Quantum Information with Solid-State Devices

VO 141.A55
SS2016
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Lecture 2

ATOMINSTITUT
Solids 4 Fun BUILDING SOLIDS FOR FUNCTION
CoQuS ComplexQuantumSystems
TU WIEN

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

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

The Pauli matrices σ_i are hermitian and unitary. Eigenvalues are -1,1.

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

$$\sigma_x \sigma_y = -\sigma_y \sigma_x = \mathrm{i}\sigma_z$$
$$\sigma_x^2 = \sigma_y^2 = \sigma_z^2 = \mathbb{1}$$
$$[\sigma_x, \sigma_y] = 2\mathrm{i}\sigma_z$$
$$\{\sigma_x, \sigma_y\} = 0$$

$$\mathrm{Tr}(\sigma_i) = 0$$
$$\det(\sigma_i) = -1$$

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

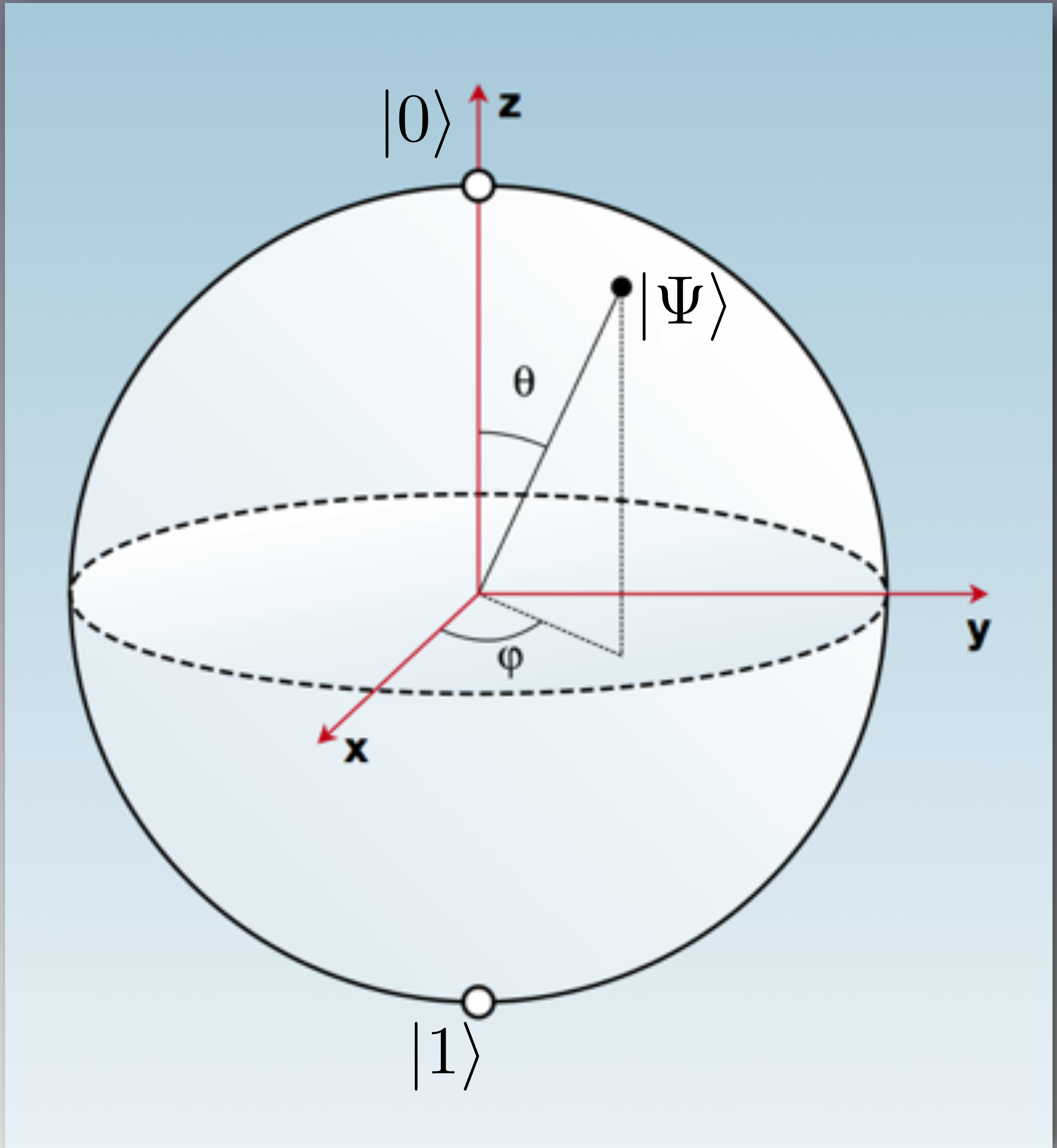
$$\sigma_- = \frac{1}{2}(\sigma_x - \mathrm{i}\sigma_y) = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

