Quantum Measurement

Zeno Effect

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Modeling Quantum Hardware: open dynamics and control
Universität Konstanz

No phenomenon is a real phenomenon until it is an observed phenomenon.

– John Archibald Wheeler 1970

Historical Note

1900 Plank & Einstein: Blackbody Radiation

1920 Bohr, Heisenberg: Copenhagen interpretation
Born: Probabilistic interpretation $P(m) = |\langle m|\psi\rangle|^2$

1930 EPR Paradox

1926 Schrödinger: Measurement Problem

1932 von Neumann: *Mathematical Foundations of Quantum Mechanics*

1970 Decoherence Theory

Experimental Interest

Projective Measurement

Measurement Operator $\hat{M} = \sum m|m\rangle$ on ψ:

$$p(m) = |\langle m|\psi\rangle|^2$$

$$\psi \xrightarrow{\text{Measuring } m} |m\rangle$$

Neglegting Normalization and Degenercy: POVM Measurement

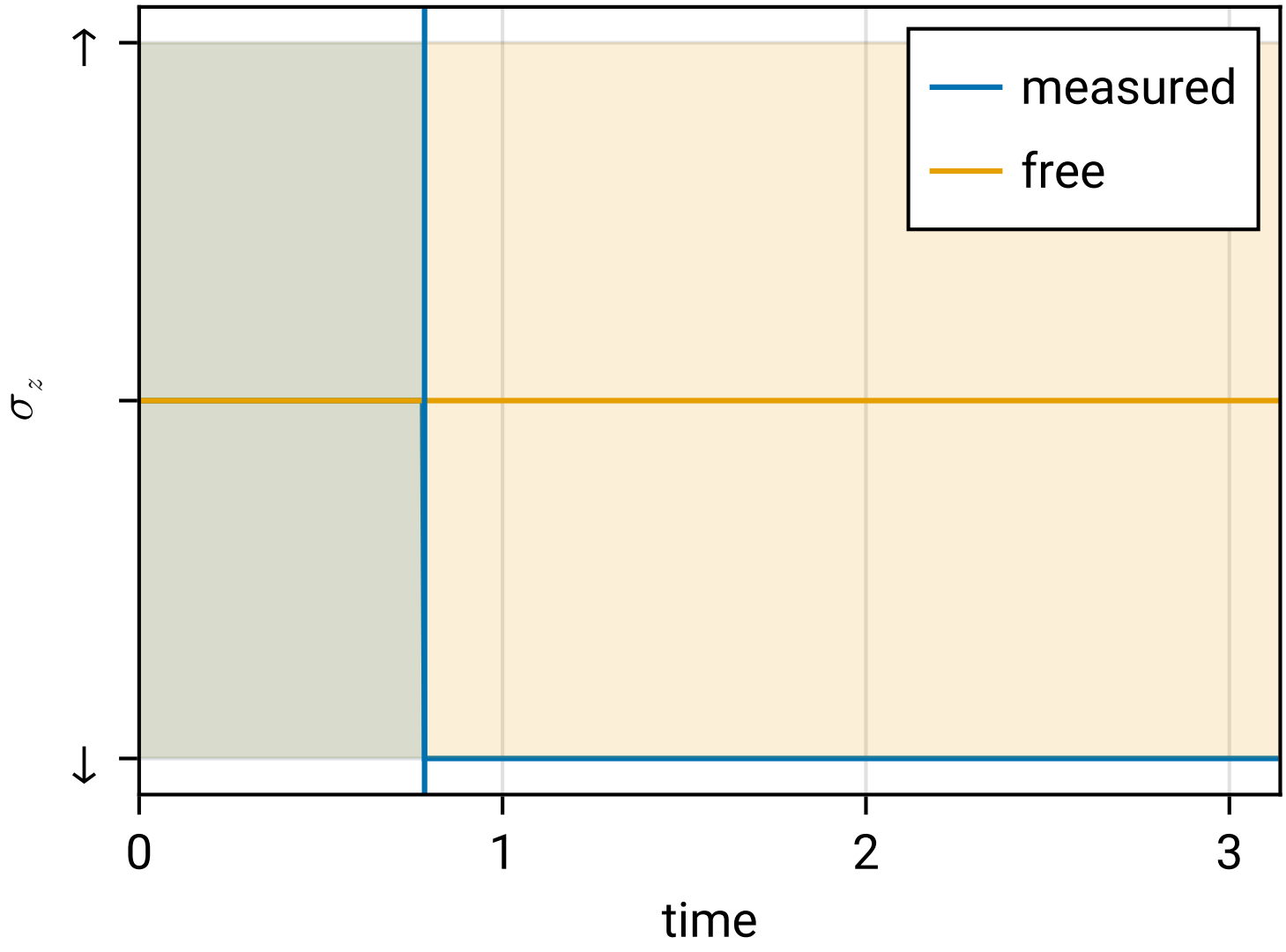
Quantum Computation and Quantum Information, M. A. Nielsen et al. 2010 (2.2.3)

