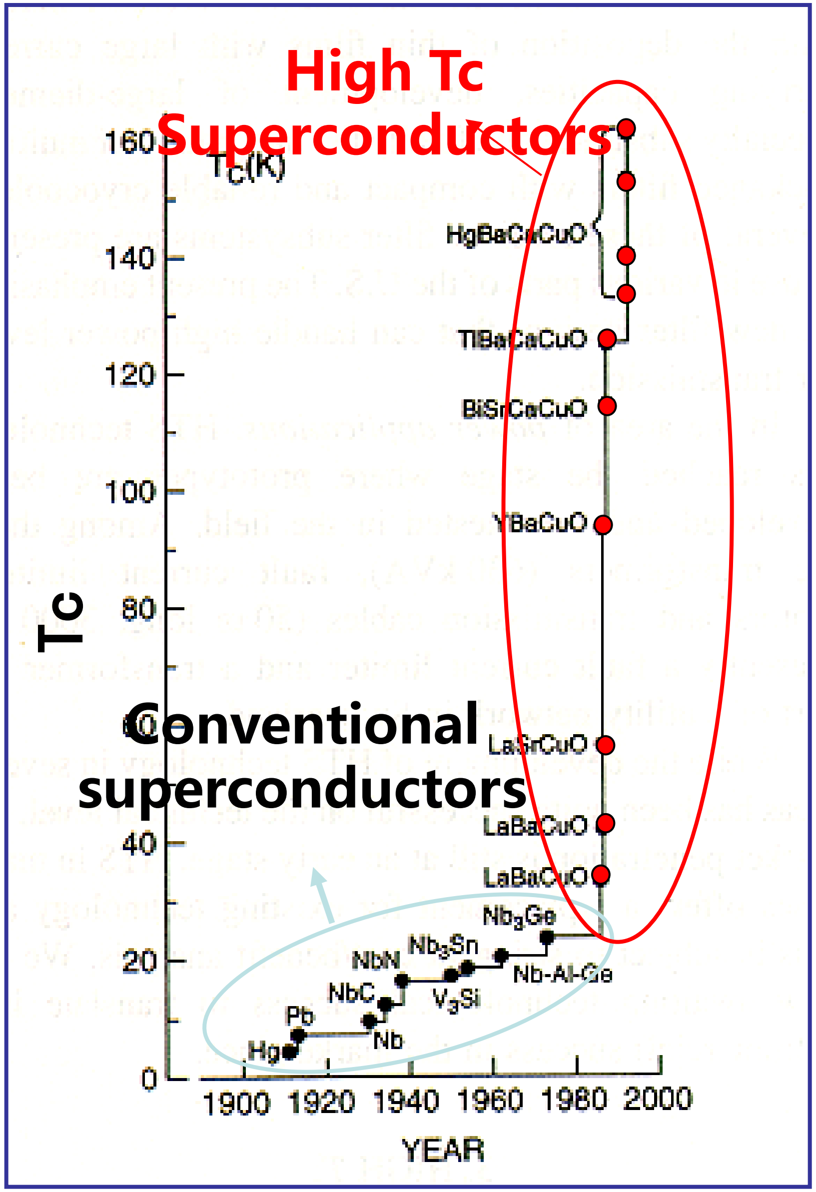
3). Nearly isotropic superconducting gap.

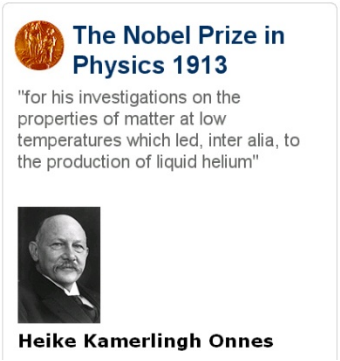
Ideal system for studying mechanism of superconductivity in the iron-based superconductors

D. F. Liu , W. H. Zhao, D. X. Mou, J. F. He, X. C. Ma, Q. K. Xue, X. J. Zhou et al., Nature Communications 3, 931 (2012).

