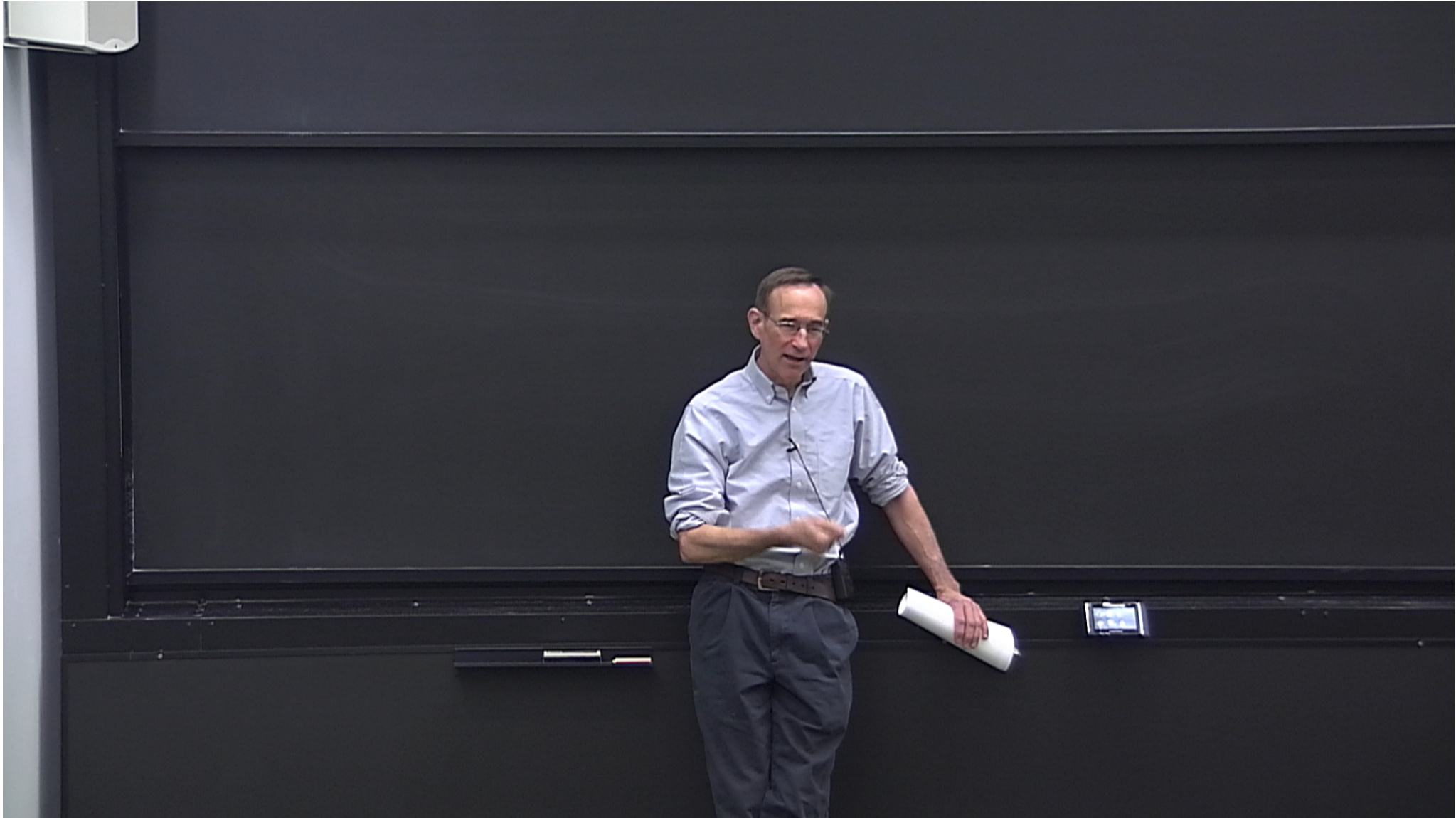


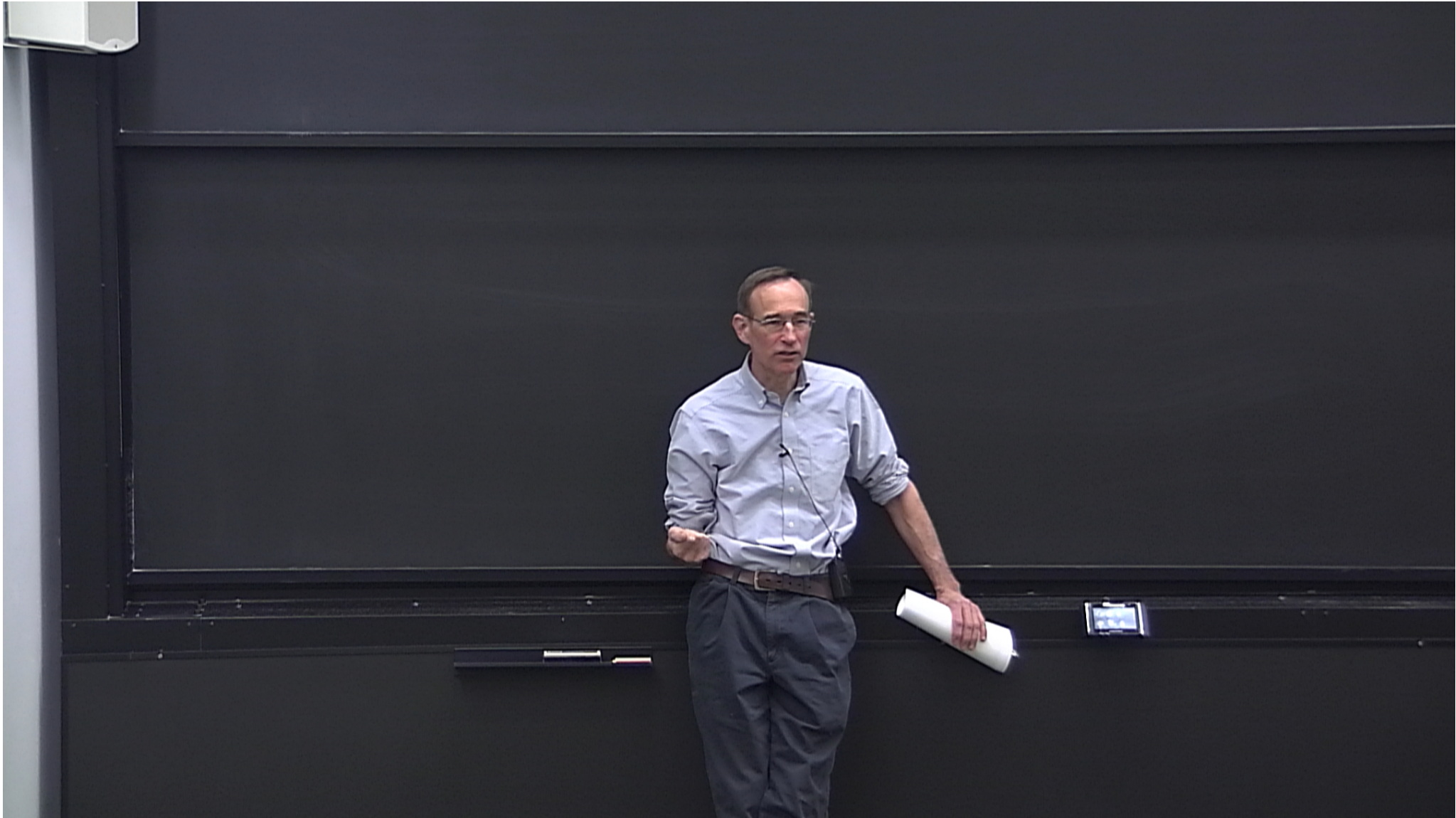
Title: PSI 2015/2016 Quantum Information - Lecture 6

Date: Feb 29, 2016 11:30 AM

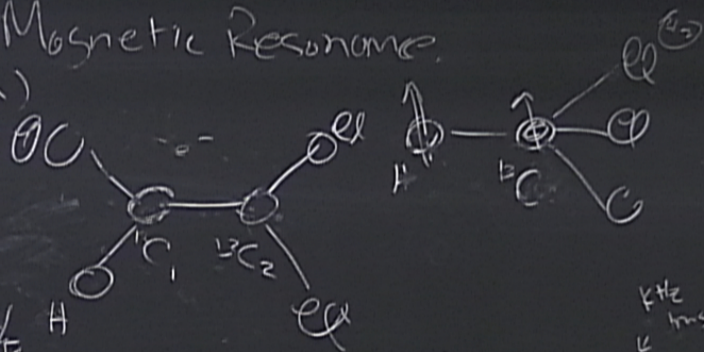
URL: <http://pirsa.org/16020083>

Abstract:





Nuclear Magnetic Resonance (electron)



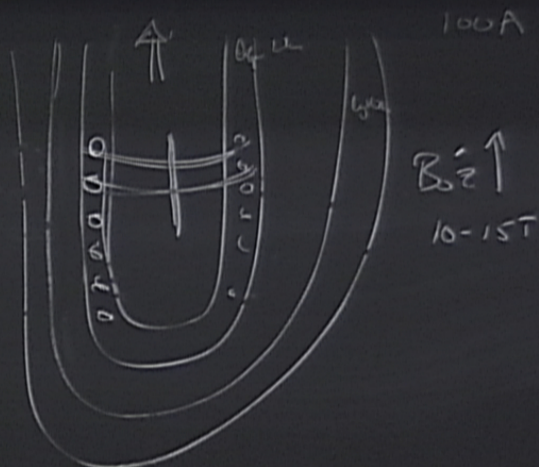
$$\mu_B = 2.6 \times 10^{-27} \text{ J/T}$$

$$\frac{\omega}{kT} \sim 10^{-5}$$

$$e^{-\beta H} \approx \frac{1}{2}(1 - \beta \hat{H})$$

$$\nu_{C1} = \nu_{C2} + \delta$$

$$\begin{aligned} 100 \text{ MHz} \\ T_2 \sim 1 \text{ s} \\ T_1 \sim 3 \text{ s} \end{aligned}$$



Nuclear Magnetic Resonance (electron)

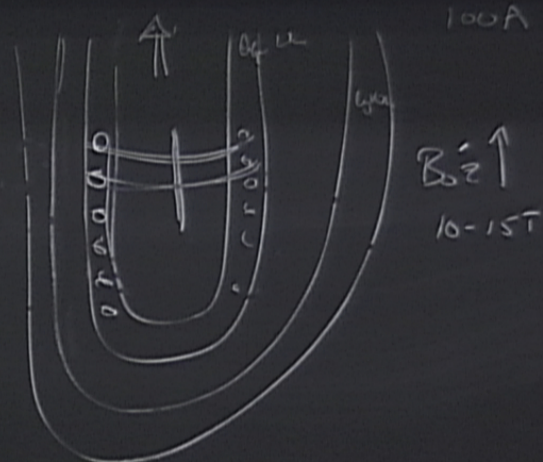
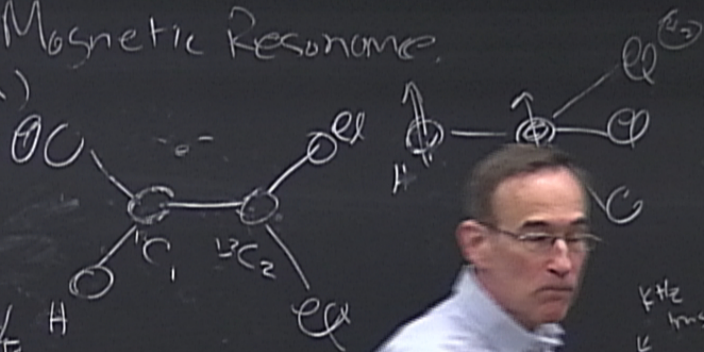
$$H = \vec{\mu} \cdot \vec{B}$$

