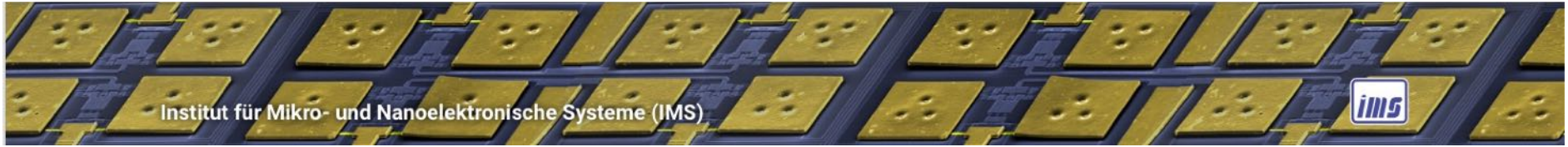
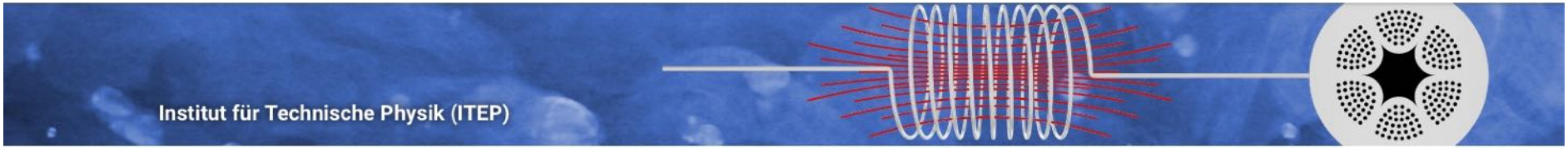
Karlsruher Institut für Technologie

Superconductivity for Engineers

Prof. Dr. Sebastian Kempf, Prof. Dr. Bernhard Holzapfel

Summer term 2021





(Preliminary) Schedule

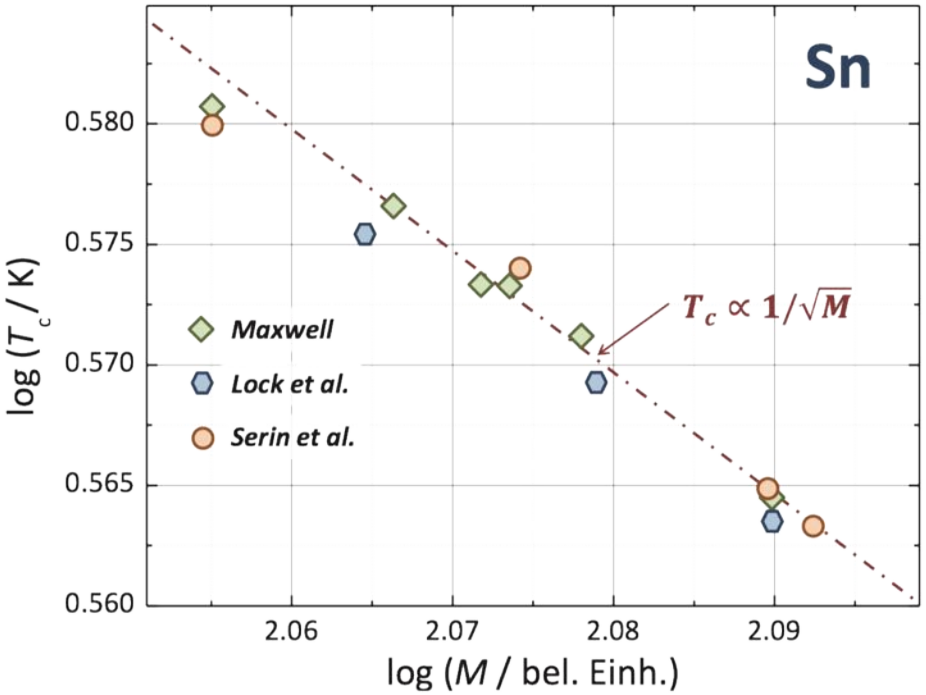
	Day	Date	Lecture / Tutorial	Day	Date	Lecture / Tutorial
1	Mon	21-04-12	Lecture 1 (SK)	Wed	21-04-14	
2	Mon	21-04-19	Lecture 2 (BH)	Wed	21-04-21	
3	Mon	21-04-26	Lecture 3 (SK)	Wed	21-04-28	Tutorial 1 (IMS)
4	Mon	21-05-03	Lecture 4 (SK)	Wed	21-05-05	
5	Mon	21-05-10	Lecture 5 (SK)	Wed	21-05-12	~~Tutorial 2 (IMS)~~
6	Mon	21-05-17	Lecture 6 (SK)	Wed	21-05-19	Tutorial 2 (IMS)
7	Mon	21-05-24	---	Wed	21-05-26	
8	Mon	21-05-31	Lecture 7 (BH)	Wed	21-06-02	Tutorial 3 (IMS)
9	Mon	21-06-07	Lecture 8 (BH)	Wed	21-06-09	Tutorial 4 (ITEP)
10	Mon	21-06-14	Lecture 9 (BH)	Wed	21-06-16	
11	Mon	21-06-21	Lecture 10 (BH)	Wed	21-06-23	Tutorial 5 (ITEP)
12	Mon	21-06-28	Lecture 11 (BH)	Wed	21-06-30	
13	Mon	21-07-05	Lecture 12 (BH)	Wed	21-07-07	Tutorial 6 (ITEP)
14	Mon	21-07-12	Lecture 13 (SK)	Wed	21-07-14	
15	Mon	21-07-19	Lecture 14 (SK)	Wed	21-07-21	Tutorial 7 (IMS, ITEP)

