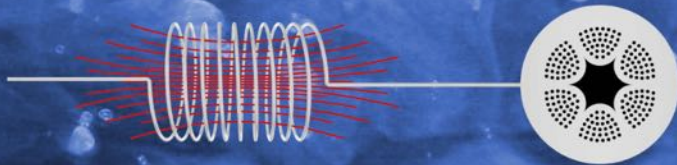


Superconductivity for Engineers

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Summer term 2021

Institut für Technische
Physik (ITEP)



Institut für Mikro- und
Nanoelektronische Systeme (IMS)



Lecture overview

Lecture 01:	(SK)	Introduction and overview
Lecture 02:	(BH)	Superconductor applications
Lecture 03:	(SK)	Normal metals and properties of the normal conducting state
Lecture 04:	(SK)	Perfect conductor, ideal diamagnetism, two-fluid model, London theory
Lecture 05:	(SK)	Disordered superconductors, Pippard theory, microwave properties
Lecture 06:	(SK)	BCS theory
Lecture 07:	(BH)	Ginzburg-Landau theory
Lecture 08:	(BH)	Type-I superconductors
Lecture 09:	(BH)	Type-II superconductors
Lecture 10:	(BH)	Type-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
Lecture 14:	(SK)	SQUIDs

Literature

■ Primary literature:

- C. Enss, S. Hunklinger, Low Temperature Physics, Springer (2005)
- M. Tinkham, Introduction to Superconductivity, McGraw-Hill (1996)
- R. Gross, A. Marx, Applied Superconductivity, Lecture Notes, www.wmi.badw.de

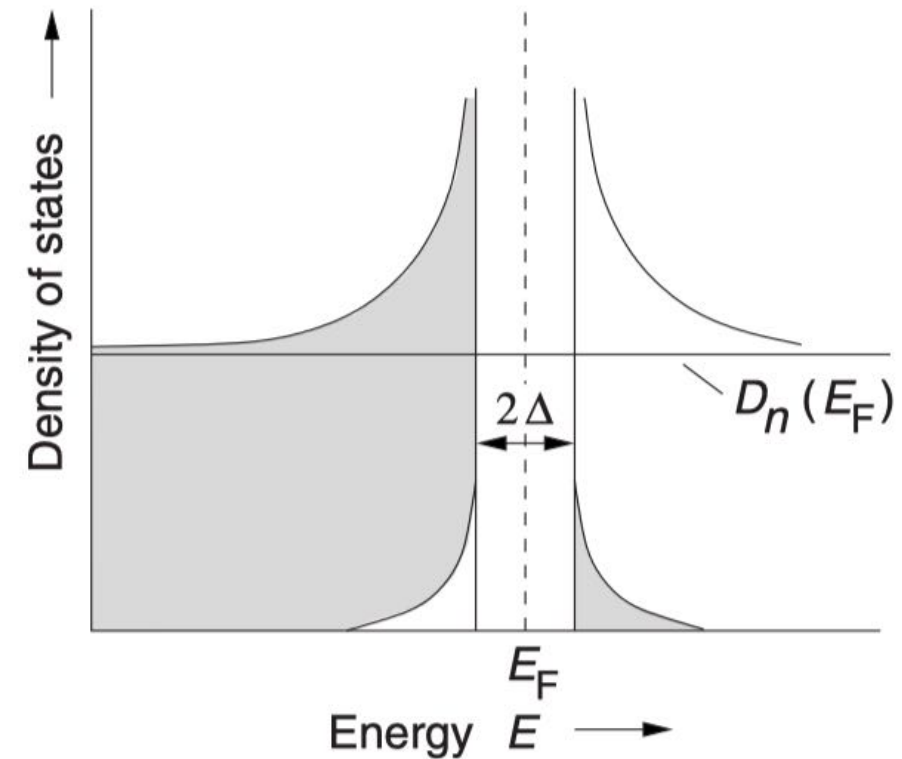
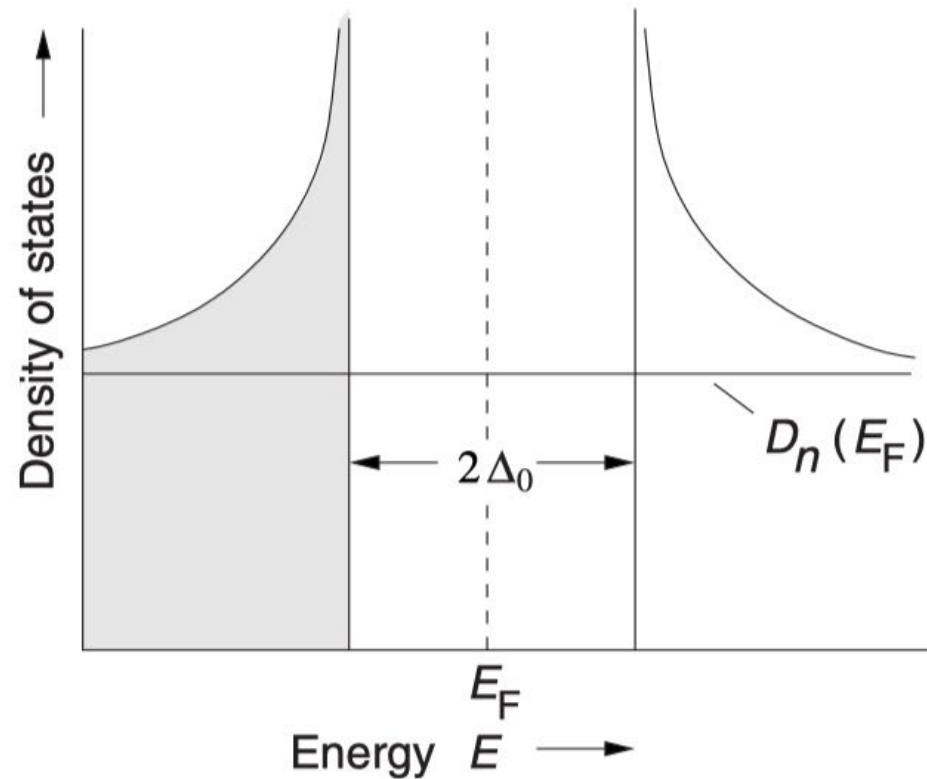
■ Secondary literature:

- R. Gross, A. Marx, Festkörperphysik, De Gruyter (2018)
- S. Hunklinger, Festkörperphysik, De Gruyter (2018)

Reminder: BCS theory

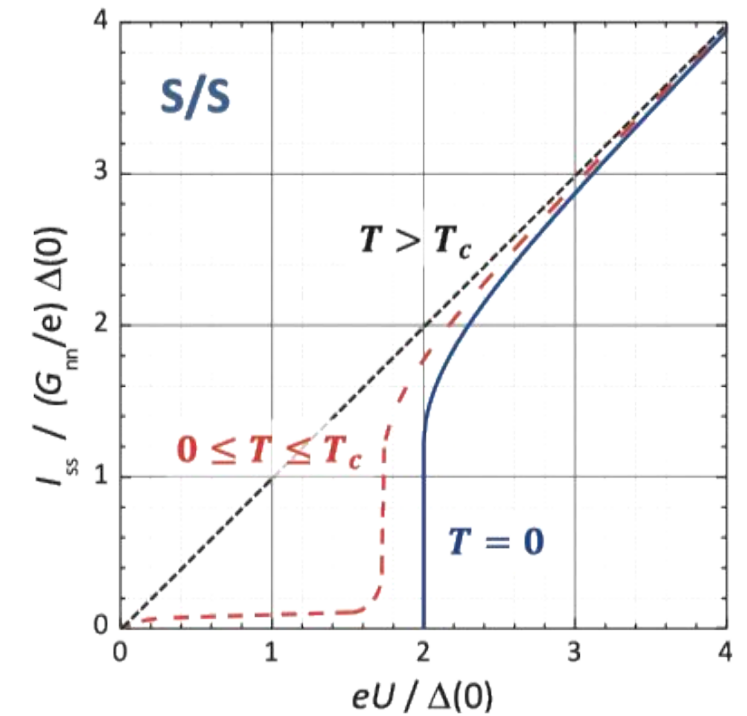
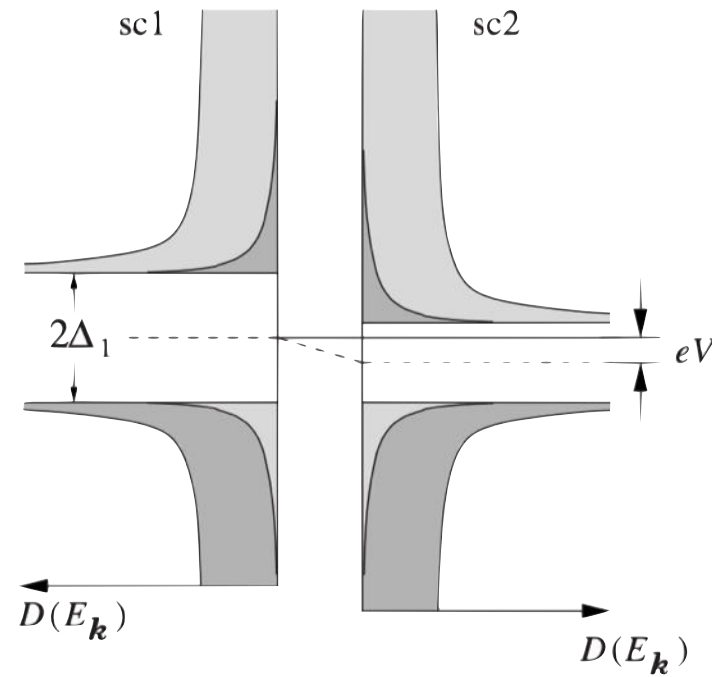
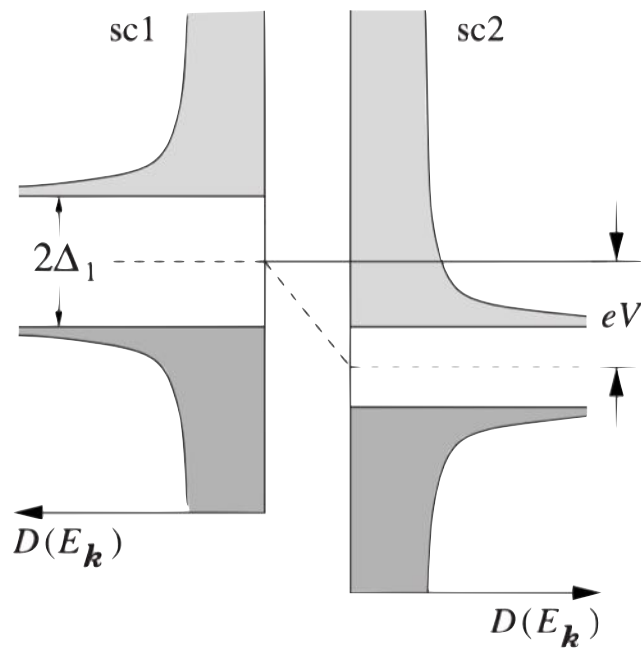
Reminder: Macroscopic wave function

