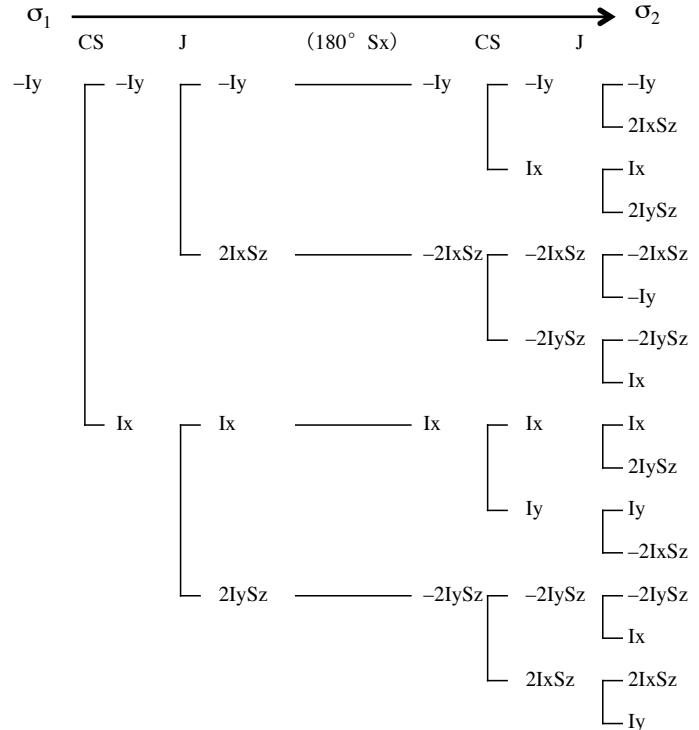
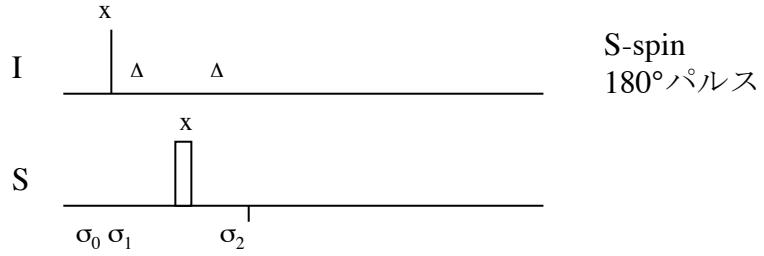


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CS-term J-term refocused



Ordered

$-Iy \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IxSz \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Ix \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $2IySz \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-Iy \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IySz \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Ix \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $Ix \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IySz \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Iy \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IySz \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $Ix \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $2IxSz \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Iy \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$