(Preliminary) Lecture content

Lecture 1:	(SK)	Introduction and overview
Lecture 2:	(BH)	Superconductor applications
Lecture 3:	(SK)	Normal metals and properties of the normal conducting state
Lecture 4:	(SK)	Perfect conductor, ideal diamagnetism, Two-Fluid-Model, London theory
Lecture 5:	(SK)	Disordered superconductors, Pippard theory, microwave properties
Lecture 6:	(SK)	BCS theory
Lecture 7:	(BH)	Ginzburg-Landau theory
Lecture 8:	(BH)	Typ-I superconductors
Lecture 9:	(BH)	Typ-II superconductors
Lecture 10:	(BH)	Typ-II superconductors
Lecture 11:	(BH)	Current transport, ac-losses, thermal aspects
Lecture 12:	(BH)	Current transport, ac-losses, thermal aspects
Lecture 13:	(SK)	Josephson junctions and SQUIDs
Lecture 14:	(SK)	Josephson junctions and SQUIDs

Historical remarks

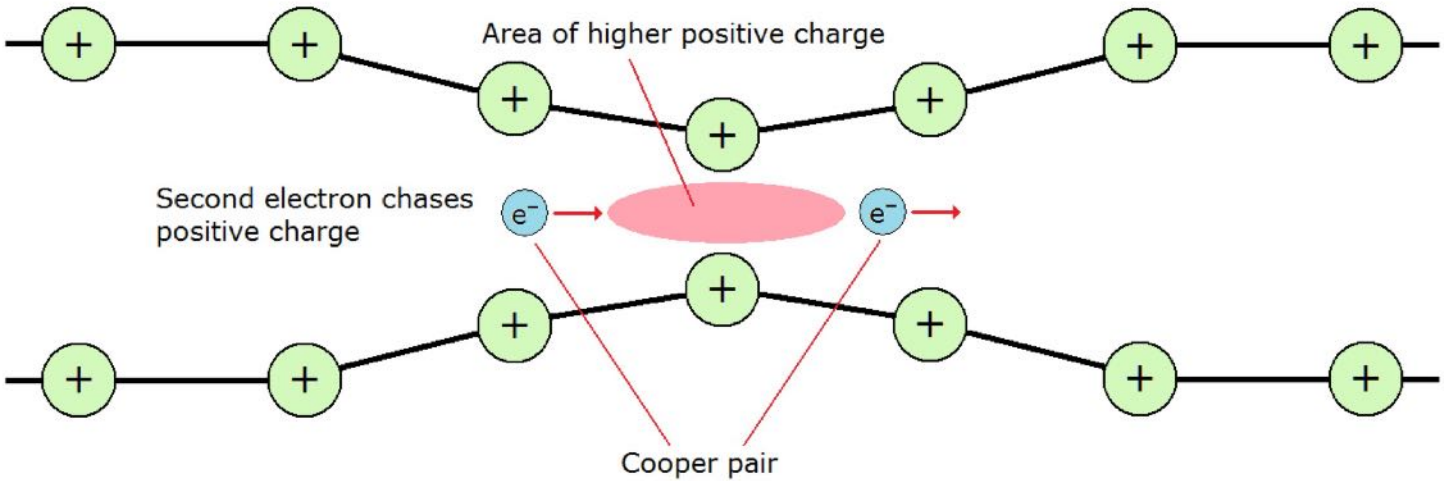
Isotope effect



Cooper pairs

Attractive electron interaction

Electron interaction via virtual phonons



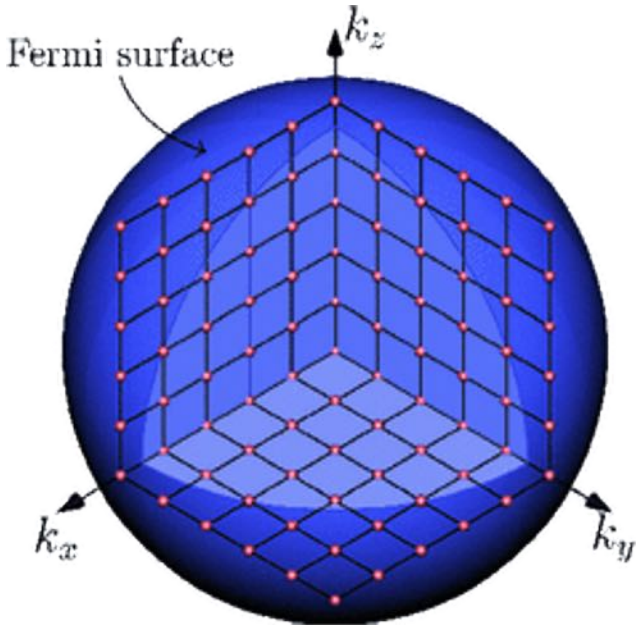
Isotope effect

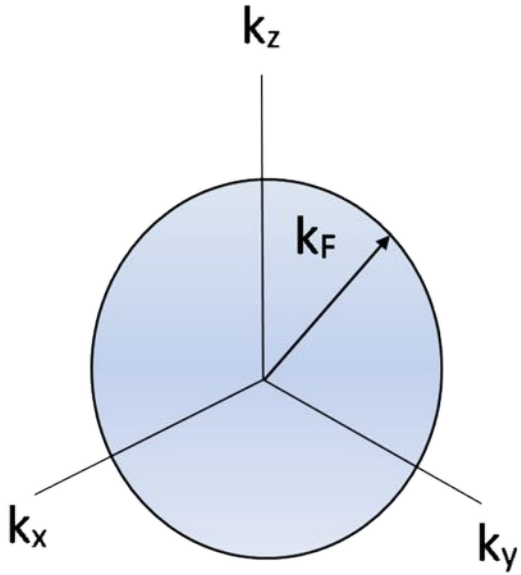
Normal conducting vs. Superconducting materials

