Quantum Information with Solid-State Devices

VO 141.246

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I Basic Concepts

qubit/quantum bit
Bloch sphere
Rabi oscillation
open quantum systems
density matrix
decoherence/dephasing
Lindblad equation
Ramsey oscillation
echo techniques

Pauli Matrices

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \qquad \sigma_y = \begin{pmatrix} 0 & -\mathrm{i} \\ \mathrm{i} & 0 \end{pmatrix} \qquad \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

$$\sigma_i \sigma_j = \delta_{ij} + \mathrm{i}\epsilon_{ijk}\sigma_k$$

$$\sigma_x \sigma_y = -\sigma_y \sigma_x = \mathrm{i}\sigma_z$$

$$\sigma_x^2 = \sigma_y^2 = \sigma_z^2 = \mathbb{1}$$

$$[\sigma_x, \sigma_y] = 2\mathrm{i}\sigma_z$$

$$\{\sigma_x, \sigma_y\} = 0$$

$$\mathrm{Tr}(\sigma_i) = 0$$

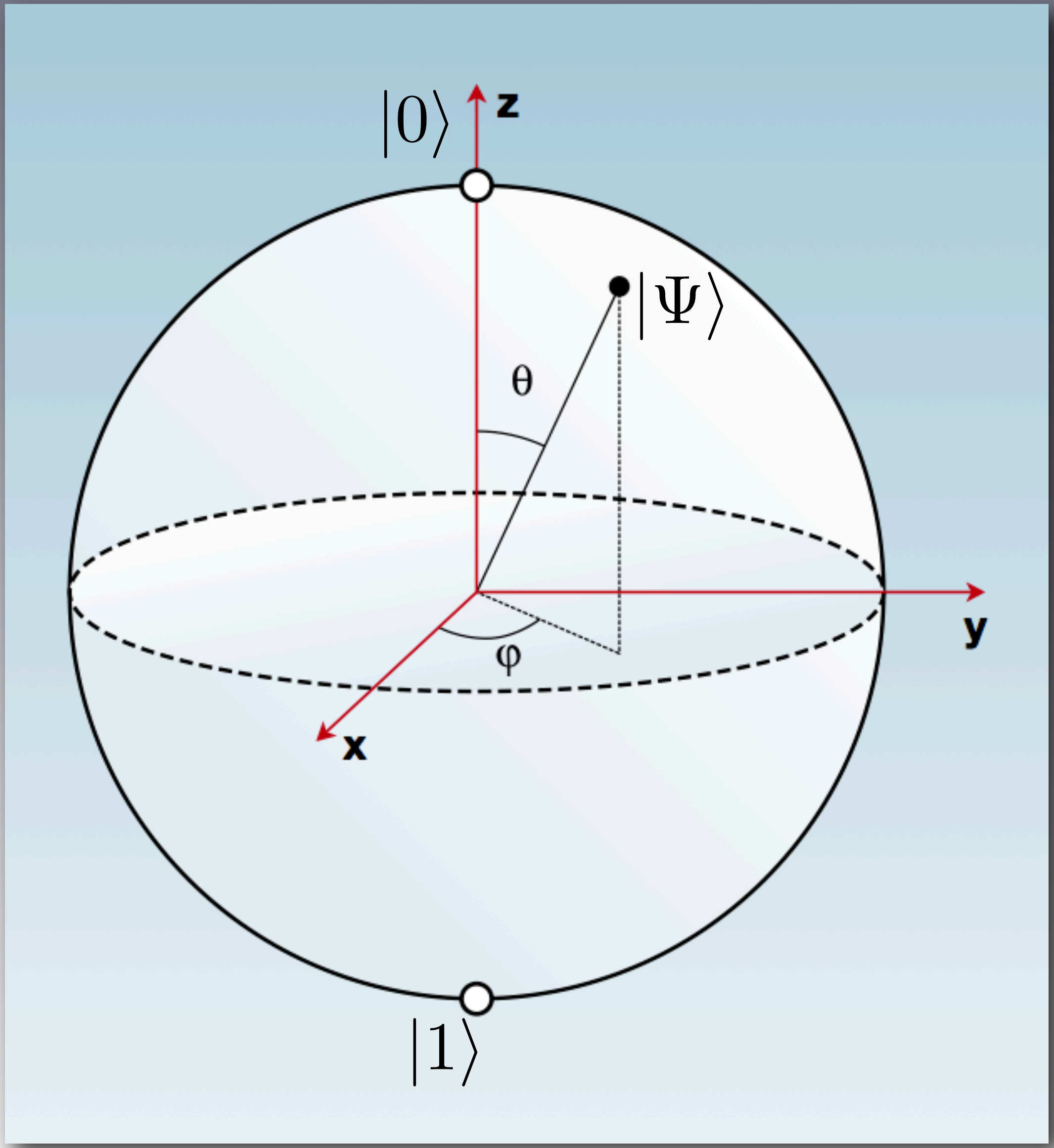
$$\det(\sigma_i) = -1$$

$$\sigma_+ = \frac{1}{2}(\sigma_x + \mathrm{i}\sigma_y) = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$$

$$\sigma_- = \frac{1}{2}(\sigma_x - \mathrm{i}\sigma_y) = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

$$\sigma_x = \sigma_+ + \sigma_- \qquad \sigma_y = \frac{1}{\mathrm{i}}(\sigma_+ - \sigma_-)$$

