

②

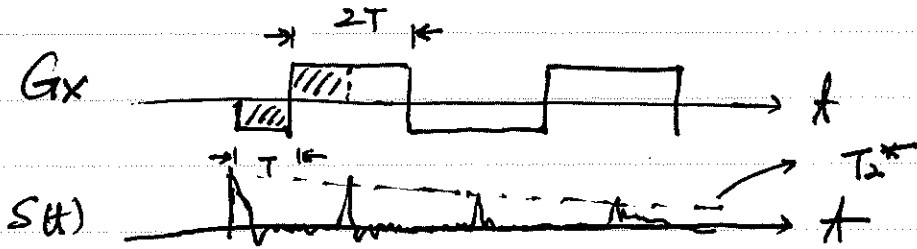
Echo \rightarrow undo dephasing effects

$$S(t) = \iint_V m(\vec{r}) e^{-i\phi(\vec{r}, t)} dV$$

$$\phi(\vec{r}, t) = \gamma \int_0^t \underbrace{\vec{G}(\tau) \vec{r}}_{\text{controlled by } G} d\tau$$

① Gradient echo

$$\phi = \gamma \int_0^t G(\tau) \vec{r} d\tau = 0 \quad \underbrace{\hspace{2cm}}_{GE}$$



Gradient recalled echoes (GREs)

\rightarrow echo "peaks" when returns to k-space origin

\rightarrow 2DFT with $PE = 0$

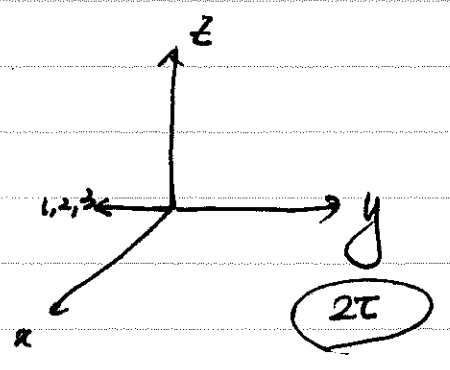
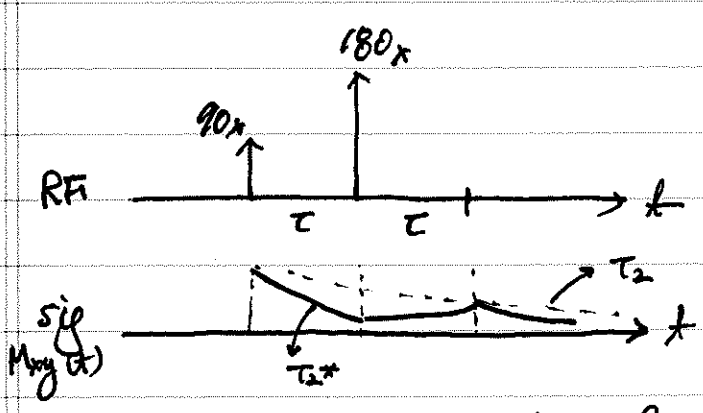
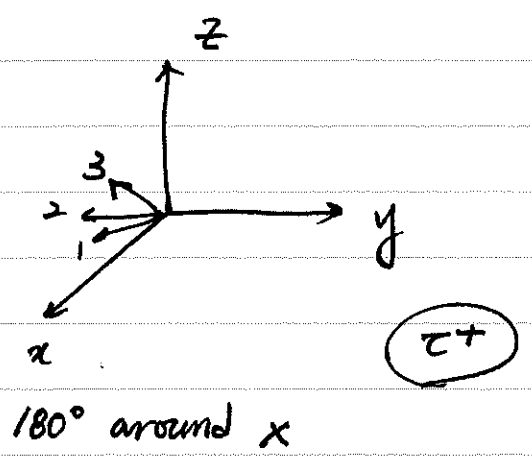
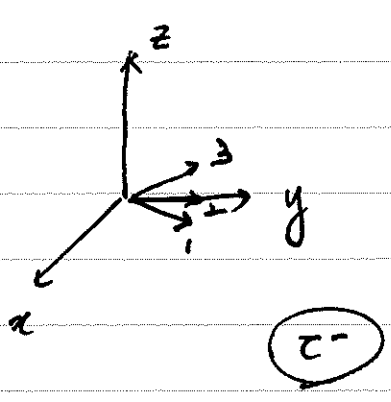
$PE \neq 0$ still calls it a GRE when

$$\int G_x = 0$$

② Spin echo (SE)

- Ignore \vec{G}
- undo dephasing due to off-resonance

Idea Apply a 180° excitation at $t = \tau$ and see what happens



\Rightarrow spins rephased formed "spin echo"