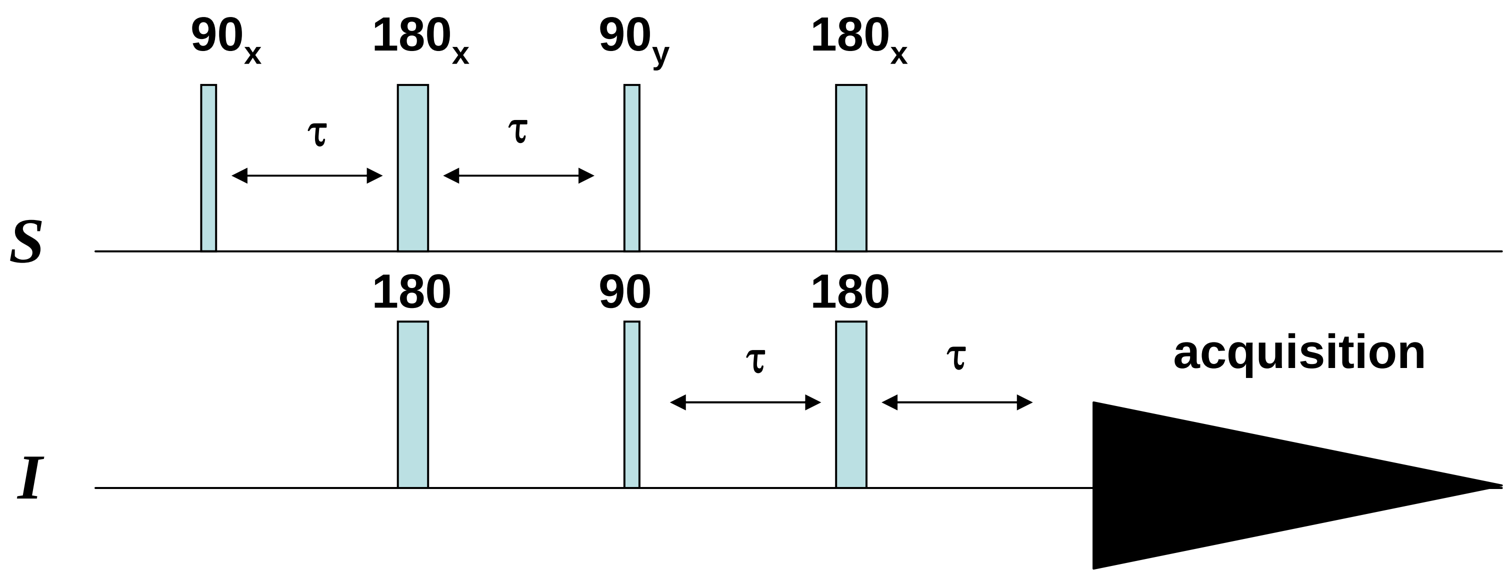
# INEPT

## Insensitive Nuclei Enhanced by Polarization Transfer

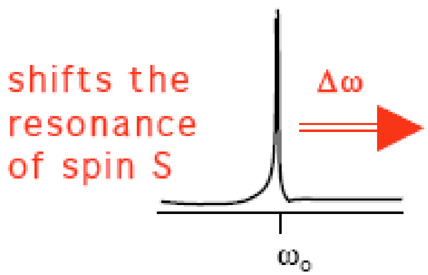
*Gareth A. Morris and Ray Freeman JACS*, **101**, *1979, 760-762*

# INEPT Pulse sequence

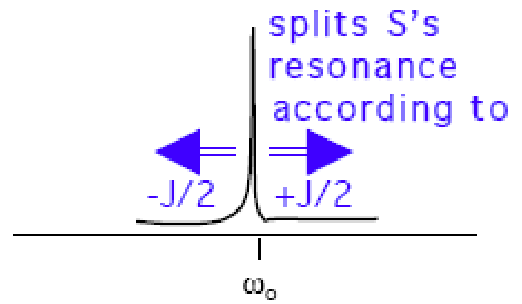


# Main Interactions in solution NMR

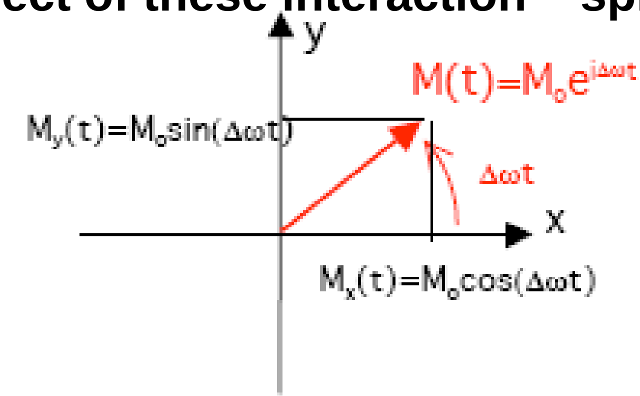
## The chemical shift
(a single-spin coupling)