Reminder: One-particle representation of DoS



Tunnel junctions

Reminder: SIS tunneling



Josephson tunnel junctions

Cooper pair tunneling

Thick and thin insulation layers

Josephson equations

Josephson equations

Dc-Josephson effect

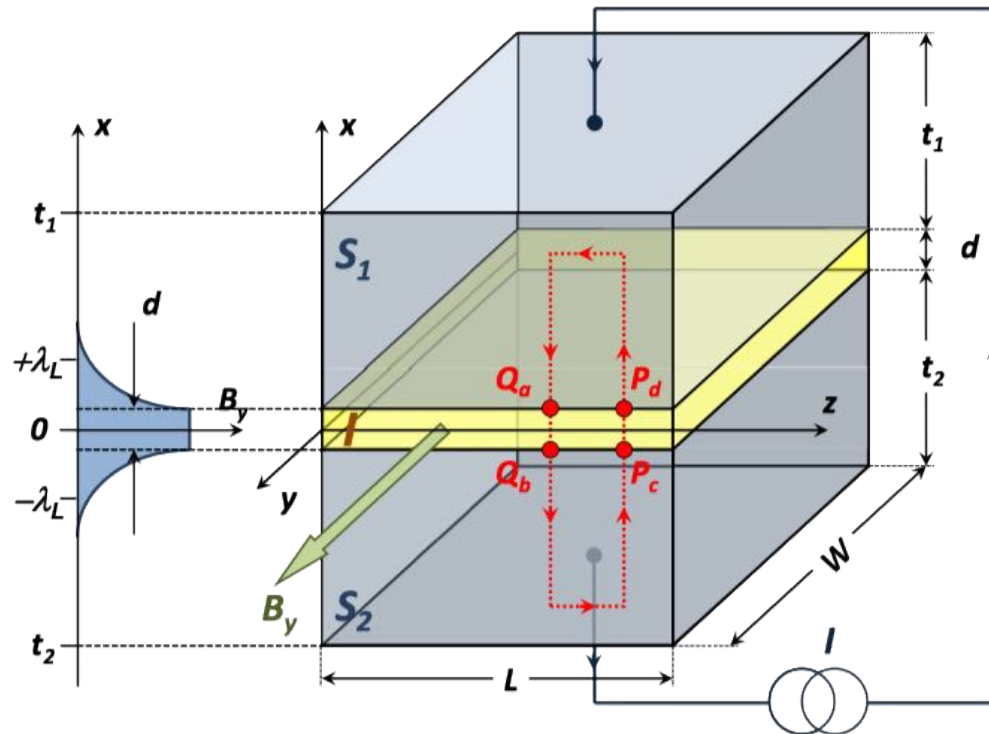
Ac-Josephson effect

Lumped Josephson junctions

Josephson coupling energy

