

# Quantum Information with Solid-State Devices

VO I4I.246  
Dr. Johannes Majer



# Lecture Notes

## 15 March 2010 - Lecture 1 Introduction

QISS Lecture Notes 1.pdf

## 22 March 2010 - Lecture 2

QISS Lecture 2 Notes.pdf

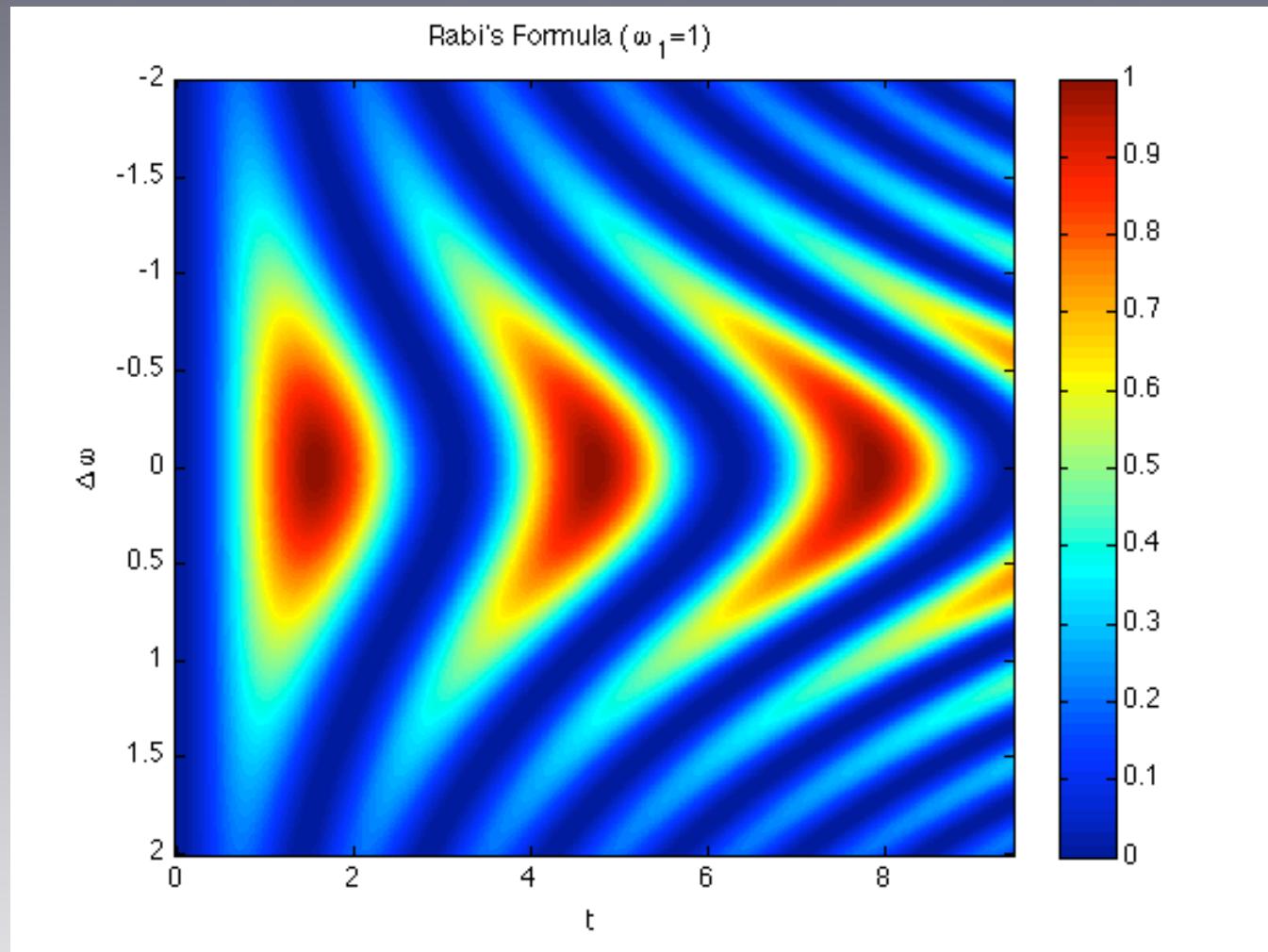
QISS Lecture 2 Slides.pdf

Matlab Lecture 2.zip

The screenshot shows a Mac OS X Finder window with a title bar "Matlab Lecture 2". The window contains a sidebar on the left with sections for "DEVICES", "SHARED", and "PLACES", and a main list view on the right showing files in the "Matlab Lecture 2" folder. The list view has columns for Name, Date Modified, Size, and Kind. The files listed are all MATLAB scripts (m files) and were created between March 28 and March 30, 2010.