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

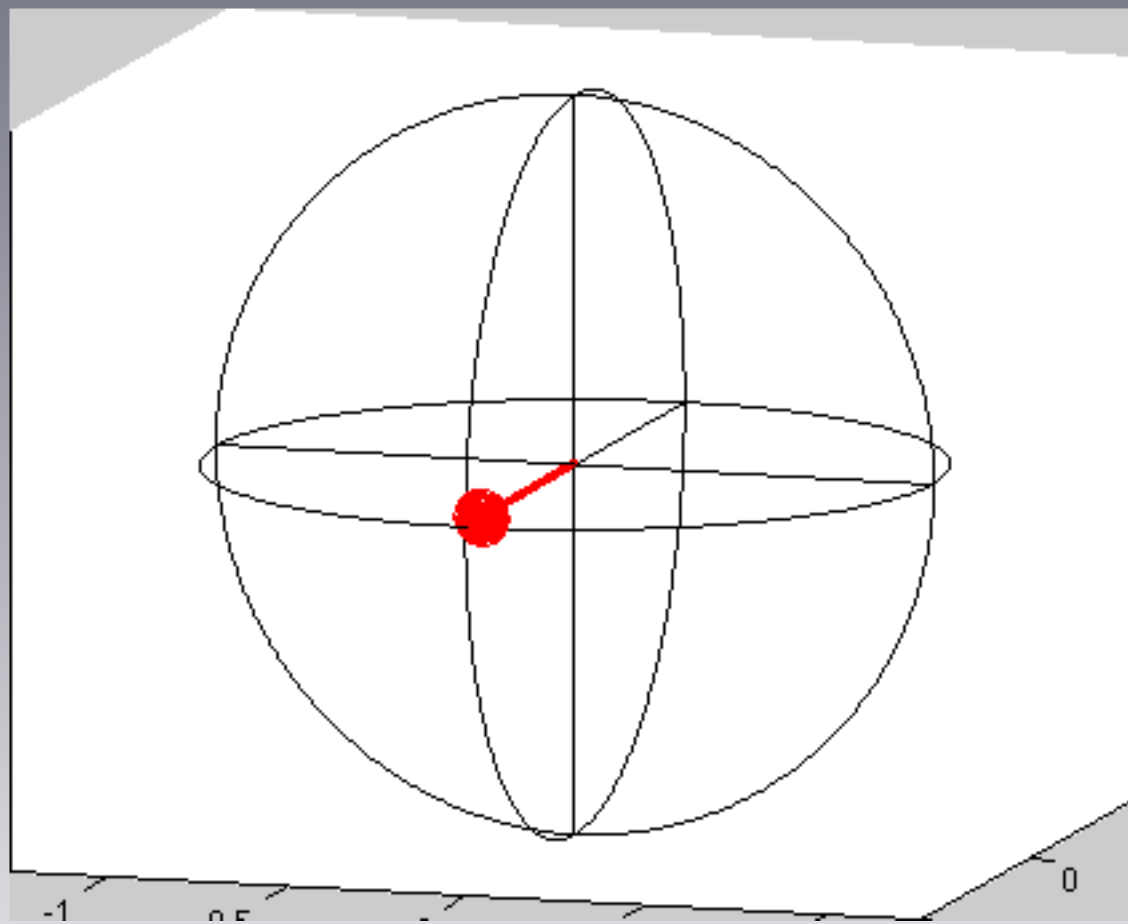
$$\sigma_+\sigma_- = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} \qquad \sigma_-\sigma_+ = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$$

$$\mathbb{1} = \sigma_+\sigma_- + \sigma_-\sigma_+ \qquad \sigma_z = \sigma_+\sigma_- - \sigma_-\sigma_+ \quad 2\sigma_+\sigma_- = \mathbb{1} + \sigma_z$$

