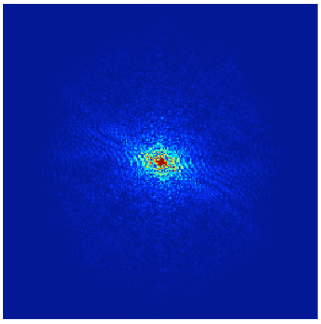
Bioengineering 208
Magnetic Resonance Imaging

Winter 2008
Lecture 5

- MRI Artifacts
  - Noise spikes
  - Clipping
  - Gibbs Ringing
  - Quadrature ghost
  - Wraparound
  - Motion
  - Chemical Shift
- SNR in MRI
  - RF Coil
  - Magnetization
  - Sampling time

Normal Image



K-space

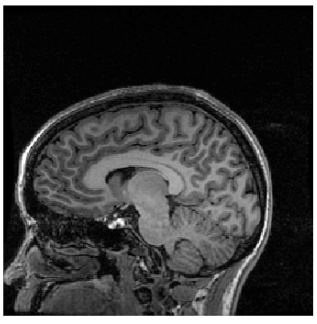
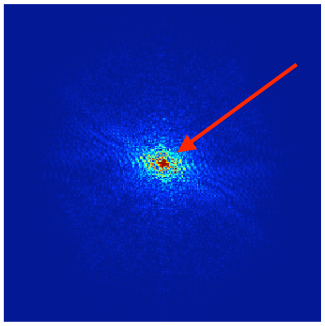


Image space

Noise Spike



K-space

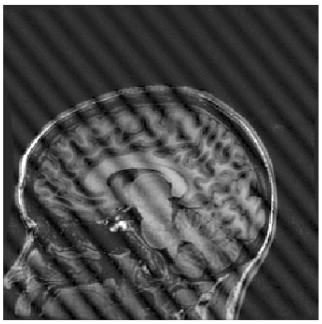
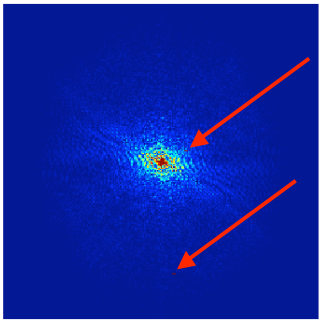


Image space

- Localized in K-space
- Extends outside object in image space
- Come from arcing, loose connections, ground spikes

More Noise Spikes



K-space

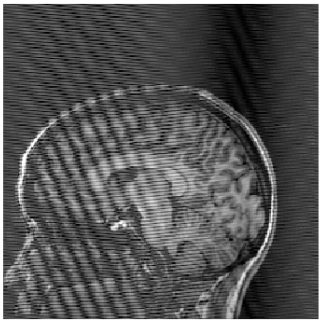
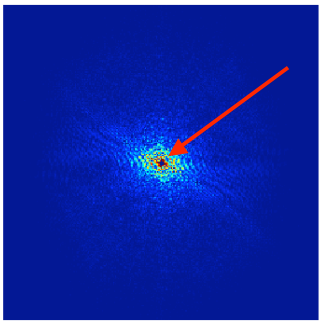


Image space

- Multiple spikes create multiple sinusoids and generate 'herringbone' patterns

Data clipping



K-space

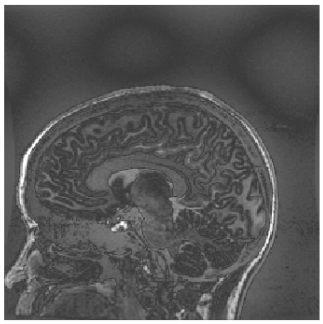
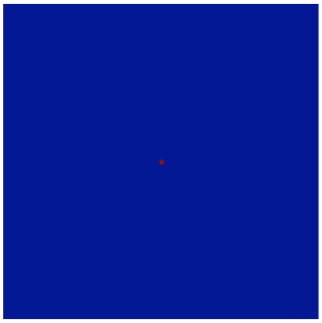


