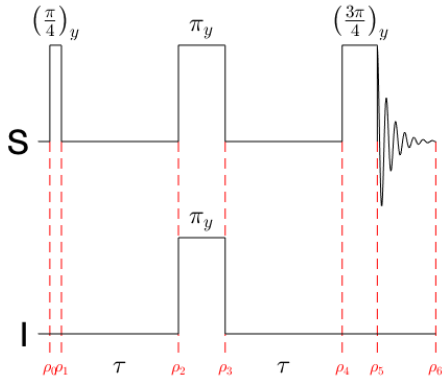
January 2022 NMR Topic of the Month: The TANGO Pulse Sequence



For what does the acronym TANGO stand?

TANGO = Testing for Adjacent Nuclei with a Gyration Operator

What is the role of the TANGO sequence?

The TANGO sequence is a filter, it removes S-spin signals that do not have a J-coupling to an I-spin. This filter is a common building block within other sequences, as it eliminates large uncoupled signals and details the coupled signals.

How does the TANGO work?

With the initial pulse some of the magnetization is put in the transverse plane and conditioned to either add to or subtract from the remaining magnetization at the final pulse. To do this, it uses the coupling terms from the free evolutions (τ periods) and a sign change from the π pulse on the I spins to condition half of the magnetization of the S spins. Then the total S spin magnetization is made transverse with the final pulse. Specifically, where $c_X = \frac{1}{4}\left(\gamma_X B_0/k_B T\right)$:

$$\rho_0 = c_I I_z + c_S S_z$$

$$\rho_1 = c_I I_z + \frac{c_S}{\sqrt{2}} S_x + \frac{c_S}{\sqrt{2}} S_z$$

$$\rho_2 = c_I I_z + \frac{c_S}{\sqrt{2}} S_x cos\left(\omega_S \tau\right) cos(\pi J \tau) + \frac{c_S}{\sqrt{2}} 2 I_z S_y cos\left(\omega_S \tau\right) sin(\pi J \tau) + \frac{c_S}{\sqrt{2}} S_y sin\left(\omega_S \tau\right) cos(\pi J \tau) - \frac{c_S}{\sqrt{2}} 2 I_z S_x sin\left(\omega_S \tau\right) sin(\pi J \tau) + \frac{c_S}{\sqrt{2}} S_z$$

$$\rho_3 = -\, c_I I_z - \frac{c_S}{\sqrt{2}} S_x cos\left(\omega_S \tau\right) cos(\pi J \tau) - \frac{c_S}{\sqrt{2}} 2 I_z S_y cos\left(\omega_S \tau\right) sin(\pi J \tau) + \frac{c_S}{\sqrt{2}} S_y sin\left(\omega_S \tau\right) cos(\pi J \tau) - \frac{c_S}{\sqrt{2}} 2 I_z S_x sin\left(\omega_S \tau\right) sin(\pi J \tau) - \frac{c_S}{\sqrt{2}} S_z$$

$$\rho_4 = -\, c_I I_z - \frac{c_S}{\sqrt{2}} S_x cos(2\pi J \tau) - \frac{c_S}{2\sqrt{2}} 2 I_z S_y sin(2\pi J \tau) - \frac{c_S}{\sqrt{2}} S_z$$

$$\rho_5 = -\, c_I I_z + \frac{c_S}{2} S_x cos(2\pi J \tau) + \frac{c_S}{2} S_z cos(2\pi J \tau) - \frac{c_S}{2\sqrt{2}} 2 I_z S_y sin(2\pi J \tau) + \frac{c_S}{2} S_z - \frac{c_S}{2} S_x$$

Notice that if $J = 0$ then $\rho_5 = -\, c_I I_z + c_S S_z$, so no signal. But if $\tau = \frac{1}{|2J|}$ then $\rho_5 = -\, c_I I_z - c_S S_x$, so for that timing (and in the absence of relaxation) the TANGO output looks like a $\pi/2$-pulse along $-\,\hat{y}$ on the S spins and a π pulse on the I spins.

References

1. S. Wimperis and R. Freeman, *J. Magn. Reson.* **58**(2), 348-353 (1984).
2. T. Parella, F. Sanchez-Ferrando, and A. Virgili, *J. Magn. Reson. Ser. A.* **112**(2), 241-245 (1995).
3. S. Berger and S. Braun, *200 and More NMR Experiments. A Practical Course*, Wiley-VCH, Weinheim (2004).