THE UNIVERSITY OF TOKYO

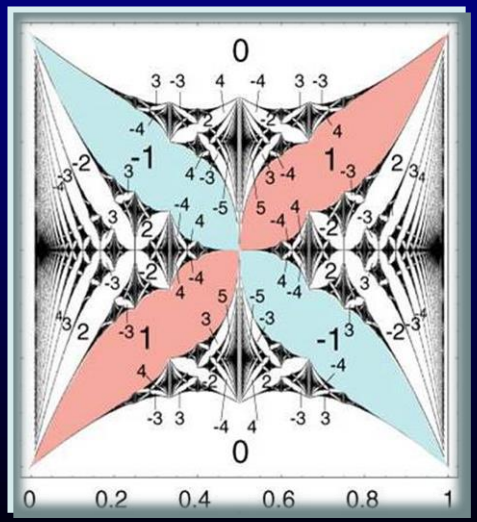
7 Oct 2015

東京大学 大学院
理学系研究科・理学部
SCHOOL OF SCIENCE, THE UNIVERSITY OF TOKYO

「固体物理学III」（理学部4年冬学期）
Solid State Physics III (undergraduate)
「物性物理学III」（大学院理学系共通講義）
Condensed Matter Physics II (graduate)
Academic year 2015

講義資料（超伝導1） © H. Aoki

物理学専攻
青木 秀夫
Hideo Aoki

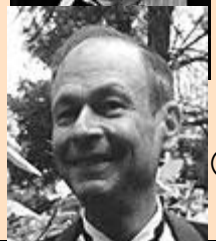


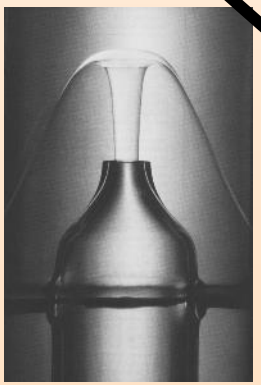
Breakdown involving gauge in condensed-matter physics