Image space

•Center of K-space over-ranges ADC and clips
•Image is (correct image) - (low frequency image)

Data clipping



K-space

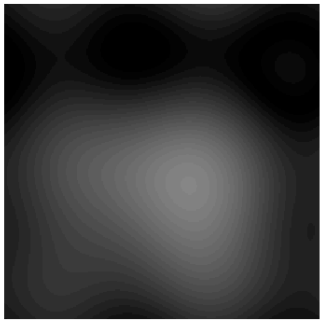
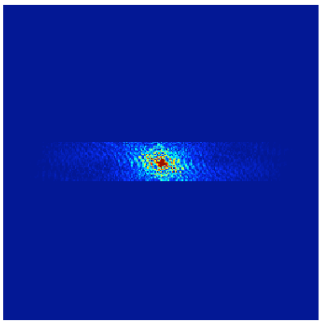


Image space

•Here is the data that was clipped

Gibbs Ringing



K-space

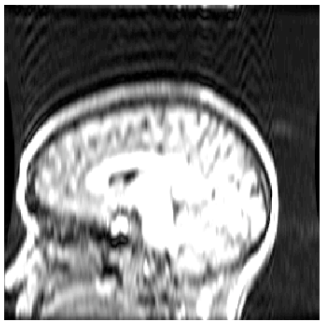
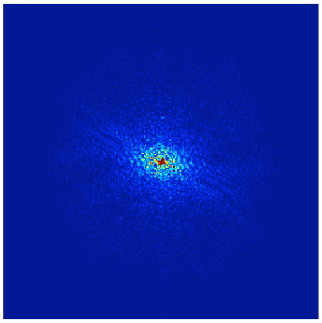


Image space

•Data is truncated before it decays into the noise
•Result is an image convolved with FT of the window in k-space

Quadrature Ghost



K-space

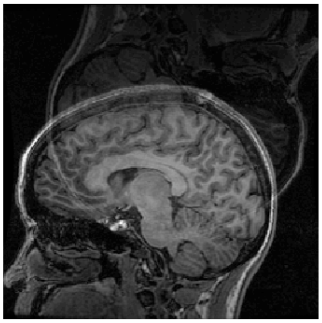
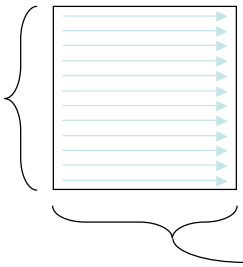


Image space

•K-space data is a superposition of good_data and good_data*
•=>Image space is a superposition of good_image(x,y) and good_image(-x,-y)

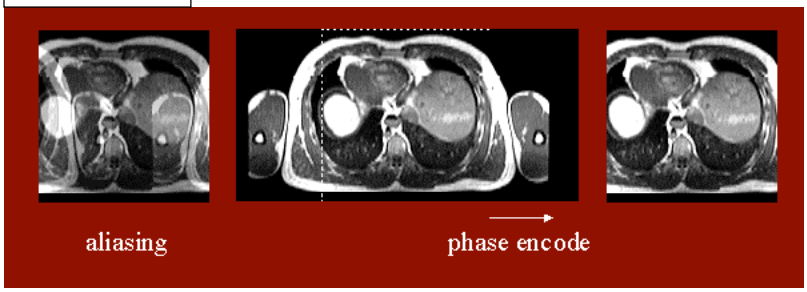
Wraparound

Phase Encode
•K-space sampled discretely
•Susceptible to aliasing



Frequency Encode
•K-space traveled continuously, but data is digitized
•Wraparound can be prevented by either analog or digital bandpass filter

