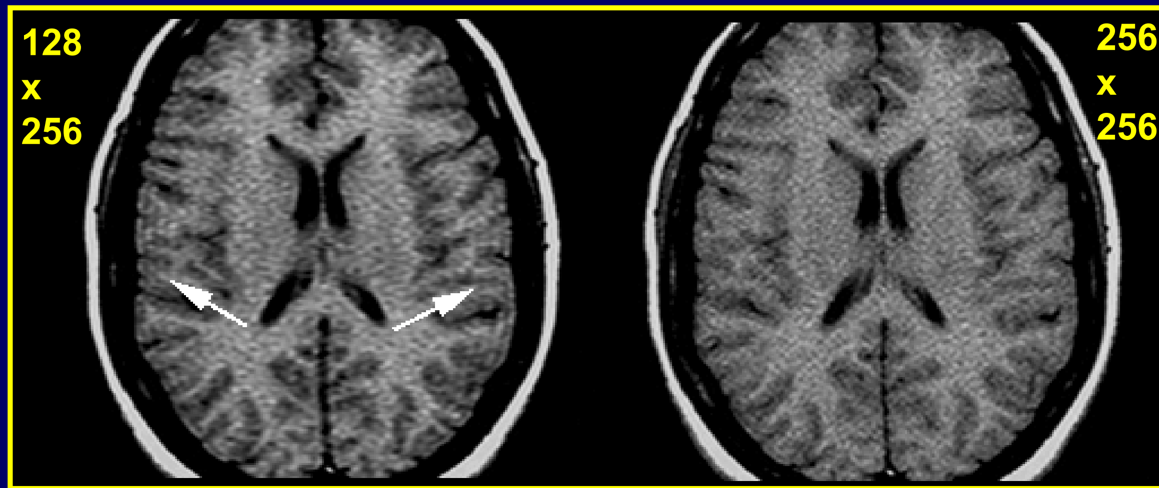
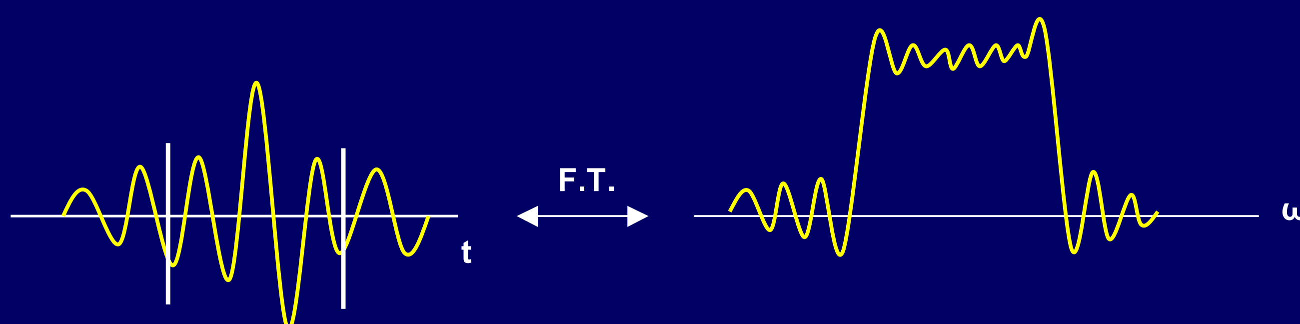
3. Resolution/Sequence Artefacts

- Truncation artefact
- Chemical Shift artefact (Types I and II)

Truncation Artefact - Brain



- Also known as Gibbs (‘ringing’) artefact.
- Usually occurs in the PE direction at high contrast borders.
- Due to undersampling of high spatial frequencies (sharp edged borders)
- Remedied by taking more samples (e.g. 256 PE steps).
- Truncation artefact causes ring-down effect because F.T. of truncated sinc function has ripples at the edges.



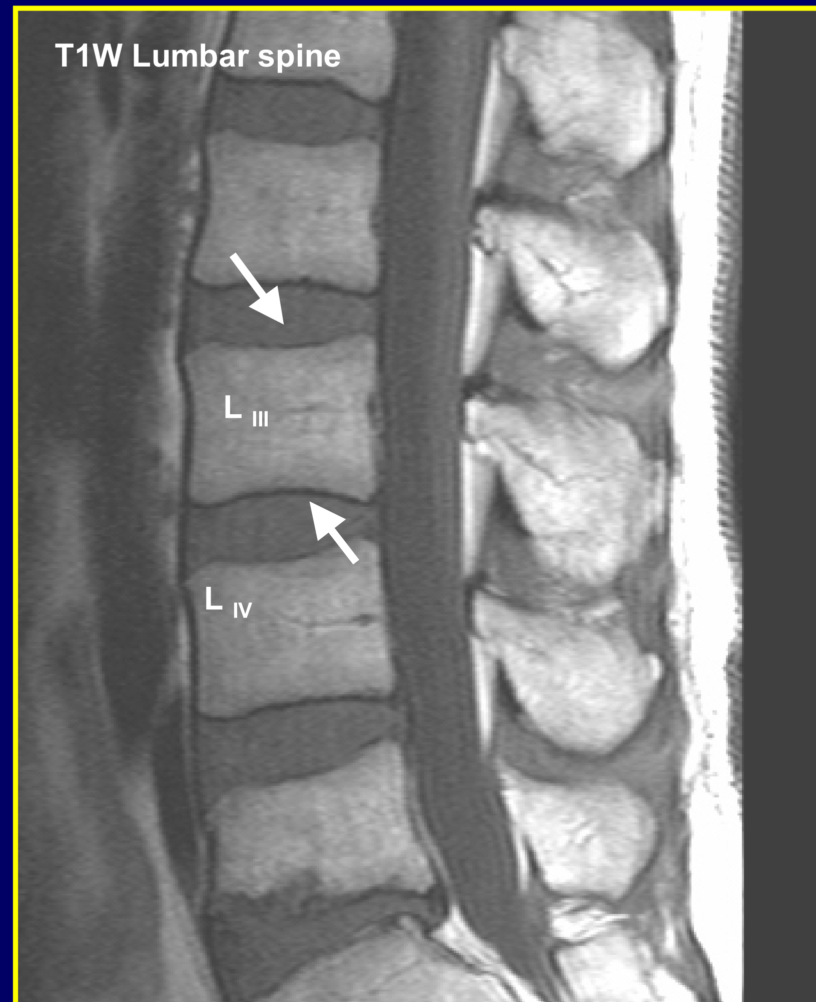
Truncation Artefact or Syrinx?

