Coupled superconducting qubits

new Address from Jan. 2006
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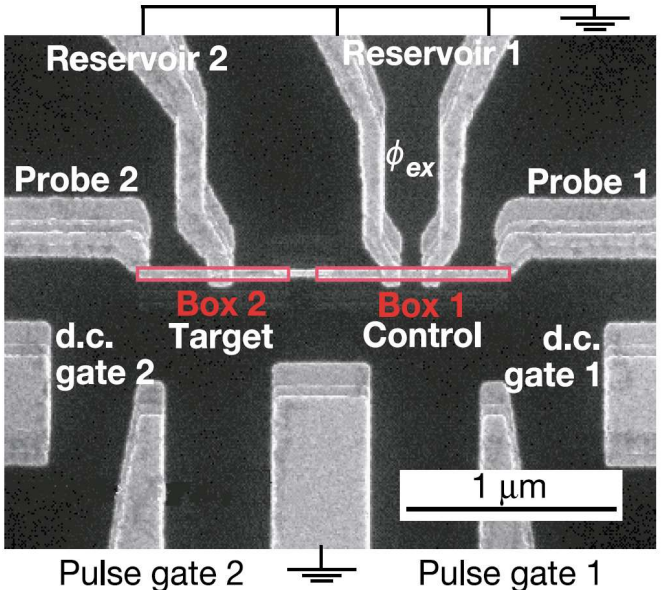
Efficient gates



Charge Basis

$$H=\sum_{n1,n2} E_{ch,n1,n2}\left|n1,n2\right\rangle\left\langle n1,n2\right|$$

$$-\frac{E_{J,1}}{2}\sum_{n}\left(\left|n1\right\rangle\left\langle n1+1\right|+\left|n1\right\rangle\left\langle n1-1\right|\right)\otimes\hat{1}$$

$$-\frac{E_{J,2}}{2}\sum_{n}\hat{1}\otimes\left(\left|n2\right\rangle\left\langle n2+1\right|+\left|n2\right\rangle\left\langle n2-1\right|\right)$$

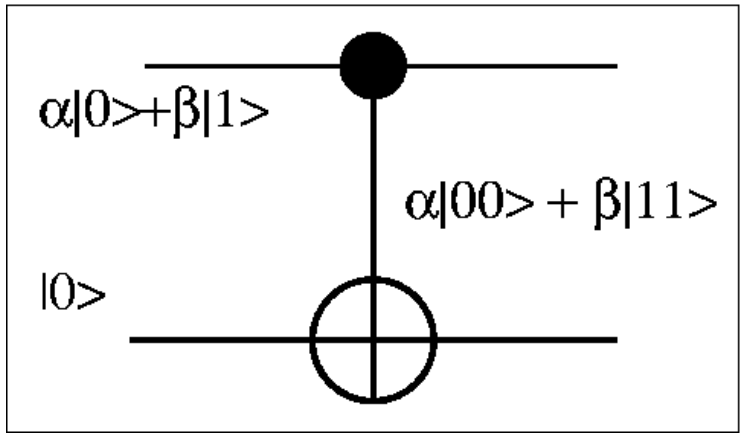
Pseudospin Representation

$$H=\frac{1}{4}\left[E_m(1-2n_{g2})+2E_{c1}(1-2n_{g1})\right]\sigma_z\otimes\hat{1}-\frac{E_{J1}}{2}\sigma_x\otimes\hat{1}$$

$$+\frac{1}{4}\left[E_m(1-2n_{g1})+2E_{c2}(1-2n_{g2})\right]\hat{1}\otimes\sigma_z-\frac{E_{J2}}{2}\hat{1}\otimes\sigma_x+\frac{E_m}{4}\sigma_z\otimes\sigma_z$$