Sorted

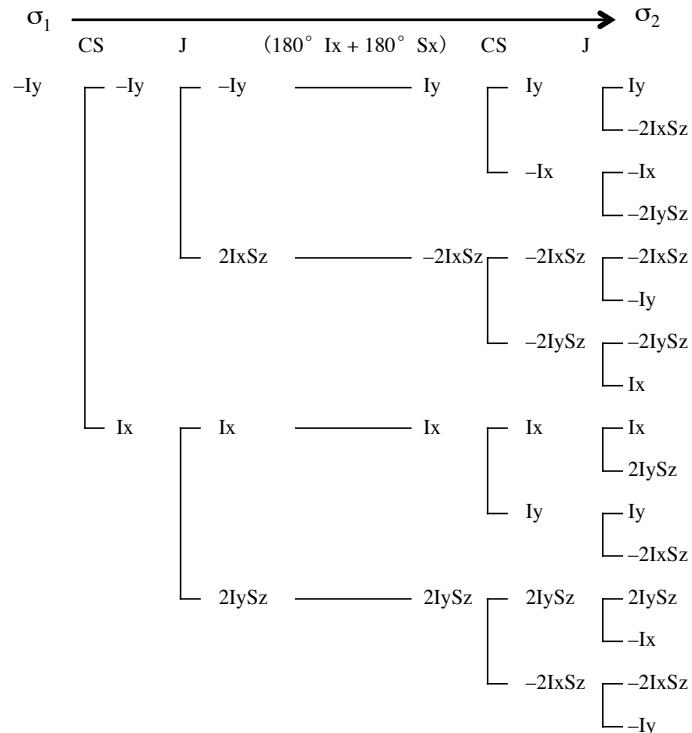
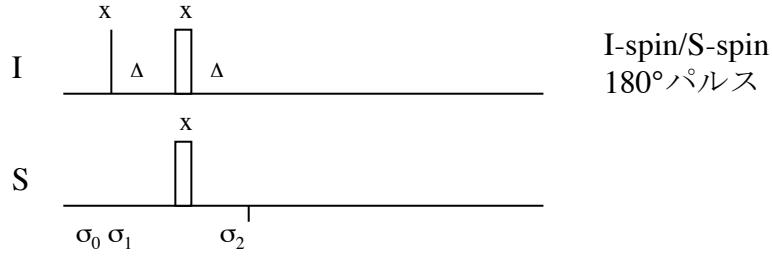
$Ix \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Ix \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $Ix \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $Ix \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-Iy \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-Iy \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Iy \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Iy \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $2IxSz \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $2IxSz \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $2IySz \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IySz \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $2IySz \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IySz \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$

Summarized

$$\begin{aligned}
 & Ix 2 \cos\omega\Delta \sin\omega\Delta (\cos^2\pi J\Delta + \sin^2\pi J\Delta) = Ix \sin 2\omega\Delta \\
 & -Iy (\cos^2\omega\Delta - \sin^2\omega\Delta) (\cos^2\pi J\Delta + \sin^2\pi J\Delta) = -Iy \cos 2\omega\Delta \\
 & 2IxSz (\cos^2\omega\Delta - \sin^2\omega\Delta) (\cos\pi J\Delta \sin\pi J\Delta - \cos\pi J\Delta \sin\pi J\Delta) = 0 \\
 & 2IySz 2 \cos\omega\Delta \sin\omega\Delta (\cos\pi J\Delta \sin\pi J\Delta - \sin\pi J\Delta \cos\pi J\Delta) = 0
 \end{aligned}$$

J-term refocused

CS-term not-refocused  
CS-term not-refocused



#### Ordered

$Iy \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-Ix \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-2IySz \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-Iy \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IySz \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Ix \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $Ix \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IySz \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Iy \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $2IySz \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-Ix \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-Iy \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$

#### Sorted

$-Ix \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Ix \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $Ix \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-Ix \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Iy \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-Iy \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Iy \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-Ix \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-2IySz \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IySz \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $2IySz \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $2IySz \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$