- Problematic down centre of spinal cord – could be misinterpreted as a syrinx

Syrinx
(fluid filled cavity in spinal cord)

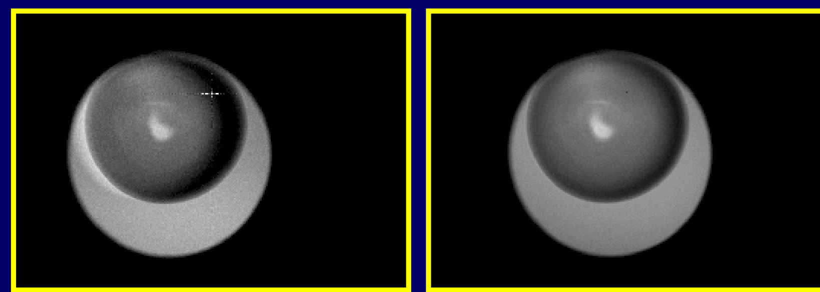
Chemical Shift Artefact – Type I

- T1W image of lumbar spine.
- Low BW sequence used.
- Frequency shift of a few pixels is visible at the base of each vertebra (black line).
- Vertebra-disc boundary detail is lost at the top of each vertebra.
- Observation of small disc herniations in L spine difficult.



Chemical Shift (I) - Explained

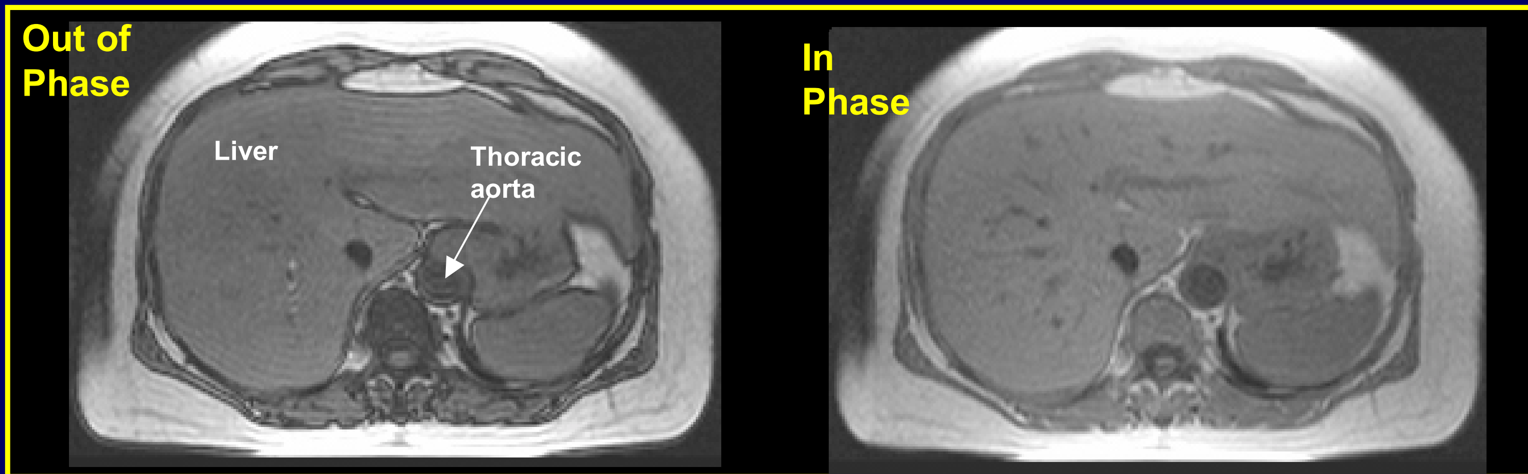
Displacement of yolk (fat) on LHS image



Egg (low BW) Egg (high BW)

- Protons from different molecules (eg: fat & water) precess at different frequencies.
- Protons in H_2O precess slightly faster than those in fat, (diff. is 3.5 ppm)
- Chemical shift = 3.5ppm = 224Hz at 1.5T [$\omega_0 = \gamma.B_0$ :: (42.6MHz/T)(1.5T) :: 64MHz :: 3.5ppm x 64MHz = 224Hz]
- LHS = 12.5kHz (low BW), 256 resolution.
- Chemical shift is 4.6 pixels [224 / (12.5kHz/256)]
- Chemical shift also occurs between silicone & fat/water (Breast MRI)
- Modify CS by using fat suppression, increase the bandwidth, swap freq and phase directions, or lower the Bo field (impractical)!

