Triple quantum T_2 measurements

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Introduction:

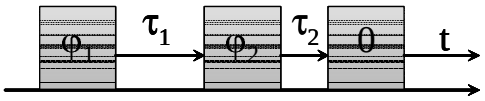
The exact determination of transverse relaxation times of sodium ions in biological media is a prerequisite for sodium triple quantum (TQ) filtered MRI. The direct experimental estimation based on a single FID measurement is unreliable for *in vivo* applications. Due to variations in tissue susceptibility, B_0 inhomogeneities are present which are difficult to compensate through shim optimization in a reliable and timely fashion. In this work, we demonstrate the use of a particular class of Triple Quantum Filtered experiments for accurate measurement of spin-3/2 relaxation rates in biological systems.

Theory:

The three pulse experiment, depicted in the figure below, is characterized by twenty one possible coherence pathways. By using the TQ filter with the ten phases cycle given by $\varphi_1 = -\varphi_3 = \pi/5, \varphi_2 = 0, \psi = k\pi, 0 \le k < 9$, only one of the pathways is selected and each infinitesimal volume contribution to the total signal can e expressed [1]

$$s(t,\tau_1,\tau_2;\theta,\delta) \approx \left(e^{-\tau_1/T_S} - e^{-\tau_1/T_F}\right) e^{-\tau_2/T_S} \left(e^{-t/T_S} - e^{-t/T_F}\right) \sin^7\theta e^{-i(t-\tau_1-3\tau_2)\delta}$$

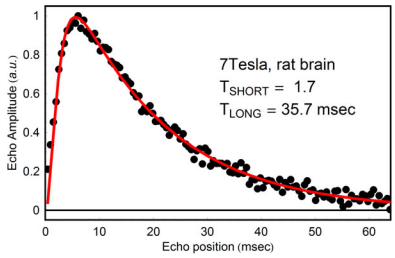
a function depending only on the timing parameter of the sequence (τ_1 the preparation time, and τ_2 the evolution time), the flip angle θ, and the off-resonance parameter, δ, the difference between the applied RF and local Larmor frequencies. The total signal is therefore



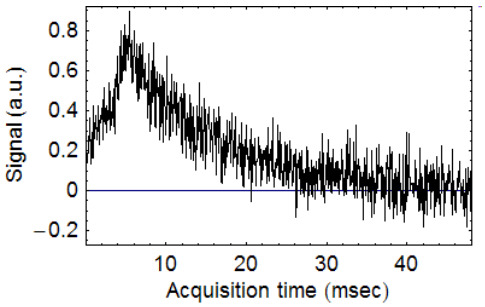
$$s(t,\tau_1,\tau_2;\theta,\delta) \approx \left(e^{-\tau_1/T_S} - e^{-\tau_1/T_F}\right) e^{-\tau_2/T_S} \left(e^{-t/T_S} - e^{-t/T_F}\right) \iiint d\mathbf{r} \sin^7\theta(\mathbf{r}) e^{-i(t-\tau_1-3\tau_2)\delta(\mathbf{r})}$$

The last expression shows that, at the echo moment $t=\tau_1+3\tau_2$, the measurement of the filtered signal is proportional with a function depending on the relaxation parameters of the sample, only. By performing the experiment, while varying the preparation time, an unbiased extraction of relaxation times is possible.

Results:



In the picture there are presented the results of this variable echo method applied for a sample consisting of a whole, intact, rat brain, at seven Tesla. In spite of the low quality of the single FID data, presented below, the 2D acquisition is able to retrieve correct physical quantities.



Conclusions:

Because of its inherent B0 and B1 robustness, this scheme is ideally suited for the measurement of spin-3/2 transversal relaxation times, especially in the case of *in vivo* MRI, where B_0 and B_1 can not be fully optimized.

References:

[1] C. Tanase, and F. Boada, JMR, (under revision)
[3] I. Hancu, J. van der Maarel and F. Boada, JMR, 147 (2001)
[4] G. Bodenhausen, H. Kogler, and R.R. Ernst, JMR, 58, (1984)