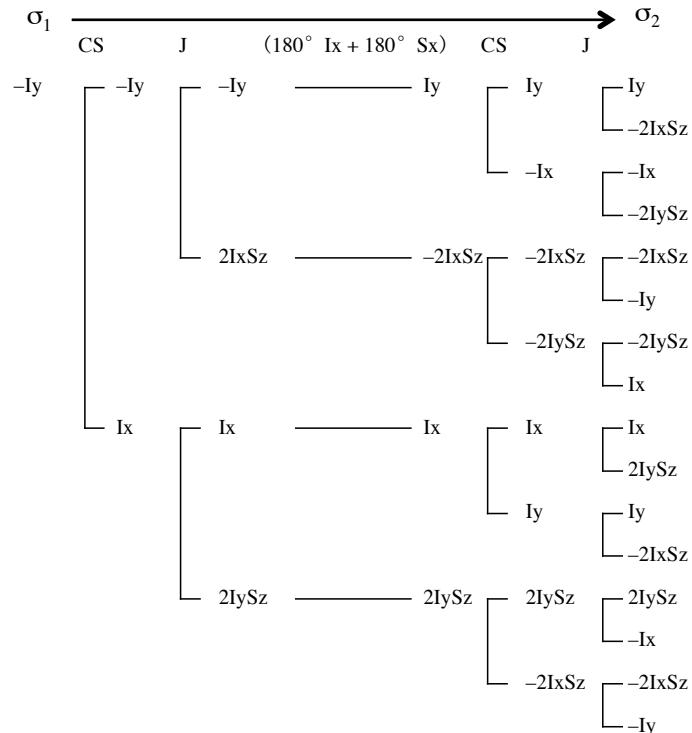
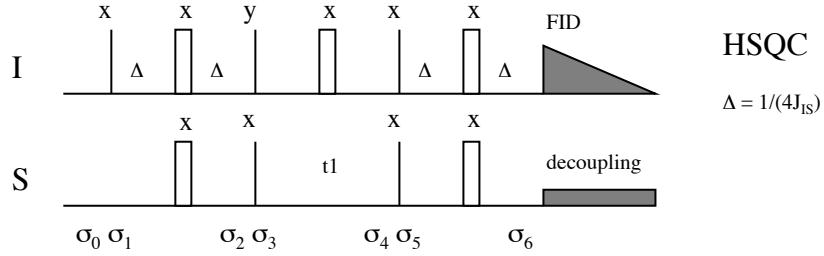
#### Summarized

$-Ix \cos\omega\Delta \sin\omega\Delta (\cos^2\pi J\Delta - \sin^2\pi J\Delta - \cos^2\pi J\Delta + \sin^2\pi J\Delta) = 0$   
 $Iy (\cos^2\omega\Delta + \sin^2\omega\Delta)(\cos^2\pi J\Delta - \sin^2\pi J\Delta) = Iy \cos 2\pi J\Delta$   
 $-2IxSz (\cos^2\omega\Delta + \sin^2\omega\Delta) 2 \sin\pi J\Delta \cos\pi J\Delta = -2IxSz \sin 2\pi J\Delta$   
 $-2IySz 2 \cos\omega\Delta \sin\omega\Delta (\cos\pi J\Delta \sin\pi J\Delta - \cos\pi J\Delta \sin\pi J\Delta) = 0$

#### CS-term refocused

J-term not-refocused

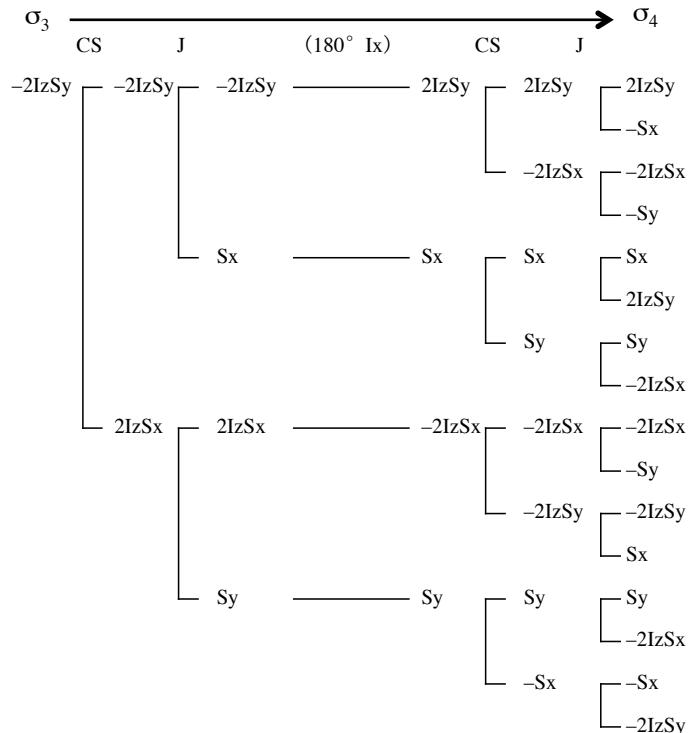
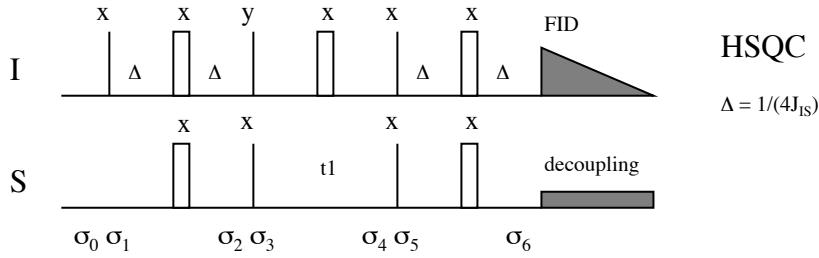
J-term not-refocused