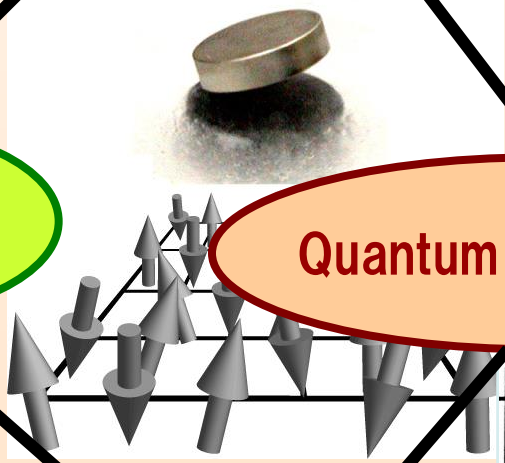
1987

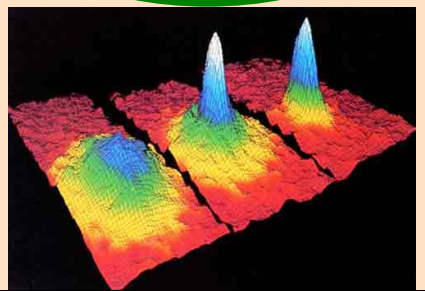
© Nobel Foundation

1996



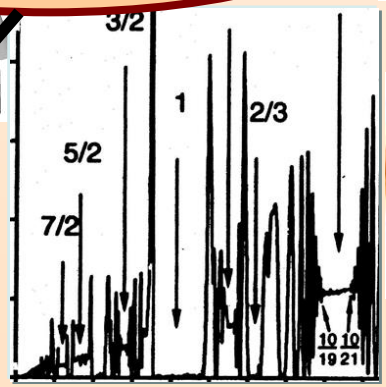






© Nobel Foundation

1985



1998