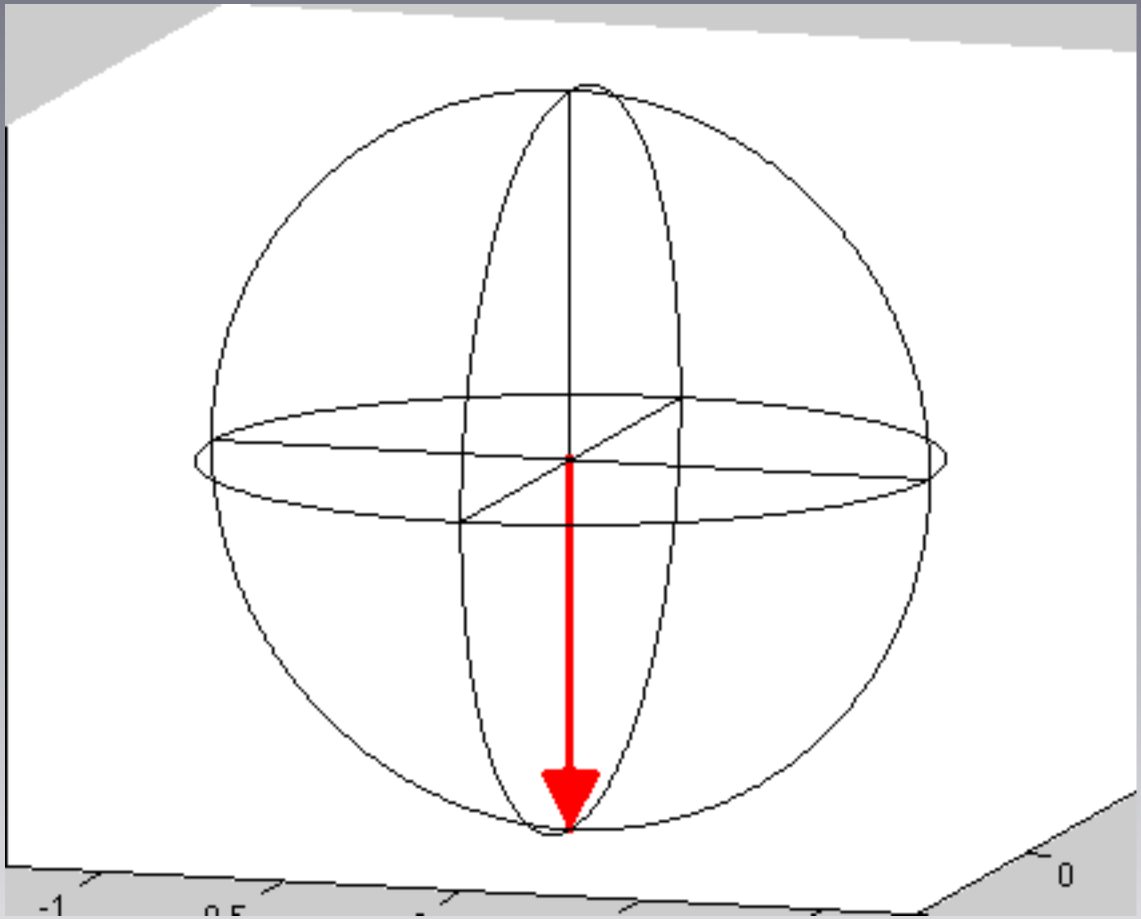
Bloch Sphere



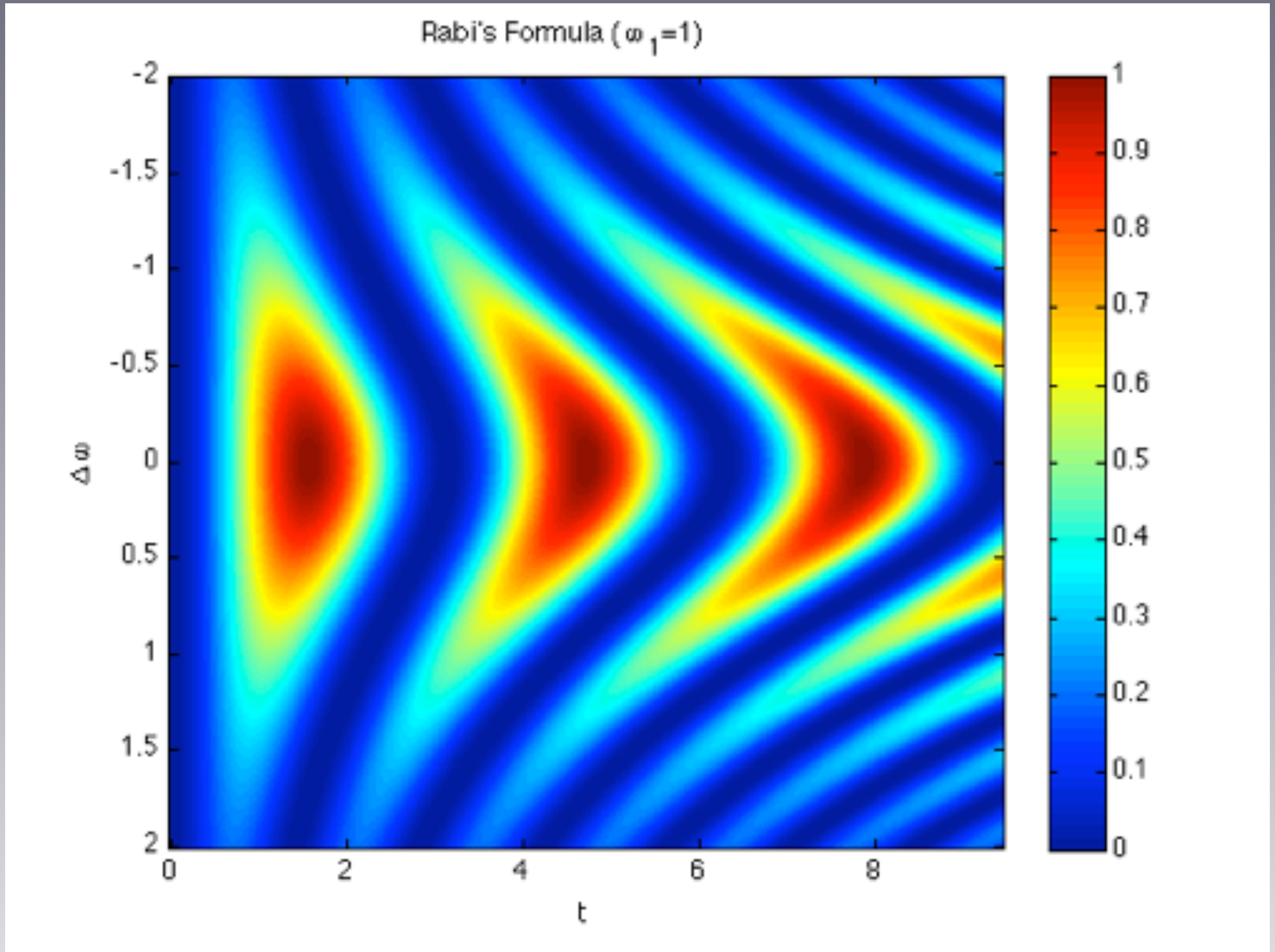
Larmor Precession



Rabi

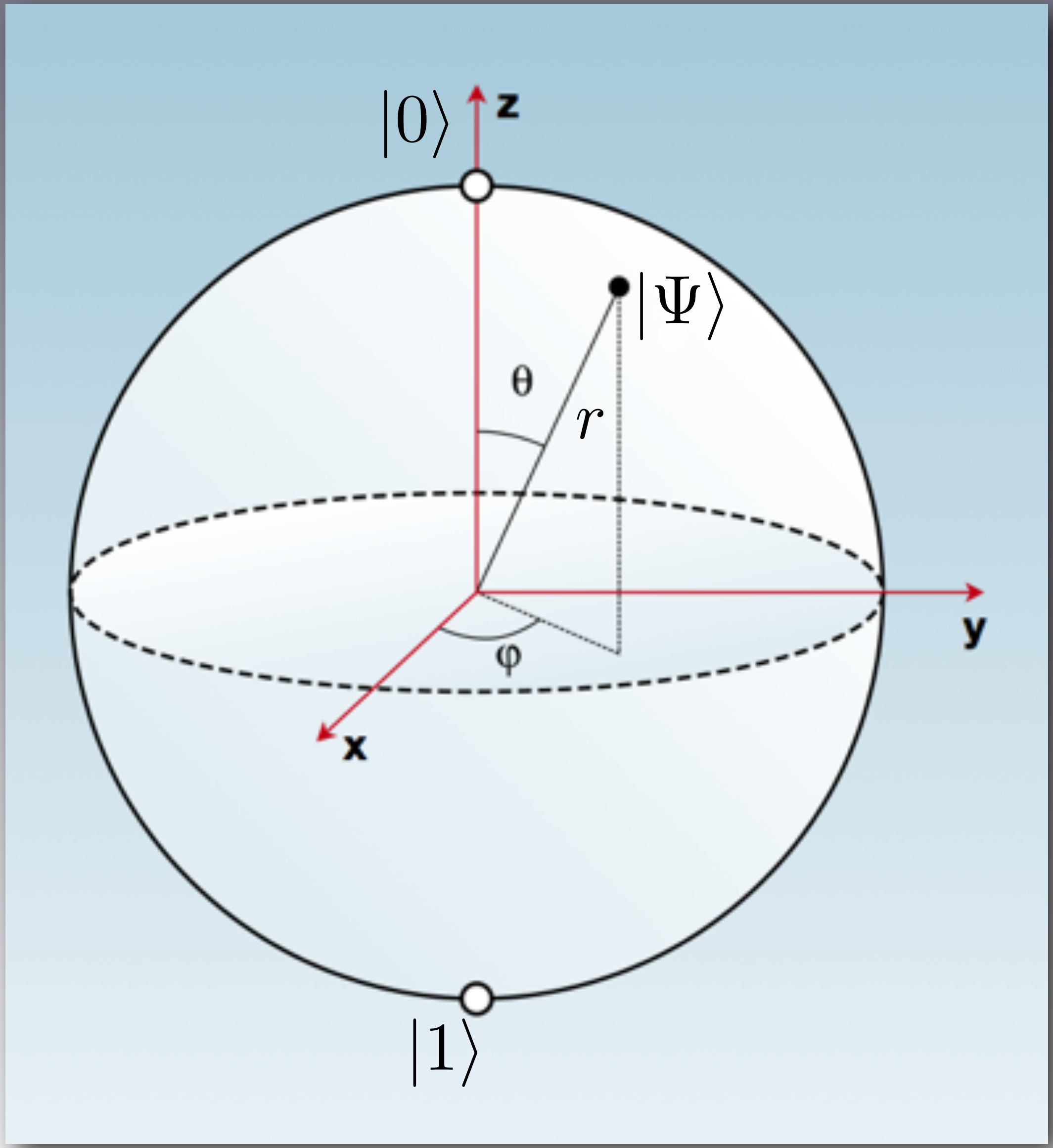


Rabi's Formula



$$P_1(t) = \frac{\omega_1^2}{\omega_1^2 + \Delta\omega^2} \sin(\sqrt{\omega_1^2 + \Delta\omega^2} t)^2$$

Bloch Sphere



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

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

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

References Lecture 2

Modern Quantum Mechanics
J. J. Sakurai
Addison Wesley

Quantum Computation and Quantum Information
Michael A. Nielsen, Isaac L. Chuang
Cambridge University Press