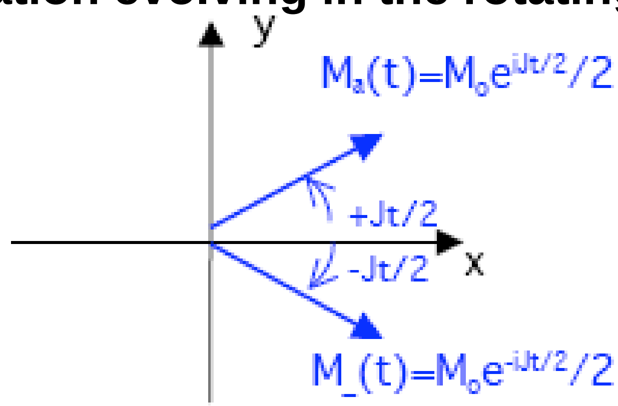



## The J coupling
(a 2-or-more spin coupling)




**Effect of these interaction – spin magnetization evolving in the rotating frame**



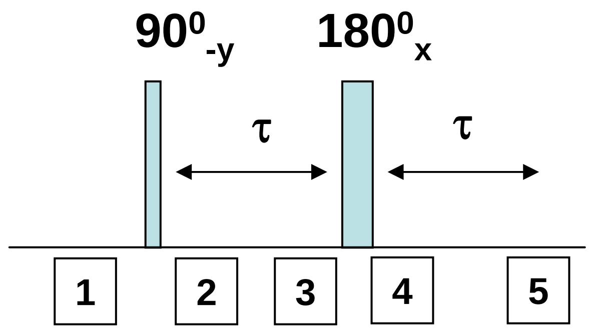

$S(t) = M_o \cdot e^{i\Delta\omega t}$

$S(t) = M_o \cdot (e^{iJt/2} + e^{-iJt/2})/2 = M_o \cdot \cos(Jt/2)$

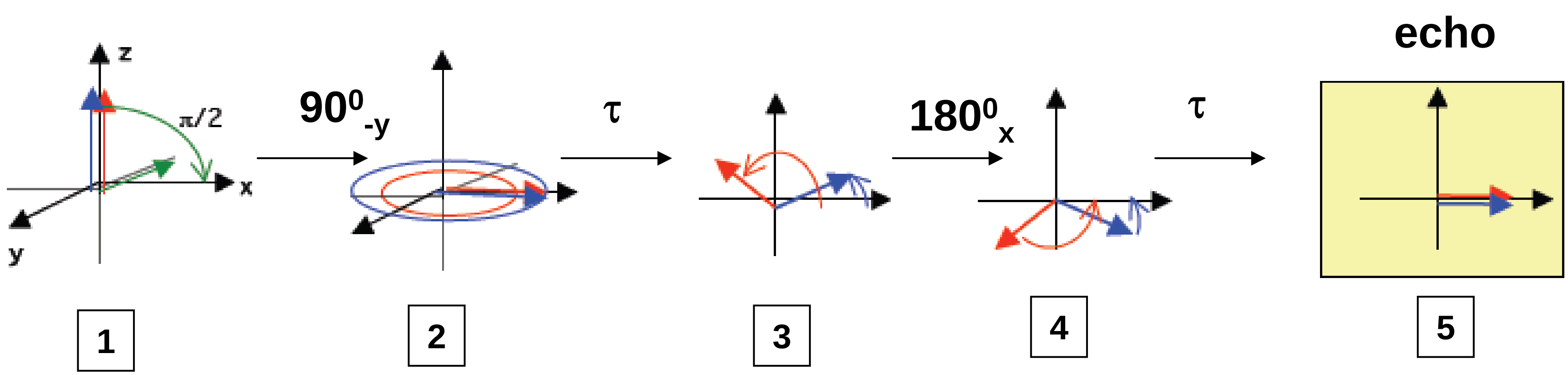
**Time domain signal**

$$\boxed{S(t) = M_o e^{i\Delta\omega t} \cos\frac{Jt}{2}}$$

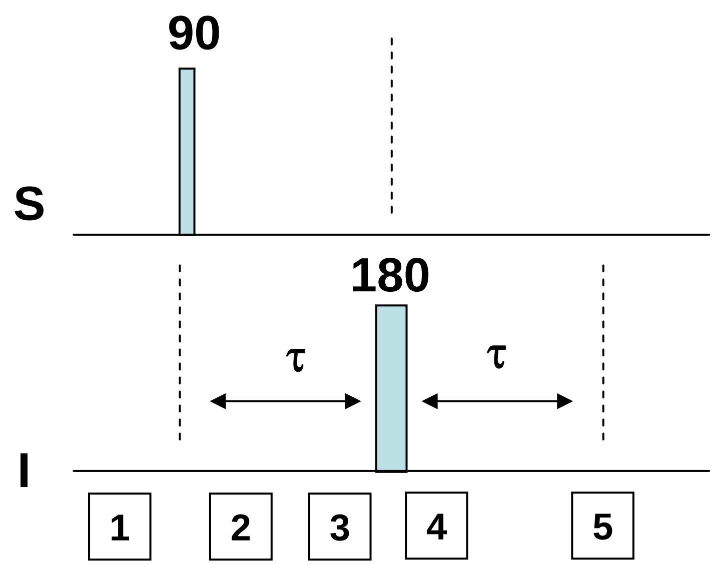