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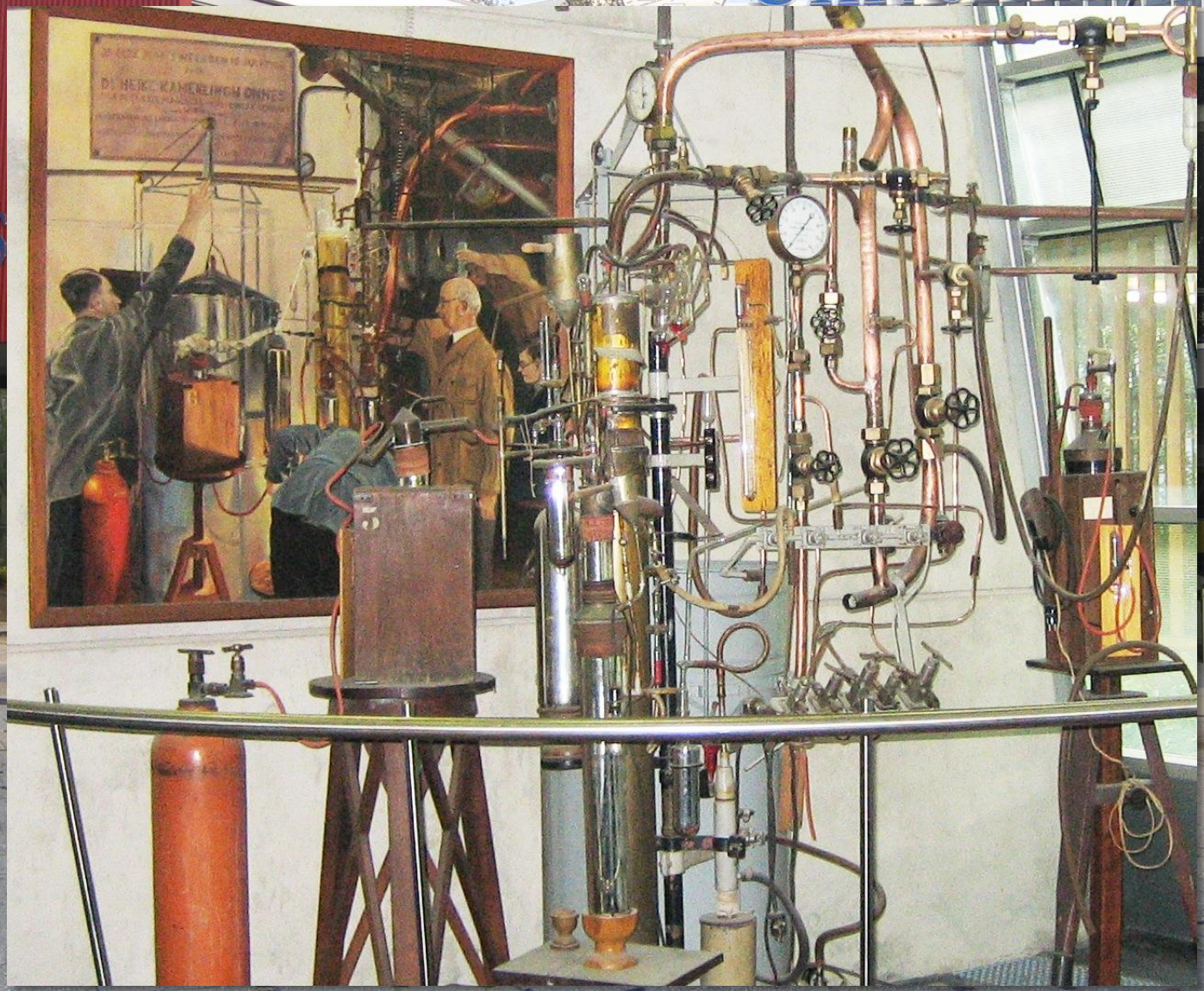
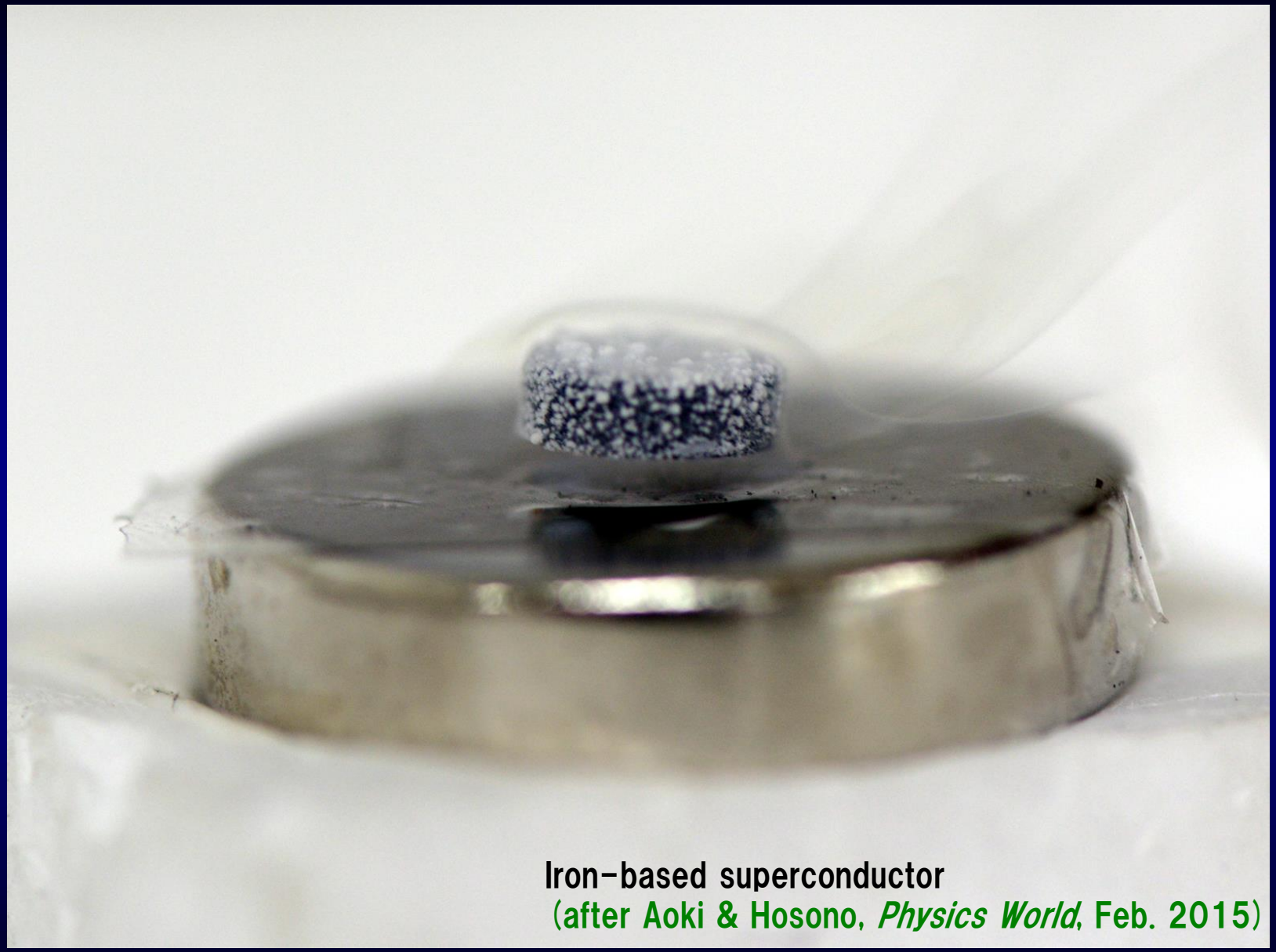
Original apparatus of Kammerlingh Onnes @ Leiden University
(© M. Kiguchi)