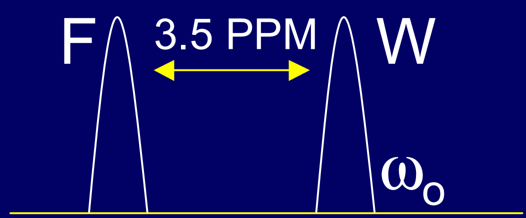
Chemical Shift – Type II Artefact

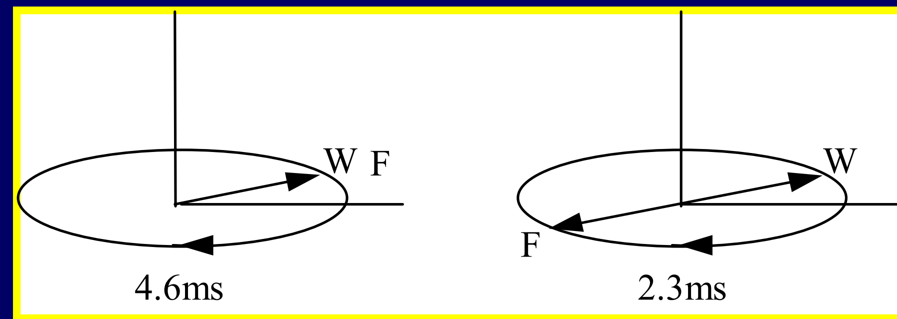


Worked example

- Applies to Gradient Echo techniques, (not in SE because of 180º refocusing pulse).
- Fat and water proton resonant frequencies differ by 3.5ppm.
- For an imaging field strength of 1.5T, $\omega = \lambda = 64$ MHz (from $\omega_0 = \gamma . B_0$).
- Difference between fat and water proton resonant frequencies is therefore about 224 Hz, (ω_{diff}).
- The phase of the fat and water spin vectors will thus coincide at $1/\omega_{diff}$, which is 4.6 ms.
- If a TE of 4.6 ms is used, then the fat and water components of the signal will be <u>in phase</u>. If a TE of 6.9 ms (4.6 + 2.3) is used then the fat and water components of the signal will be <u>out of phase</u>.

ⓘ Chemical Shift Type II Artefact





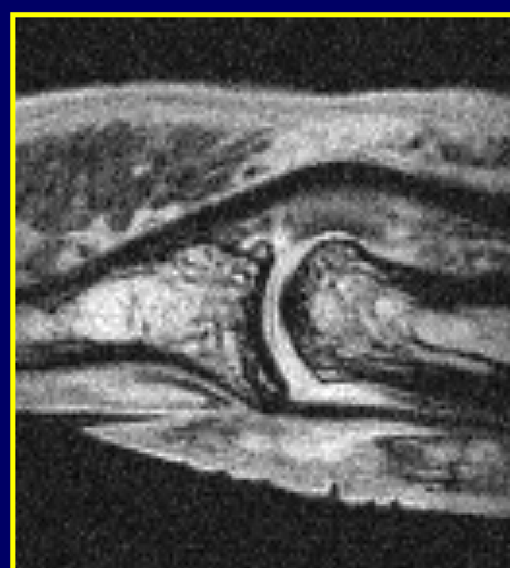
- Phase cancellation artefact – gradient echo sequences
- Water precesses slightly faster than fat (phase difference between them)
- Phase differences accumulate between water and fat signal
- Vary the TE, f+W (in phase), f-w (out of phase – black boundary artefact)
- At 1.5T, f-w occurs in 4.6ms multiples, starting at about 2.3ms (then 6.9, 11.5, 16.1 ms) - artefact
- At 1.5T, f+w occurs at 4.6ms (then 9.2, 13.8, 18.4 ms) – no artefact
- Dixon technique – ip+op images = water image, ip-op = fat image
- The artefact can occur in both encoding directions
- Not a problem in SE images since 180^{o} pulse refocuses chemical shift

4. B_o Artefacts

- Susceptibility artefacts
- Metallic artefacts
- B_o Inhomogeneity

Susceptibility Artefacts

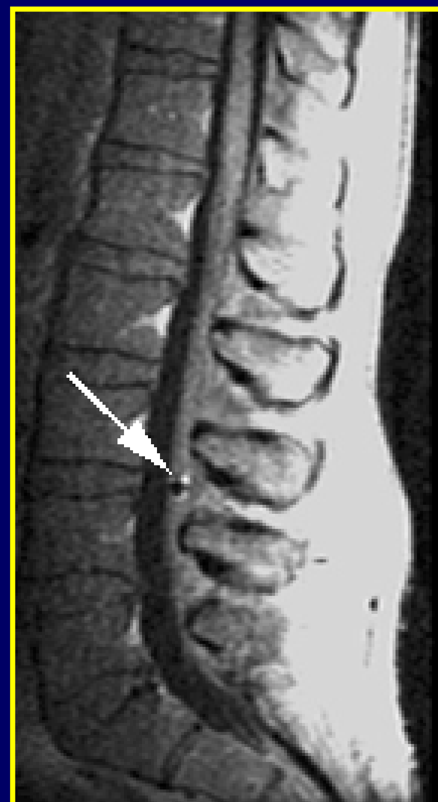
- Occur when two materials with different magnetic susceptibility (χ) lie together, (tissue-air & tissue-fat).
- Local B_o changes cause spin dephasing at the boundary causing signal loss.
- Haemosiderin (end stage of haemorrhage) deposits (high χ) – local susceptibility changes in tissue.
- Susceptibility artefacts can be useful - bony trabeculae (low χ).
- Use a FSE and keep TE short to minimise susceptibility artefacts.