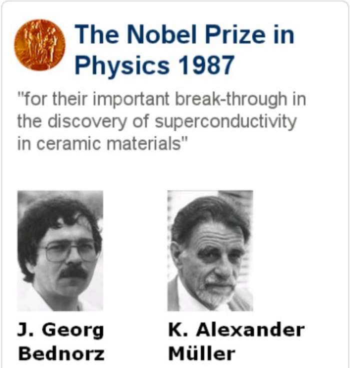
Summary and Perspective

Exploration of New Superconductors





Conventional (Tc < 40K)



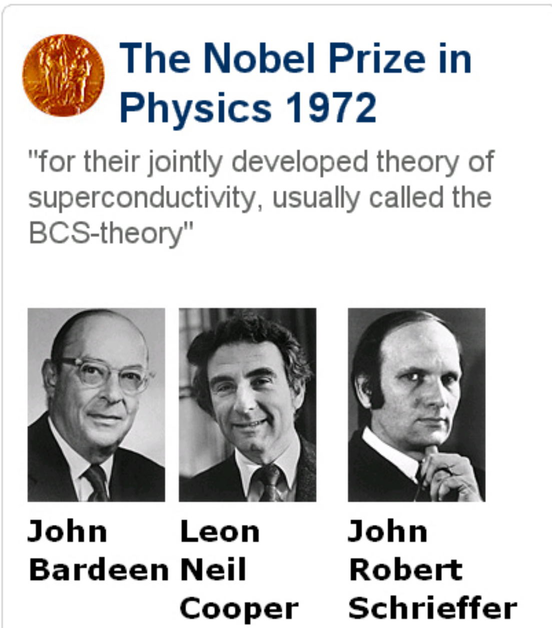
Copper-Oxide High-Tc SCs (Tc ~165K)

Next?

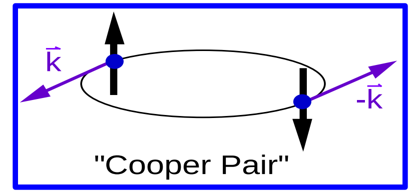
Room Temperature Superconductors? (Tc~300K)

Theory for High Tc Superconductivity—To Be Developed

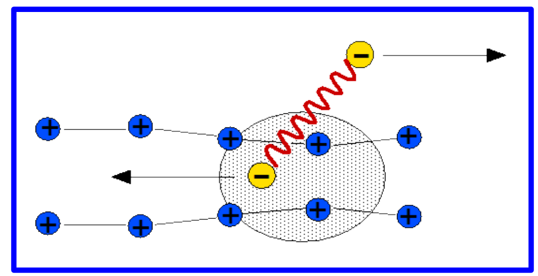
Bardeen, Cooper and Schrieffer (1957)



- **Formation of Cooper pairs in the superconducting state;**



- **The pairing is mediated by phonons.**



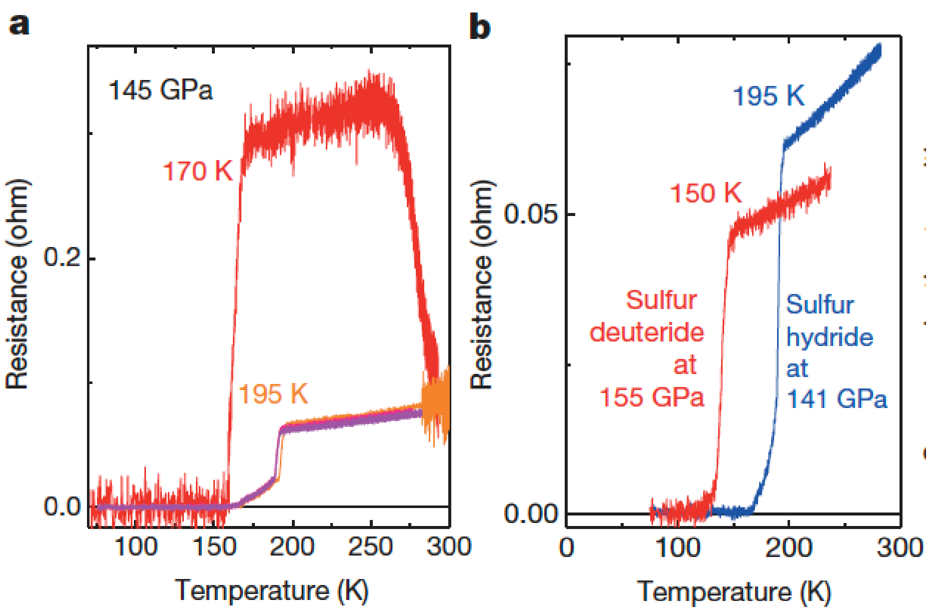
Next?