<b>Ordered</b> <ul style="list-style-type: none"> <li>-Iy cosωΔ cosπJΔ cosωΔ cosπJΔ</li> <li>-2IxSz cosωΔ cosπJΔ cosωΔ sinπJΔ</li> <li>-Ix cosωΔ cosπJΔ sinωΔ cosπJΔ</li> <li>-2IySz cosωΔ cosπJΔ sinωΔ sinπJΔ</li> <li>-2IxSz cosωΔ sinπJΔ cosωΔ cosπJΔ</li> <li>-Iy cosωΔ sinπJΔ cosωΔ sinπJΔ</li> <li>-2IySz cosωΔ sinπJΔ sinωΔ cosπJΔ</li> <li>Ix cosωΔ sinπJΔ sinωΔ sinπJΔ</li> <li>Ix sinωΔ cosπJΔ cosωΔ cosπJΔ</li> <li>2IySz sinωΔ cosπJΔ cosωΔ sinπJΔ</li> <li>Iy sinωΔ cosπJΔ sinωΔ cosπJΔ</li> <li>-2IxSz sinωΔ cosπJΔ sinωΔ sinπJΔ</li> <li>2IySz sinωΔ sinπJΔ cosωΔ cosπJΔ</li> <li>-Ix sinωΔ sinπJΔ cosωΔ sinπJΔ</li> <li>-2IxSz sinωΔ sinπJΔ sinωΔ cosπJΔ</li> <li>-Iy sinωΔ sinπJΔ sinωΔ sinπJΔ</li> </ul>	<b>Sorted</b> <ul style="list-style-type: none"> <li>-Ix cosωΔ cosπJΔ sinωΔ cosπJΔ</li> <li>Ix cosωΔ sinπJΔ sinωΔ sinπJΔ</li> <li>Ix sinωΔ cosπJΔ cosωΔ cosπJΔ</li> <li>-Ix sinωΔ sinπJΔ cosωΔ sinπJΔ</li> <li>Iy cosωΔ cosπJΔ cosωΔ cosπJΔ</li> <li>-Iy cosωΔ sinπJΔ cosωΔ sinπJΔ</li> <li>Iy sinωΔ cosπJΔ sinωΔ cosπJΔ</li> <li>-Ix sinωΔ sinπJΔ sinωΔ sinπJΔ</li> <li>-2IxSz cosωΔ cosπJΔ cosωΔ sinπJΔ</li> <li>-2IxSz cosωΔ sinπJΔ cosωΔ cosπJΔ</li> <li>-2IxSz sinωΔ cosπJΔ sinωΔ sinπJΔ</li> <li>-2IxSz sinωΔ sinπJΔ sinωΔ cosπJΔ</li> <li>-2IySz cosωΔ cosπJΔ sinωΔ sinπJΔ</li> <li>-2IySz cosωΔ sinπJΔ sinωΔ cosπJΔ</li> <li>2IySz sinωΔ cosπJΔ cosωΔ sinπJΔ</li> <li>2IySz sinωΔ sinπJΔ cosωΔ cosπJΔ</li> </ul>
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#### Summarized