Name	Date Modified	Size	Kind
blochAngles.m	March 29, 2010 15:39	4 KB	MATLAB
blochVectorAnim.m	March 28, 2010 20:37	4 KB	MATLAB
Contents.m	March 30, 2010 20:45	4 KB	MATLAB
draw3DArrow.m	March 28, 2010 20:36	8 KB	MATLAB
drawBlochSphere.m	March 28, 2010 14:06	8 KB	MATLAB
Hamiltonian.m	March 30, 2010 20:46	4 KB	MATLAB
LarmorPrecession.m	March 29, 2010 16:13	4 KB	MATLAB
RabiOscillation.m	March 30, 2010 20:46	4 KB	MATLAB
RabisFormula.m	March 30, 2010 20:46	4 KB	MATLAB
unitaryEvolution.m	March 30, 2010 20:46	4 KB	MATLAB

# Rabi's Formula



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

# Supplement

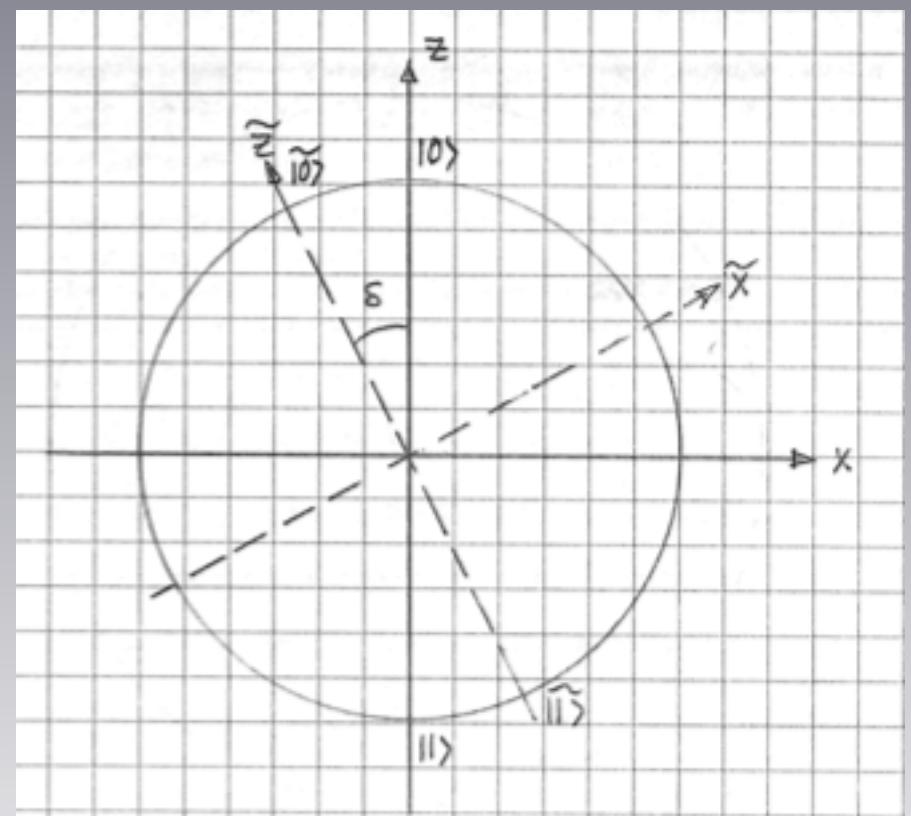
$$\hat{H} = \alpha G_z + \beta G_x = \begin{pmatrix} \alpha & \beta \\ \beta & -\alpha \end{pmatrix}$$

$$\tilde{\hat{H}} = \begin{pmatrix} \sqrt{\alpha^2 + \beta^2} & 0 \\ 0 & -\sqrt{\alpha^2 + \beta^2} \end{pmatrix}$$