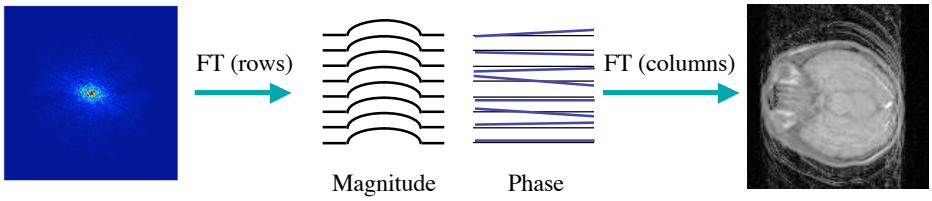
'No Phase Wrap'



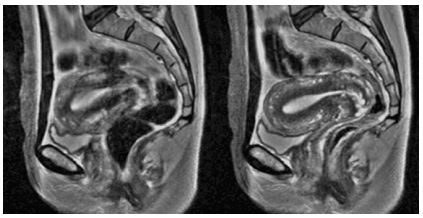
E. Wong, BE208, UCSD Winter 2008

http://www.fmrib.ox.ac.uk/~peterj/lectures/kspace/img034.GIF

Motion Artifact



•Motion between TR periods generates inconsistency between lines of K-space
•Ghosts propagate in the phase encode direction
•Period motion generates structured ghosts (analogous to EPI Nyquist Ghosts)



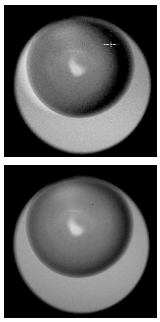
Normal Peristalsis Paralyzed Bowel

http://wwwrad.pulmonary.ubc.ca

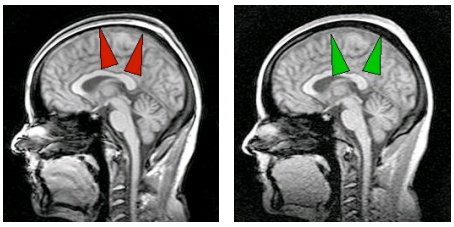
E. Wong, BE208, UCSD Winter 2008

Chemical Shift

- Magnetic field of electron clouds shields nucleus from external magnetic field
- =>Actual magnetic field experienced by nucleus is smaller than applied field
- Differences in local field are called chemical shift, and are measured in PPM
- Water and fat differ in chemical shift by 3.5 PPM = 440Hz at 3T
- Chemical shift causes phase twist across readout
- Fourier shift theorem tells you how far things are shifted

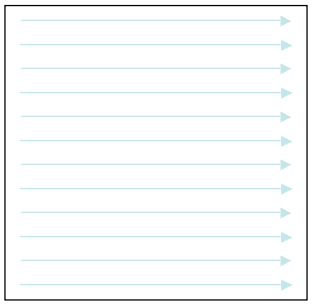


http://chickscope.beckman.uiuc.edu/roosts/carl/artifact/cs_a001.gif



http://www.mr-tip.com/serv1.php?type=art&sub=Chemical%20Shift%20Artifact

CONVENTIONAL IMAGING



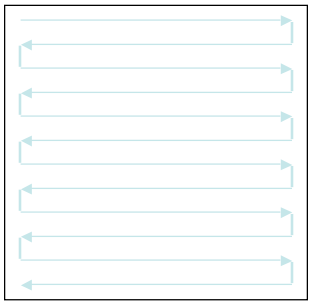
0ms

1 / 0ms = ∞ Hz / pixel

8ms

1 / 8ms = 125 Hz / pixel

Off Resonance Behavior : EPI



40ms

1 / 40ms = 25 Hz / pixel

0.5ms

1 / 0.5ms = 2000 Hz / pixel

Signal to Noise Ratio in MRI

$$SNR \propto (coil\_factor) \times (magnetization\_factor) \times (sampling\_factor)$$

- Proportional to local B1
- Sample noise increases with coil size
- Depends on coil geometry, coil quality (internal coil losses)

- Proportional to M_{xy} at time of readout
- Depends on B_0, pulse sequence, TR, TE, PD, T_1, T_2, T_2*, voxel volume

- Proportional to sqrt(total readout time)

$$SNR \propto (voxel\_volume)\sqrt{total\_readout\_time}$$