Metallic Artefacts

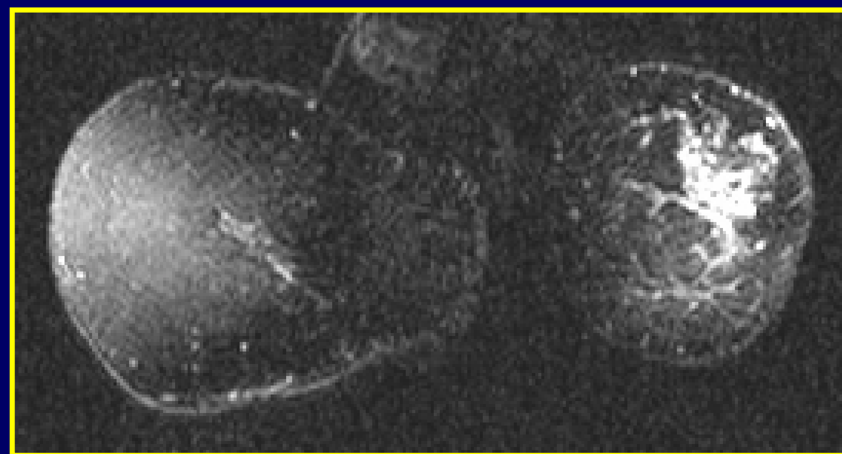
- Similar to susceptibility artefacts.
- Metals have much higher susceptibility than tissue.
- Large B_o inhomogeneities around object causing signal loss and distortion.
- Implants absorb RF energy, so local field varies.
- RF problems affect SE sequences as well as GE.

Metallic Artefact



Small metal flake in lumbar spinal canal

B_o Inhomogeneity and FatSat



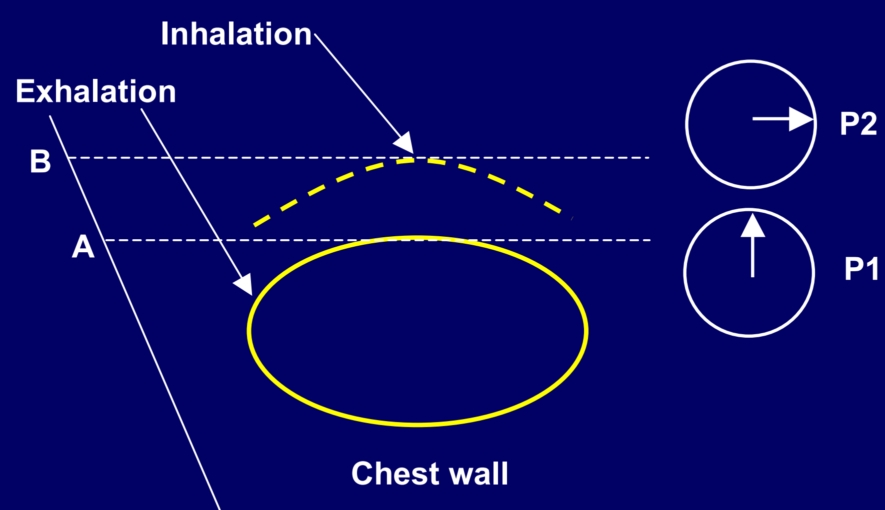
- Unsuccessful Fat suppression in T2W breast images.
- Result of poor Bo field homogeneity.
- Artefacts arise because of inability to distinguish fat and water frequencies locally.
- Usually more prominent in images with a large FOV or off-axis.
- Solution – improve the magnet shimming.
- Modern magnets – auto shimming for very reliable fatsat.

5. RF Artefacts

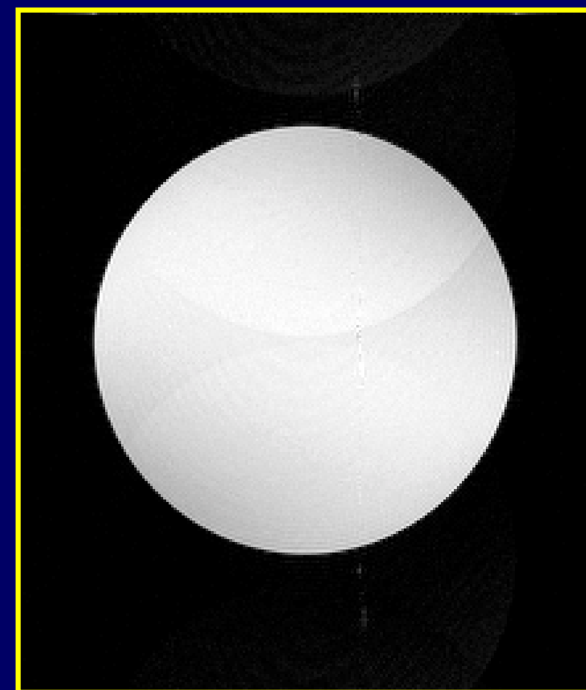
- Ghosting
- RF interference
- Stimulated Echoes
- RF Coil artefacts
- Steady State artefacts

Ghosting

- Arises from any structure that moves during acquisition of data eg: chest wall, pulsatile movement of vessels, swallowing etc.)
- Ghosts displaced along PE axis due to inherent time delay between phase encoding and readout.
- Number and intensity depends upon period of modulation and the TR.