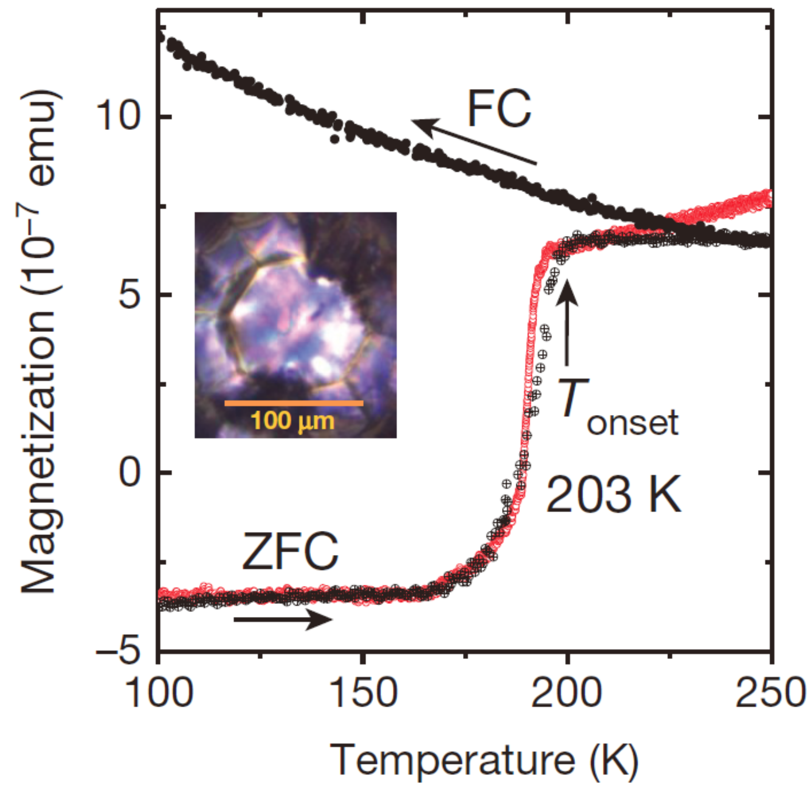
Mechanism of High-Tc Superconductivity?

doi:10.1038/nature14964

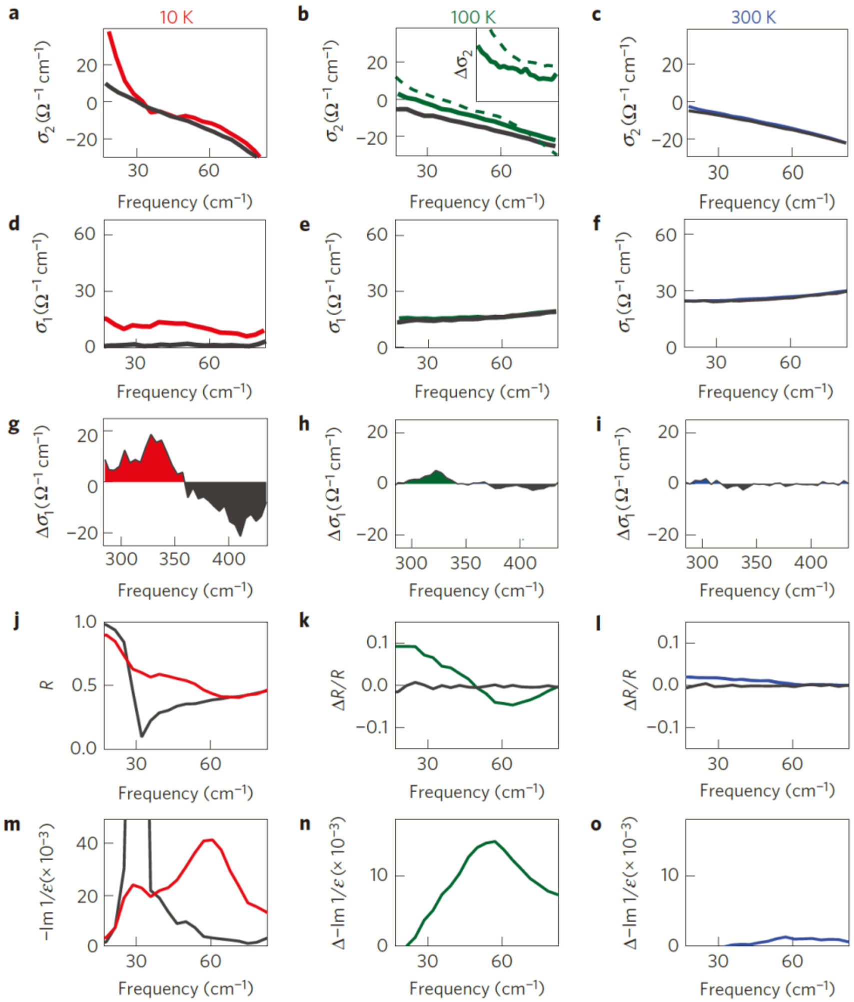
Conventional superconductivity at 203 kelvin at high pressures in the sulfur hydride system