浮いた 土佐ノ海
TOSANOUMI
(Sumo Wrestler)
Height of Tosanoumi 186cm
Weight of Tosanoumi 142kg
Weight of disk 60kg
Total weight 202kg
As of February '99
協力：財団法人 日本相撲協会



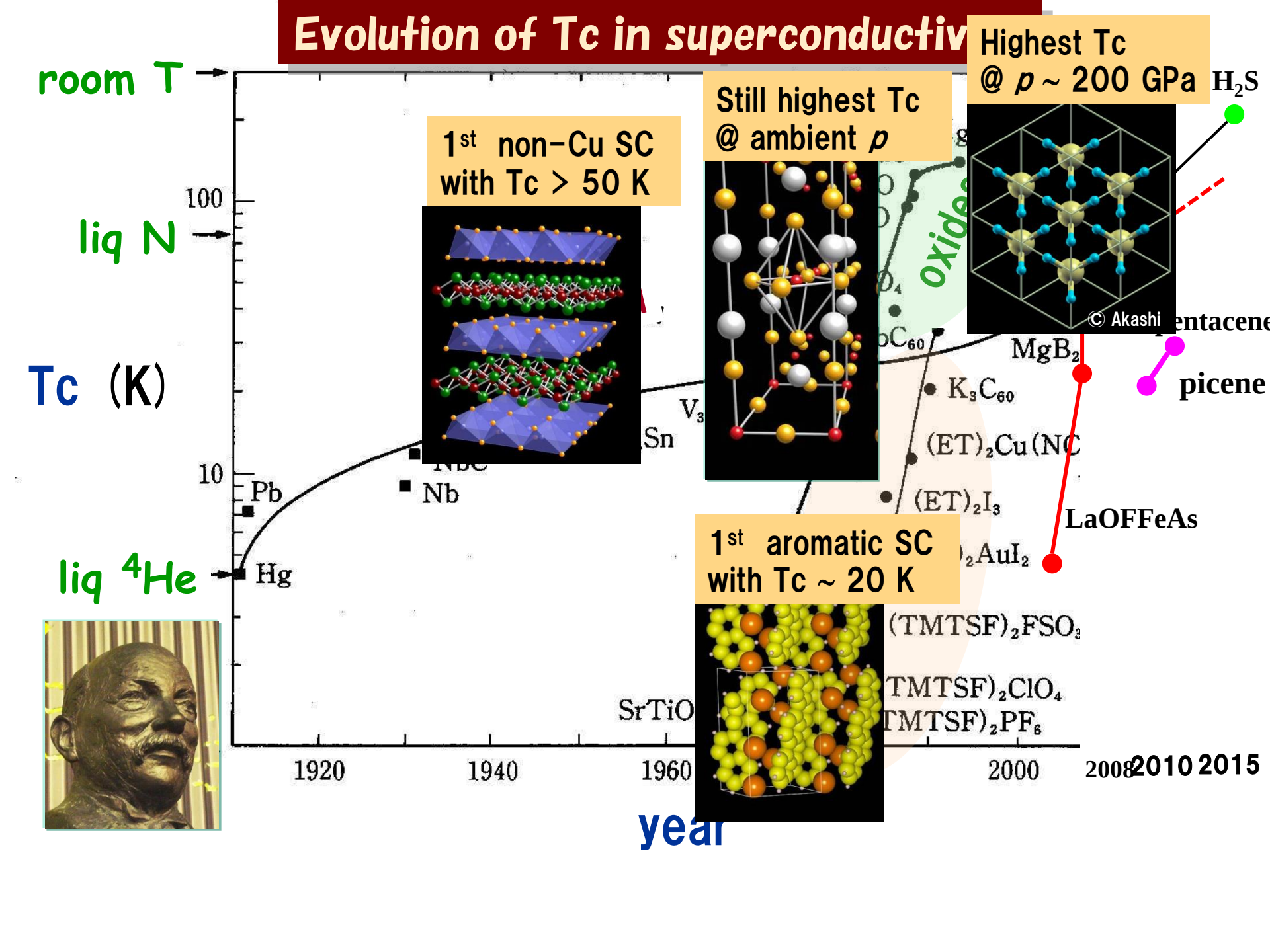
Iron-based superconductor
(after Aoki & Hosono, *Physics World*, Feb. 2015)