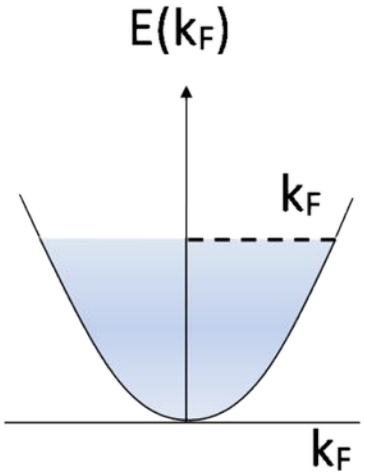
Virtual phonon exchange

Virtual phonon exchange

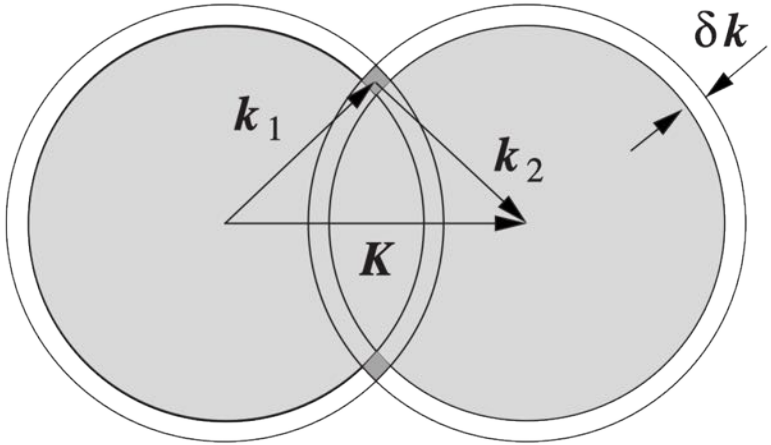
Fermi surface

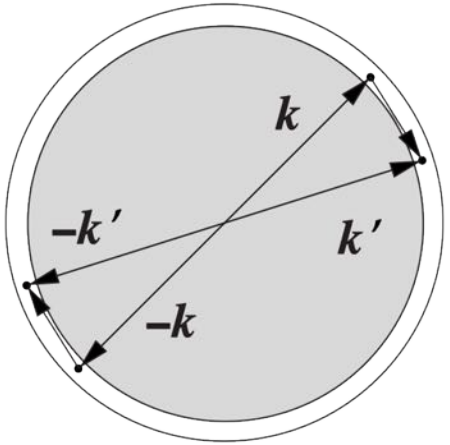






Fermi surface

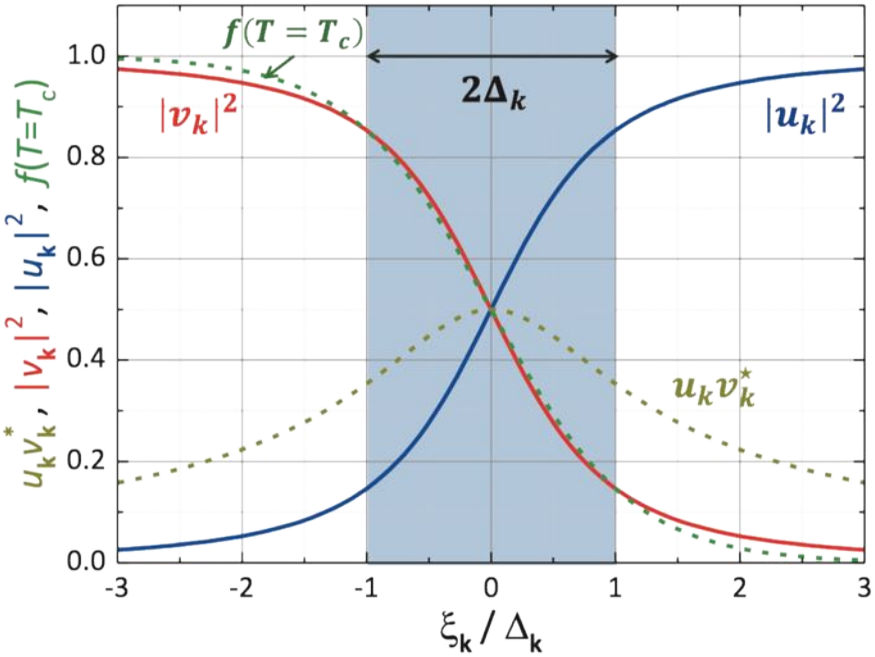




Cooper pairs

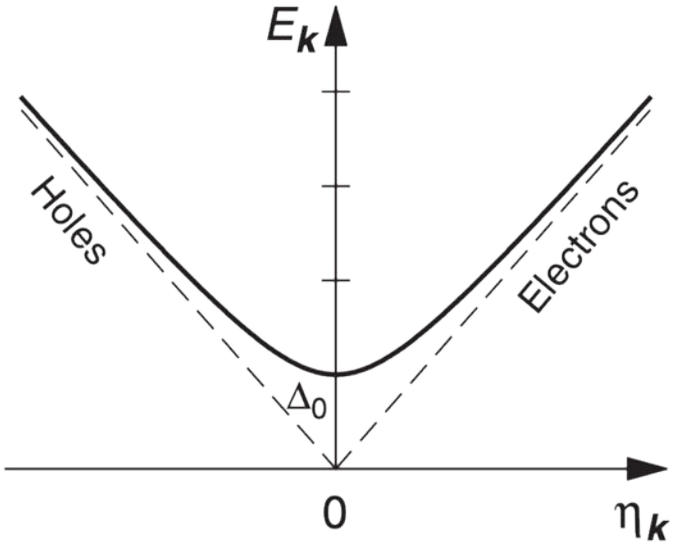
