



UCL

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$$S_x,S_y,S_z\hbar\frac{1}{2}-\frac{1}{2},\frac{1}{2}\frac{1}{2}\frac{9}{2}S_{x,y,z}S_zS_z\pm\frac{1}{2}\\ \mu\mu_e-g\mu_b\mu_b\frac{e\hbar}{2m_e}-g\mu_b\cdot S_z$$

$$H=-g\mu_bB_0S_z$$

$$B_0||\ket{0}\ket{1}\ket{\uparrow}\ket{\downarrow}$$

$$\Delta E = g_e \mu_b B,$$

$$E = h\nu$$

$$\mu_N$$

$$\hat{H} = -g\mu_b\cdot + g_I\mu_N\cdot + \hat{A}\cdot$$

$$\tfrac{1}{2}I=1/2m_s=0m_s=1B_0S_zz$$

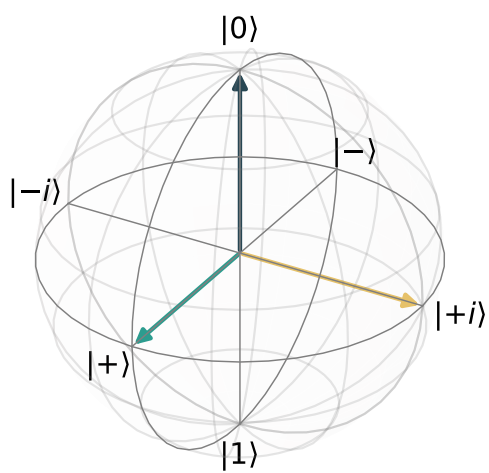
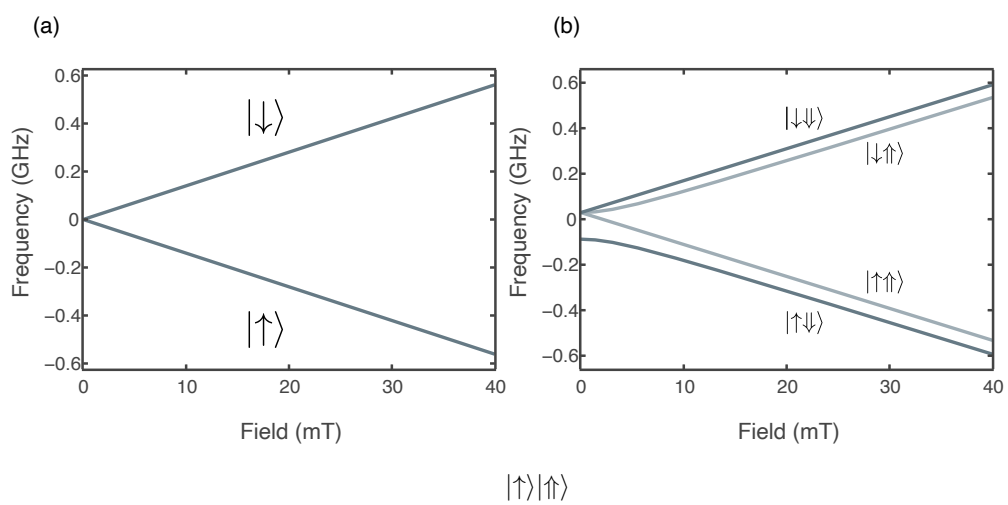
$$\omega_0=\frac{g\mu_B}{\hbar}B_0$$

$$\ket{0}\ket{1}$$

$$\ket{\psi}=\alpha\ket{0}+\beta\ket{1}$$

$$\sqrt{|\alpha^2|+|\beta^2|}\\ B_0|0\rangle|1\rangle B_1B_1B_0B_0B_1B_1x-y\omega$$

$$H=g\mu_BB_0S_z+g\mu_BB_1\left(\omega t\right)S_x$$



$$S_z \rightarrow [|0\rangle, |1\rangle], S_x \rightarrow [|+\rangle, |-\rangle], S_y \rightarrow [|+i\rangle, |-i\rangle]$$

$$U=\begin{pmatrix} e^{i\omega t} & 0 \\ 0 & e^{-i\omega t} \end{pmatrix}$$

$$\tilde{H}=\begin{pmatrix} \frac{1}{2}(\omega-\omega_0) & \omega_1\,(\omega t)e^{-i\omega t} \\ \omega_1\,(\omega t)e^{i\omega t} & \frac{1}{2}(\omega-\omega_0) \end{pmatrix}$$

$$\omega_0 B_0 \omega_1 B_1 \omega B_1$$

$$\tilde{H}=\begin{pmatrix} \frac{1}{2}(\omega-\omega_0) & \frac{\omega_1}{2} \\ \frac{\omega_1}{2} & \frac{1}{2}(\omega-\omega_0) \end{pmatrix}$$

