Quantum Information with Solid-State Devices

VO 141.246

Dr. Johannes Majer

Lecture 9

ATOMINSTITUT

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RF-SQUID

Quantum superposition of distinct macroscopic states

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external flux Φ_x applied to the loop. The dynamics of the SQUID can be described in terms of the variable Φ and are analogous to those of a particle of 'mass' C (and kinetic energy $\frac{1}{2}C\dot{\Phi}^2$) moving in a one-dimensional potential (Fig. 1a) given by the sum of the magnetic energy of the loop and the Josephson coupling energy of the junction:

$$U = U_0\left[\frac{1}{2}\left(\frac{2\pi(\Phi-\Phi_x)}{\Phi_0}\right)^2 - \beta_L\cos(2\pi\Phi/\Phi_0)\right] \qquad (1)$$

where Φ_0 is the flux quantum, $U_0 \equiv \Phi_0^2/4\pi^2 L$ and $\beta_L \equiv 2\pi L I_c/\Phi_0$. For the parameters used in our experiment, this a double-well potential separated by a barrier with a height depending on I_c. When $\Phi_x = \Phi_0/2$ the potential is symmetric. Any change in Φ_x then tilts the potential, as shown in Fig. 1a.

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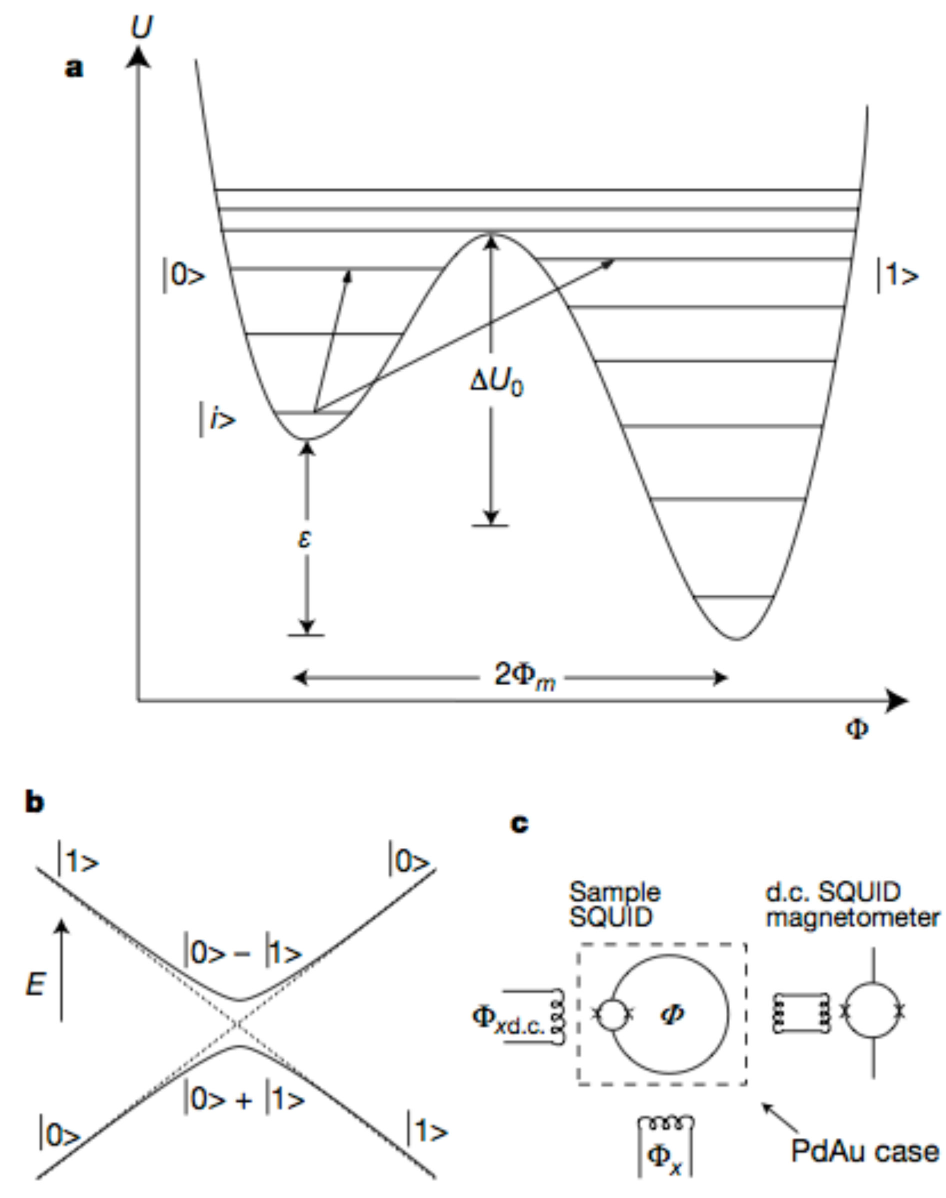
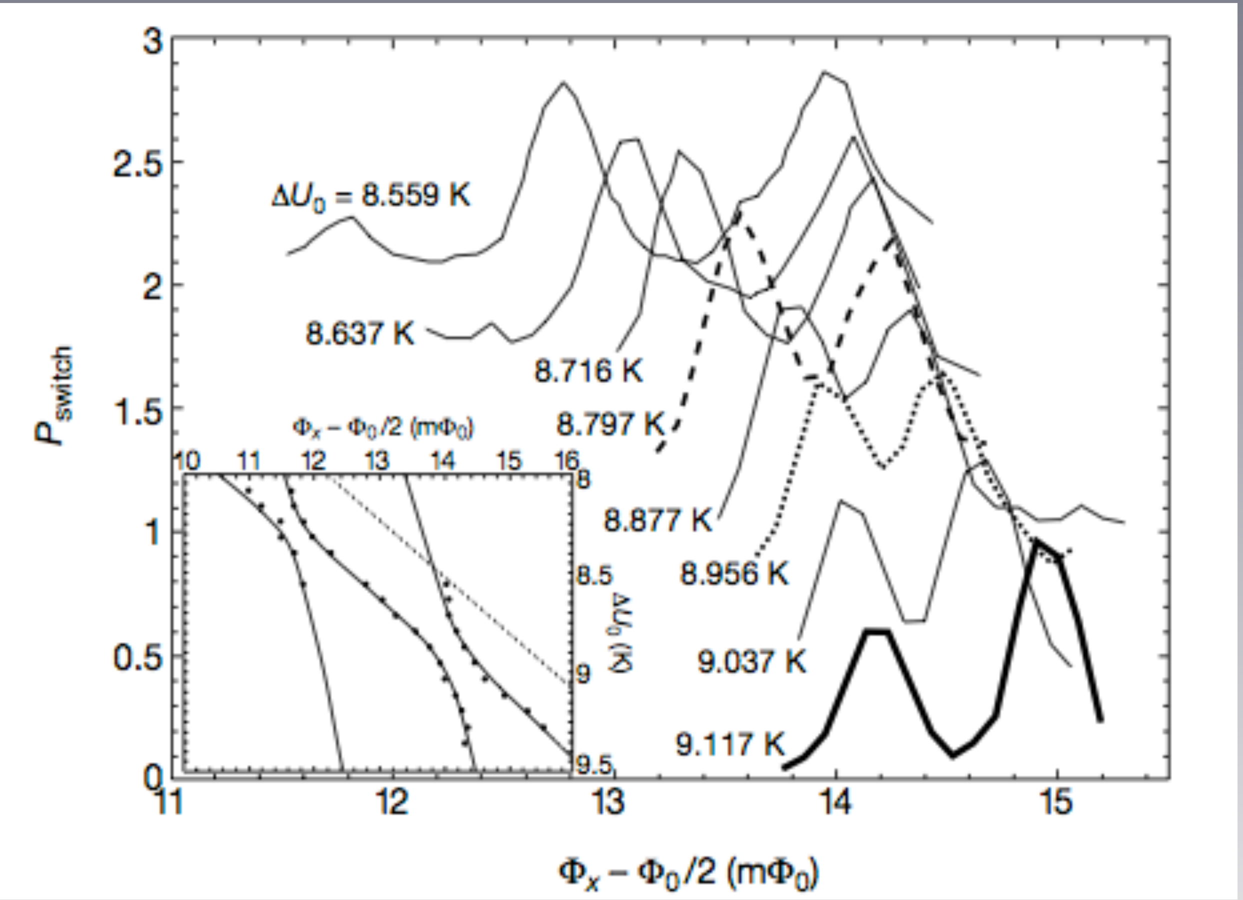
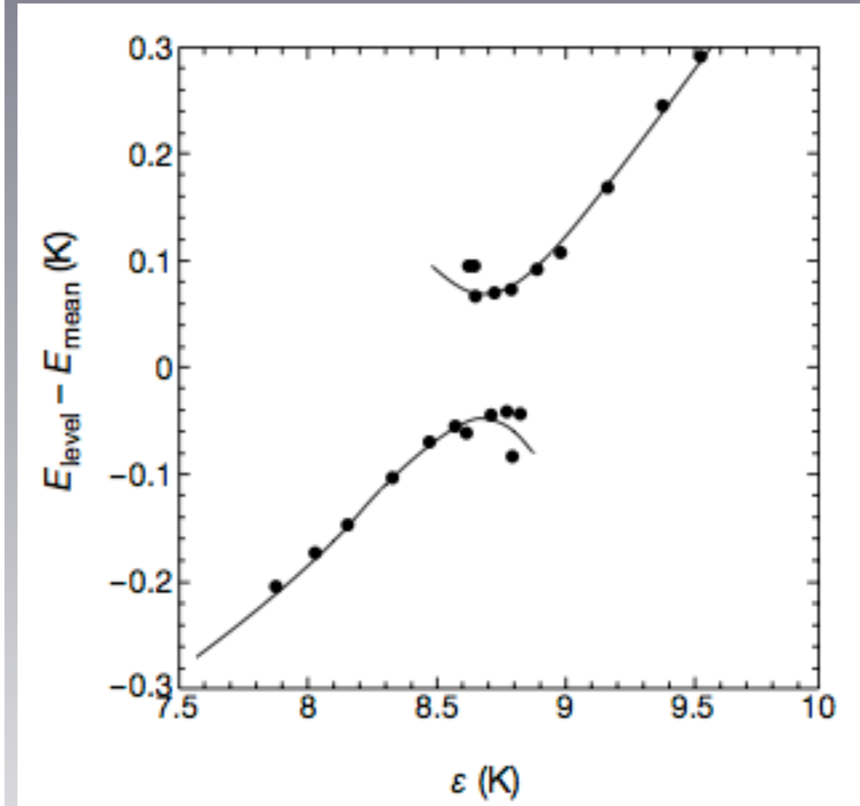