Qubit Example

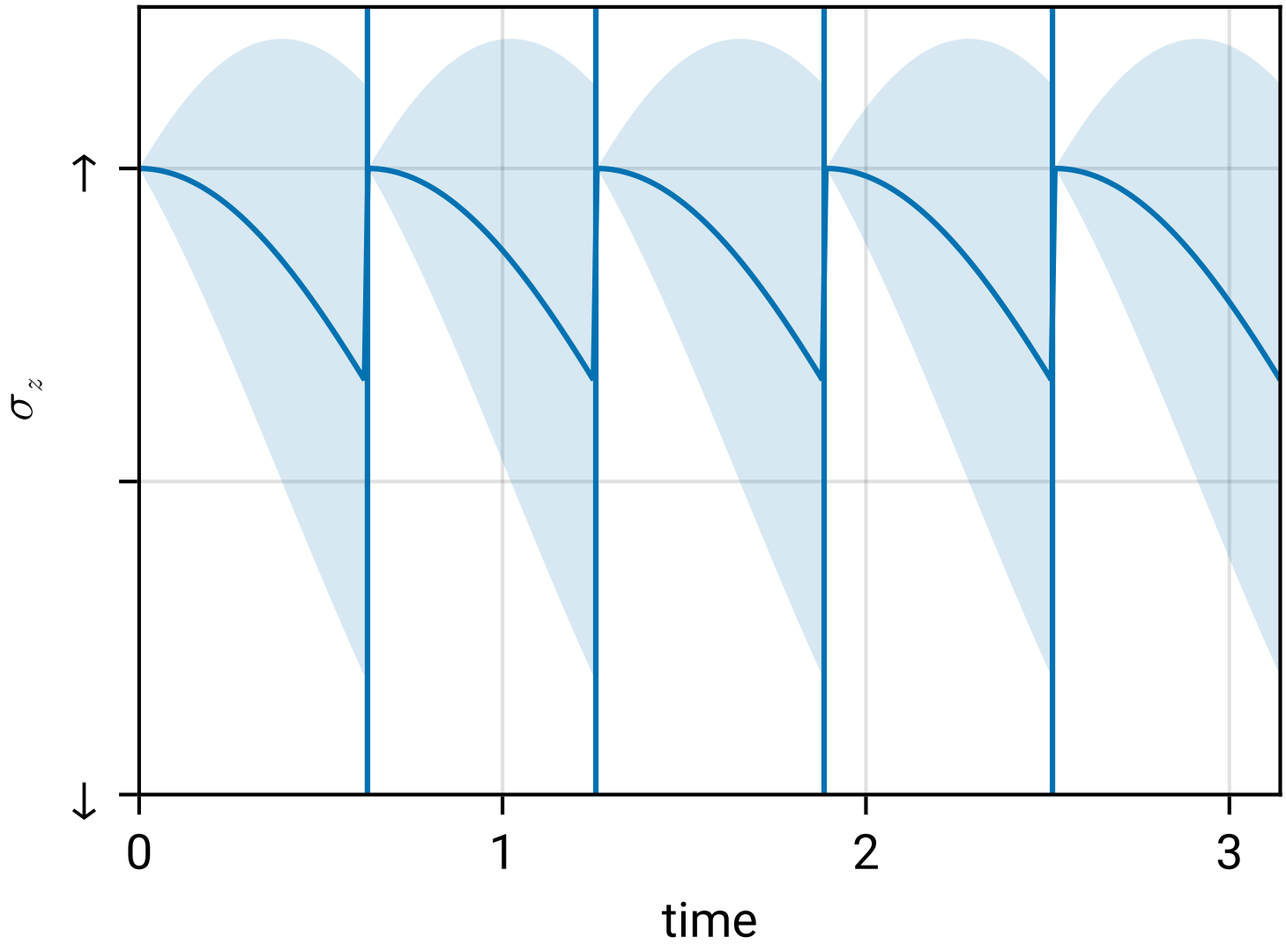
$$H = \sigma_z$$

$$C = \sigma_x$$

Measurement



Discrete Zeno



Weak Measurement

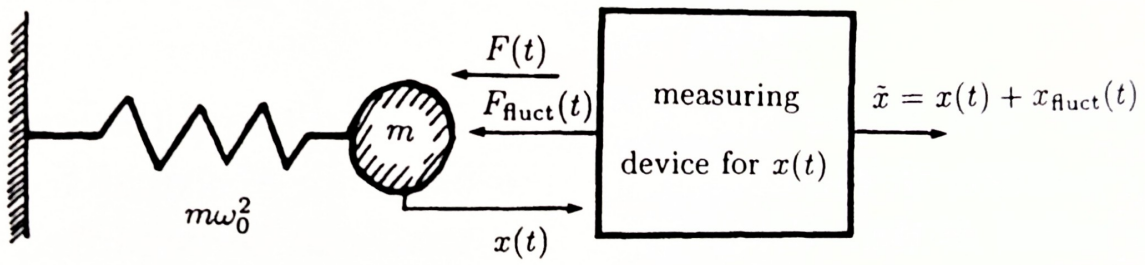
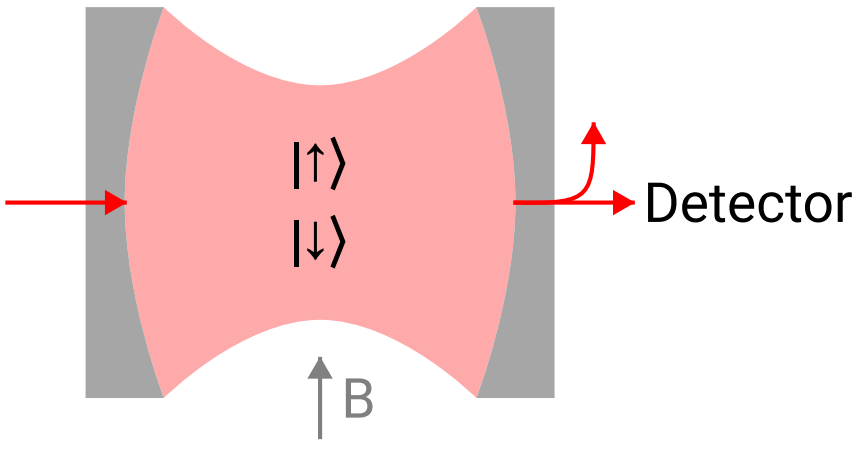


Fig. 8.4 Detection of a classical force by monitoring the coordinate of an oscillator on which it acts.

Quantum measurement, Vladimir Braginsky et al. 1992

Rabi Oscillations Setup



$$H = g\,(a^\dagger a)(\sigma^+\sigma^-) + g_s\,(\sigma^+ + \sigma^-) - i\beta(a^\dagger - a)$$

Coupling
Magnetic
Optic

$$J = \kappa\, a$$

Dissipation

$$C = \sqrt{\kappa\eta}\, a$$

Measurement

"Stochastic master equation for a probed system in a cavity", A. E. B. Nielsen et al. 2008

Time evolution