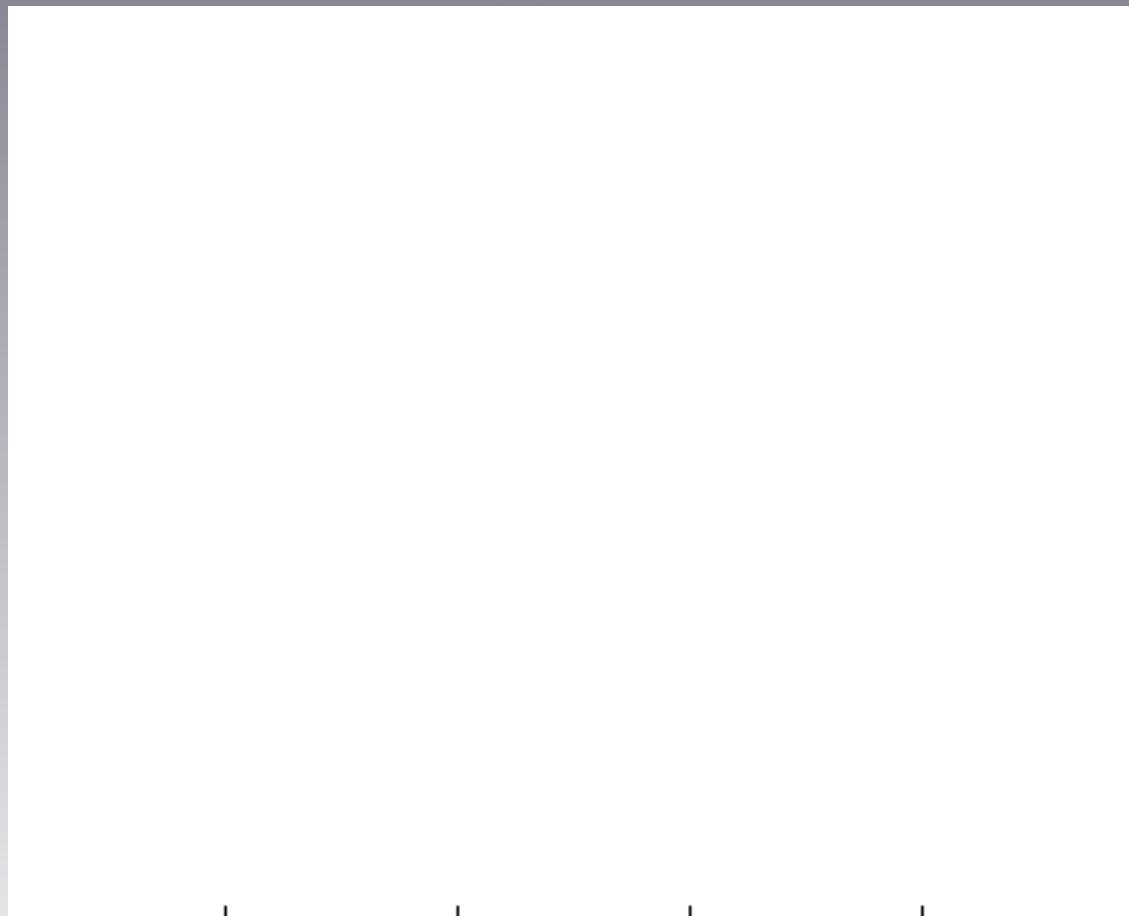
$$U = \begin{pmatrix} \cos(\delta/2) & \sin(\delta/2) \\ -\sin(\delta/2) & \cos(\delta/2) \end{pmatrix}$$

$$\tan(\delta) = \frac{\beta}{\alpha}$$

$$\hat{H} = U^\dagger \tilde{\hat{H}} U$$



# Relaxation



# Motivation

Solid-state qubit  
+environment



open quantum system

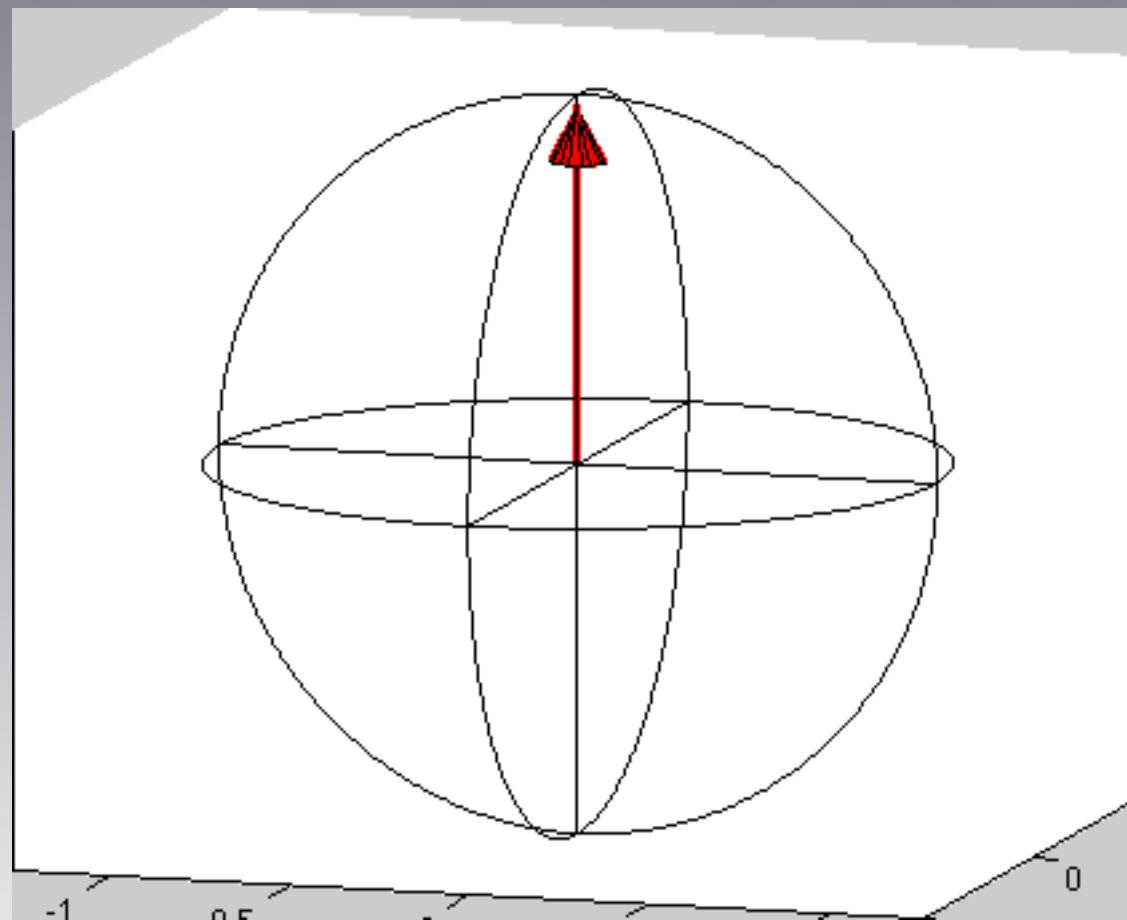
can we describe the qubit with few parameters?