$$\begin{aligned}
& -Ix \cos\omega\Delta \sin\omega\Delta (\cos^2\pi J\Delta - \sin^2\pi J\Delta - \cos^2\pi J\Delta + \sin^2\pi J\Delta) = 0 \\
& Iy (\cos^2\omega\Delta + \sin^2\omega\Delta)(\cos^2\pi J\Delta - \sin^2\pi J\Delta) = Iy \cos 2\pi J\Delta = 0 & (\Delta = 1/4J) \\
& -2IxSz (\cos^2\omega\Delta + \sin^2\omega\Delta) 2 \sin\pi J\Delta \cos\pi J\Delta = -2IxSz \sin 2\pi J\Delta = -2IxSz & (\Delta = 1/4J) \\
& -2IySz 2 \cos\omega\Delta \sin\omega\Delta (\cos\pi J\Delta \sin\pi J\Delta - \cos\pi J\Delta \sin\pi J\Delta) = 0
\end{aligned}$$



Ordered

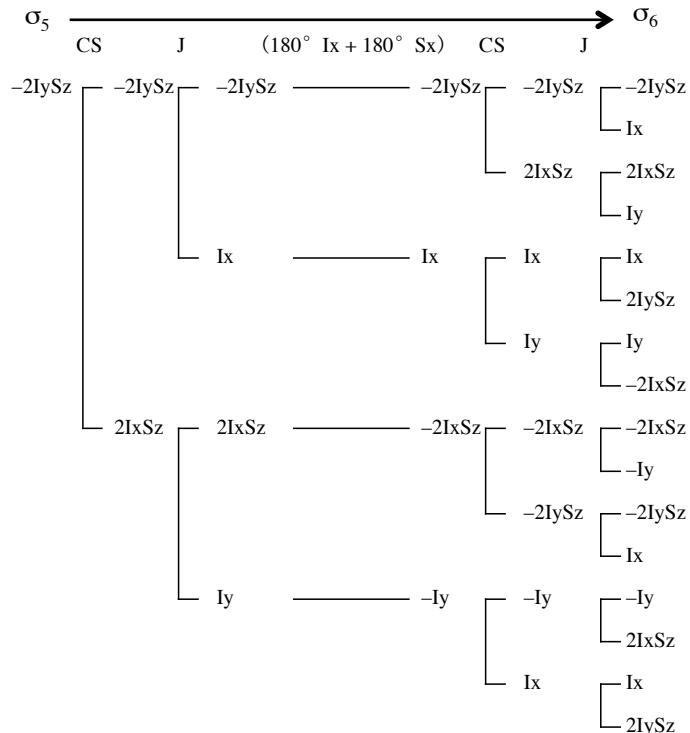
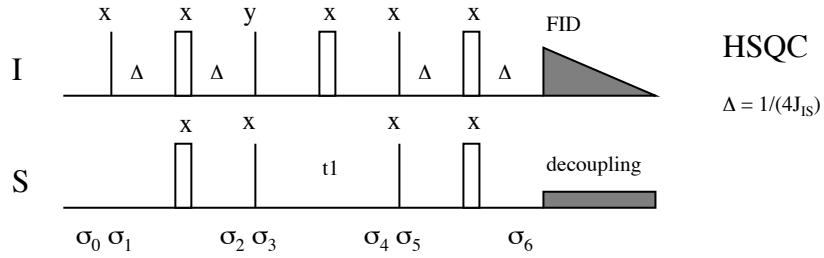
$$\begin{aligned} & 2IzSy \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & -Sx \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & -2IzSx \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & -Sy \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \\ & Sx \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & 2IzSy \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & Sy \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & -2IzSx \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \\ & -2IzSx \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & -Sy \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & -2IzSy \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & Sx \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \\ & Sy \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & -2IzSx \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & -Sx \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & -2IzSy \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \end{aligned}$$