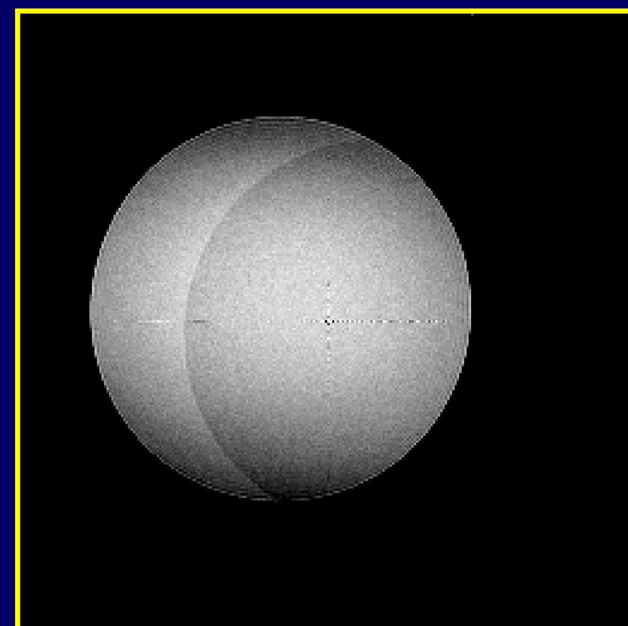


- Moving anatomy is mismapped into the FOV.



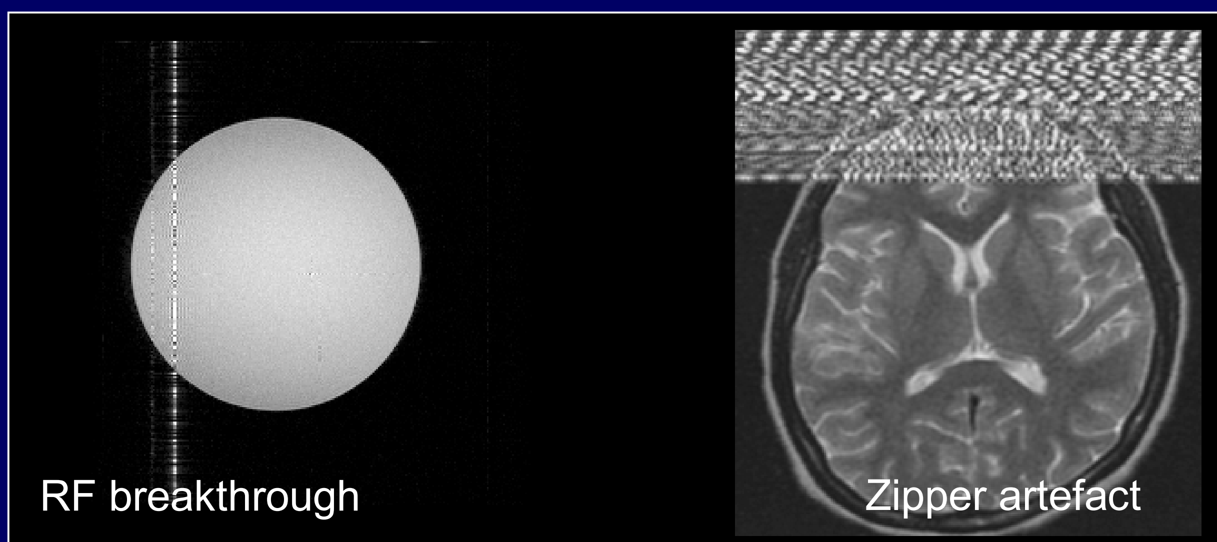
Quadrature Ghost

- Occurs due to differences in the gain of real and imaginary receiver channels
- Phase errors between the two quadrature RF receive channels can also cause this
- Ghost is displaced diagonally across the centre in both PE and FE directions
- Solution - ? phase alternating