Fig.8-2 © CERN

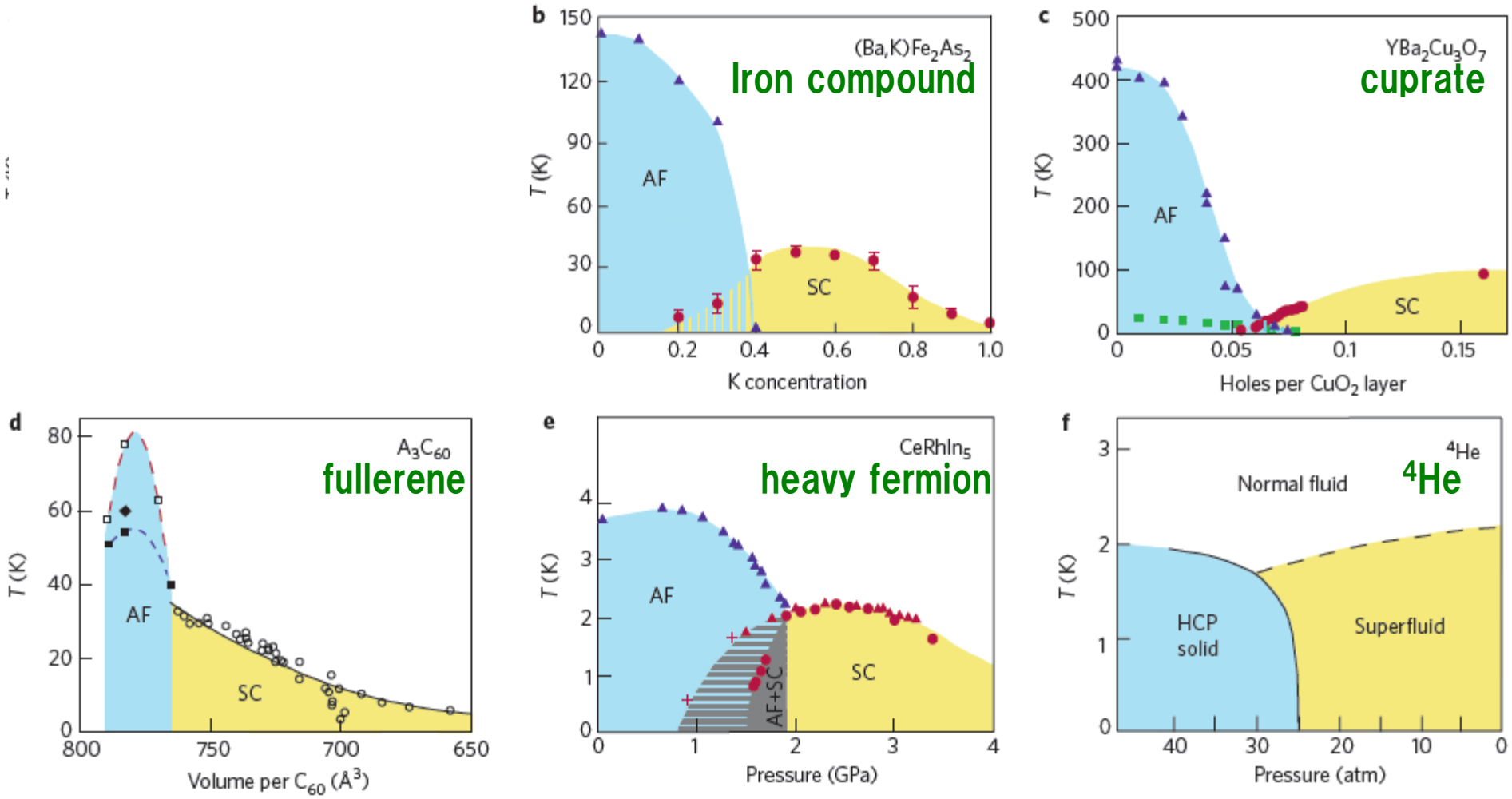
Why SC now? — a brief history

1906 Liquefaction of He (Kamerlingh Onnes)
1911 Discovery of SC in Hg (Kamerlingh Onnes; 1913 Nobel prize)
1924 Theory of Bose-Einstein condensation (Bose & Einstein)
1938 Discovery of superfluidity in ^{4}He (Kapitsa; 1978 Nobel)
1957 BCS theory for SC (Bardeen, Cooper & Schrieffer; 1972 Nobel)
1960's Theory for quantum liquids (Landau; 1962 Nobel)
1962 ODLRO (Yang)
1969 Proposal of supersolid (Andreev & Lifshitz)
1971 Discovery of superfluidity in ^{3}He (Lee, Osheroff & Richardson; 1996 Nobel)
1973 SC junctions (Josephson, 1973)
1980 Discovery of integer quantum Hall effect (von Klitzing; 1985)
1983 Discovery of fractional quantum Hall effect (Tsui, Stormer & Laughlin; 1998)
1986 Discovery of high-Tc superconductivity in cuprates (Bednorz & Muller; 1987)
1995 Discovery of Bose-Einstein condensation in cold atoms (Cornell, Ketterle & Wieman; 2001)
2003-2004 Discovery of superfluidity in fermionic cold atoms (JILA, MIT)

