Magnetic Sensor (3C)

- Josephson Effect
- Magnetic Flux Quantum
- SQUID sensor

Please send corrections (or suggestions) to youngwlim@hotmail.com.

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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 wave function 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**

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

$$I = I_c \sin\theta$$

$$R = 0 \quad \rightarrow \quad V = IR = 0$$

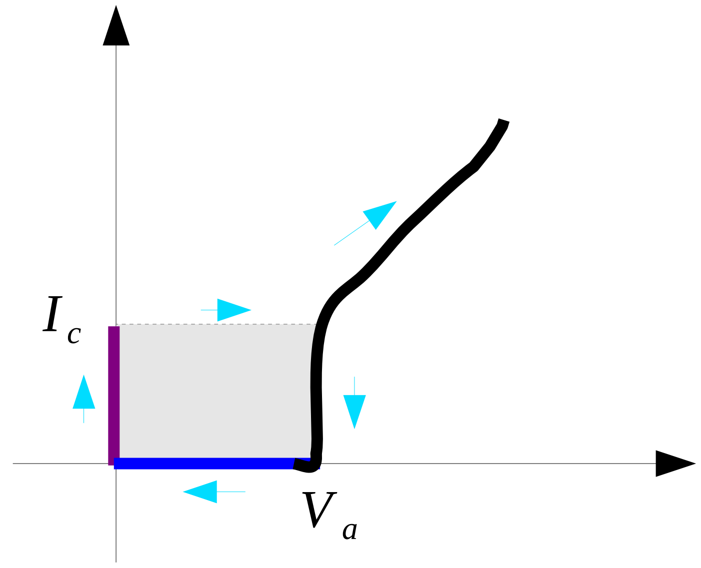
$$I \neq 0 \quad when \quad V = 0$$