Bloch Sphere



pure state

$$x = \sin(\theta)\cos(\varphi)$$

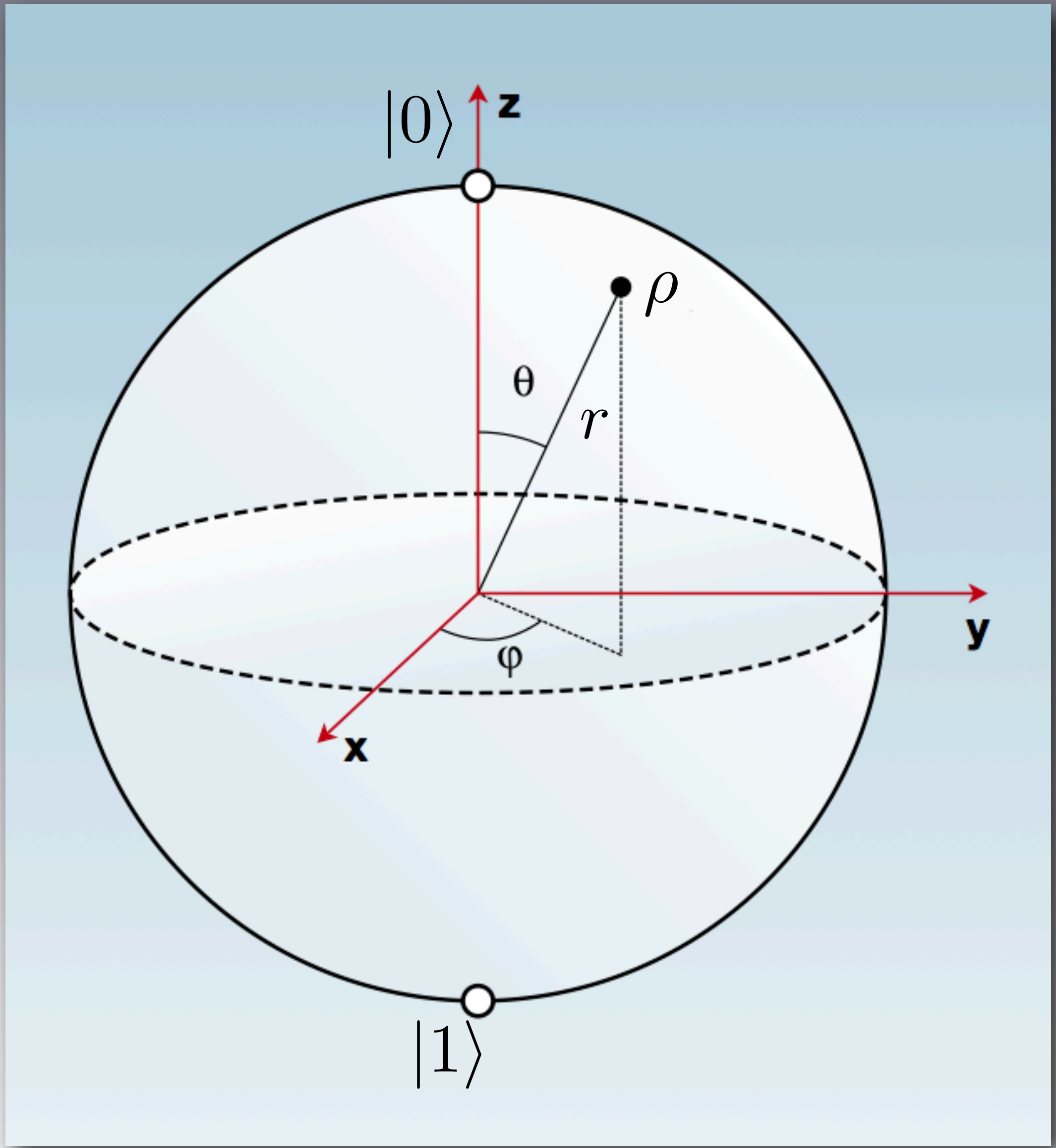
$$y = \sin(\theta)\sin(\varphi)$$

$$z = \cos(\theta)$$

$$|\Psi\rangle = \cos(\theta/2)\,|0\rangle + \sin(\theta/2)e^{i\varphi}\,|1\rangle$$

Bloch Sphere

density matrix



$$x = r\sin(\theta)\cos(\varphi)$$

$$y = r\sin(\theta)\sin(\varphi)$$

$$z = r\cos(\theta)$$

$$x = \mathrm{tr}(\rho\sigma_x) = \rho_{12} + \rho_{21}$$

$$y = \mathrm{tr}(\rho\sigma_y) = i\rho_{12} - i\rho_{21}$$

$$z = \mathrm{tr}(\rho\sigma_z) = \rho_{11} - \rho_{22}$$