A. P. Drozdov[1]*, M. I. Eremets[1]*, I. A. Troyan[1], V. Ksenofontov[2] & S. I. Shylin[2]





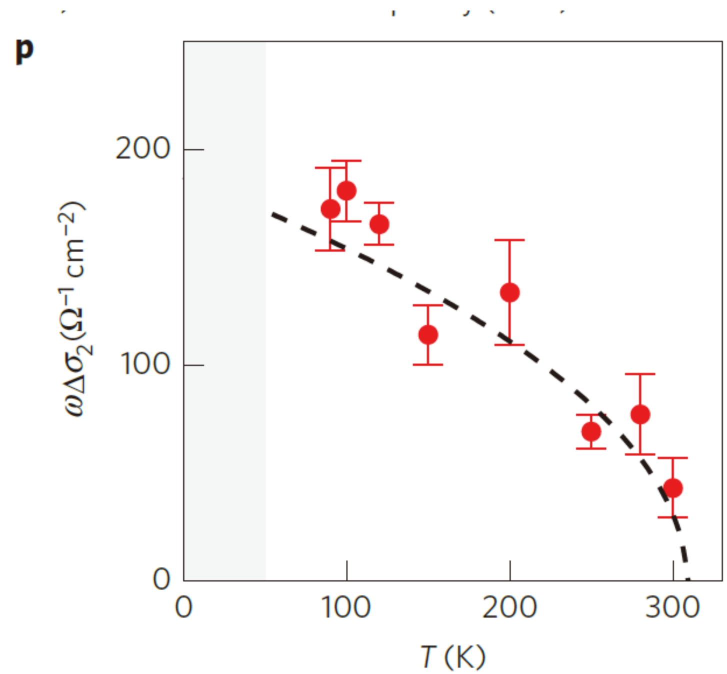
Transient Room Temperature Superconductivity?



$YBa_2Cu_3O_{6.5}$ (Tc=50 K)

Pump-Probe experiment

Tc~300 K



W. Hu, A. Cavalleri et al., Nature Materials 13, 705 (2014)

There is still a plenty of room for high temperature superconductivity

THANKS

12th International Conference on

Materials and Mechanisms of Superconductivity and High Temperature Superconductors (M^2S-2018)

August 19 - 24, 2018, Beijing, China

Organized by: National Laboratory for Superconductivity, Institute of Physics, Chinese Academy of Sciences, Beijing, China

http://www.m2s-2018.com/

Conference Contact: m2s2018@iphy.ac.cn

M^2S-HTSC-XII Beijing 2018

The M2S-2018 conference is the 12th in the series as an international event on superconductors and mechanisms of superconductivity held now every three years. The aim of the Conference is to provide a platform for members of the international superconductivity community to report their latest results, exchange information and ideas, and foster collaborations. The Conference is dedicated to all aspects of basic superconductivity research in materials, mechanisms and phenomena of superconductivity, and its applications.

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- Cuprate Superconductors
- Iron-Based Superconductors
- Heavy Fermion Superconductors
- Organic Superconductors
- Other Superconductors
- Topological Superconductors
- Mechanisms and Phenomenology of Superconductivity
- Applications
- Others

Conference Chairs

Xingjiang Zhou, Zhongxian Zhao

Program Committee Chairs

Fuchun Zhang, Tao Xiang, Xianhui Chen, Nanlin Wang

Important Dates

Registration & abstract submission open: Jan. 1, 2018

Prize nomination deadline: April 29, 2018

Early registration deadline: May 31, 2018