Sorted

$$\begin{aligned} & -Sx \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & Sx \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & Sx \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \\ & -Sx \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & -Sy \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \\ & Sy \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & -Sy \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & Sy \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & -2IzSx \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & -2IzSx \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \\ & -2IzSx \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & -2IzSx \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & 2IzSy \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta \\ & 2IzSy \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta \\ & -2IzSy \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta \\ & -2IzSy \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta \end{aligned}$$

#### Summarized

$$\begin{aligned} & -Sx (\cos^2\omega\Delta - \sin^2\omega\Delta) (\cos\pi J\Delta \sin\pi J\Delta - \sin\pi J\Delta \cos\pi J\Delta) = 0 \\ & -Sy 2 \cos\omega\Delta \sin\omega\Delta (\cos\pi J\Delta \sin\pi J\Delta - \sin\pi J\Delta \cos\pi J\Delta) = 0 \\ & -2IzSx 2 \cos\omega\Delta \sin\omega\Delta (\cos^2\pi J\Delta + \sin^2\pi J\Delta) = -2IzSx \sin 2\omega\Delta = -2IzSx \sin\omega t_1 \quad (\Delta = t_1/2) \\ & 2IzSy (\cos^2\omega\Delta - \sin^2\omega\Delta) (\cos^2\pi J\Delta + \sin^2\pi J\Delta) = 2IzSy \cos 2\omega\Delta = 2IzSy \cos\omega t_1 \quad (\Delta = t_1/2) \end{aligned}$$



Ordered

$-2IySz \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $Ix \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $2IxSz \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Iy \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $Ix \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IySz \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Iy \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $-Iy \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IySz \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Ix \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-Iy \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IxSz \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Ix \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $2IySz \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$

Sorted

$Ix \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $Ix \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $Ix \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $Ix \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $Iy \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $Iy \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-Iy \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-Iy \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IxSz \cos\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $-2IxSz \cos\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$   
 $-2IxSz \sin\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IxSz \sin\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IySz \cos\omega\Delta \cos\pi J\Delta \cos\omega\Delta \cos\pi J\Delta$   
 $2IySz \cos\omega\Delta \sin\pi J\Delta \cos\omega\Delta \sin\pi J\Delta$   
 $-2IySz \sin\omega\Delta \cos\pi J\Delta \sin\omega\Delta \cos\pi J\Delta$   
 $2IySz \sin\omega\Delta \sin\pi J\Delta \sin\omega\Delta \sin\pi J\Delta$

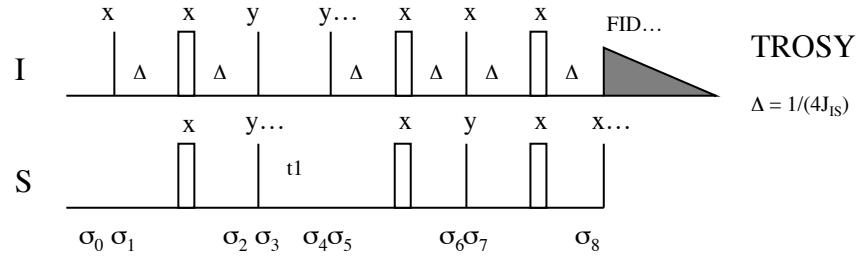
Summarized

$$Ix (\cos^2\omega\Delta + \sin^2\omega\Delta) 2 \sin\pi J\Delta \cos\pi J\Delta = Ix \sin 2\pi J\Delta = Ix \quad (\Delta = 1/4J)$$

$$Iy 2 \cos\omega\Delta \sin\omega\Delta (\cos\pi J\Delta \sin\pi J\Delta - \cos\pi J\Delta \sin\pi J\Delta) = 0$$

$$2IxSz \cos\omega\Delta \sin\omega\Delta (\cos^2\pi J\Delta - \sin^2\pi J\Delta - \cos^2\pi J\Delta + \sin^2\pi J\Delta) = 0$$