BCS ground state

Occupation probability



Energy gap and condensation energy

Quasiparticle excitation energy



Density of states

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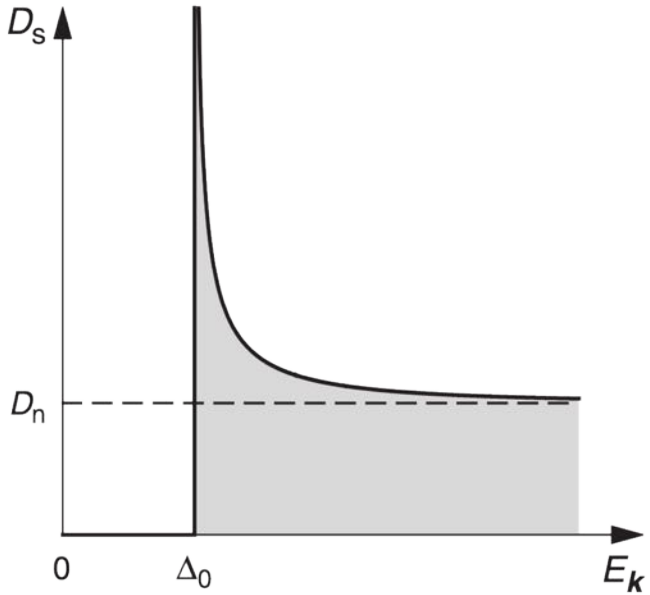
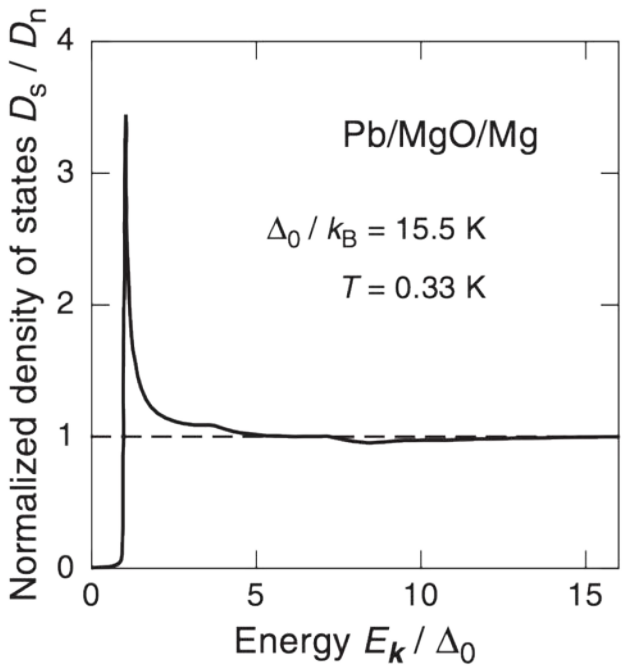
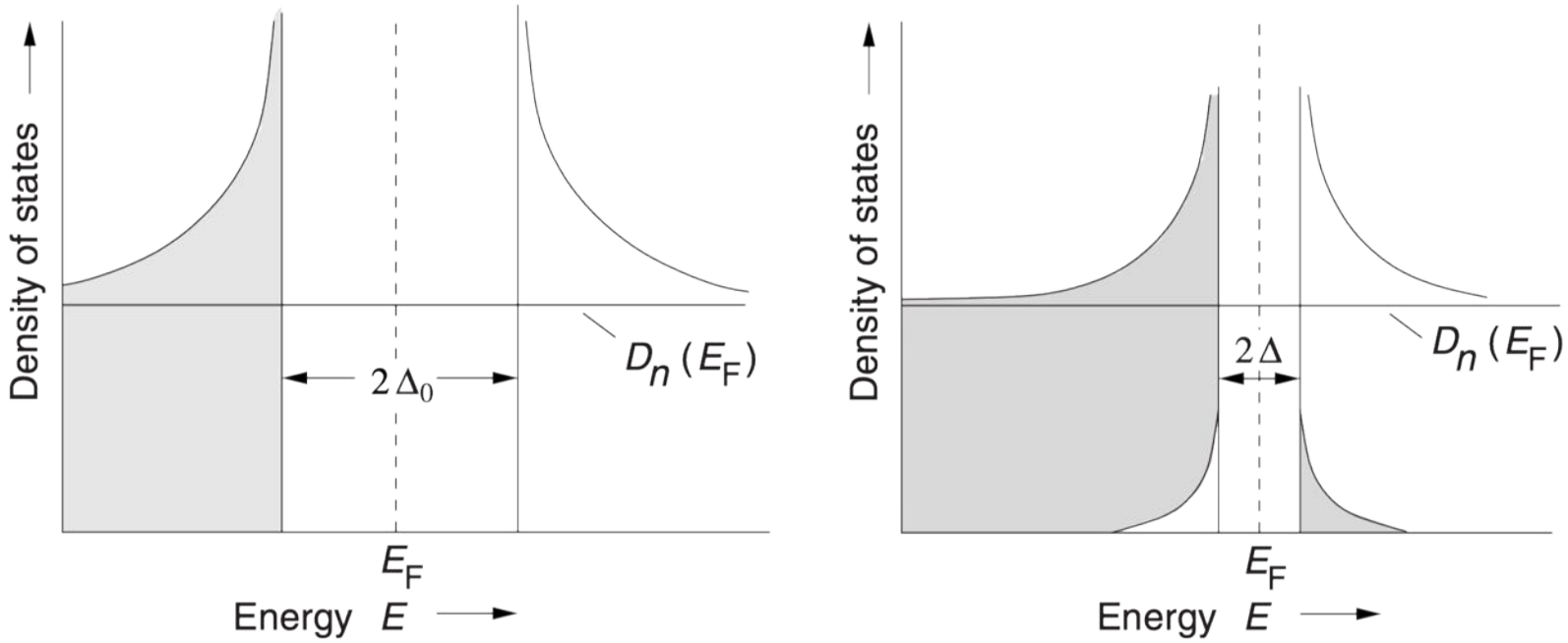