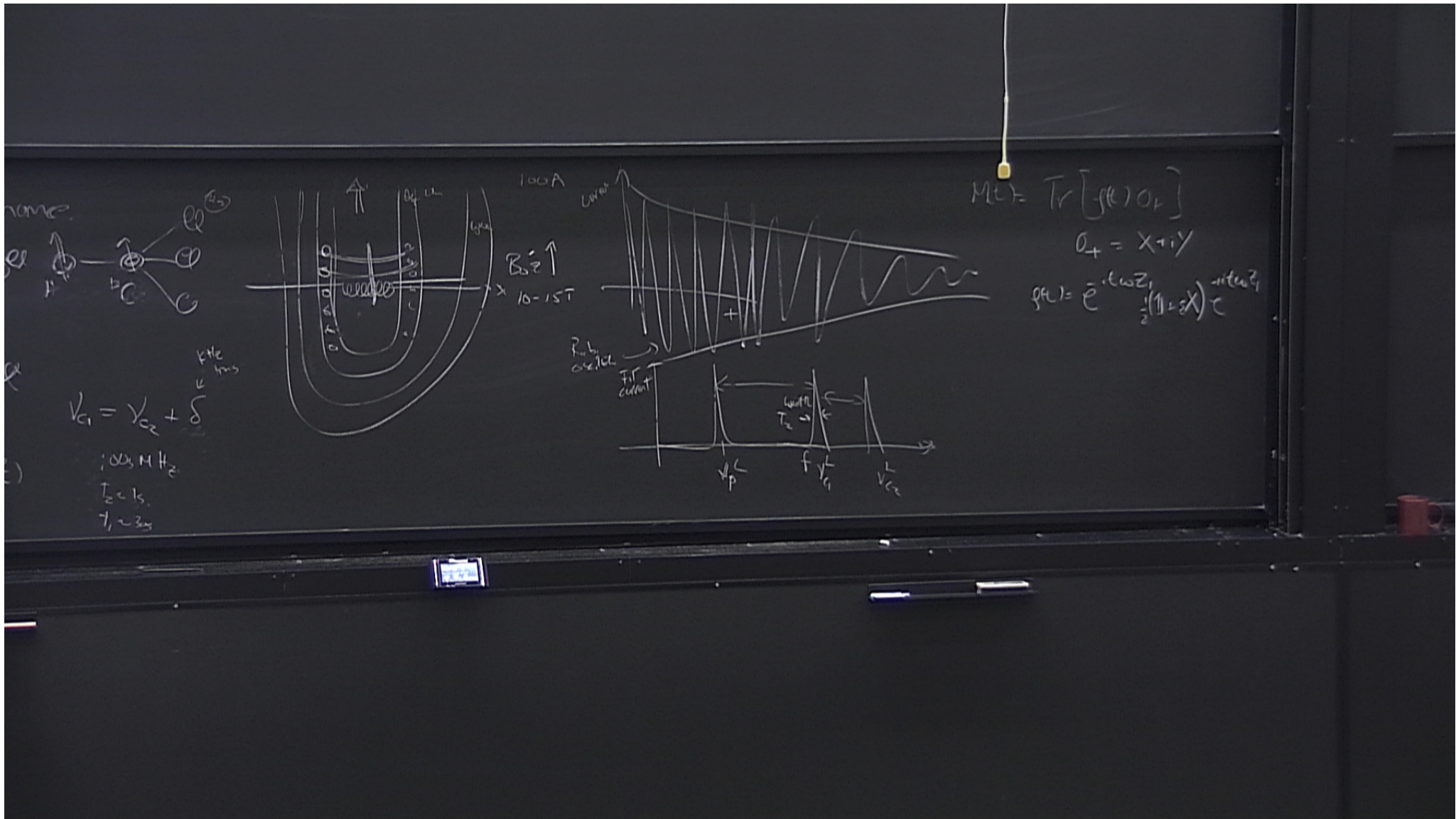
$$\mu_B = 2.67 \times 10^{-27} \text{ J/T}$$

$$\frac{\omega}{kT} \sim 10^{-5}$$

$$e^{-\beta H} \approx \frac{1}{2}(1 - \beta \hat{H})$$

$$\text{polarization} = \text{tr } \rho \hat{Z}$$



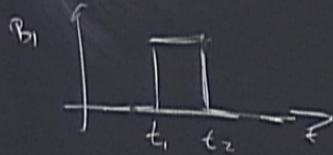


$$k_T = \frac{1}{2}(1 - \epsilon \hat{z})$$

polarization = $\text{tr } \rho \hat{z}$

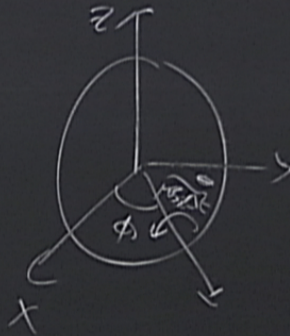
100 MHz
 $t_z \sim 1 \text{ s}$
 $t_1 \sim 3 \text{ ms}$

$$\vec{B} = B_0 \hat{z} + B_1 (\cos(\omega t + \phi) \hat{x} + \sin(\omega t + \phi) \hat{y})$$