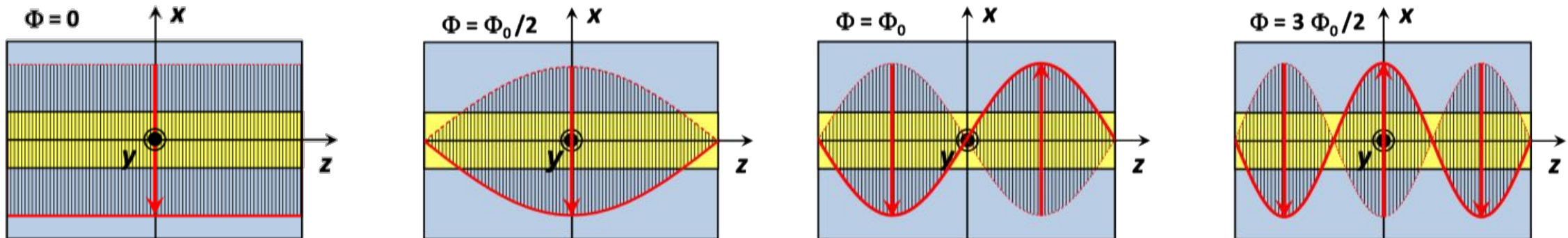
Josephson inductance

Extended (short) Josephson junctions

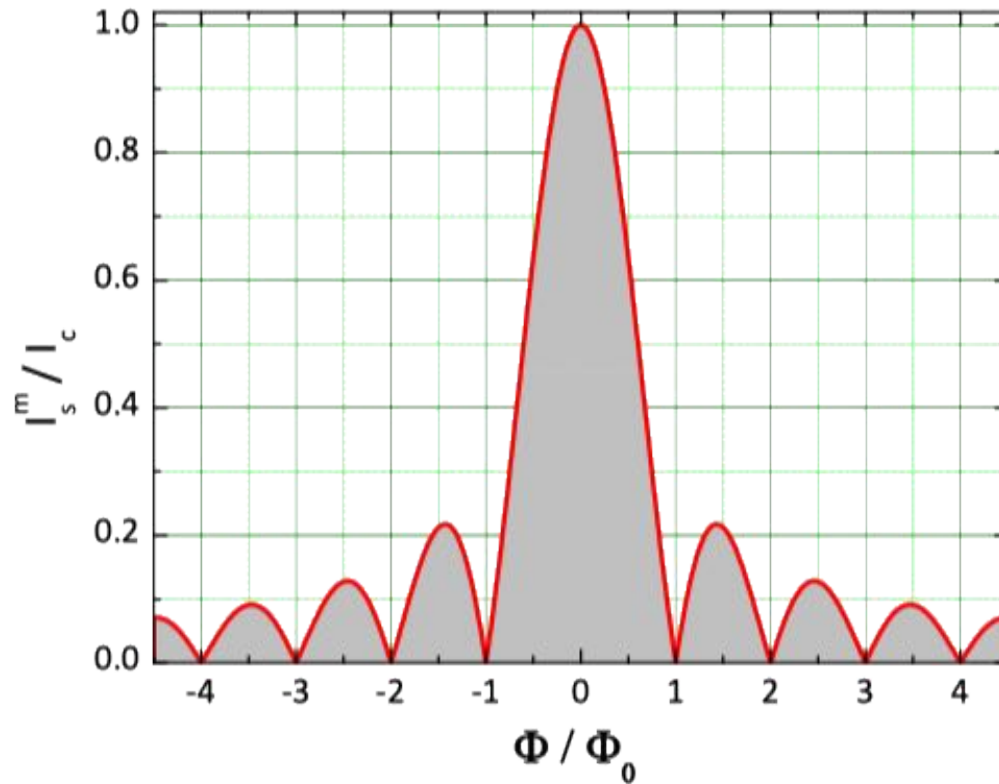


Extended (short) Josephson junctions

Current density distribution in a short JJ



Fraunhofer diffraction pattern



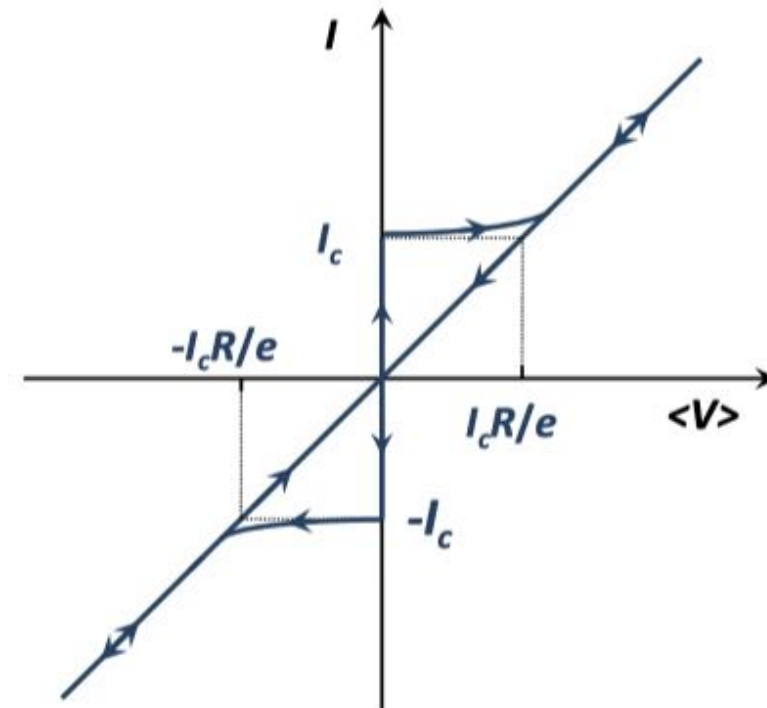
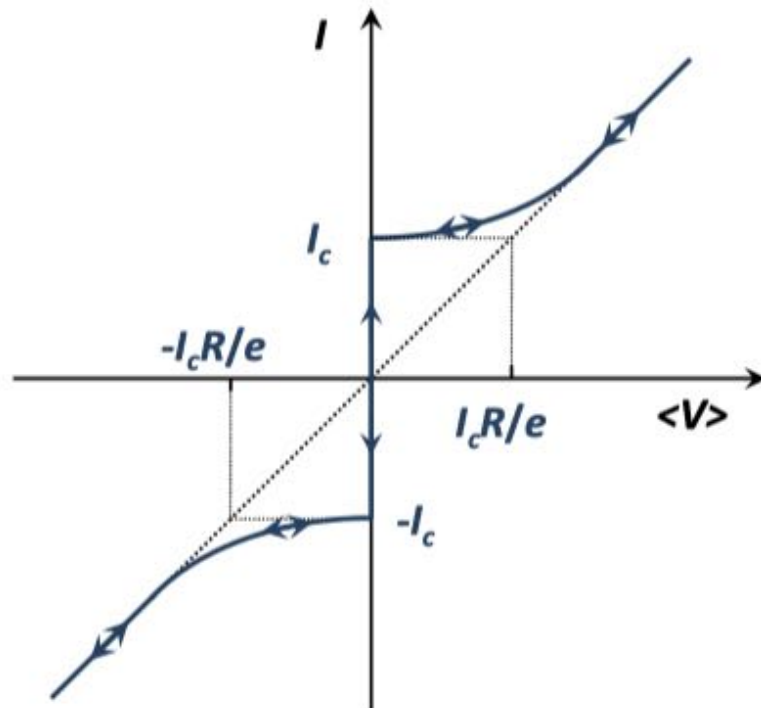
Voltage state of Josephson junctions