Evolution of Tc in superconductiv



Phase diagram for various superconductors



(Uemura, nature mat 2009)

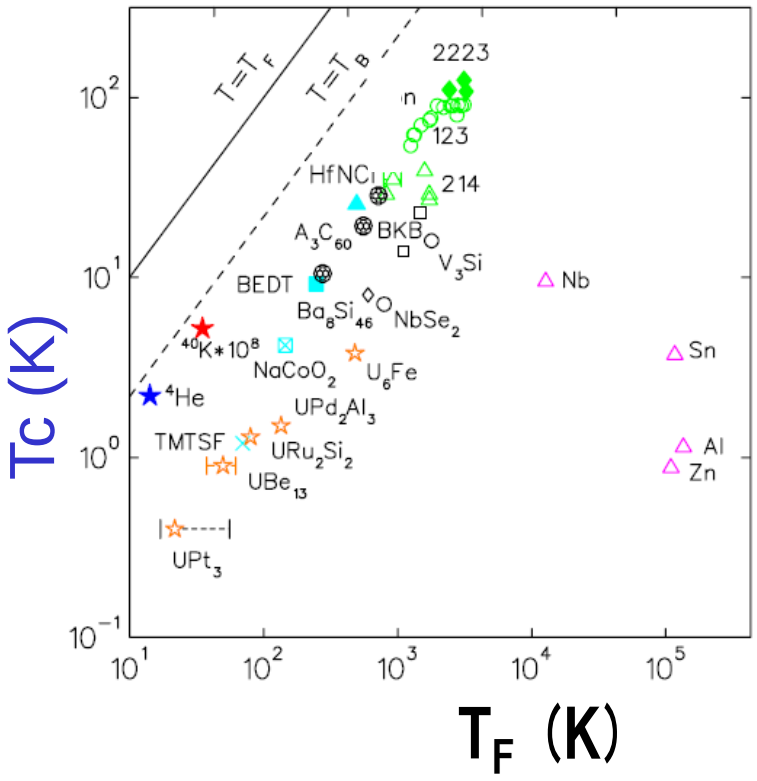
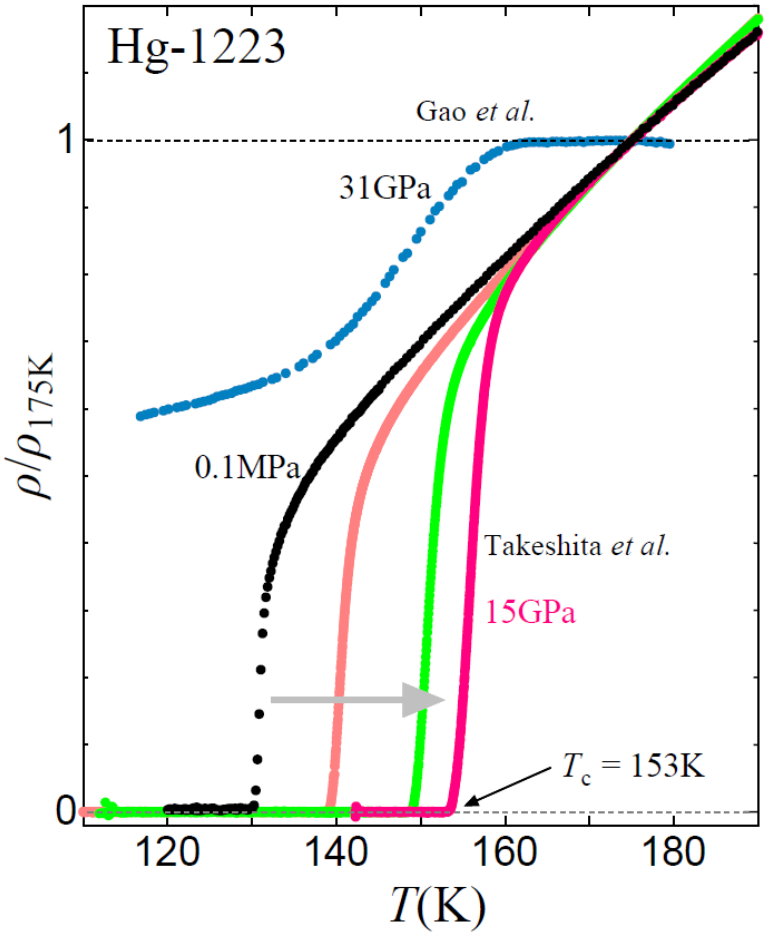


