AC JOSEPHSON EFFECT

S | I | S

ψ_1 ψ_2

"PAIR" WAVEFUNCTIONS

"WEAK LINK"

$$i\hbar \frac{\partial \psi_1}{\partial t} = \hbar T \psi_2 - eV\psi_1$$

$$i\hbar \frac{\partial \psi_2}{\partial t} = \hbar T \psi_1 + eV\psi_2$$

"AC"

$$q = 2e$$

$$\psi = n^{\frac{1}{2}} e^{i\theta}$$

$$\frac{\partial n_1}{\partial t} = -\frac{\partial n_2}{\partial t} = 2T(n_1 n_2)^{\frac{1}{2}} \sin\delta$$

$$n_1 \simeq n_2$$

$$n$$

$$\delta = \theta_2 - \theta_1 \qquad \frac{\partial(\theta_2 - \theta_1)}{\partial t} = -\frac{2eV}{\hbar} \qquad (\text{IF } n_1 = n_2)$$

$$\Rightarrow \theta_2 - \theta_1 = -\frac{2eV}{\hbar} t$$

$$J \sim \frac{\partial n_1}{\partial t} = J_0 \sin(\delta(0) - 2eVt/\hbar)$$

OSCILLATES WITH FREQ. $\frac{2eV}{\hbar}$!

$V = 1 \mu V$

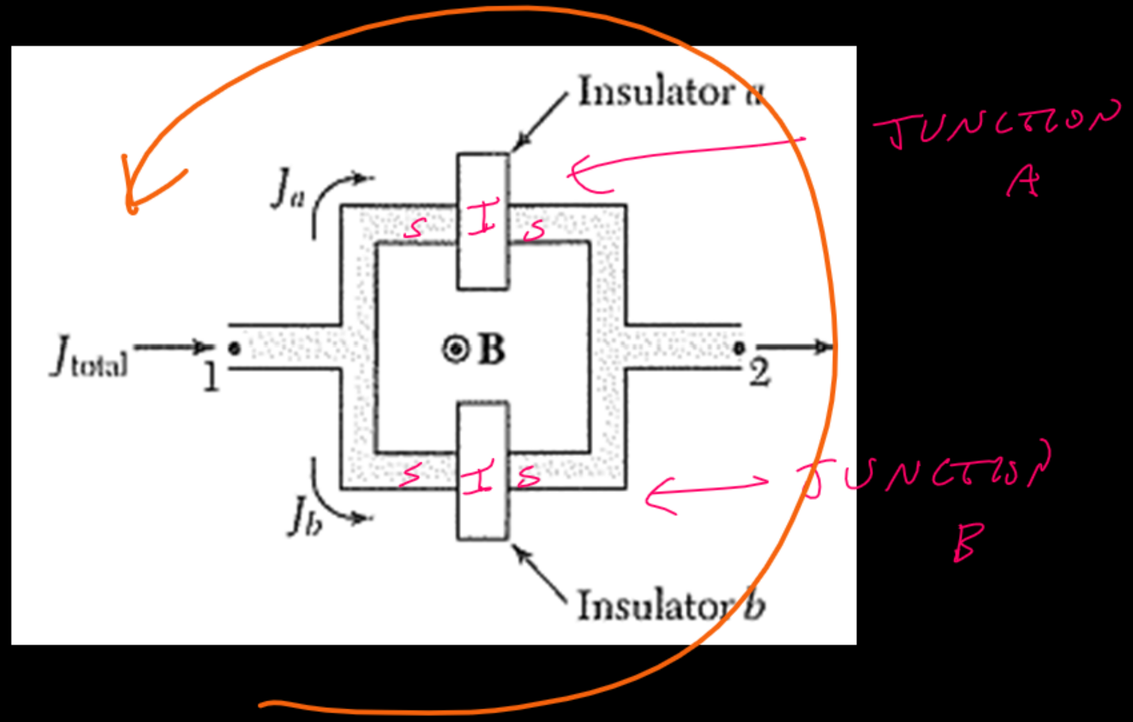
$\omega \approx 483$ MHz

DC VOLTAGE $\Rightarrow$ AC CURRENT

ACCURATE WAY TO MEASURE $e/\hbar$ (PRECISION)

MACROSCOPIC QUANTUM INTERFERENCE

(SQUID)



2 WEAK LINKS

FLUX IS QUANTIZED

$\Phi = BA$

$$\Delta\Theta = \Theta_2 - \Theta_1 = s\,2\pi = \frac{2e}{\hbar c}\Phi$$

(s → INTEGER)

δ_A = PHASE DIFF. ACROSS A

δ_B = PHASE DIFF. ACROSS B

$B = 0 \Rightarrow \delta_A = \delta_B$

$B \neq 0 \Rightarrow \delta_A \neq \delta_B$

$$\delta_A = \delta_0 - \frac{e\Phi}{\hbar c}$$

$$\delta_B = \delta_0 + \frac{e\Phi}{\hbar c}$$

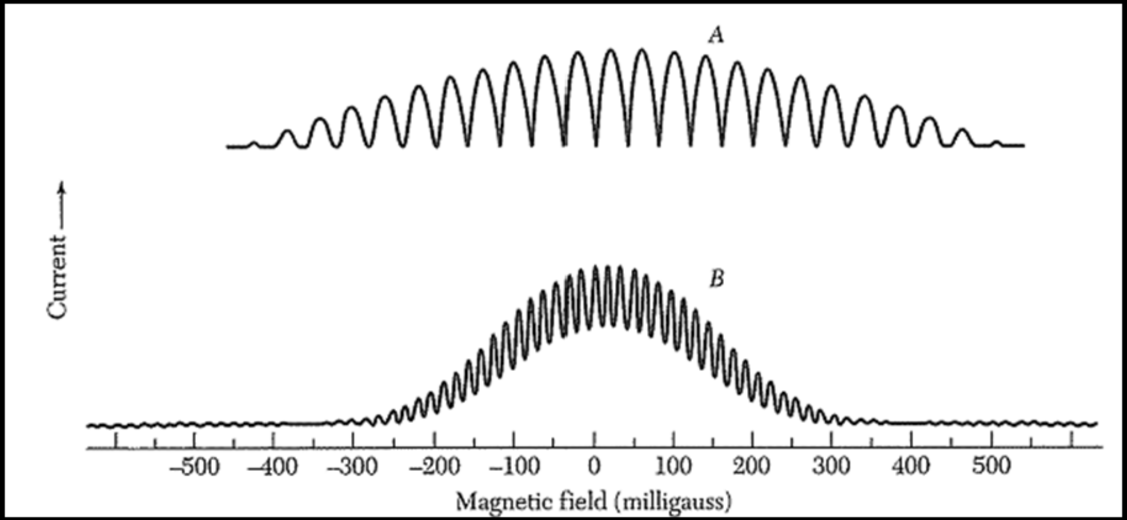
$$\delta_A - \delta_B = \frac{2e\Phi}{\hbar c}$$

$$J_{TOT} = J_A + J_B$$

$$J_{TOT} = J_0 \sin\left(\delta_0 - \frac{e\Phi}{\hbar c}\right) + J_0 \sin\left(\delta_0 + \frac{e\Phi}{\hbar c}\right)$$

$$J_{TOT} = 2 J_0 \sin\delta_0 \cos\frac{e\Phi}{\hbar c}$$

OSCILLATES WITH B & CAN ACCURATELY



(LONGER OSC. IS DUE TO FINITE SIZE!)