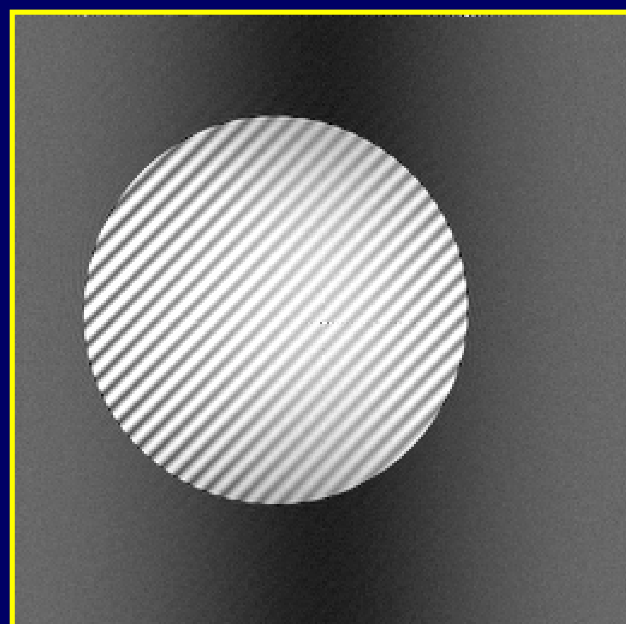
RF Interference

- Zipper artefact appears as bright and dark zipper lines along PE.
- External RF picked up by coils (e.g RF breakthrough waveguide filters).
- Pulse oximeters (monitors the percentage of haemoglobin saturated with oxygen) use RF – can be picked up by MR coils.
- RF from within the MR system may be coherent – bright spot on image.
- Mains RF – modulated by 50Hz – regularly spaced faint zipper artefacts across image.



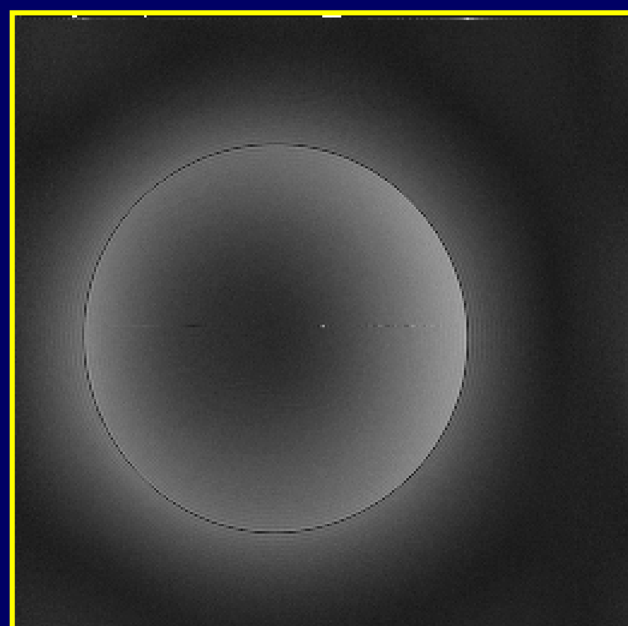
Herring-Bone Artefact

- Occurs due to the presence of a spike of noise (or an ‘arc’ from a static discharge) in the raw data.
- FT (series of spikes) which is convolved with the image data.
- Probably due to breakdown of RF system (poor RF decoupling).
- Best solution – rescan the image.

