

Magnetic Sensor (3C)

- Josephson Effect
- Magnetic Flux Quantum
- SQUID sensor

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Tunnel Junction

The SIS-junction

- 2 bulky **superconductors**
- separated by a thin ***insulating layers***

Cooper pair

- a weak *attraction* between electrons in crystal
- electrons with *opposite* spin and momentum
- free particle wavefunction model

Cooper pairs may tunnel through the layer

→ current flows

DC Josephson Effect (1)

DC Josephson Effect

- **constant current ($I < I_c$)**
- **Cooper pairs on each side of junction**
- **penetrating into insulating region**
- **locking together in phase**

$$I = I_c \sin \theta$$

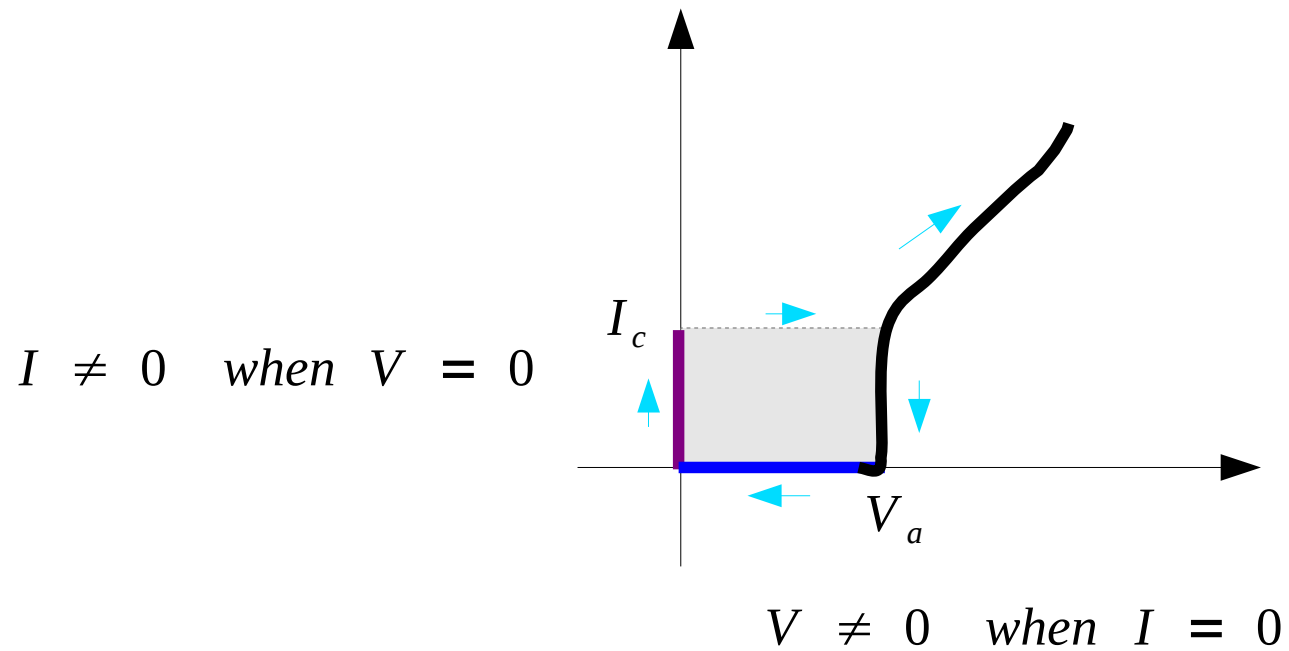
Current proportional to the *phase difference* of the wavefunctions can flow in the junction *without a voltage drop*.

$$I \neq 0 \quad \text{when} \quad V = 0$$

$$V \neq 0 \quad \text{when} \quad I = 0$$

DC Josephson Effect (2)

DC Josephson Effect



AC Josephson Effect

- **when DC voltage is applied to the junction**
- **Oscillation of Josephson frequency at the junction**
- *The phase varies linearly with times*
- ***The current is AC***

$$\frac{d\theta}{dt} = \frac{2qV}{h} = f \qquad V = \frac{h}{2q} \frac{d\theta}{dt}$$

$$I(t) = I_c \sin\left(\frac{2qV}{h} \cdot t\right)$$

Flux Quantization

The magnetic flux

- through a bulk superconducting loop
- Quantized in units of Φ_0

$$\phi = n \cdot \phi_0 = \frac{n \cdot h}{2e}$$

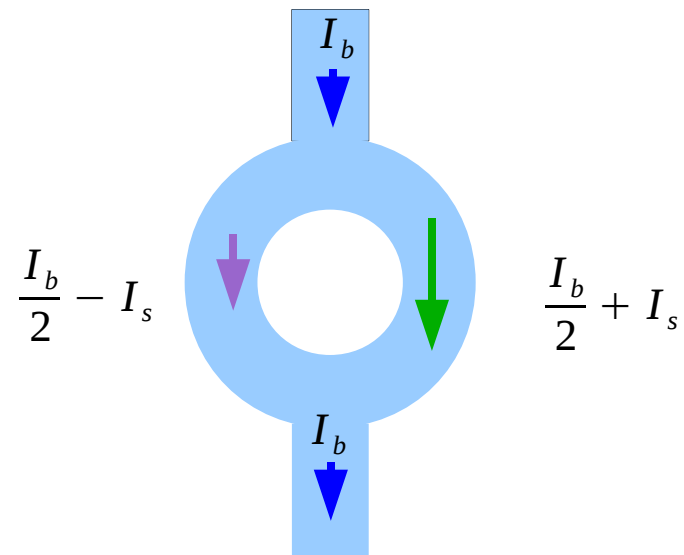
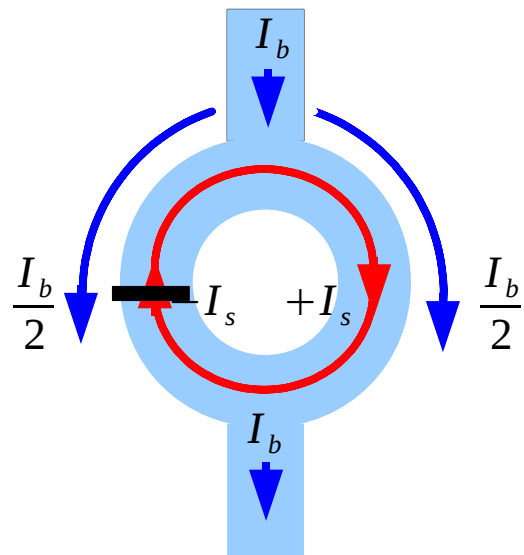
Magnetic Flux Quantum

- min magnetic flux: Φ_0

$$\phi_0 = \frac{h}{2e}$$

$$\frac{d\theta}{dt} = \frac{2qV}{h} = f$$

SQUID



References

- [1] <http://en.wikipedia.org/>
- [2] Nam Ki Min, Sensor Electronics, Dong-il Press
- [3] <http://www.sensorsmag.com/> articles