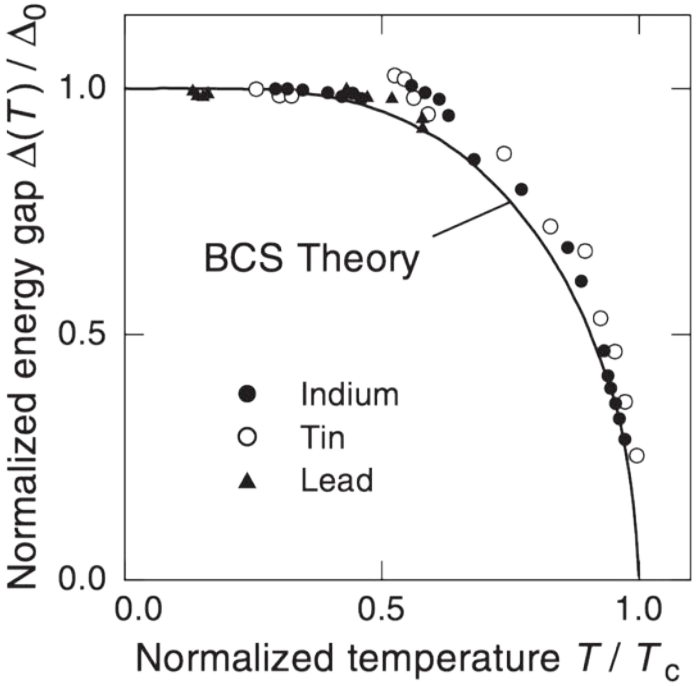
One-particle representation of DoS



BCS state at finite temperatures

Critical temperature

Temperature dependence of energy gap

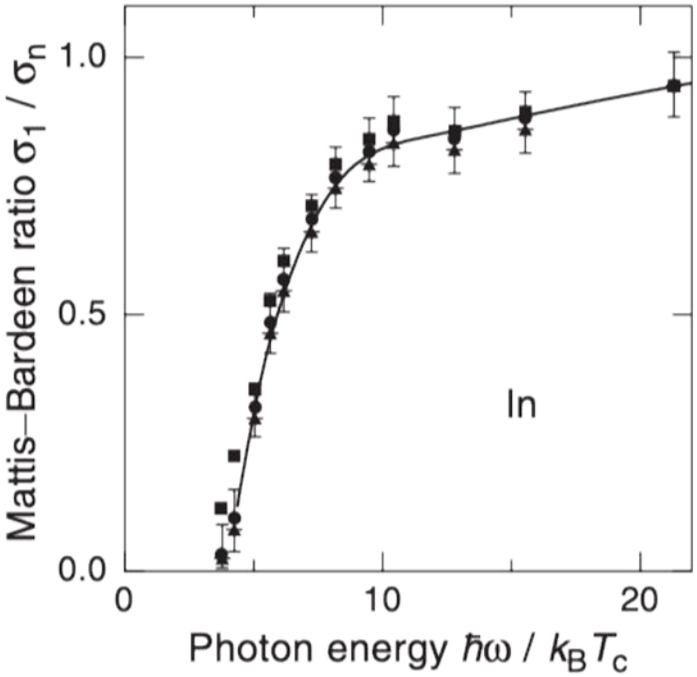


Some material properties

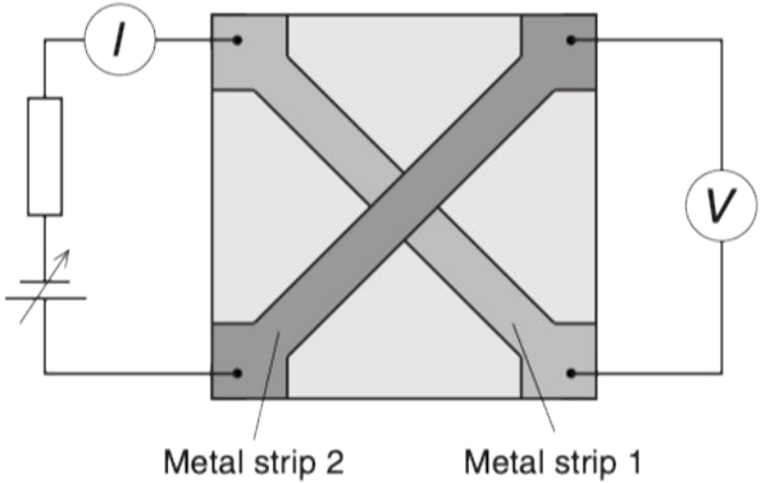
	T_c (K)	$2\Delta(0)$ (meV)	$2\Delta(0)/k_B T_c$		T_c (K)	$2\Delta(0)$ (meV)	$2\Delta(0)/k_B T_c$
Al	1.19	0.36	3.5 ± 0.1	In	3.4	1.05	3.5 ± 0.1
Nb	9.25	2.90	3.6	Hg	4.15	1.65	4.6 ± 0.1
Pb	7.2	2.70	4.3 ± 0.05	Sn	3.72	1.15	3.5 ± 0.1
Ta	4.29	1.30	3.5 ± 0.1	Tl	2.38	0.75	3.6 ± 0.1
NbN	16	4.65	3.6	Nb_3Sn	18	6.55	4.2
$NbSe_2$	7	2.2	3.7	MgB_2	40	3.6-15	1.1–4.5

