Introduction: The application of interferometric techniques provides a substantial improvement of imaging speed as compared to conventional spectroscopic imaging [1,2]. This abstract outlines the sources of information that make interferometric MR imaging advantageous. Understanding these sources clarifies the algorithm, its assumptions, and its limitations.

Theory: For spectroscopic MR imaging, a desired image, $s(\vec{r},f)$, can be characterized by collecting data $s(\vec{k},t)$ which is related by the Fourier transform. In interferometric MRI, the data from two different k-space locations are cross-correlated temporally to produce the mutual coherence function.

$$\Gamma(\vec{k}_1,\vec{k}_2) = \int S(\vec{k}_1,t) S'(\vec{k}_2,t) dt$$

By application of the van Cittert and Zernike theorem, the resulting correlation becomes equivalent to the Fourier transform of the original image squared (Chap. 14 of [3]).

$$\Gamma(\Delta \vec{k},\tau) = \iint |s(\vec{r},f)|^2 e^{-i\Delta \vec{k} \cdot \vec{r}} d\vec{r} dF$$

This new correlation domain is mapped by $\Delta \vec{k}=\vec{k}_1-\vec{k}_2$. For every $N$ original locations of k-space, up to $N(N-1)$ locations of $\Delta \vec{k}$ are provided.

Methods and Discussion: The van Cittert and Zernike theorem relies on spatial incoherence. Any two voxels that oscillate at the same frequency will interfere and confound each other. To avoid this for any single spin species, a gradient is applied during the readout. An example of a 1-D spectroscopic sample is shown in Fig. 1, where the proposed method is able to reconstruct the data using a fraction of the phase encodes.

The dependence on spatial incoherence requires sparsity in the spectral domain. Different species of spin will interfere with other voxels depending on spectral separation and gradient strength. This interference can exhibit itself as 'ghosting' that is similar to some aliasing artifacts. Fig. 2 presents a simulation where two different species are mapped for a spectroscopic image with a gradient in the y-direction. The second spin species causes a ghost artifact Fig. 2 (c,d). The larger circle presents a large ghost in the interferometric reconstructions. A stronger gradient would spread out the ghosts until they would no longer fall within the field of view. Alternatively, lower acceleration would also mitigate the coherence artifact as it provides averaging across $\Delta \vec{k}$.

By directly imaging the square of the image, the proposed method exhibits phase ambiguity. The phase ambiguity presents a reduction of the degrees of freedom in the system by a factor of two.