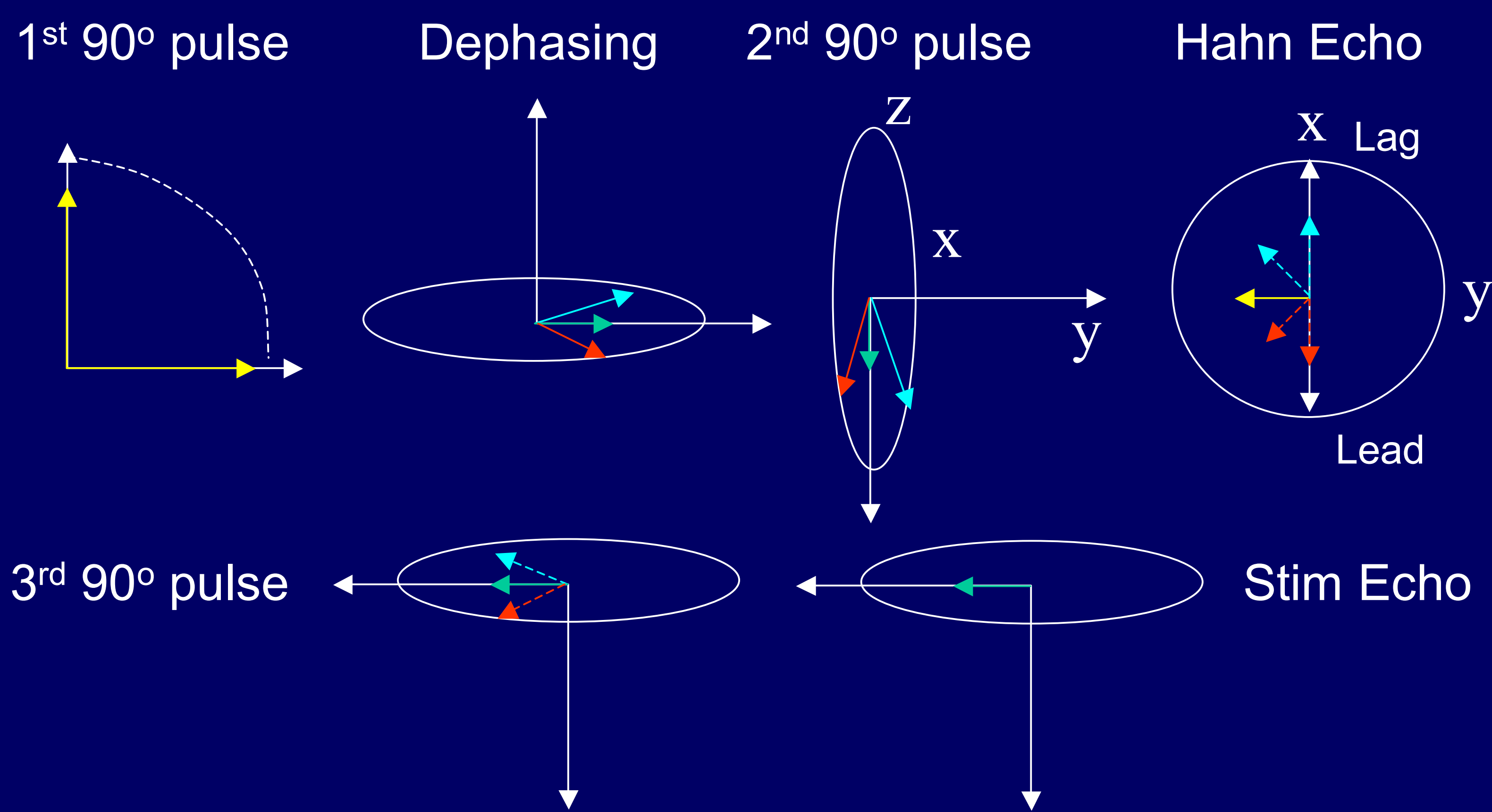


Halo Artefact

- Results from signal clipping caused by overflow on the ADC's.
- Occurs if receiver gain is incorrectly set.
- Signal becomes too large for the ADC range and information in the centre of k-space is lost.
- Unusual - unless receiver gain is manually set.

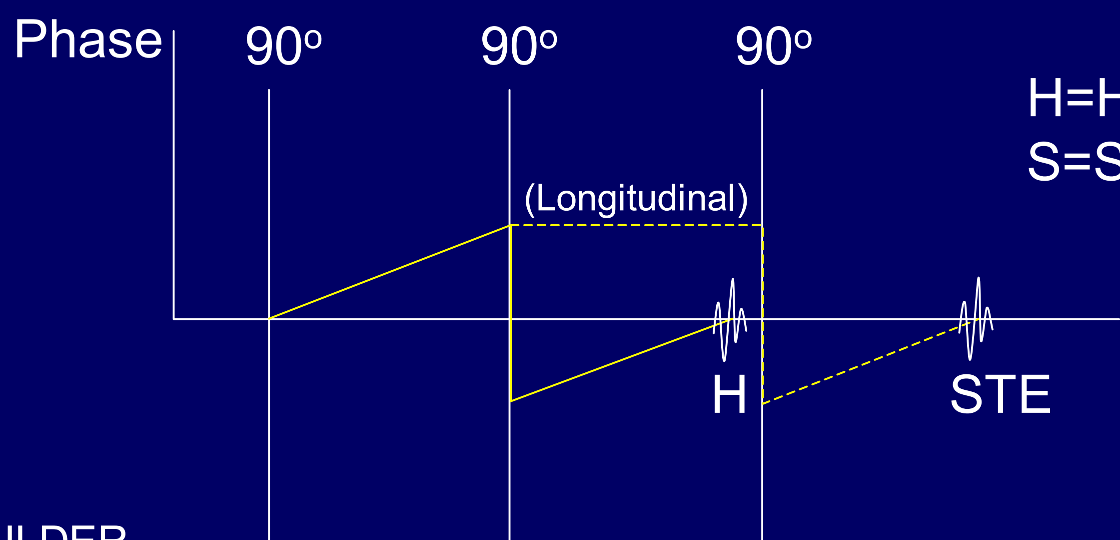


Stimulated Echoes (STE)



- 1st pulse forms transverse magnetisation
- 2nd pulse – remaining transverse components form Hahn echo
- 3rd pulse converts longitudinal magnetisation to transverse magnetisation, and components re-phase to form stimulated echo

STE – Coherence Pathways



H=Hahn Echo
S=Stimulated Echo

SHOULDER

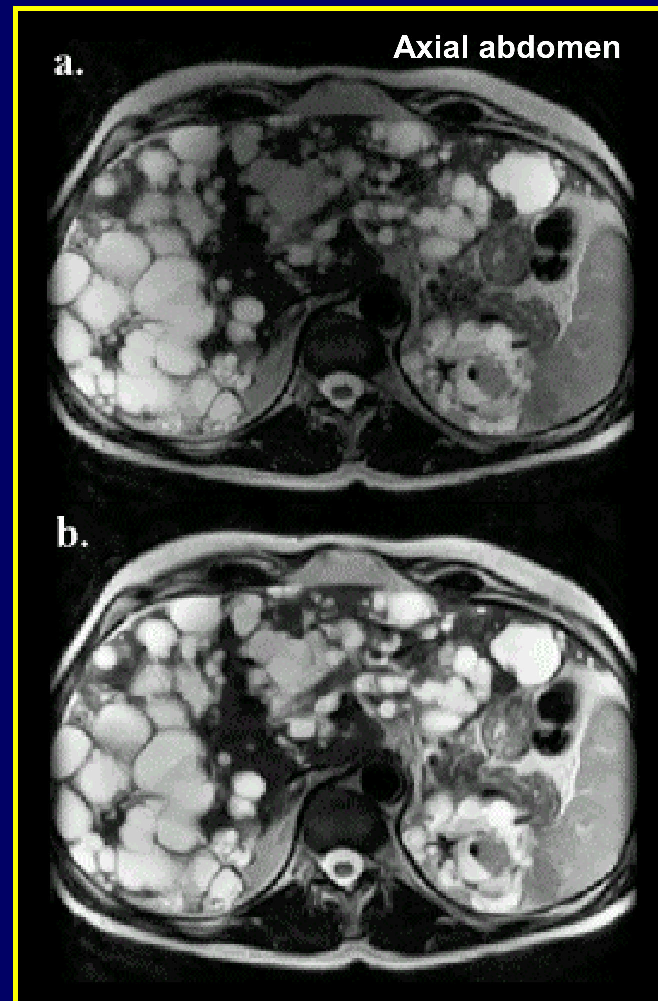
- STE has different spatial encoding and contrast
- Avoid STE by using 'spoiler' gradients to destroy residual transverse magnetisation, or use 'rewinder' gradients to prevent the STE occurring in the sampling window
- Can also widen the bandwidth, or alter the TE to avoid STE