Relevance of the energy gap

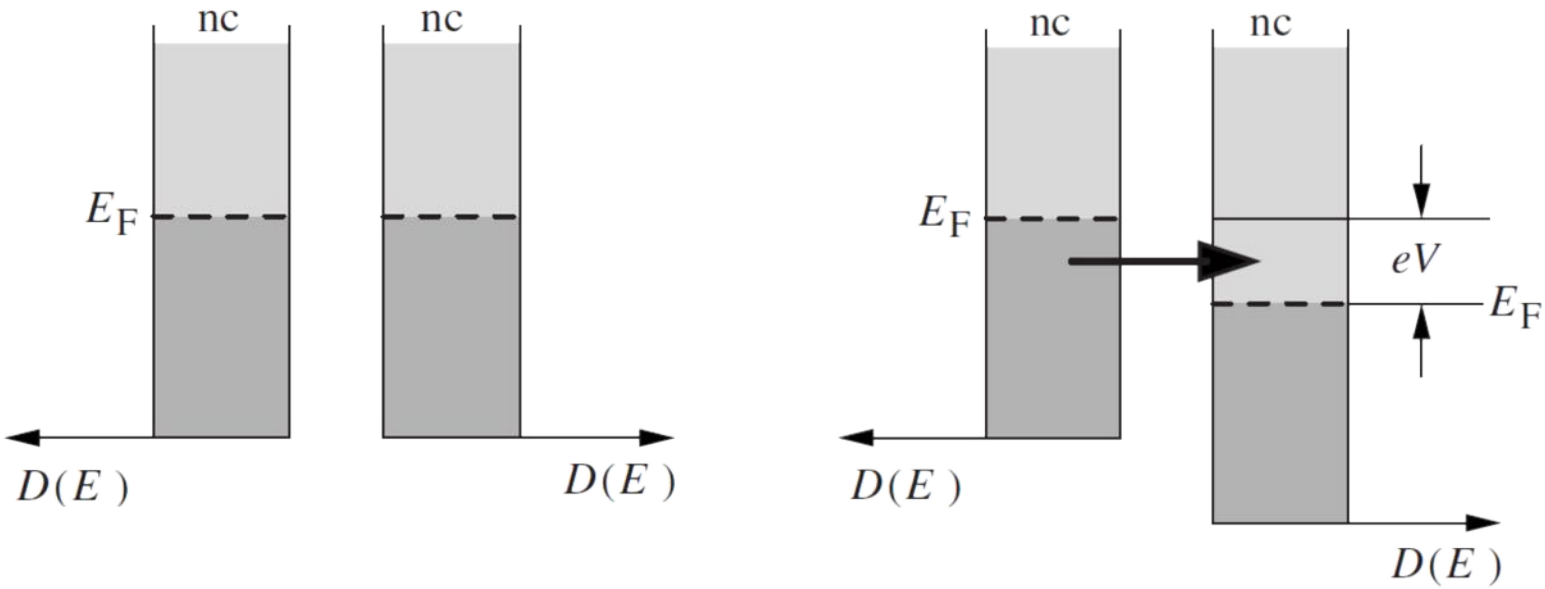
Infrared absorption of superconductors



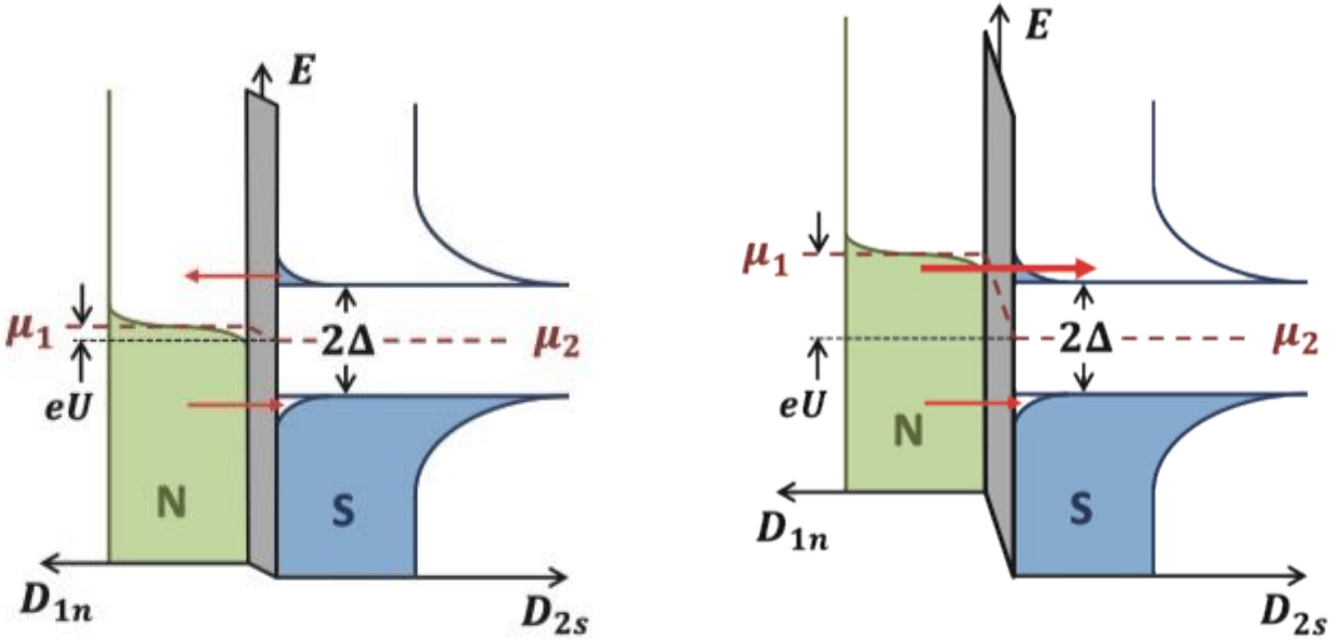
Tunnel junctions



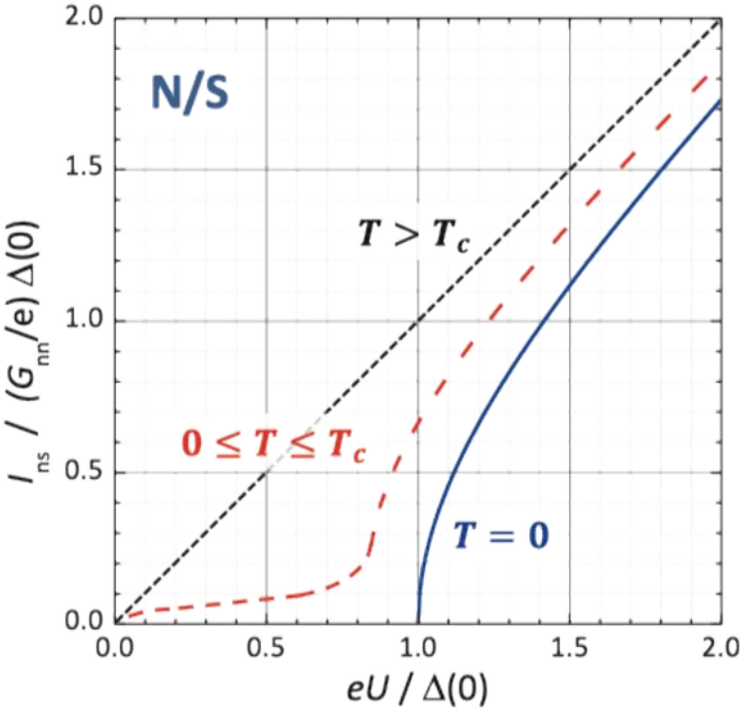
NIN tunneling



