Abstract

MR imaging with polarized noble gases has shown promise in both, biomedical and material's imaging applications. Its advantage over the conventional proton MRI lies in its ability to produce high signal-to-noise ratio (SNR), high-resolution images at low magnetic field strengths. In this work:

1. We implemented and studied in detail two methods for detecting hyperpolarization levels of ^{129}Xe and ^{3}He: NMR (Nuclear Magnetic Resonance) and EPR (Electron Paramagnetic Resonance). The ^{3}He NMR and EPR data allowed for a comparison of these two polarimetry methods, while ^{129}Xe NMR and EPR data showed promise for the calibration of ^{129}Xe EPR shifts.

2. We investigated the possibility of using a *pulsed* resistive low-field MR scanner for spin echo imaging of hyperpolarized gases. By collecting CPMG spin echo trains containing 4096 echoes and lasting over 30 seconds, we demonstrated a high degree of stability for the pulsed resistive low-field scanner.

3. We developed a single-shot PGSE sequence for measuring diffusion coefficients of hyperpolarized gases which removed the effects of background gradients, thus allowing a separation of the T_2^{CPMG} relaxation from diffusion-induced signal loss. The theoretical estimations of ^{3}He and ^{129}Xe diffusion coefficients which were based on the Lennard-Jones potential agreed well with our measured ^{3}He and ^{129}Xe diffusion coefficients within the experimental errors.

4. We determined the inherent T_2 relaxation times of ^{3}He and ^{129}Xe by varying the interecho time in the conventional CPMG spin echo sequence and by modelling the functional dependence of the T_2^{CPMG} relaxation time on the interecho spacing.

5. We collected first ever ^{3}He gradient echo images on a pulsed resistive low-field scanner.

In addition, we modelled numerically the effects of flip-angle, diffusion and relaxation rates on signal decay during gradient echo imaging with hyperpolarized gases.

6. We show, with simulations and experiments, that central ordering of RARE k-space acquisition significantly reduces diffusion-induced signal loss. The 1-D RARE images of ^{3}He show a factor of a 100 improvement in the SNR (for 1.6 mm resolution) when using centrally ordered phase-encode gradients.