$$-2IySz (\cos^2\omega\Delta + \sin^2\omega\Delta)(\cos^2\pi J\Delta - \sin^2\pi J\Delta) = -2IySz \cos 2\pi J\Delta = 0 \quad (\Delta = 1/4J)$$



$$\begin{array}{ccccccc}
 \sigma_4 & \xrightarrow{\quad} & \sigma_5 & \xrightarrow{\quad} & \sigma_6 & \xrightarrow{\quad} & \sigma_7 & \xrightarrow{\quad} & \sigma_8 \\
 \text{CS}(t_1)J(t_1) \quad (90^\circ \text{ Iy}) & & J(2\Delta) & & (90^\circ \text{ Ix} + 90^\circ \text{ Sy}) & & J(2\Delta) & & (90^\circ \text{ Sx}) \\
 2\text{IxSz} & \xrightarrow{\quad} & 2\text{IxSz} & \xrightarrow{\quad} & 2\text{IxSz} & \xrightarrow{\quad} & -2\text{IxSz} & \xrightarrow{\quad} & 2\text{IxSz} \\
 & & & & & & \left[ \begin{array}{c} 2\text{IxSz} \\ \text{Iy} \end{array} \right] & & \left[ \begin{array}{c} -2\text{IxSy} \\ \text{Iy} \end{array} \right] \\
 \text{Sy} & \xrightarrow{\quad} & \text{Sy} & \xrightarrow{\quad} & -\text{Sy} & \xrightarrow{\quad} & -\text{Sy} & \xrightarrow{\quad} & \text{Sy} \\
 & & & & \left[ \begin{array}{c} 2\text{IxSz} \\ -2\text{IxSz} \end{array} \right] & & \left[ \begin{array}{c} \text{Sz} \\ 2\text{IxSy} \end{array} \right] & & \left[ \begin{array}{c} \text{Sz} \\ 2\text{IxSy} \end{array} \right] \\
 & & & & 2\text{IxSz} & \xrightarrow{\quad} & 2\text{IySz} & \xrightarrow{\quad} & -2\text{IySz} \\
 & & & & & & \left[ \begin{array}{c} -2\text{IySz} \\ -\text{Ix} \end{array} \right] & & \left[ \begin{array}{c} -2\text{IySz} \\ -\text{Ix} \end{array} \right] \\
 2\text{IzSy} & \xrightarrow{\quad} & 2\text{IxSy} & \xrightarrow{\quad} & -2\text{IxSy} & \xrightarrow{\quad} & -2\text{IxSy} & \xrightarrow{\quad} & 2\text{IxSz} \\
 -\text{Sx} & \xrightarrow{\quad} & -\text{Sx} & \xrightarrow{\quad} & -\text{Sx} & \xrightarrow{\quad} & \text{Sz} & \xrightarrow{\quad} & \text{Sy} \\
 & & & & \left[ \begin{array}{c} 2\text{IxSy} \\ \text{Sz} \end{array} \right] & & \left[ \begin{array}{c} -\text{Sz} \\ -2\text{IySz} \end{array} \right] & & \left[ \begin{array}{c} \text{Sy} \\ -2\text{IySz} \end{array} \right]
 \end{array}$$

Observed

$$\begin{aligned}
 \text{Iy cos}\omega_1 \cos\pi J_1 \sin\pi J_2 \Delta &= \text{Iy cos}\omega_1 \cos\pi J_1 \\
 -\text{Ix cos}\omega_1 \sin\pi J_1 \sin\pi J_2 \Delta &= -\text{Ix cos}\omega_1 \sin\pi J_1 \\
 2\text{IxSz} \sin\omega_1 \cos\pi J_1 & \\
 -2\text{IySz} \sin\omega_1 \sin\pi J_1 \sin\pi J_2 \Delta &= -2\text{IySz} \sin\omega_1 \sin\pi J_1
 \end{aligned}$$

Phase cycling is necessary for TROSY!