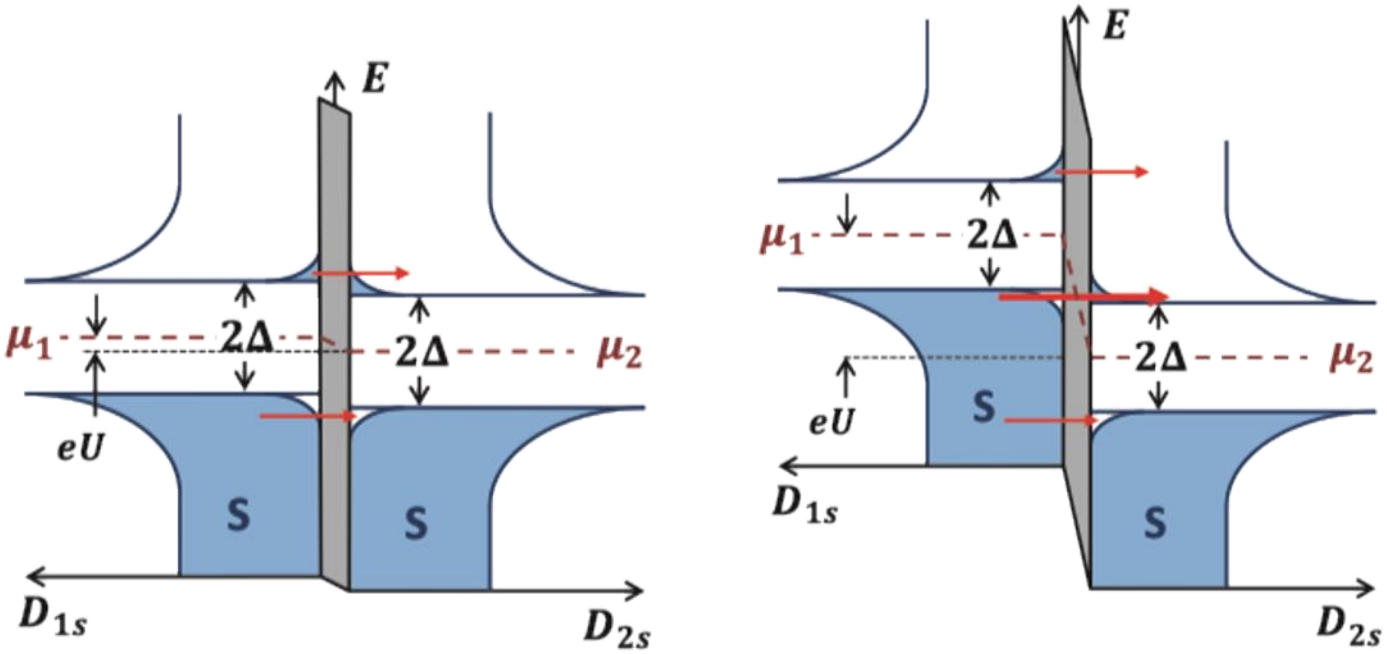
NIS tunneling



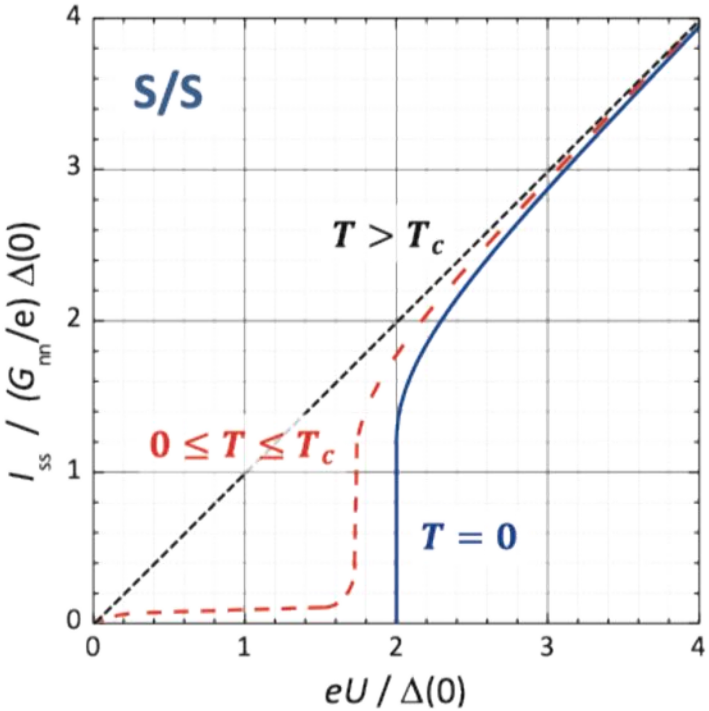
NIS tunneling



SIS tunneling



SIS tunneling



Zero dc resistance of a superconductor

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