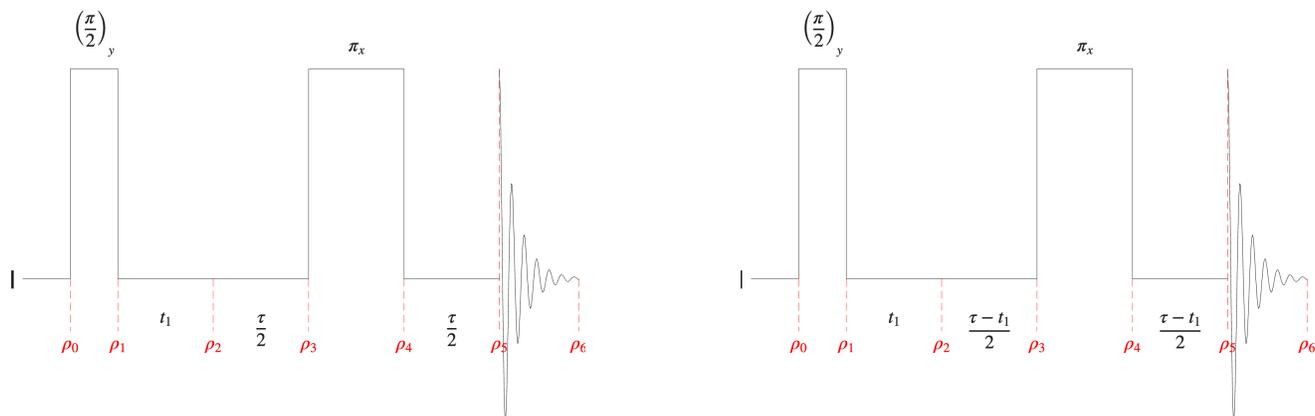


February 2026 NMR Topic of the Month: Constant Time



“... as simple as possible, and no simpler.”

The pulse sequence diagramed above on the left is a simple 2D experiment involving a single spin echo. Analyzing this first experiment for two J-coupled spins of the same type using product-operators is straightforward.

$$\rho_0 = I_{1z} + I_{2z} \rightarrow \rho_1 = I_{1x} + I_{2x} \rightarrow$$

$$\begin{aligned} \rho_2 = & I_{1x} \cos(\omega_1 t_1) \cos(\pi J t_1) + 2I_{1y} I_{2z} \cos(\omega_1 t_1) \sin(\pi J t_1) + I_{1y} \sin(\omega_1 t_1) \cos(\pi J t_1) - 2I_{1x} I_{2z} \sin(\omega_1 t_1) \sin(\pi J t_1) \\ & + I_{2x} \cos(\omega_2 t_1) \cos(\pi J t_1) + 2I_{1z} I_{2y} \cos(\omega_2 t_1) \sin(\pi J t_1) + I_{2y} \sin(\omega_2 t_1) \cos(\pi J t_1) - 2I_{1z} I_{2x} \sin(\omega_2 t_1) \sin(\pi J t_1) \rightarrow \end{aligned}$$

$$\begin{aligned} \rho_5 = & I_{1x} \cos(\omega_1 t_1) \cos[\pi J(t_1 + \tau)] + 2I_{1y} I_{2z} \cos(\omega_1 t_1) \sin[\pi J(t_1 + \tau)] + I_{1y} \sin(\omega_1 t_1) \cos[\pi J(t_1 + \tau)] \\ & - 2I_{1x} I_{2z} \sin(\omega_1 t_1) \sin[\pi J(t_1 + \tau)] + I_{2x} \cos(\omega_2 t_1) \cos[\pi J(t_1 + \tau)] + 2I_{1z} I_{2y} \cos(\omega_2 t_1) \sin[\pi J(t_1 + \tau)] \\ & + I_{2y} \sin(\omega_2 t_1) \cos[\pi J(t_1 + \tau)] - 2I_{1z} I_{2x} \sin(\omega_2 t_1) \sin[\pi J(t_1 + \tau)] \end{aligned}$$

A Little Twist

Now suppose that we keep the total experiment time constant by subtracting the indirect dimension time from the echo time as shown in the experiment above on the right. The product-operator analysis for the original experiment is still valid, just substitute $\tau \rightarrow \tau - t_1$, which leads to a new ρ_5 .

$$\begin{aligned} \rho_5 = & I_{1x} \cos(\omega_1 t_1) \cos(\pi J \tau) + 2I_{1y} I_{2z} \cos(\omega_1 t_1) \sin(\pi J \tau) + I_{1y} \sin(\omega_1 t_1) \cos(\pi J \tau) - 2I_{1x} I_{2z} \sin(\omega_1 t_1) \sin(\pi J \tau) \\ & + I_{2x} \cos(\omega_2 t_1) \cos(\pi J \tau) + 2I_{1z} I_{2y} \cos(\omega_2 t_1) \sin(\pi J \tau) + I_{2y} \sin(\omega_2 t_1) \cos(\pi J \tau) - 2I_{1z} I_{2x} \sin(\omega_2 t_1) \sin(\pi J \tau) \end{aligned}$$

What has been accomplished is that all of the terms involving t_1 come only from the chemical shift terms. Which means that there is no J-splitting of the signals in the indirect dimension. This sequence sacrifices the J-coupling content in the indirect dimension but concentrates the signal into the remaining peaks.

References

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