AbstractID: 8484 Title: An Alternative Spatial Encoding Method for Magnetic Nanoparticle Imaging

Purpose: Magnetic particle imaging, MPI, was introduced in 2005 and promises to be sufficiently sensitive to allow molecular imaging. We introduce and explore numerically an alternative method of encoding position in magnetic nanoparticle imaging. The original MPI method localized the nanoparticle signal at the 3rd harmonic frequency using a strong magnetic field to saturate the nanoparticles outside of the field free point (FFP). We present an alternative method of encoding the signal position in which the signal at the second harmonic is recorded so signal is produced along a magnetic field gradient.

Method and Materials: The signal from 20nm magnetic nanoparticles was simulated with a Langevin model using iron oxide properties. Response matrices were calculated for a linear gradient across the sample and the condition number of the matrices was used as the metric for stability of the reconstruction.

Results: The conditioning of the second harmonic is significantly better conditioned than that for the third harmonic. The condition number of the response matrix used to reconstruct the spatial distribution of the signal is nearly one for ideal cases. The size of the field gradient increases for increasing number of encoded pixels but need not be as large as that required to saturate the nanoparticles outside a single voxel. For a single size nanoparticle, the response function approximates a smoothed Haar wavelet function at the smallest scale and the best conditioning occurs when the scaling of the response functions approximates the scaling of a dyadic wavelet basis.

Conclusion: A linear gradient can be used to encode nanoparticle position using the second or third harmonics. The signal at the second harmonic is significantly larger than at the third harmonic frequency and the conditioning is significantly better; the combination should allow an increase in sensitivity by a factor of from 2 to 8.