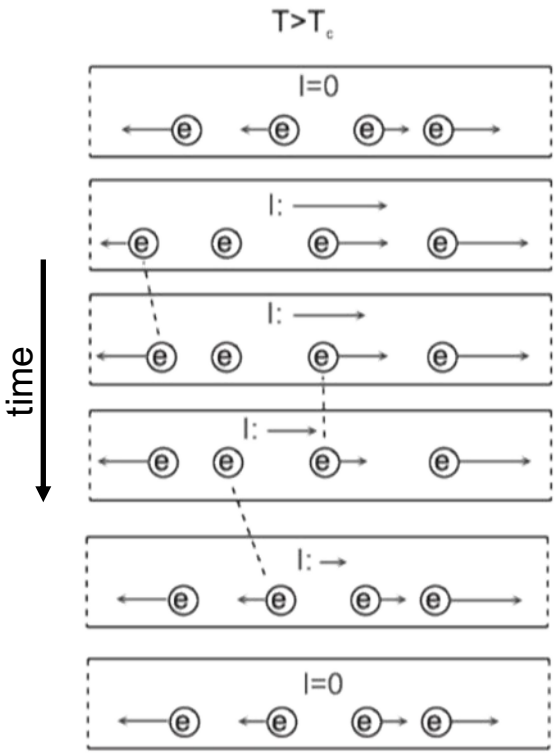

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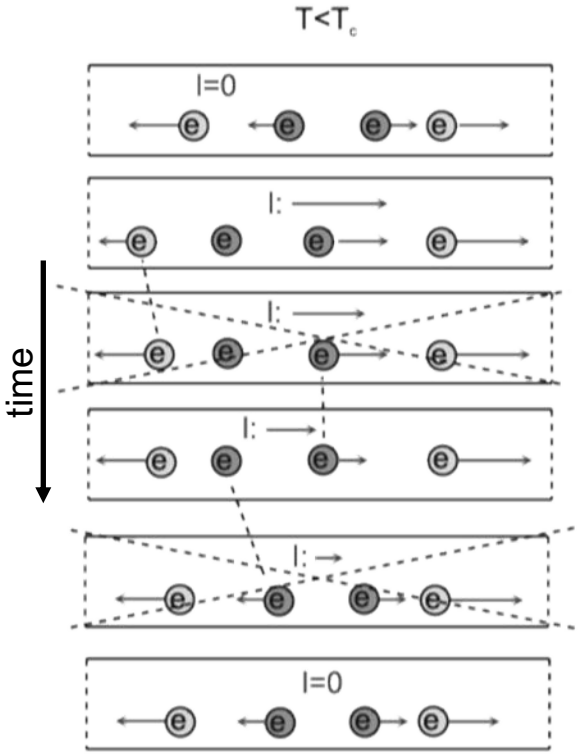

Coherence length

Critical current and energy gap

Macroscopic wave function

Magnetic flux quantization