Magnetic Resonance Imaging with Hyperpolarized ^{13}C Contrast Agents

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Hyperpolarized ^{13}C substrates offer the potential to non-invasively image metabolism and enzymatic activity. However, hyperpolarization introduces a number of difficulties, and imaging is hampered by non-equilibrium magnetization and the need for spectral encoding. There is therefore a need for fast and RF efficient spectral imaging techniques. This work presents a number of new methods that can be used to improve polarization, increase RF efficiency and improve modeling accuracy in hyperpolarized ^{13}C experiments. In particular, a novel encoding and reconstruction algorithm is presented that can generate spatially and spectrally resolved images with a single RF excitation and echo time. This reconstruction framework increases data acquisition efficiency, enabling accelerated acquisition speed, preserved polarization, and/or improved temporal or spatial resolution. Overall, the methods enumerated in this dissertation have the potential to improve modeling accuracy and to mitigate the conventional tradeoffs between SNR, spatial resolution, and temporal resolution that govern image quality in hyperpolarized ^{13}C experiments.