dephasing rate, relaxation time, ...

how to measure them?

relaxation measurement, Ramsey, Hahnecho

# Relaxation

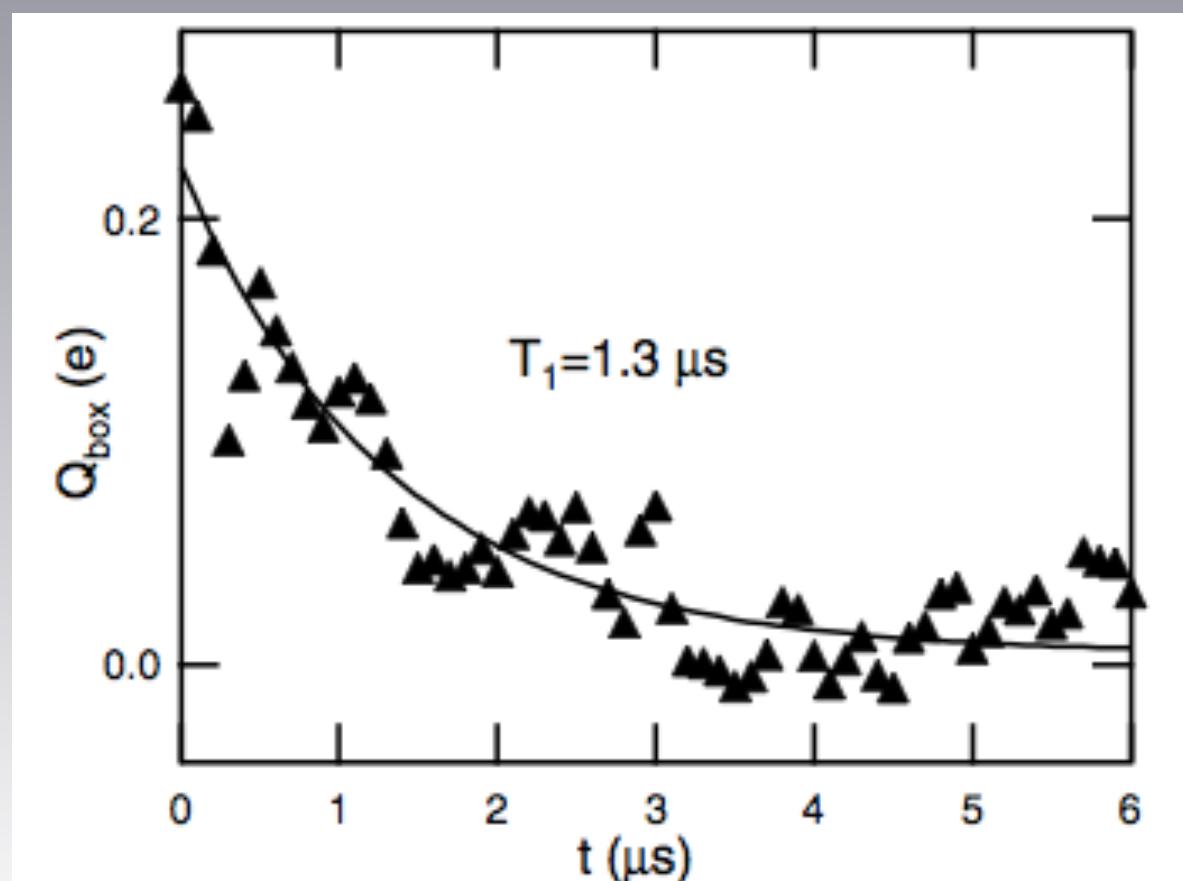


## Measurement of the Excited-State Lifetime of a Microelectronic Circuit

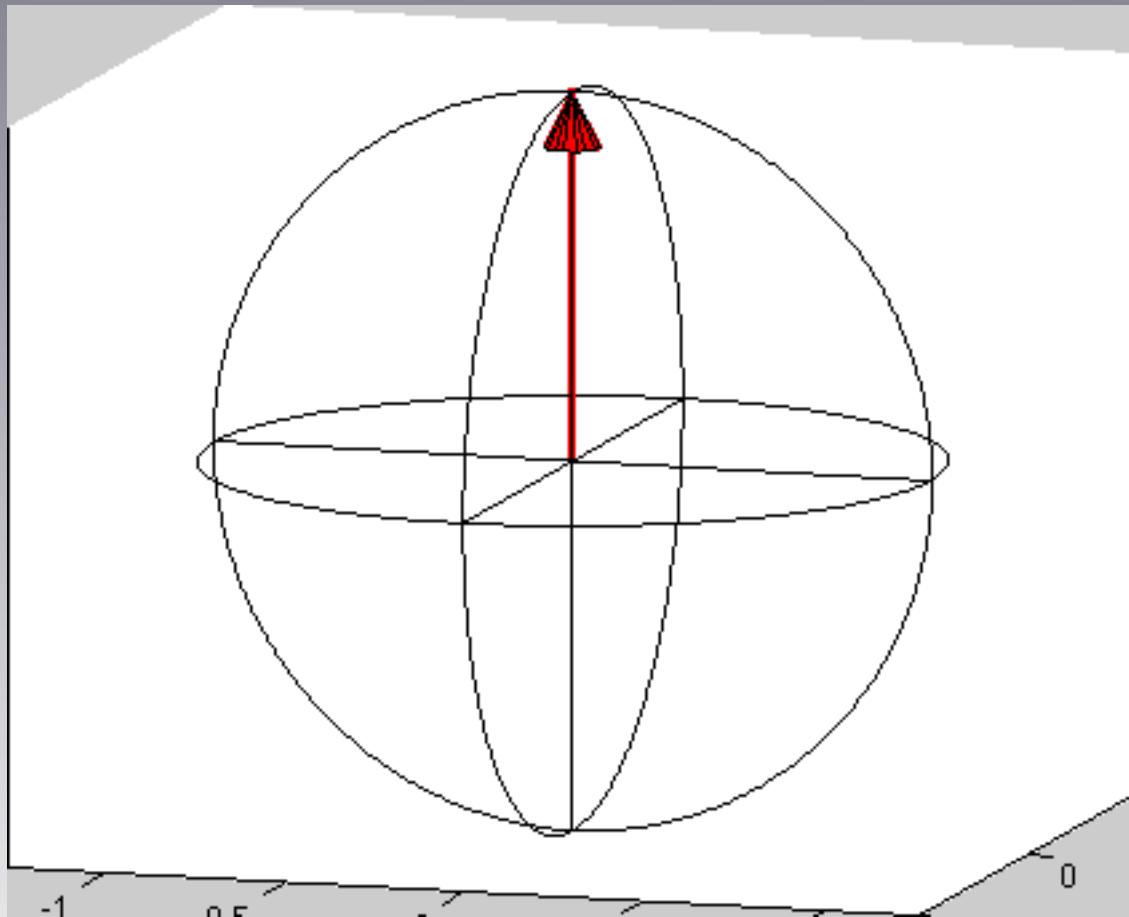
K. W. Lehnert,<sup>1,\*</sup> K. Bladh,<sup>2</sup> L. F. Spietz,<sup>1</sup> D. Gunnarsson,<sup>2</sup> D. I. Schuster,<sup>1</sup> P. Delsing,<sup>2</sup> and R. J. Schoelkopf<sup>1</sup>

<sup>1</sup>*Department of Applied Physics and Physics, Yale University, New Haven, Connecticut 06511*

