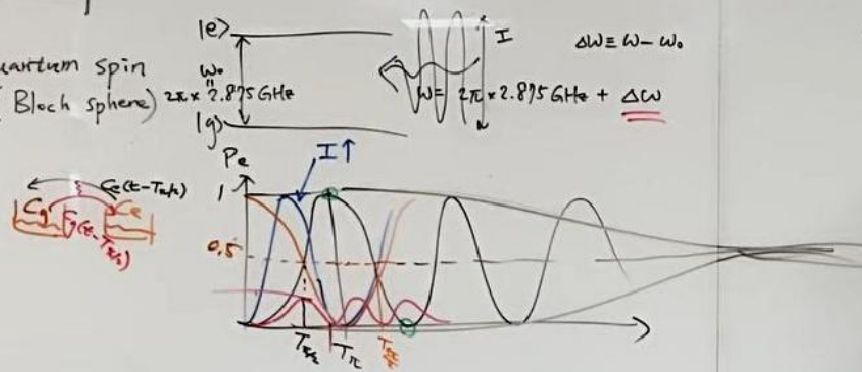




# Lecture6 Ramsey interferometry

- Ramsey interferometry

- classical and quantum spin  
(Bloch sphere)



(2)

$$C_g(t) = e^{-i\frac{\Delta t}{2}} \left[ \left[ \cos\left(\frac{\Omega t}{2}\right) + \frac{i\Delta}{\Omega} \sin\left(\frac{\Omega t}{2}\right) \right] C_g(0) + \frac{i\Omega_R}{\Omega} e^{-i\phi} \sin\left(\frac{\Omega t}{2}\right) C_e(0) \right]$$

$$C_e(t) = e^{i\frac{\Delta t}{2}} \left[ \frac{i\Omega_R}{\Omega} e^{i\phi} \sin\left(\frac{\Omega t}{2}\right) C_g(0) + \left[ \cos\left(\frac{\Omega t}{2}\right) - \frac{i\Delta}{\Omega} \sin\left(\frac{\Omega t}{2}\right) \right] C_e(0) \right]$$

$$\Delta \equiv \omega - \omega_0$$

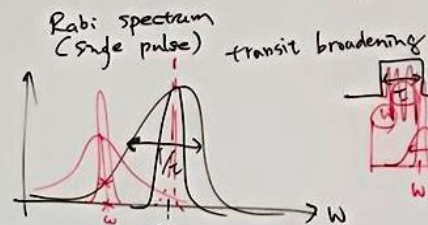
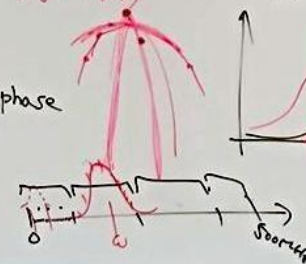
$$\Omega_R = \frac{|V_{mg}|}{\hbar}$$