## I / S 2-spin system

### Product Operator Calculation Guide

#### Pulses

I 核のパルス項は I-spin にのみ、S-spin とは独立に作用する

$$\begin{array}{ll}
 (\beta^\circ \text{ Ix}) & (\beta^\circ \text{ Iy}) \\
 \text{Iz} \quad \left[ \begin{array}{c} \text{Iz cos}\beta \\ -\text{Iy sin}\beta \end{array} \right] & \text{Iz} \quad \left[ \begin{array}{c} \text{Iz cos}\beta \\ \text{Ix sin}\beta \end{array} \right] \\
 (\beta^\circ \text{ Ix}) & (\beta^\circ \text{ Iy}) \\
 \text{Ix} \quad \text{—} \quad \text{Ix} & \text{Ix} \quad \left[ \begin{array}{c} \text{Ix cos}\beta \\ -\text{Iz sin}\beta \end{array} \right] \\
 \text{Iy} \quad \left[ \begin{array}{c} \text{Iy cos}\beta \\ \text{Iz sin}\beta \end{array} \right] & \text{Iy} \quad \text{—} \quad \text{Iy}
 \end{array}$$

#### Chemical Shift

I 核の化学シフト項は I-spin にのみ、S-spin とは独立に作用する

$$\begin{array}{lll}
 (\omega_l t \text{ Iz}) & (\omega_l t \text{ Iz}) & (\omega_l t \text{ Iz}) \\
 \text{Iz} \quad \text{—} \quad \text{Iz} & \text{Ix} \quad \left[ \begin{array}{c} \text{Ix cos}\omega_l t \\ \text{Iy sin}\omega_l t \end{array} \right] & \text{Iy} \quad \left[ \begin{array}{c} \text{Iy cos}\omega_l t \\ -\text{Ix sin}\omega_l t \end{array} \right]
 \end{array}$$

#### J-coupling

J 項は I-spin、S-spin 同時に作用する

$$\begin{array}{lll}
 (\pi J_{IS} t \text{ IzSz}) & (\pi J_{IS} t \text{ IzSz}) & (\pi J_{IS} t \text{ IzSz}) \\
 \text{Iz} \quad \text{—} \quad \text{Iz} & \text{Ix} \quad \left[ \begin{array}{c} \text{Ix cos}\pi J_{IS} t \\ 2\text{IySz sin}\pi J_{IS} t \end{array} \right] & \text{Iy} \quad \left[ \begin{array}{c} \text{Iy cos}\pi J_{IS} t \\ -2\text{IxSz sin}\pi J_{IS} t \end{array} \right] \\
 2\text{IxSx} \quad \text{—} \quad 2\text{IxSx} & 2\text{IxSz} \quad \left[ \begin{array}{c} 2\text{IxSz cos}\pi J_{IS} t \\ \text{Iy sin}\pi J_{IS} t \end{array} \right] & 2\text{IySz} \quad \left[ \begin{array}{c} 2\text{IySz cos}\pi J_{IS} t \\ -\text{Ix sin}\pi J_{IS} t \end{array} \right] \\
 2\text{IxSy} \quad \text{—} \quad 2\text{IxSy} & \text{Sx} \quad \left[ \begin{array}{c} \text{Sx cos}\pi J_{IS} t \\ 2\text{IzSy sin}\pi J_{IS} t \end{array} \right] & \text{Sy} \quad \left[ \begin{array}{c} \text{Sy cos}\pi J_{IS} t \\ -2\text{IzSx sin}\pi J_{IS} t \end{array} \right] \\
 2\text{IySx} \quad \text{—} \quad 2\text{IySx} & 2\text{IzSz} \quad \left[ \begin{array}{c} 2\text{IzSz cos}\pi J_{IS} t \\ \text{Sy sin}\pi J_{IS} t \end{array} \right] & 2\text{IzSy} \quad \left[ \begin{array}{c} 2\text{IzSy cos}\pi J_{IS} t \\ -\text{Sx sin}\pi J_{IS} t \end{array} \right]
 \end{array}$$