The goal of this project was to investigate different models which have been proposed in our data. Over the past decade, several theoretical models have been proposed to explain the generation of this phenomenon. Theoretical calculations show that diffusion narrowing substantially affects signal loss in BOLD imaging. The $R_2^*$ signal has been shown to decay with a complex behavior, normal Non-Lorentzian, and thus is not adequately described by the traditional model of simple mono-exponential decay. BOLD (Blood Oxygenation Level Dependent) imaging is used in MRI to show differences in activation of the brain based on the relative changes of the $T_2^*$ (> 1.4 $T_2$) signal of the blood. However, quantification of blood oxygenation level based on the $T_2^*$ signal has been hindered by the lack of a predictive model which accurately correlates the $T_2^*$ signal to the oxygenation level of blood.

Figure 1: $T_2^*$ relaxation, also known as transverse relaxation, is the loss of magnetic moments in the transverse plane. This generates local field inhomogeneities, which causes protons to experience different phase shifts, leading to depolarization and the $T_2^*$ signal decay. Diffusion narrowing is seen under all conditions: vertical vs. horizontal positions of NMR tube axis, rotating vs. not rotating vs. shaker. The complex $T_2^*$ behavior is seen under all conditions, thus allowing the fundamental non-Lorentzian nature of the blood MR signal.

**BACKGROUND**

**METHODS and MATERIALS**

The MR blood data used originated from the work of Spores et al.

**Preparation of Blood**

Both human and animal blood were prepared at varying oxygenation levels and sealed in entirely blood-filled NMR tubes without gas bubbles prior to every experiment Spores et al. performed.

**MR Acquisition**

Spores et al. performed all MR measurements on a Siemens Magnetom Vision system operating at 1.5T (Siemens, Erlangen, Germany). Blood samples were contained in NMR tubes placed horizontally inside the magnet in a temperature-controlled ($37\pm0.5$) C bath. To avoid heating of the cryostat, the blood sample was sealed around an air gap at a rate of approximately 100 rpm.

**Pulse Sequence**

Data were obtained by Spores et al. using a single spin-echo-based 1D radar localization spectroscopy technique in which 90° and 180° RF pulses were applied in the presence of slice-selective gradients. A single 4-mm thick slice perpendicular to the NMR tube axis at the center of the tube was examined. Individual HIDs were acquired at starting at spin-echo echo time TE = 12T, varying the TE from 2ms to 7ms throughout the experiments.

**Bayesian Analysis**

Potential models describing the blood MR signal were analyzed using the Bayesian Analysis Package (http://bayesiananalysis.wustl.edu/index.html) to determine behavior of the blood $R_2^*$ and $R_1T_1$ parameters. Over 200 blood datasets were run with most parameters determined for each dataset except for $\omega_0$ which was determined to a single value for all datasets.

Theoretical calculations show that diffusion narrowing substantially affects signal loss in our data. Over the past decade, several theoretical models have been proposed to describe this non-Lorentzian behavior in the blood $T_2^*$ signal in BOLD MRI imaging. The goal of this project was to investigate different models which have been proposed over the years and determine a semi-phenomenological model for the $T_2^*$ behavior using actual MR blood data.