Equivalent circuit model

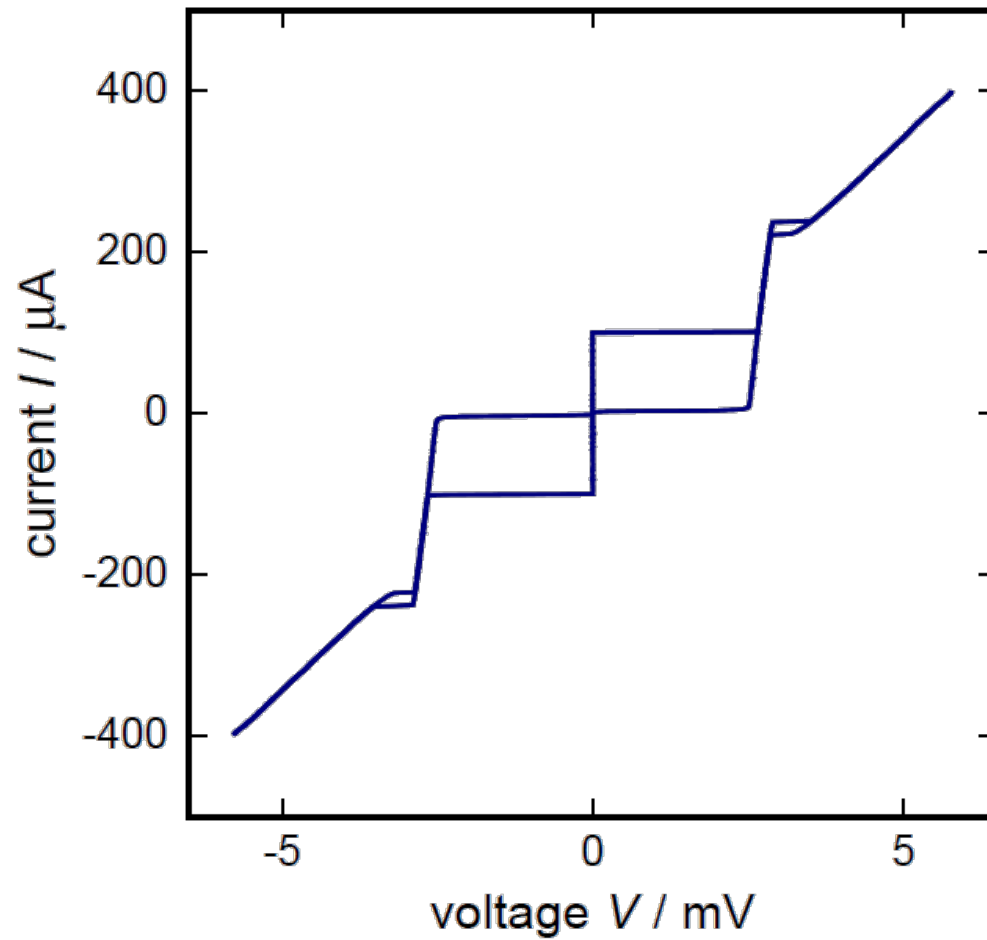
Basic junction equation

RCSJ model

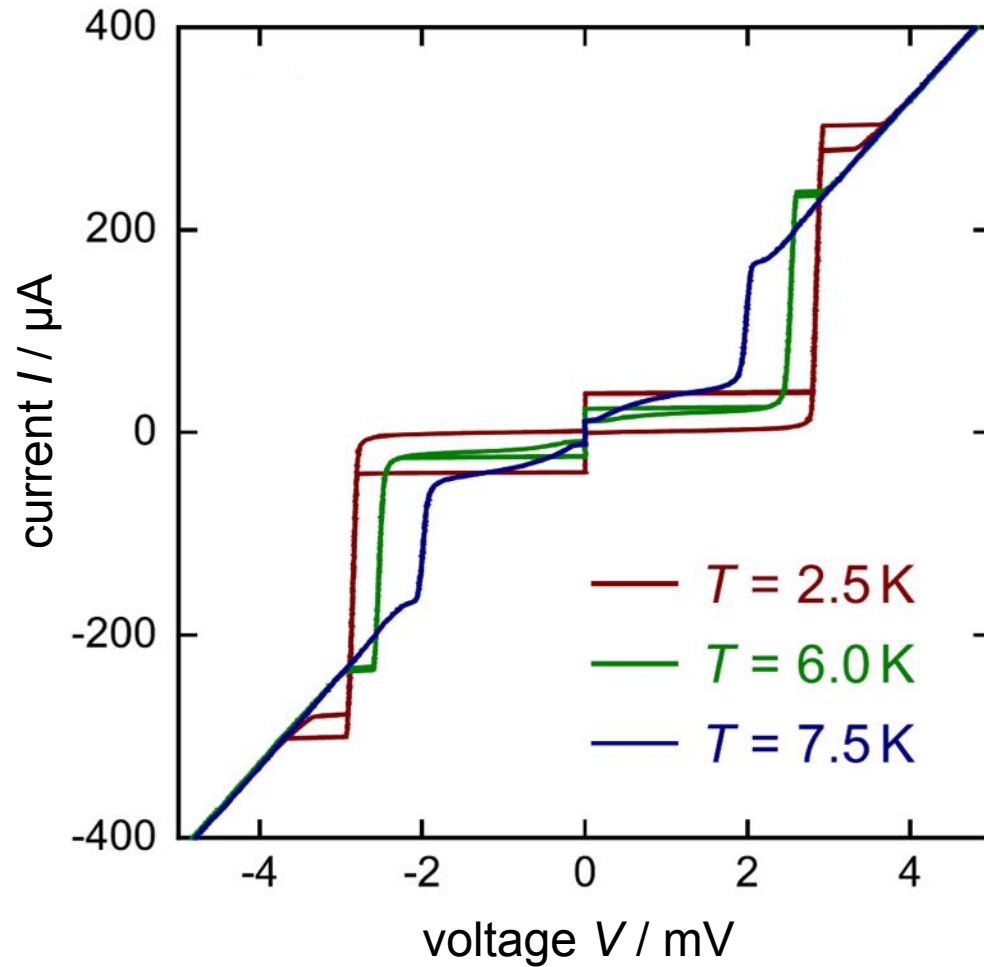
***I*-*V*-characteristics of