$$V \neq 0 \quad when \quad I = 0$$

Young Won Lim
10/3/11

DC Josephson Effect

$$I \neq 0 \quad when \quad V = 0$$



$$V \neq 0 \quad when \quad I = 0$$

AC 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***

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

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

AC current

$$I = I_c \sin\theta$$

DC current

Flux Quantization

The magnetic flux

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

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

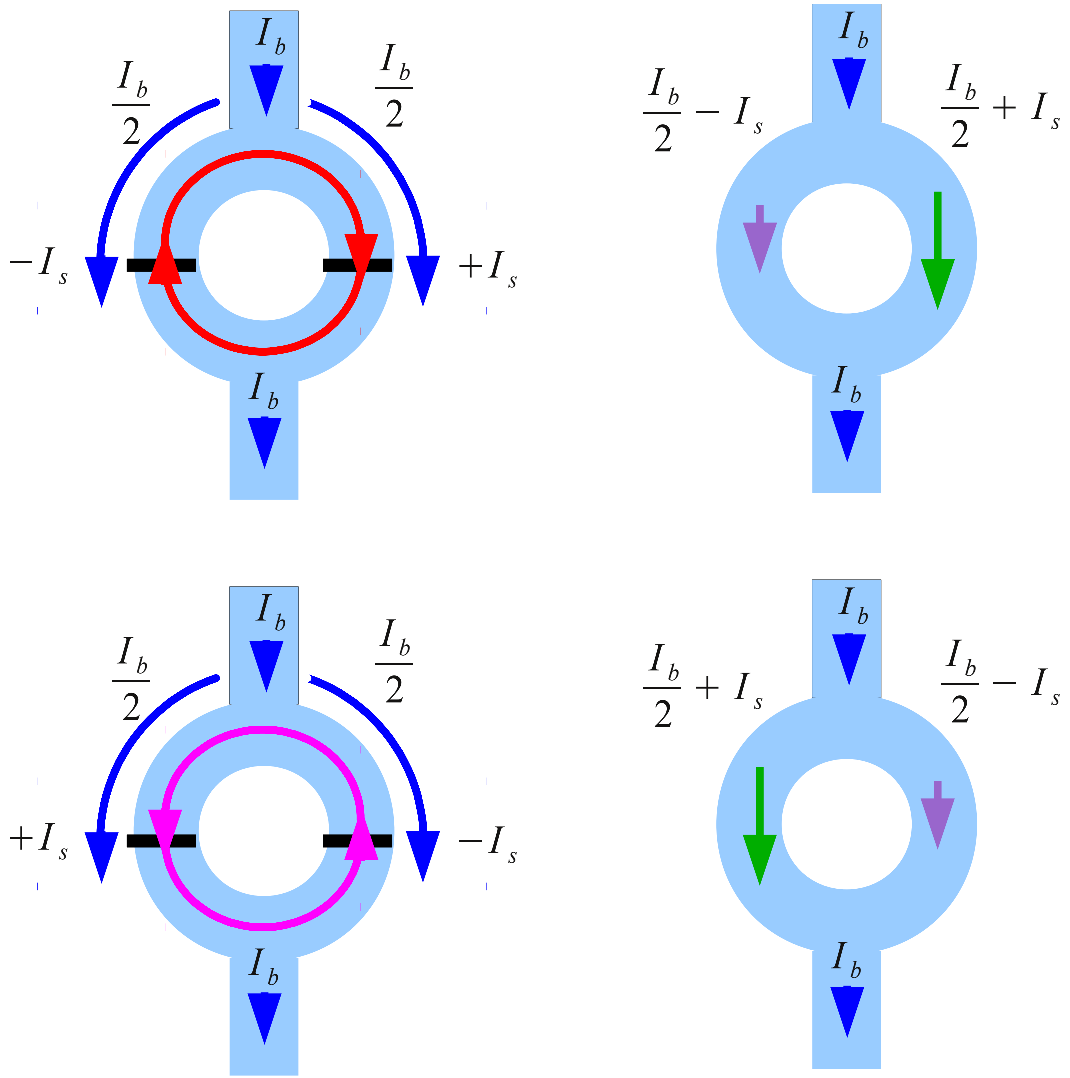
Magnetic Flux Quantum

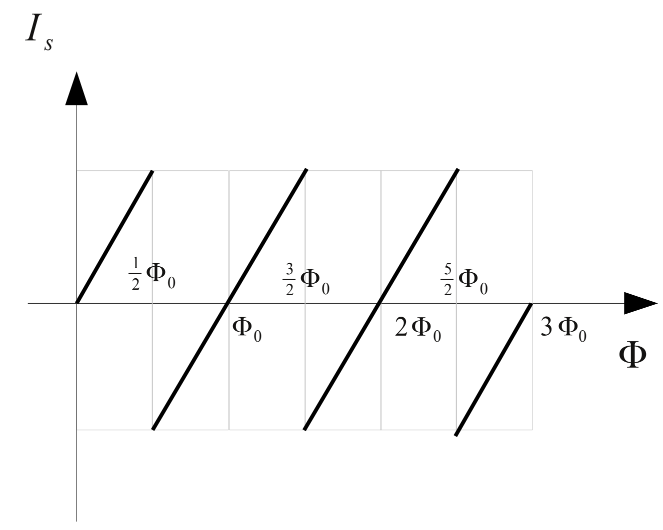
- **min magnetic flux: Φ_0**

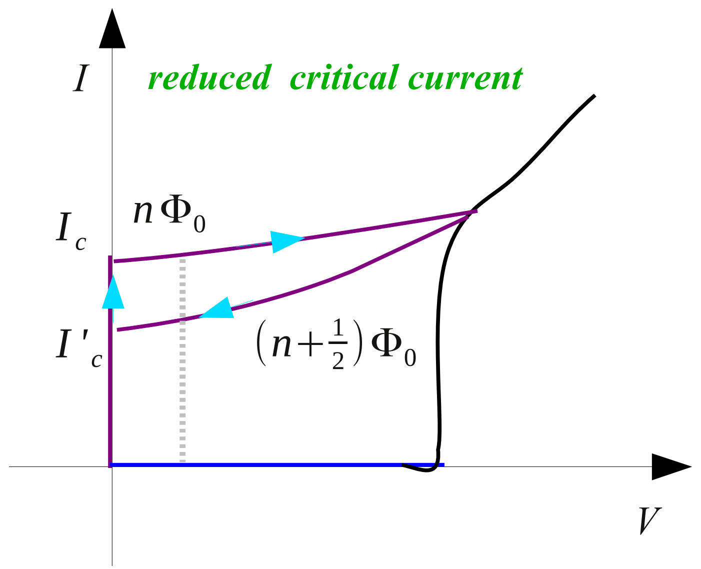
$$\phi_0 = \frac{h}{2e}$$

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

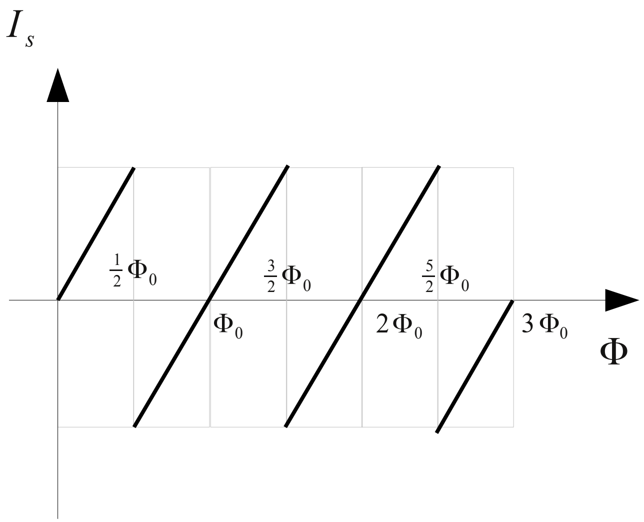
SQUID – Screening Current

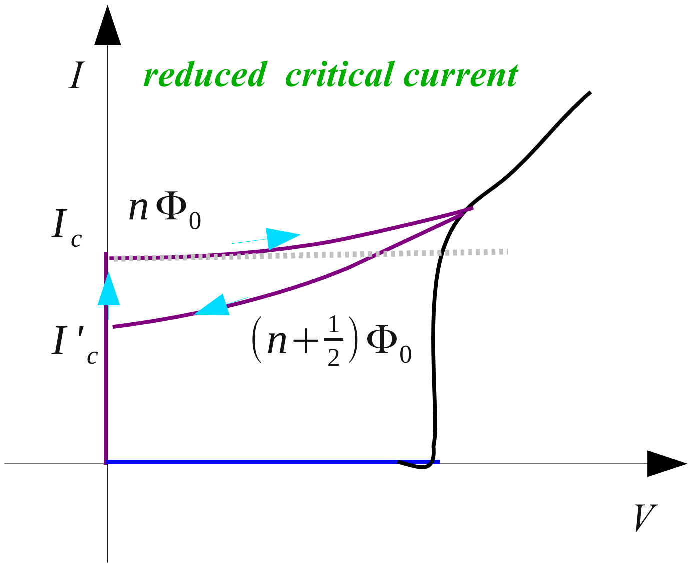


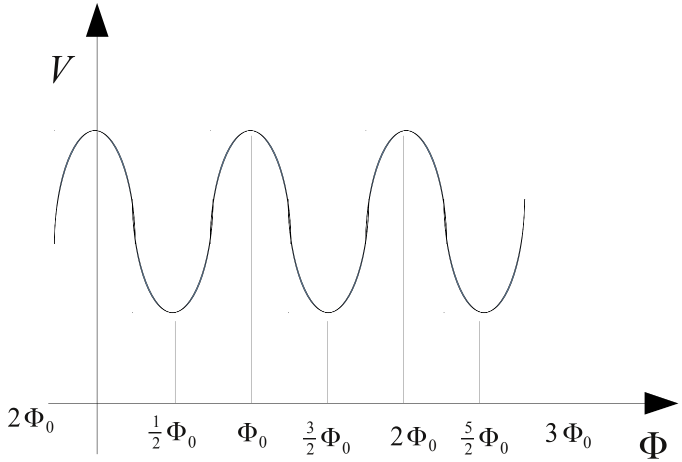




SQUID – Periodic Dependence







References

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