Quantitative imaging of tissue microstructure using high field MRI

The advent of ultra high field (UHF > 3T) MRI technologies, both hardware and MRI sequence physics, has introduced the possibility of visualizing *in vivo* changes in human tissue structure and physiology with an unprecedented level of accuracy. However, the current breadth of application of UHF MRI to neurological diseases represents only the tip of the iceberg. The challenge moving forward will be to leverage advanced techniques in MRI physics, primarily developed at 3 T, for use with 7 T MRI. This requires addressing several critical challenges inherent in high field imaging. First, the decreased radiofrequency (RF) field wavelength associated with UHF MRI requires consistent mapping of the transmit RF field (B_1^+). Second, UHF MRI is also associated with increased static magnetic field inhomogeneities.

In my presentation, I will discuss the application of gradient echo, 7 T MRI using phase and magnitude processing for quantifying sub-cortical gray matter (GM) iron accumulation and diffusely abnormal white matter in early relapsing-remitting patients and matched controls. Apparent transverse relaxation rate (R_2^*) and quantitative magnetic susceptibility (QS) in subcortical GM are strongly correlated with MS disability, defined by the expanded disability status scale (EDSS). Voxel-level QS maps also identify the important contribution of age to demyelination in patients with MS, suggesting that age-adjusted clinical scores may provide more robust measures of MS disease severity. I will follow this discussion by reviewing an application of 3 T MRI for identifying anatomically localized regions of the brain, along the outer superior temporal, superior/inferior parietal and posterior/anterior cingulate cortices of both hemispheres, where MS patients have reduced cortical surface magnetization transfer ratio, suggestive of myelin loss, compared to matched controls. The results of this study corroborate findings from histopathology, which identify the outer cortex as the primary site of sub-pial lesions in MS due to the presence of inflammatory B-cell and microglial infiltrates.