over- and underdamped JJs**



Current-voltage characteristics



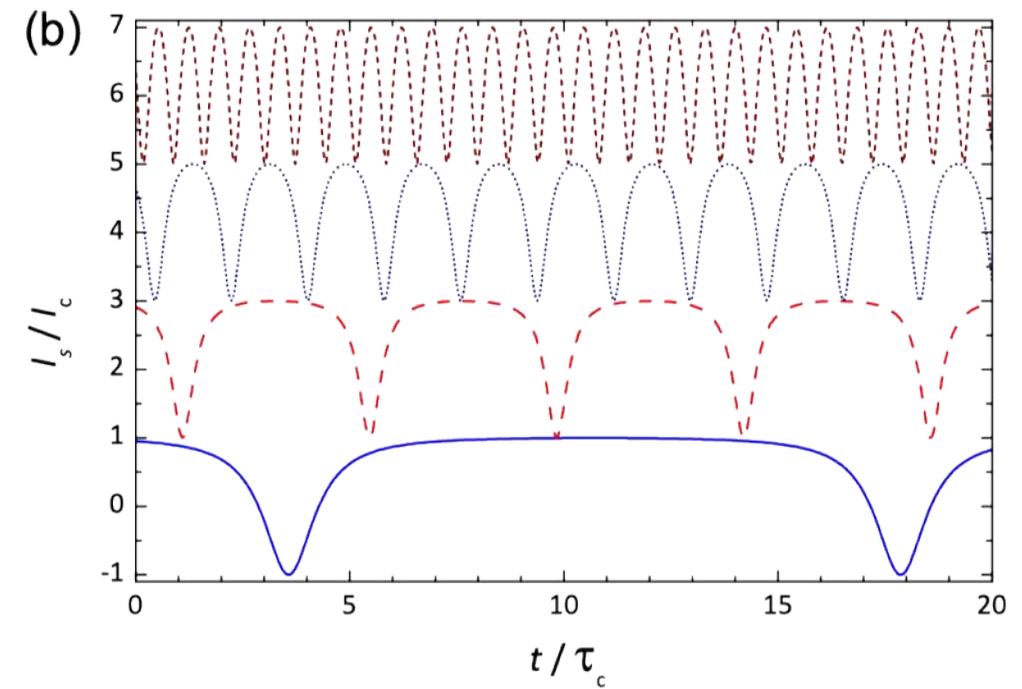
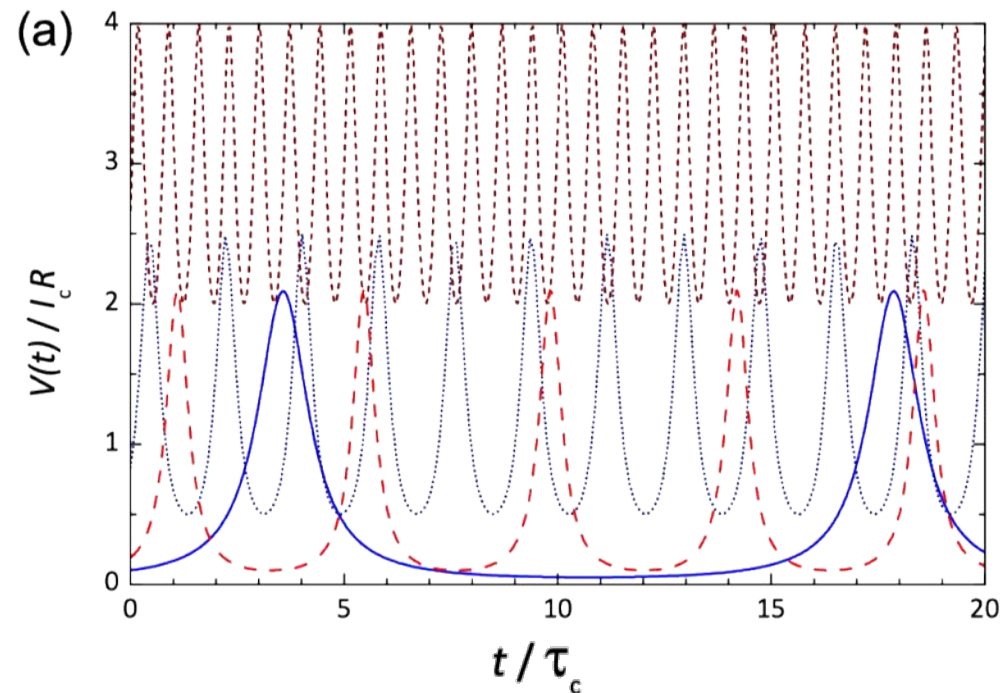
Current-voltage characteristics



