

Initial Investigation into Effect of Radiation Damping on Magnetization Transfer Parameters Extracted From Inversion Recovery Experiments

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Purpose

We seek to understand how radiation damping (RD) affects the confidence of magnetization transfer (MT) measurements when using the selective inversion recovery (SIR) model for MT. This research is a response to earlier work by Szantay and Demeter¹ in which the need for better quantification of the effects of radiation damping on measurements of MT parameters was noted. RD has also been shown to be present in low power saturation pulse MT experiments,² and we expect its effects to be relevant to MR parameters measured by SIR. This work communicates our initial steps of simulating differing levels of RD into NMR spectra as it experiences an inversion recovery experiment, with the goal of extending it to selective inversion recovery. This research seeks to benefit both research and clinical physicists dealing with effects of RD in MT experiments.

Methods

We simulated a single spin system of water with $T_1 = 3.2$ s and $T_{2*} = 2.6$ s by numerically solving the Bloch equations and predicting the NMR spectra that would result from an inversion recovery experiment. The inversion pulse was ~ 15 μ s long and the field strength 9.4 T. The recovery delay was $5^* T_1$. All work was done in Matlab. We included a factor of RD into the model using the variable T_{RD} , the radiation damping time, and chose T_{RD} values of 0.1, 1.5, and 2.9 s to correspond to strong, mild, and weak RD respectively, as well as a scenario of no RD. The integral of the NMR spectra for a range of times of delay after inversion was fit to a biexponential decay model,² and parameters from this fit extracted. While we do not expect to see significant difference in all MT parameters extracted from this simulation, we use this initial work to investigate the overall method of introducing RD into SIR data and determining the effect on extracted MT parameters.

Results

The results from the single spin simulation with a water sample and four levels of radiation damping (none, weak, mild, and strong) are depicted in Figure 1. As expected for a single-spin system, there is no significant change in R_1^+ or b_f , but we do note differences in the other parameters as RD level increases.

Discussion

By statistically interpreting the behavior of parameter fits for spin systems experiencing varying levels of RD, we hope to make inference about the behavior of such parameters for multiple pool systems experiencing similar levels of RD. This work demonstrates our ability to simulate different levels of RD in inversion recovery experiments, and we will next extend the work to multiple pool systems. Eventually, we hope to develop a statistical model sophisticated enough to “see through” the radiation damping that a system experiences and garner a more accurate picture of the actual model parameters.

Conclusion

Quantifying the effects of radiation damping on the parameters for magnetization transfer experiments enables us to extract real measurements from beneath layers of uncertainty created by RD. These predictions will provide more accurate picture of the presence of RD in a given experiment and therefore the interaction of the two pools within it. Finding better ways to visualize and model magnetization transfer experiments is of import in clinical studies. As so much of the body involves the interaction of macro-molecular and liquid pools, creating better models for such interaction would give researchers further ability to deal with RD effects.

References

¹ Szantay and Demeter, Conc. Mag. Res. **11**, 121 (1999). ² Williamson et al. J. Mag. Res. **183**, 203 (2006).

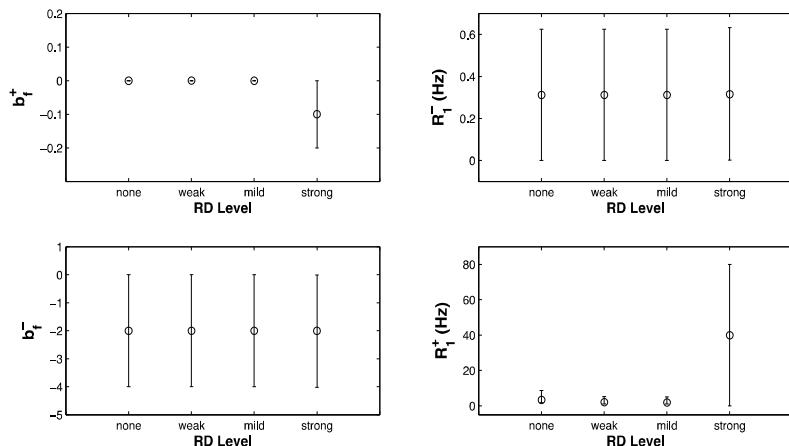


Figure 1: Extracted MT parameter as a function of RD