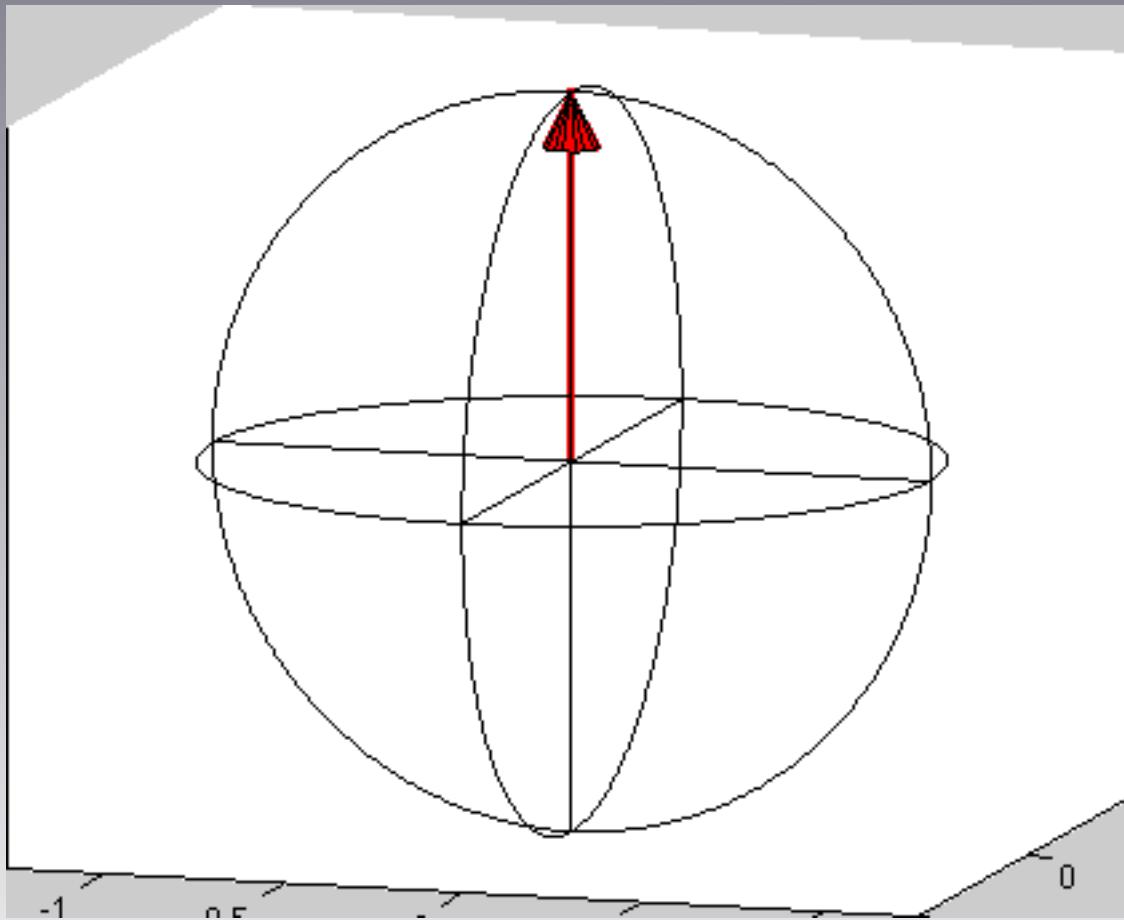
<sup>2</sup>*Microtechnology Center at Chalmers MC2, Department of Microelectronics and Nanoscience, Chalmers University of Technology and Göteborg University, SE-412 96, Göteborg, Sweden*  
(Received 20 June 2002; published 17 January 2003)