Fig.3-12 © Y. Uemura

Pressure effect in cuprates

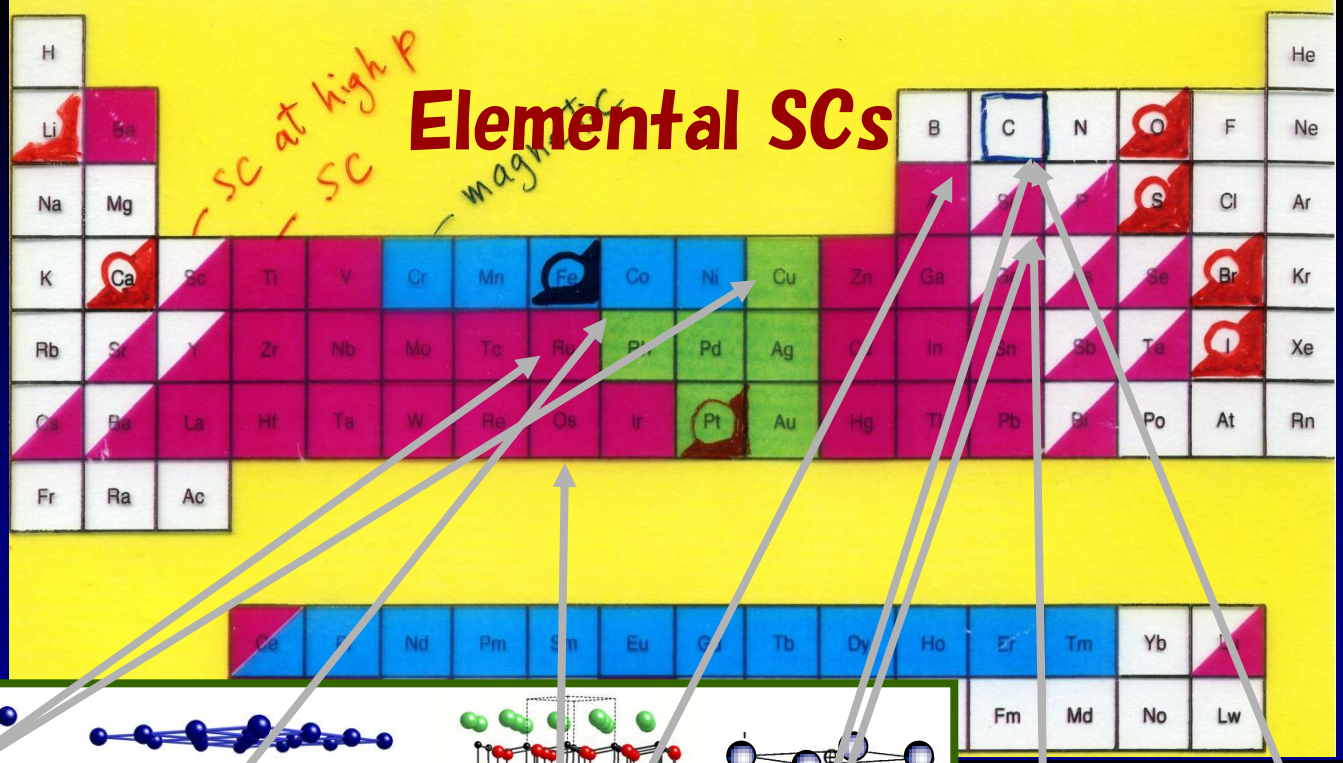
(Takeshita et al, JPSJ 2013)