$$B_0B_1$$

$$\tilde{H}=\frac{\omega_1}{2}\sigma_x$$

$$B_1B_1|0\rangle xB_1B_1B_0|B_1|\ll |B_0|B_1B_1\Omega B_1z-yB_1x-yxB_1$$

$$B_0B_1\mu$$

$$B_0B_1B_0$$

$$B_1M\Omega t=\pi\pi|0\rangle$$

$$ket1\frac{\pi}{2}|0\rangle x-y$$

$$B_0x-y|0\rangle|1\rangle x-y$$

$$x-yB_0$$

$$|0\rangle\frac{\pi}{2}x-yx-y\tau\pi B_0\tau$$

$$T_1T_2T_2^*$$

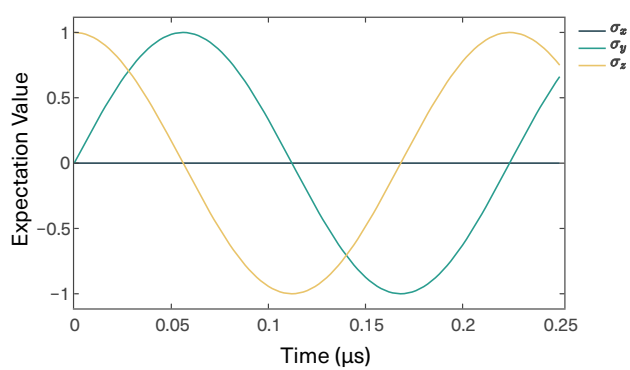
$$|0\rangle$$

$$T_1\propto B_0^{-4}T^{-1}$$

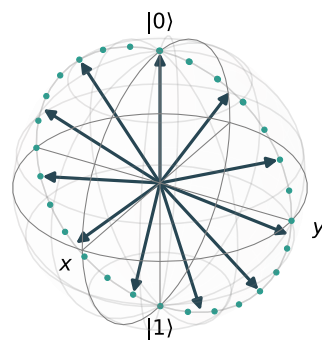
$$\omega_p\omega_0\omega_p+\omega_0$$

$$T_1\propto T^{-9}$$

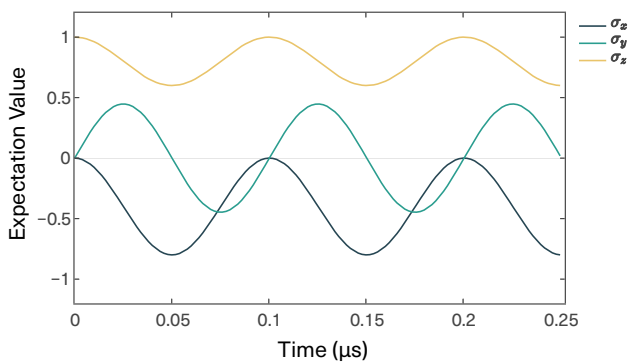
(a)



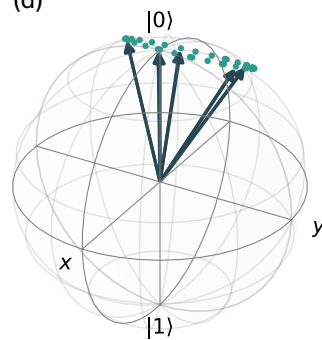
(b)



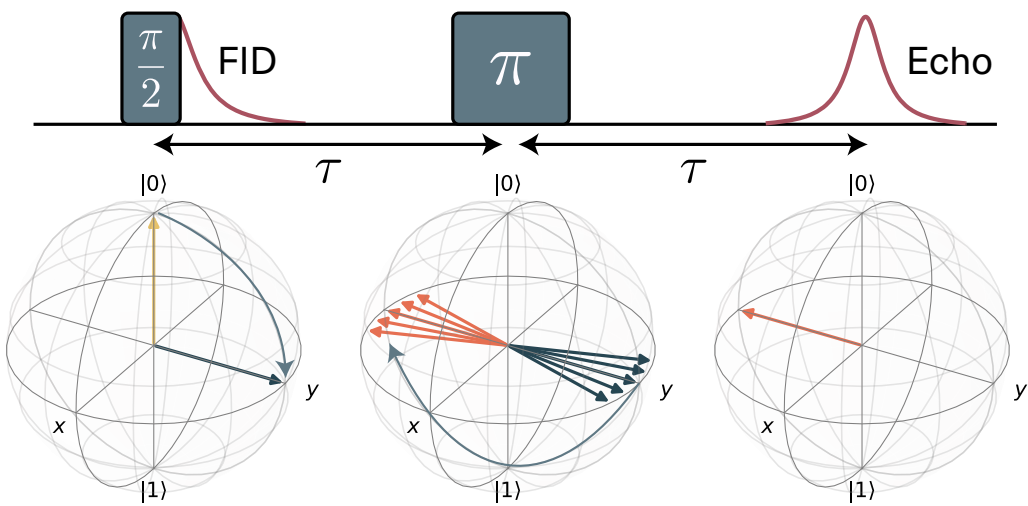
(c)



(d)

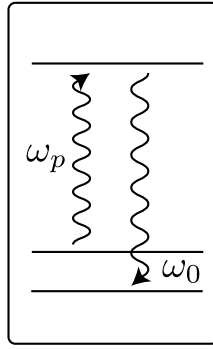
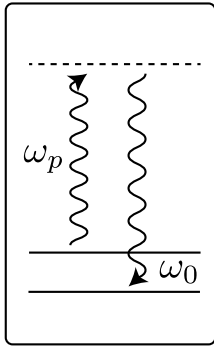
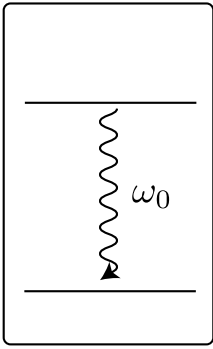


$$B_1 B_1 B_0 \sigma_x, \sigma_y \sigma_z B_1 0.5$$



$$\frac{\pi}{2} |0\rangle x - y \pi \tau \tau$$

$$T_1 \propto e^{-\Delta E/k_b T}$$



10.1103/PhysRev.70.460
10.1103/PhysRevLett.8.13
10.1103/PhysRev.114.1219
10.1103/PhysRev.114.1245

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