# Ramsey Oscillations



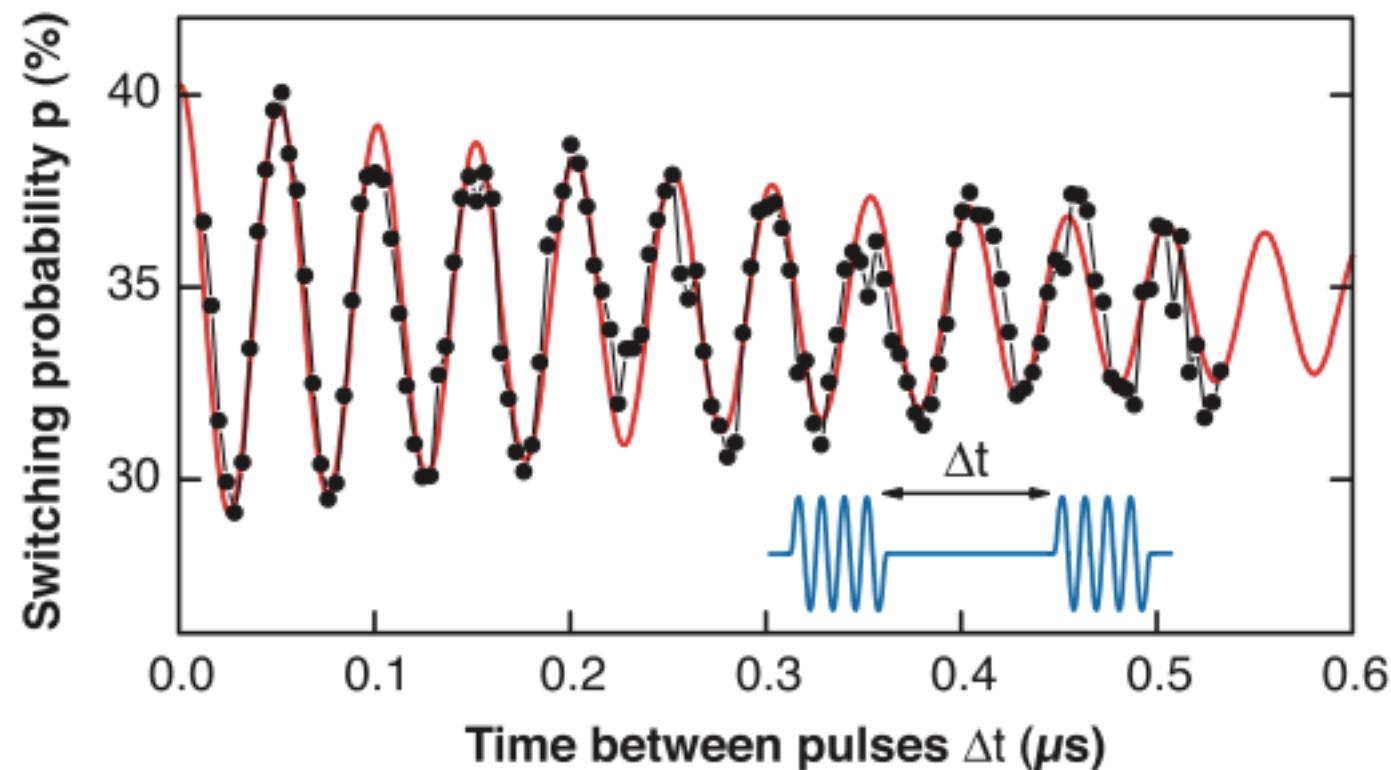
# Ramsey Oscillations



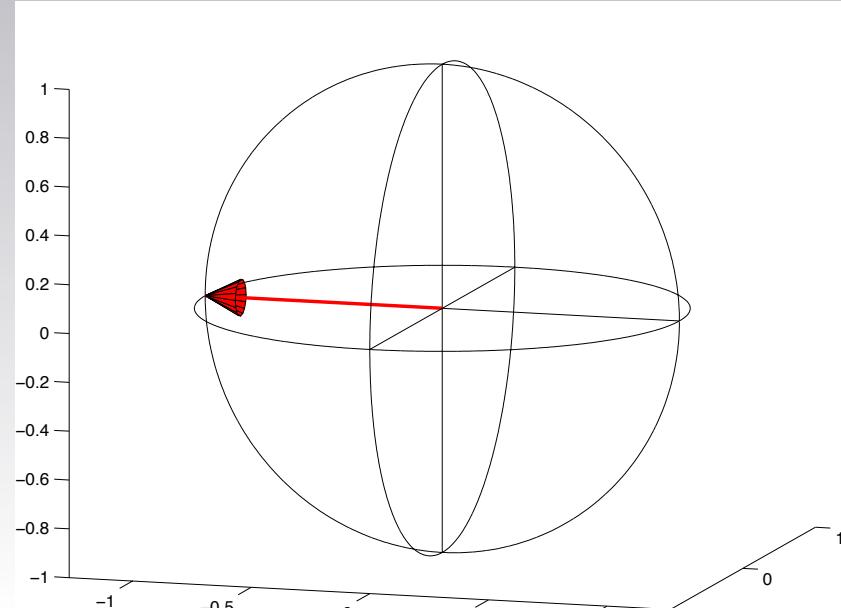
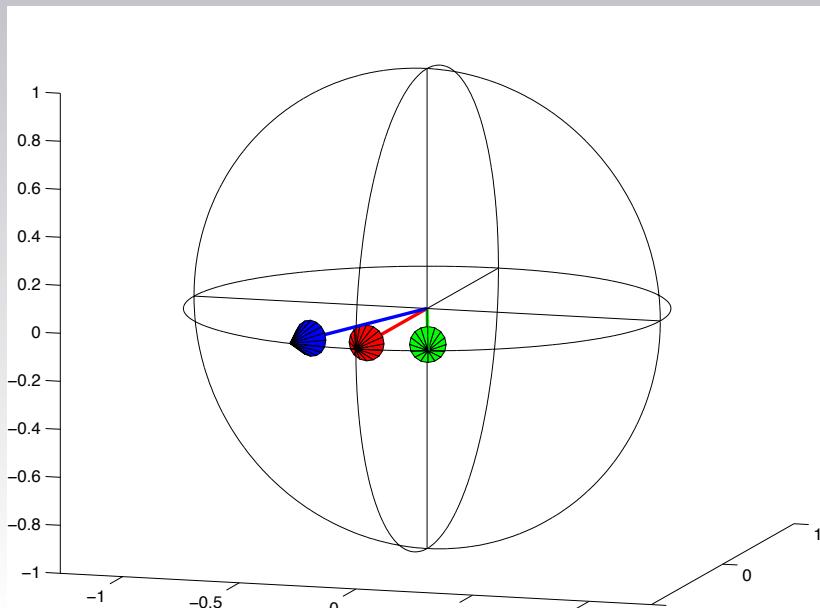
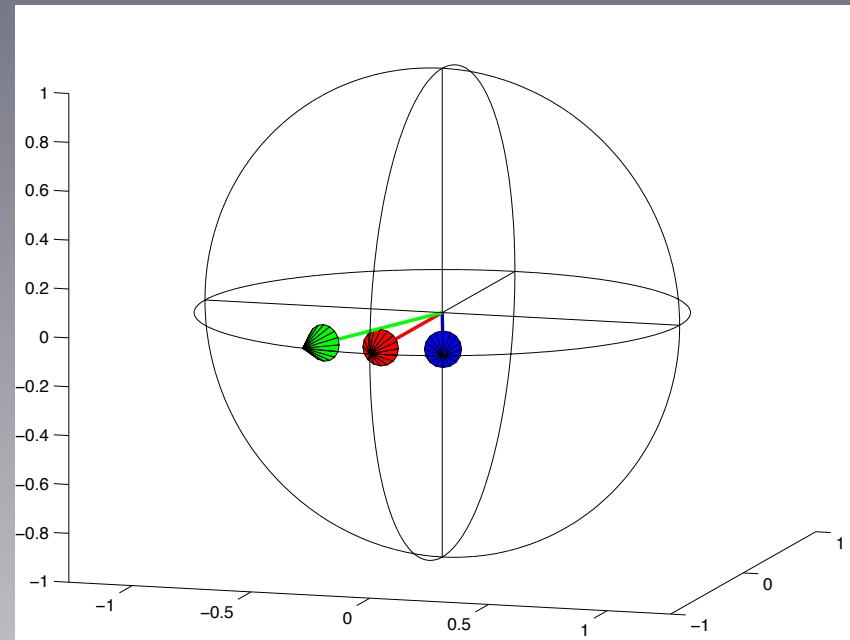
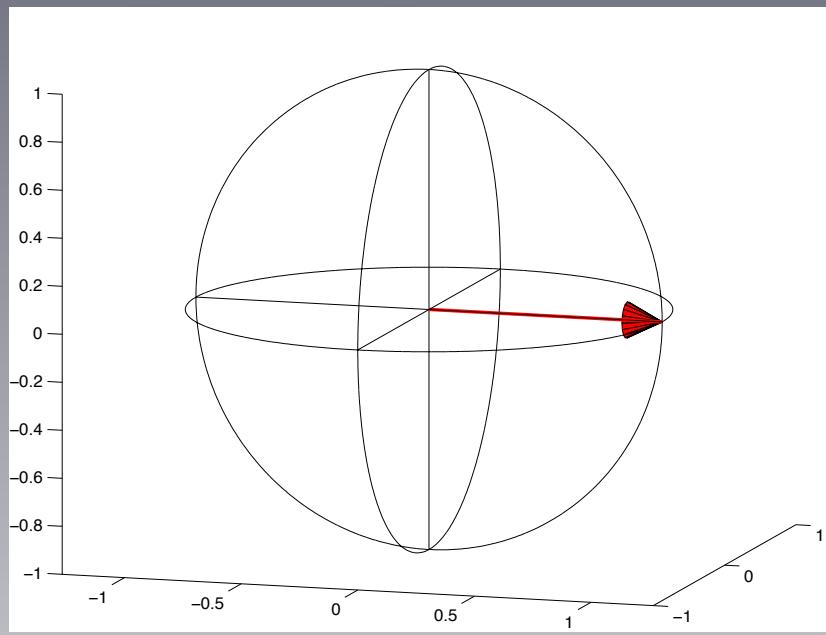
# Manipulating the Quantum State of an Electrical Circuit

D. Vion,\* A. Aassime, A. Cottet, P. Joyez, H. Pothier,  
C. Urbina,† D. Esteve, M. H. Devoret‡

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# Hahn Echo



# Rabi