# Spin Echo

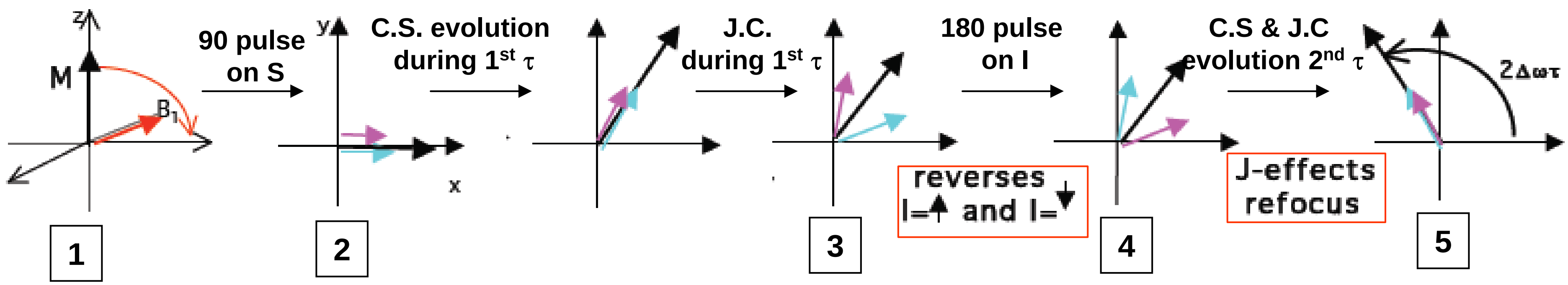



Two spins fast and slow precessing sites



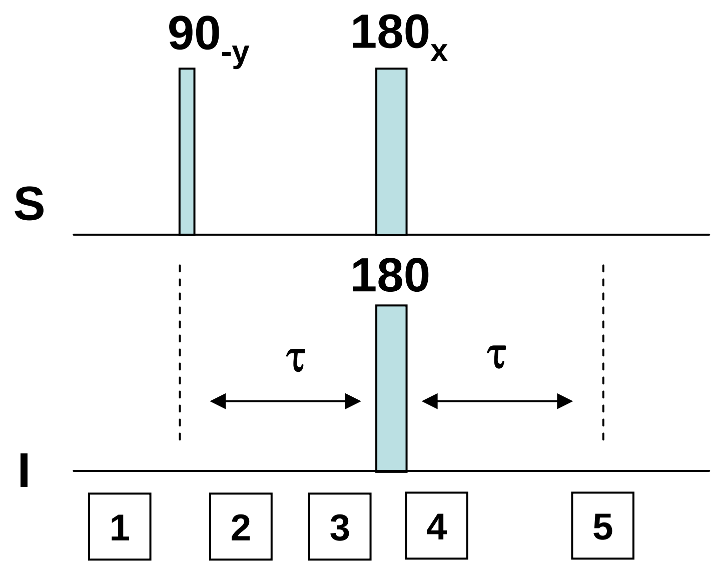
# Decoupling

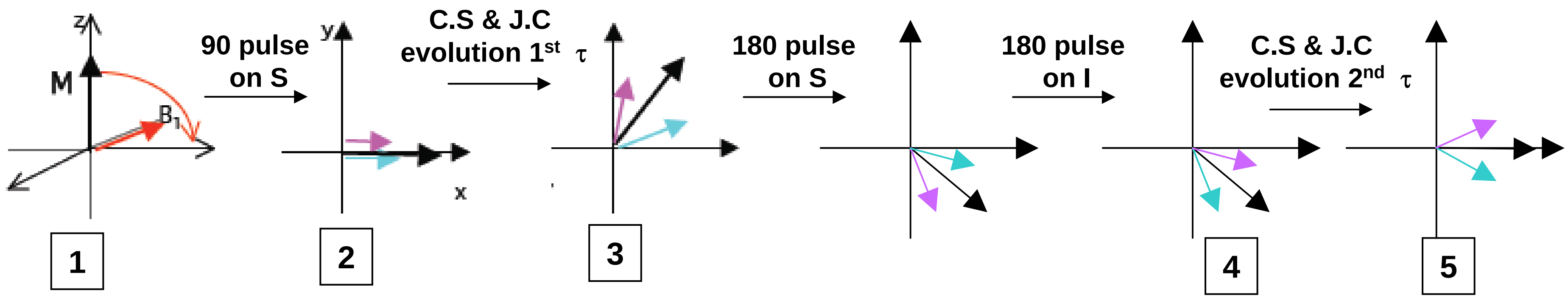



**refocusing the J-coupling effect but not the chemical shift - DECOUPLING**

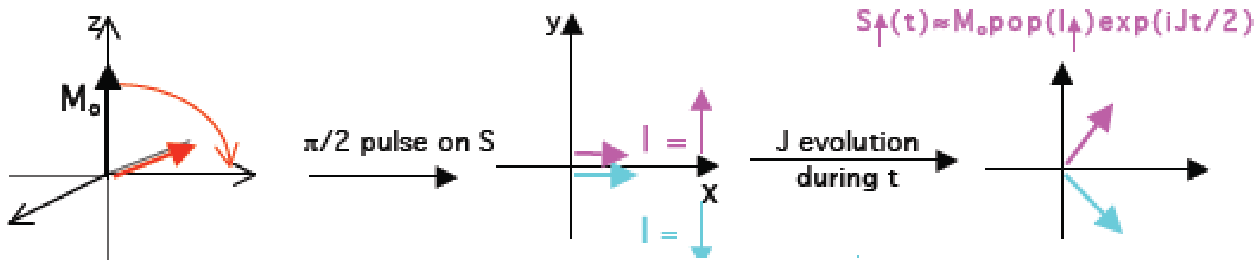
# Combining the spin echo & decoupling




**This block refocuses S chemical shift but not S-I J coupling**

# The INEPT Experiment




***M$_x$* Magnetization**

$$M_x = M_o^s\left[pop(I_\uparrow)\cdot\cos\left(\frac{Jt}{2}\right) + pop(I_\downarrow)\cdot\cos\left(\frac{-Jt}{2}\right)\right] \approx M_o^S\cos\frac{Jt}{2}$$

$$pop(I_\uparrow) \approx pop(I_\downarrow) \approx \frac{1}{2}$$

$$\cos\left(\frac{Jt}{2}\right) = \cos\left(\frac{-Jt}{2}\right)$$

---

***M$_y$* Magnetization**

$$M_y = M_o^s\left[pop(I_\uparrow)\cdot\sin\left(\frac{Jt}{2}\right) + pop(I_\downarrow)\cdot\sin\left(\frac{-Jt}{2}\right)\right] =$$

