Phase contrast MRI is a specialized MRI technique that allows for the visualization of small changes in the phase of protons in tissues. This technique is particularly useful for imaging moving fluids, such as blood flow, as well as for imaging tissues with different magnetic susceptibilities, such as the brain.

In phase contrast MRI, the magnetic field is manipulated to introduce a phase shift between the protons in different tissues. The resulting image shows the phase difference between the tissues, which can be used to visualize differences in the flow of fluids, such as blood flow in vessels or cerebrospinal fluid flow in the brain.

One of the main advantages of phase contrast MRI is that it can be used to quantify the velocity of fluid flow, which can be useful for diagnosing and monitoring a variety of conditions, such as stroke, aneurysms, and hydrocephalus. In addition, phase contrast MRI can be used to study the microstructure of tissues, such as the organization of nerve fibers in the brain.

Overall, phase contrast MRI is a powerful tool that can provide valuable diagnostic and research information for a variety of medical applications.

The brain tissue phase contrast in MRI sequences reflects the spatial distributions of multiple substances, such as iron, myelin, calcium, and proteins. These substances with paramagnetic and diamagnetic susceptibilities often colocalize in one voxel in brain regions. Both opposing susceptibilities play vital roles in brain development and neurodegenerative diseases. Conventional QSM methods only provide voxel-averaged susceptibility value and cannot disentangle intravoxel susceptibilities with opposite signs. Advanced susceptibility imaging methods have been recently developed to distinguish the contributions of opposing susceptibility sources for QSM. The basic concept of separating paramagnetic and diamagnetic susceptibility proportions is to include the relaxation rate R2* with R2' in QSM. The magnitude decay kernel, describing the proportionality coefficient between R2' and susceptibility, is an essential reconstruction coefficient for QSM separation methods. In this study, we proposed a more comprehensive complex signal model that describes the relationship between 3D GRE signal and the contributions of paramagnetic and diamagnetic susceptibility to the frequency shift and R2* relaxation. The algorithm is implemented as a constrained minimization problem in which the voxel-wise magnitude decay kernel and sub-voxel susceptibilities are determined alternately in each iteration until convergence. The calculated voxel-wise magnitude decay kernel could realistically model the relationship between the R2' relaxation and the volume susceptibility. Thus, the proposed method effectively prevents the errors of the magnitude decay kernel from propagating to the final susceptibility separation reconstruction. Phantom studies, ex vivo macaque brain experiments, and in vivo human brain imaging studies were conducted to evaluate the ability of the proposed method to distinguish paramagnetic and diamagnetic susceptibility sources. The results demonstrate that the proposed method provides state-of-the-art performances for quantifying brain iron and myelin compared to previous QSM separation methods. Our results show that the proposed method has the potential to simultaneously quantify whole brain iron and myelin during brain development and aging. The proposed model was also deployed with multiple-orientation complex GRE data input measurements, resulting in high-quality QSM separation maps with more faithful tissue delineation between brain structures compared to those reconstructed by single-orientation QSM separation methods [1)].

1)

Li Z, Feng R, Liu Q, Feng J, Lao G, Zhang M, Li J, Zhang Y, Wei H. APART-QSM: an improved sub-voxel quantitative susceptibility mapping for susceptibility source separation using an iterative data fitting method. Neuroimage. 2023 Apr 29:120148. doi: 10.1016/j.neuroimage.2023.120148. Epub ahead of print. PMID: 37127191.