RF-SQUID



ΔU_0 = 8.559 K
8.637 K
8.716 K
8.797 K
8.877 K
8.956 K
9.037 K
9.117 K
P_{switch}
$\Phi_x - \Phi_0/2$ (mΦ_0)
ΔU_0 (K)



$E_{level} - E_{mean}$ (K)
ε (K)

Phase Qubit

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Energy-Level Quantization in the Zero-Voltage State of a Current-Biased Josephson Junction

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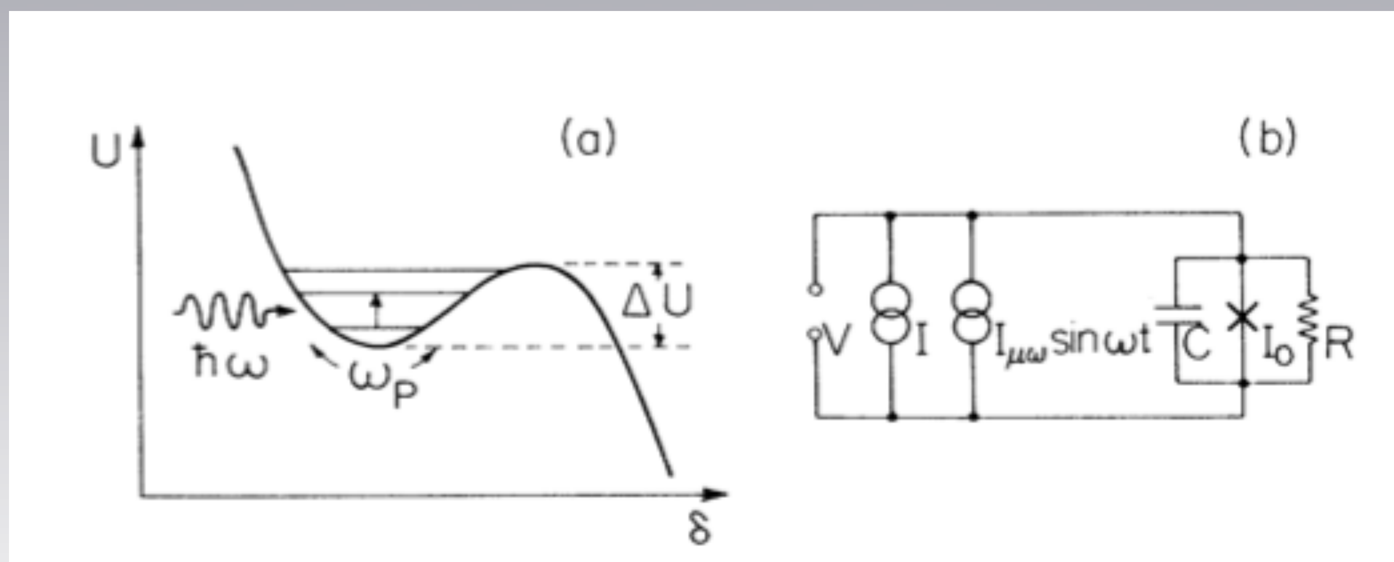
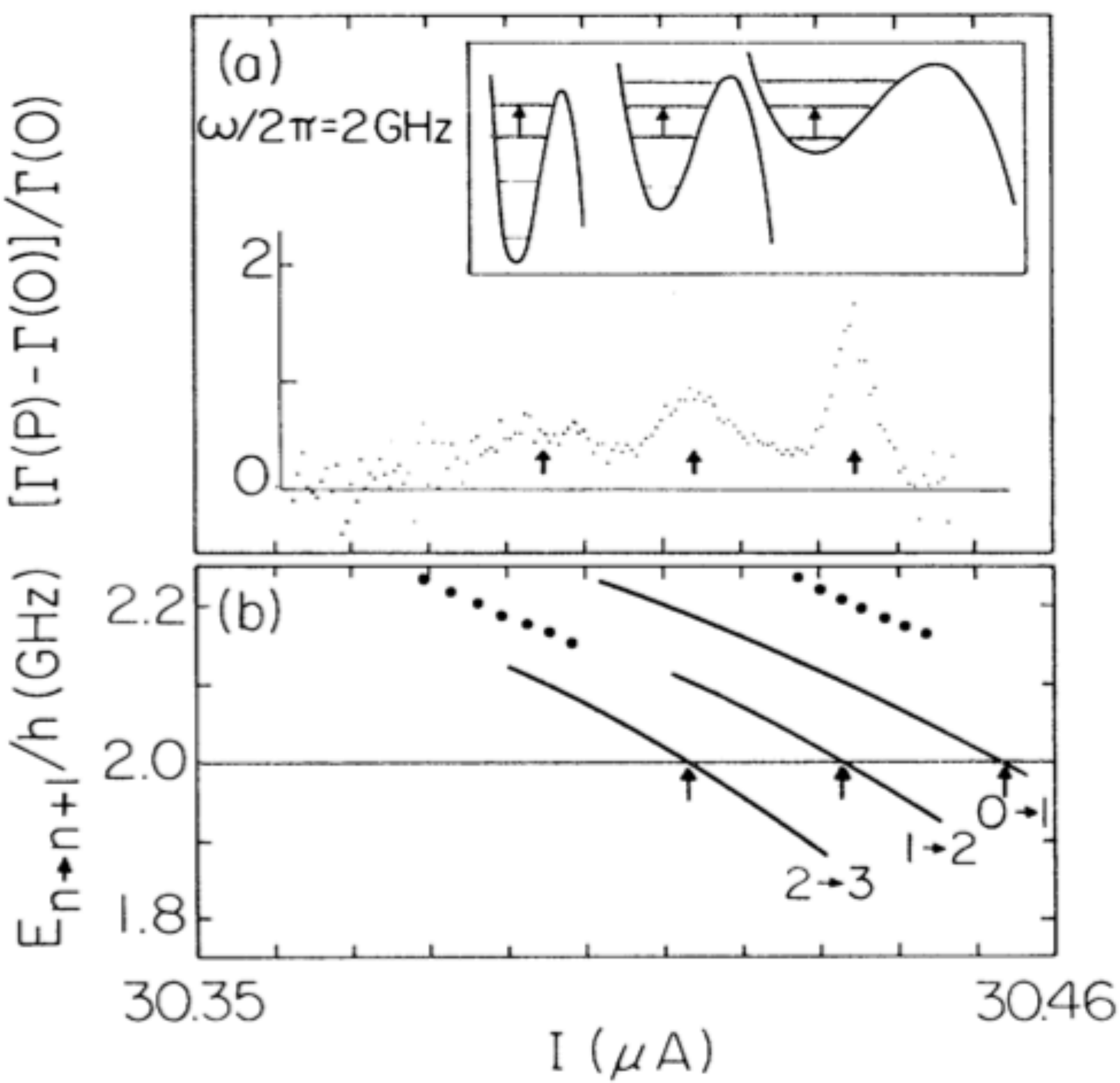


Phase Qubit



(a)
ω/2π=2GHz
[Γ(P)-Γ(O)]/Γ(O)
2
0
(b)
2.2
2.0
1.8
$E_{n\to n+1}/h$ (GHz)
0→1
1→2
2→3
30.35
30.46
I (μA)