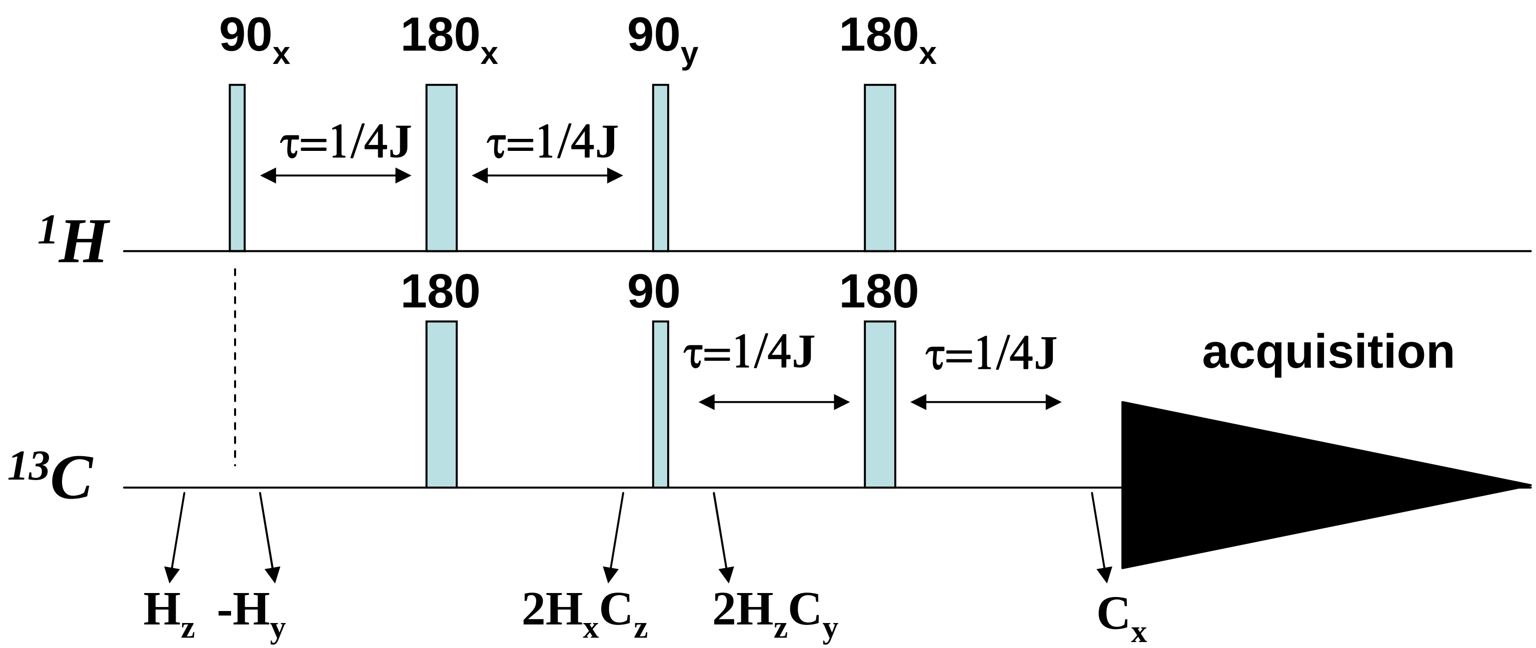
$$= M_o^S\left[pop(I_\uparrow) - pop(I_\downarrow)\right]\sin\left(\frac{Jt}{2}\right) = 2M_0^S M_0^I\sin\left(\frac{Jt}{2}\right)$$

$$\sin\left(\frac{-Jt}{2}\right) = -\sin\left(\frac{Jt}{2}\right)$$

$$pop(I_\uparrow) - pop(I_\downarrow) = 2M_0^I$$

$$S_x(t=0)\xrightarrow{J}\underbrace{S_x}_{\text{In-phase (observable)}}\cos\left(\frac{Jt}{2}\right) + \underbrace{2S_yI_z}_{\text{Anti-phase (invisible)}}\sin\left(\frac{Jt}{2}\right)$$

**Keep in mind:** $S_x(t=0) \xrightarrow{J} \underbrace{S_x}_{\text{In-phase (observable)}} \cos\left(\frac{Jt}{2}\right) + \underbrace{2S_yI_z}_{\text{Anti-phase (invisible)}} \sin\left(\frac{Jt}{2}\right)$



# INEPT - summery

$^{13}$C comes from J-mediated transfer from the $^{1}$H

– Intensity given by $\gamma_H$ not $\gamma_C$

$\gamma_H > \gamma_C$ : signal enhancement by the ratio $\gamma_H / \gamma_C$

– Relaxation given by $T_1^H$ not $T_1^C$

$T_1^H < T_1^C$ : faster repetition rates