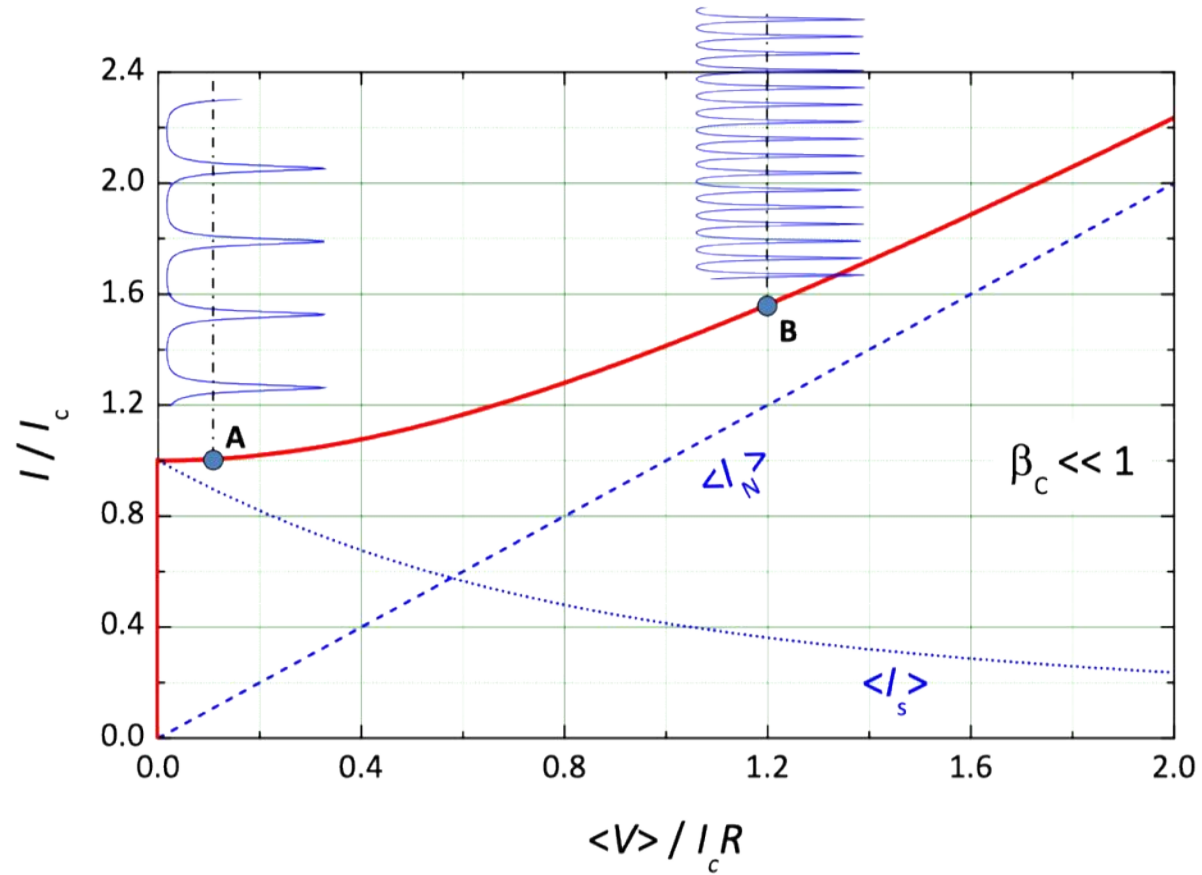
Response to driving sources

Response to a dc current source

Response to a dc current source

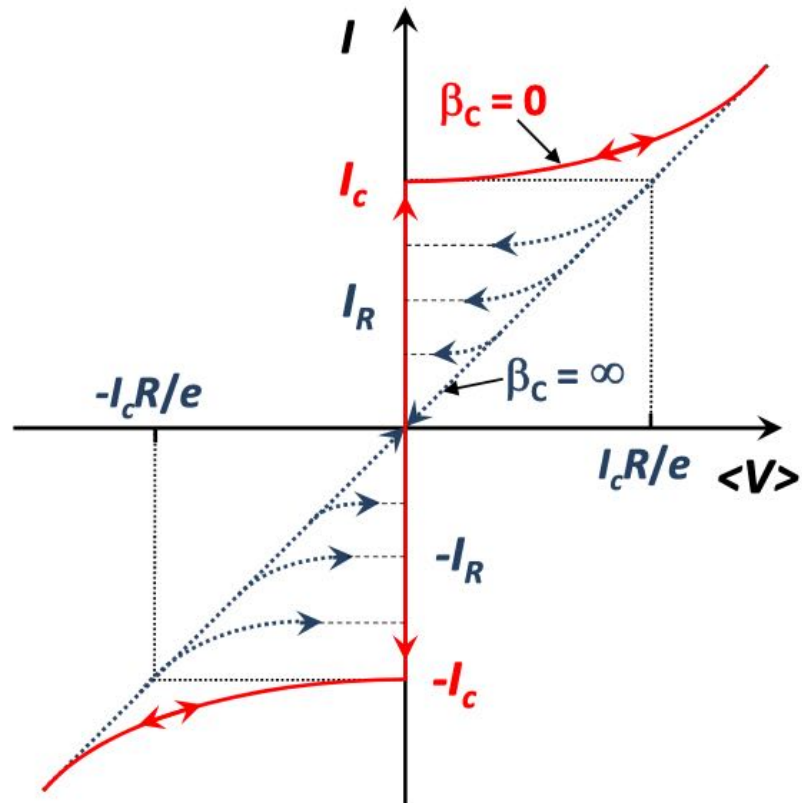


Dc current biased overdamped JJ