Partially controlled Hamiltonian with crosstalk

CNOT quantum logic gate



Target flips, iff control =1

$$U = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

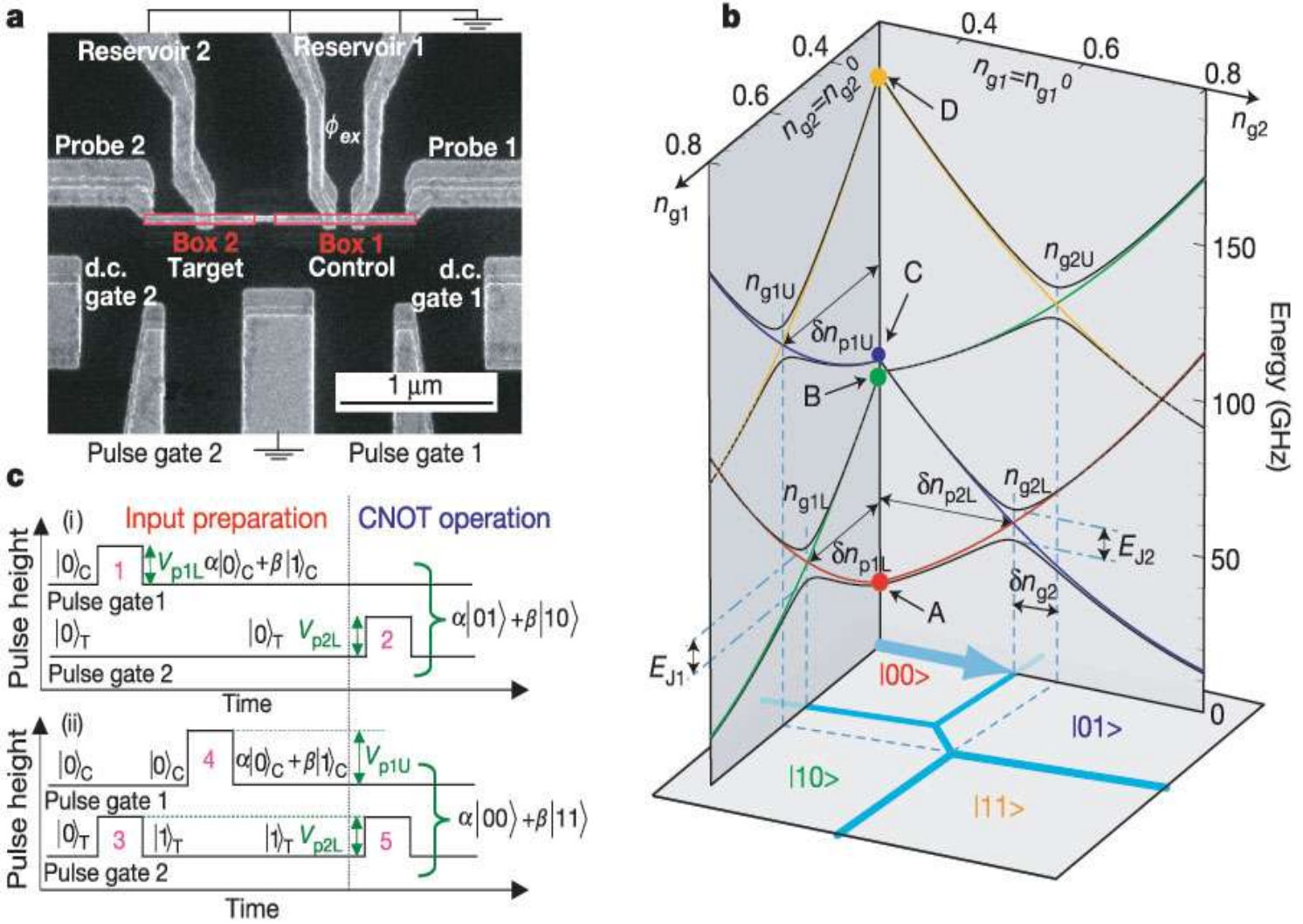
- Part of the standard universal set of gates
- 3 CNOTs + single-qubit rots: Arbitrary 2-qubit gate