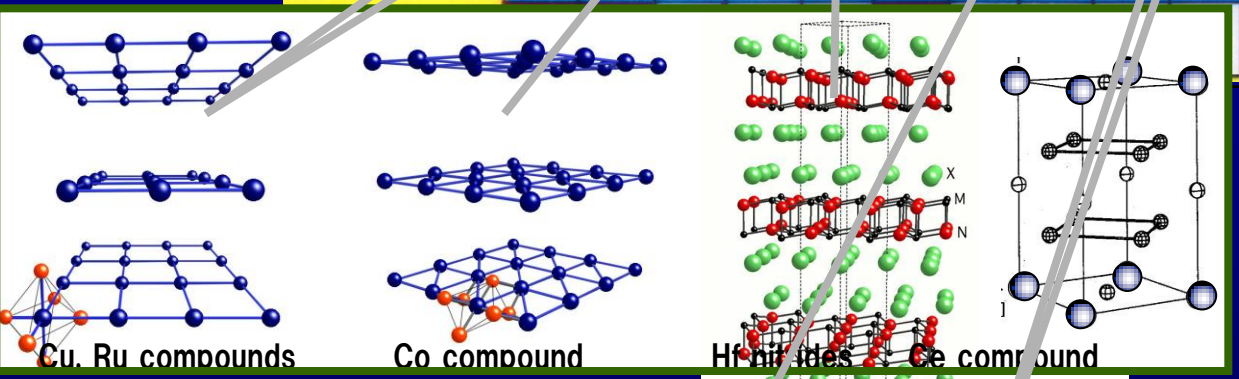
高温超伝導体ゼロ抵抗の世界記録を達成

	T_C (K):	Pairing symmetry:	"Glue":
Carbon-based:			
GIC	12	s	Phonon
Diamond	4	s	Phonon
Organic	14	s; d or p	Phonon; +el-el?
Fullerene	33	s	El-ph + el-el?
Aromatic	18	?	El-ph + el-el?
MgB_2	40	s	Phonon
H_xS	203 (p)	?	Phonon
Curates	130 160 (p)	d	El-el
Hf, Zr nitrides	24	?	El-el?
Iron-based	55	$s_{\pm}$; s_{++}	El-el
Heavy fermions	18	spin/orbit mixed	El-el + SOI

Elemental SCs

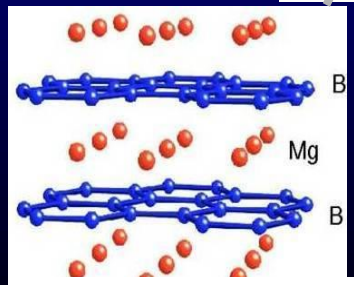


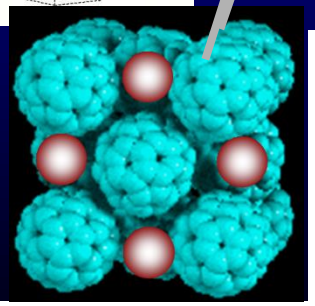
d

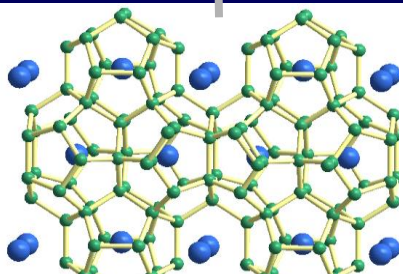


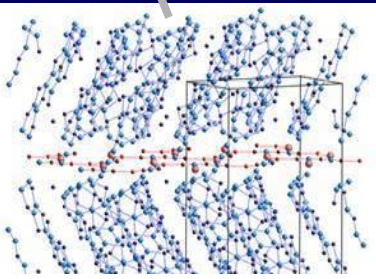
Cu, Ru compounds Co compound Hf nitrides Ce compound

p









intermetallic/GIC compounds fullerene clathrates organic metals

Elemental superconductors (Shimizu, Osaka Univ)

Li: Matsuoka & Shimizu, ***Nature*** (2009).
Li: Shimizu et al, ***Nature*** (2002).
Fe: Shimizu et al, ***Nature*** (2001).
O: Shimizu et al, ***Nature*** (1998).