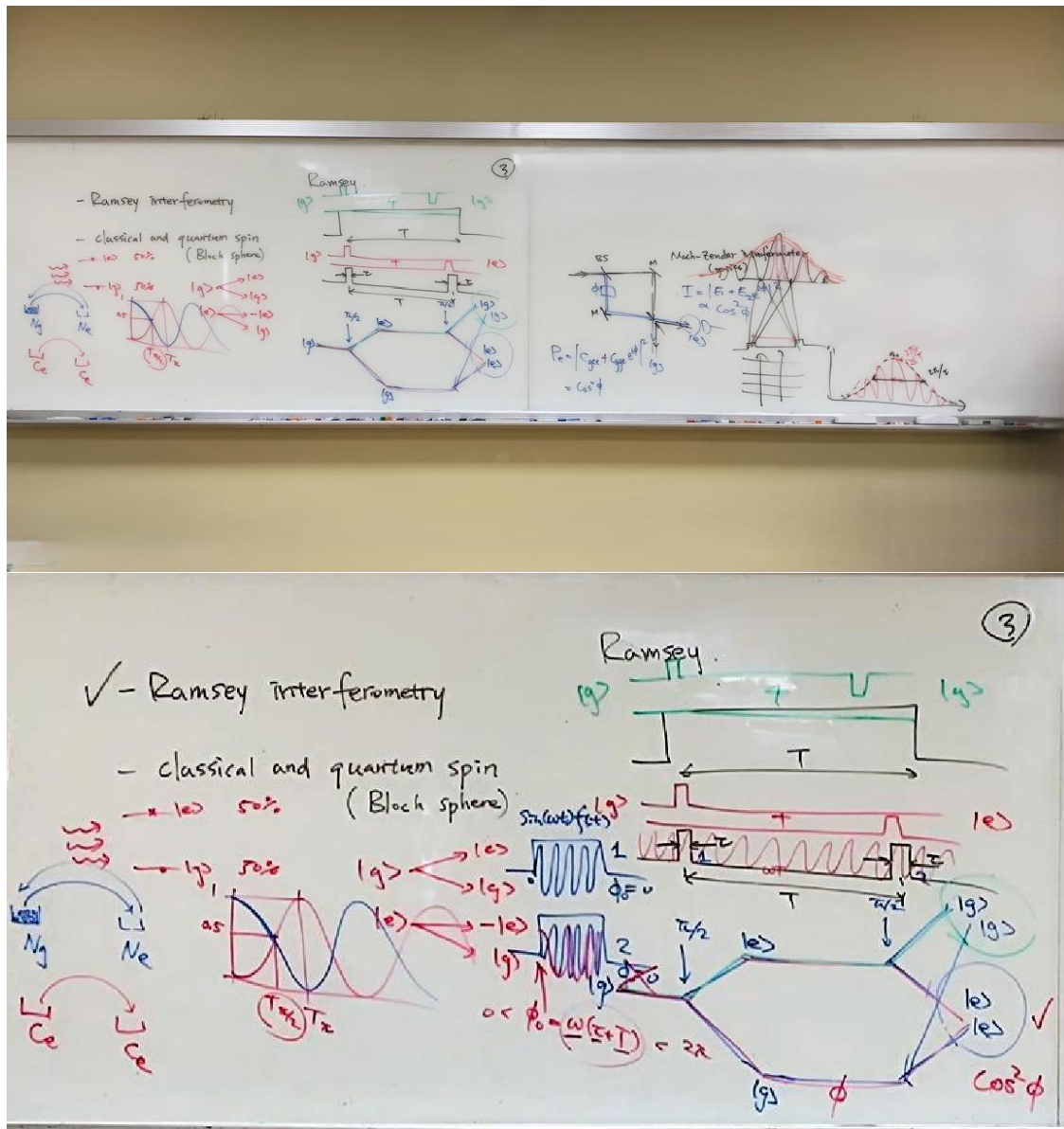
$$\Omega = \sqrt{\Omega_R^2 + \Delta^2}$$

$\phi$  = microwave initial phase

$$H_{int} \propto e^{-i\omega t + i\phi}$$

$\tau$  = pulse duration







(4)

$$C_g(t) = e^{-i\frac{\Delta t}{2}} \left[ \cos\left(\frac{\Omega t}{2}\right) + \frac{i\Delta}{\Omega} \sin\left(\frac{\Omega t}{2}\right) \right] C_g(0) + \frac{i\sqrt{\Omega}}{\Omega} e^{-i\phi} \sin\left(\frac{\Omega t}{2}\right) C_e(0)$$
$$C_e(t) = e^{i\frac{\Delta t}{2}} \left[ \frac{i\sqrt{\Omega}}{\Omega} e^{i\phi} \sin\left(\frac{\Omega t}{2}\right) C_g(0) + \left( \cos\left(\frac{\Omega t}{2}\right) - \frac{i\Delta}{\Omega} \sin\left(\frac{\Omega t}{2}\right) \right) C_e(0) \right]$$

Diagram illustrating the Ramsey interferometry setup. A system starts in state  $|g\rangle$ . It passes through a  $\pi/2$  pulse, then evolves for time  $T$  with detuning  $\Delta$ , and finally passes through another  $\pi/2$  pulse. The resulting state is  $|g\rangle$  or  $|e\rangle$ . The probability of finding the system in state  $|e\rangle$  is given by:

$$P_e = \frac{1}{4} (1 + 1 - e^{i\Delta(t+T)} - e^{-i\Delta(t+T)}) = \frac{1}{2} (1 - \cos(\Delta(t+T))) = \sin^2\left(\frac{\Delta(t+T)}{2}\right)$$

Note:

$ g\rangle$	$\xrightarrow{\pi/2}$	$\frac{1}{\sqrt{2}} g\rangle + \frac{1}{\sqrt{2}} e\rangle$
$ e\rangle$	$\xrightarrow{\pi/2}$	$\frac{1}{\sqrt{2}} g\rangle - \frac{1}{\sqrt{2}} e\rangle$

✓ - Ramsey Interferometry

- classical and quantum spin  
(Bloch sphere)