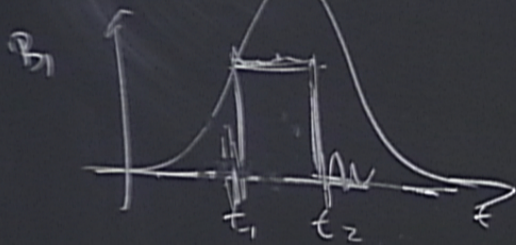


$$U = e^{-i \mu_B \int_{t_1}^{t_2} B_1 (\cos \phi \hat{x} + \sin \phi \hat{y}) dt}$$

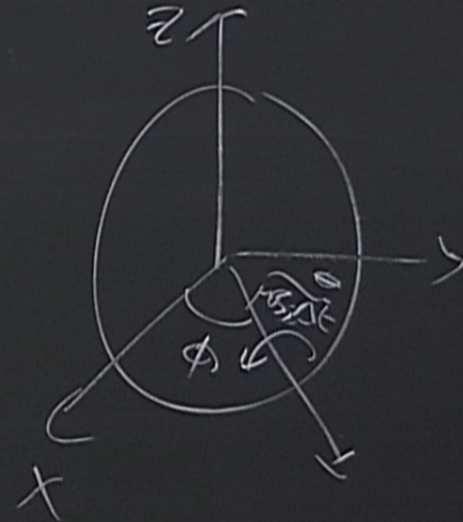
$$= e^{-i \mu_B B_1 (t_2 - t_1) \Delta \phi}$$



$$\vec{B} = B_0 \hat{z} + B_1 (\cos(\omega t + \phi) \hat{x} + \sin(\omega t + \phi) \hat{y})$$



$$U = e^{-i\mu \int_{t_1}^{t_2} B_1(t) dt} B_1 (\cos \phi \hat{x} + \sin \phi \hat{y})$$



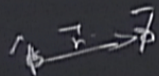
$$|L\rangle = |0\rangle + |1\rangle$$

$$|L\rangle = |0\rangle - |1\rangle$$

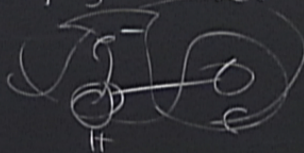
$$2\phi$$

2 qubit gates

dipole-dipole $\sim \frac{1}{r^3}$



scoping indirect interaction



$$H = \omega_1 Z_1 + \omega_2 Z_2 + \frac{\pi J}{2} Z_1 Z_2$$

$$\delta \gg \frac{\pi J}{2}$$

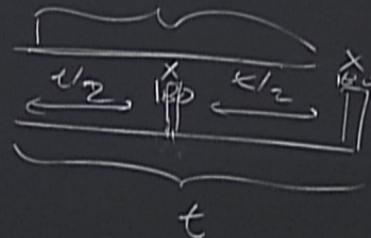
$$C_2: |0\rangle_{Z_1}, |1\rangle_{Z_2} \quad (\omega_1 + \frac{\pi J}{2}) Z_1$$

$$C_2: |1\rangle_{Z_1}, |0\rangle_{Z_2} \quad (\omega_1 - \frac{\pi J}{2}) Z_1$$

$$\frac{\pi J}{2} \left(\cancel{\frac{1}{2} \frac{1}{2}} + \cancel{\frac{1}{2} \frac{1}{2}} - \cancel{\frac{1}{2} \frac{1}{2}} - \cancel{\frac{1}{2} \frac{1}{2}} \right) (Z_1 Z_2)$$

$\downarrow$
 $-x_2$
 $-y_2$

Relaxation $U = H$



$$\theta^2 = 1$$

$$Z_1 Z_2 X_1 = -X_1 Z_1 Z_2$$

$$XZ = -ZX$$

$$\begin{aligned}
 & e^{-i\frac{\pi}{2}X} e^{-i\Delta Z_1 Z_2} e^{-i\frac{\pi}{2}X} e^{-i\frac{\pi}{2}Z_1 Z_2} \\
 & \times (\cos \Delta \pi - i \sin \Delta \pi Z_1 Z_2) X (\cos \Delta \pi - i \sin \Delta \pi Z_1 Z_2) \\
 & \times X (\cos \Delta \pi + i \sin \Delta \pi Z_1 Z_2)
 \end{aligned}$$