- Infidelity $1 - F = \left\| U - U_{CNOT} \right\|_2 < 0.2$

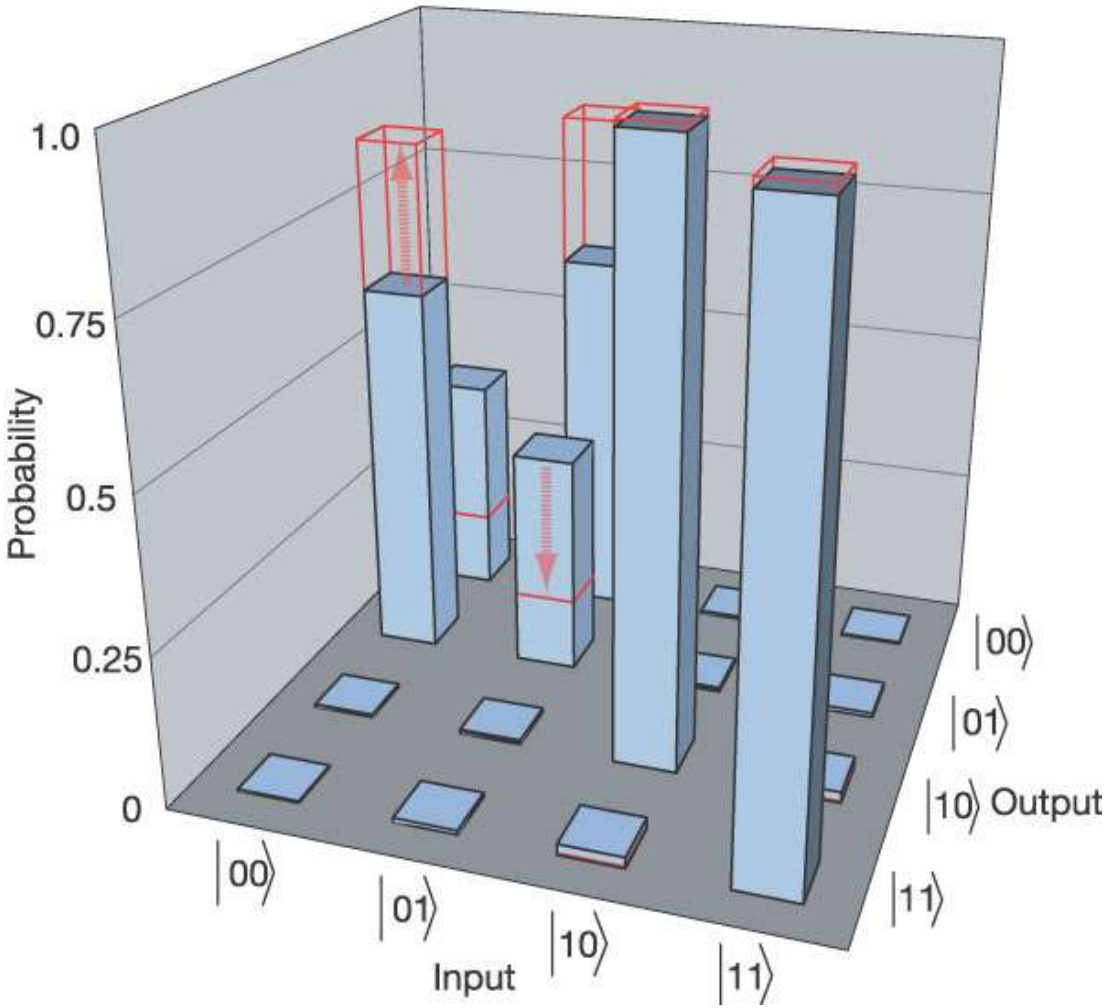
  for showing entangled states at output

G. Vidal and G.M. Dawson, Phys. Rev. A 69, 010301 (2004)

Test object: The NEC CNOT



Experimental status



- Visibility limted by rise times even in theory
- even with short rise time not at all perfect
- phase twist
- not decoherence-limited

T. Yamamoto, Y. A. Pashkin, O. Astaviev, Y. Nakamura, and J. S. Tsai, Nature (London) 425, 941 (2003).

Summary

SUPERCONDUCTING QUANTUM COMPUTING: STATUS AND PROSPECTS *

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We review the experimental and theoretical status of superconducting quantum bits based on Josephson junctions in view of DiVincenzo's criteria.

To appear in „DiVincenzo criteria 2004“, World Scientific and on cond-mat