RF Coil Artefacts

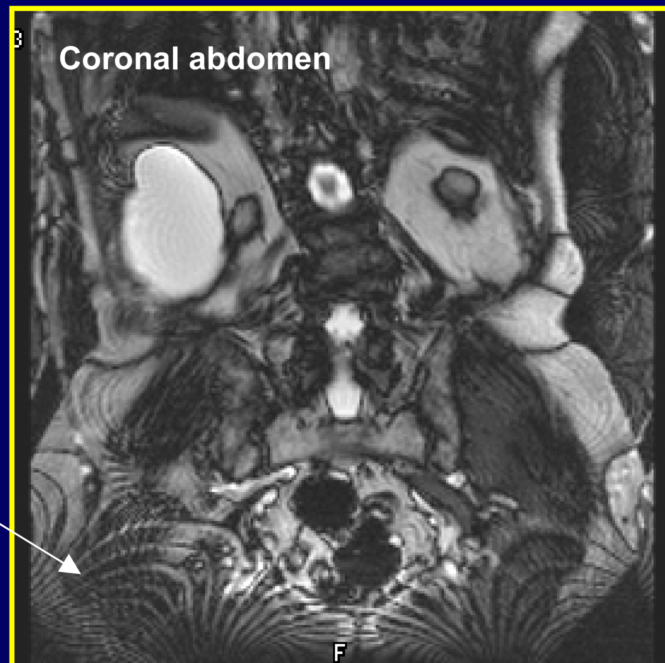
- One of the arrays of a phased array coil is out of phase with the other coils.
- Bands of signal addition and cancellation.
- Solution – call engineer!

Surface Coil Flare

- The result of signal saturation at edge of surface coil.
- Optimal signal is further in from edge.
- Solution – Surface Coil Intensity Correction (SCIC) – algorithm that reduces the high intensity fat signal nearest the coil for improved visualisation.
- SCIC is very useful for correcting sagittal and axial spine images.



ⓘ Steady State Imaging - Artefacts



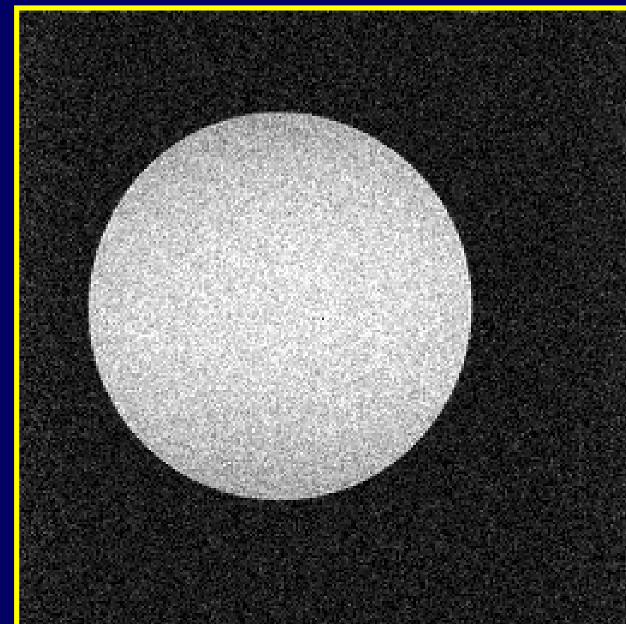
Moire Fringes

- Common on True FISP, balanced FFE, FIESTA (fully balanced gradients).
- Related to variation of steady state condition due to B_o inhomogeneities.
- Aliasing of one side of the body to the other results in superimposition of signals of different phases that alternatively add and cancel.
- Equivalent to introducing a systematic error to the flip angle.
- Require a short TE and good shimming – otherwise bands ~ $1/B_0$
- Solution – phase alternation of RF pulse

Noise

Random Noise

- Noise can be considered an artefact since it is unwanted.
- Grainy, snowy, no recognisable pattern.
- Solution – improve the SNR
- Increase slice thickness, increase TR, reduce TE, decrease bandwidth, decrease pixel resolution, increase the FOV, increase phase steps, increase the number of averages
- Remember ‘trade-offs’ (scan time [2D] = TR x N_Y x NEX).



And finally…

Observer Artefact

- Self explanatory
- Otherwise known as "Upside-down Error"
- Solution – apply for time off !

References

NHS Tayside

- MRI from Picture to Proton: Donald W. McRobbie, Elizabeth A.Moore, Martin J.Graves and Martin R.Prince Cambs Uni Press
- All you need to know about MRI Physics: Moriel NessAiver

For further information

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