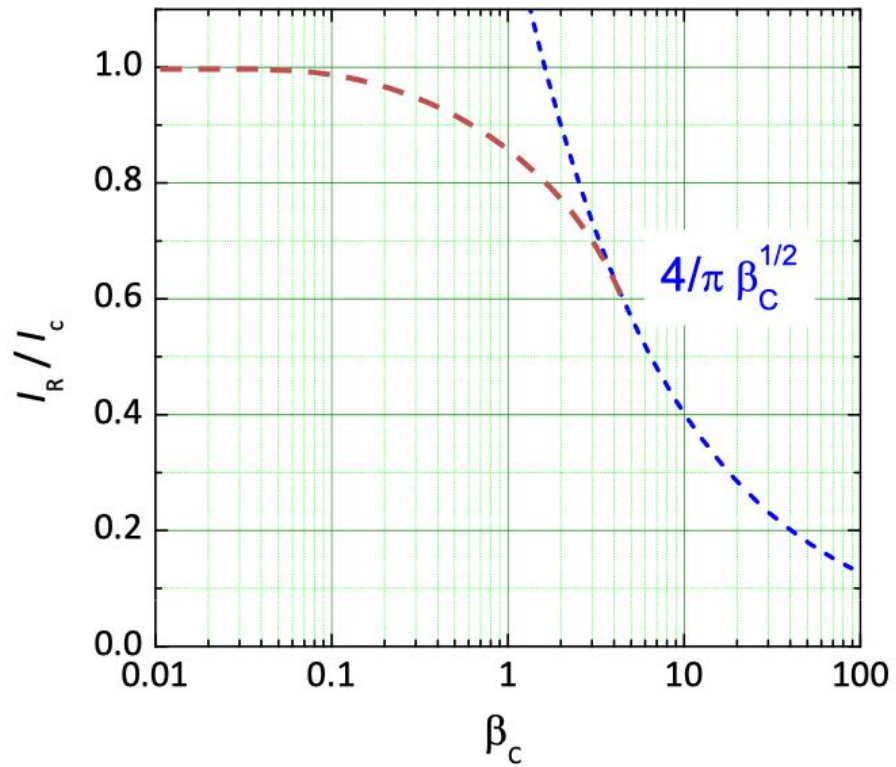


Dc current biased underdamped JJ

Dc current biased JJ with intermediate damping



Dc current biased JJ with intermediate damping



Shunting of Josephson junctions