Medical Equipment II - 2010

Magnetic Resonance Imaging(2)

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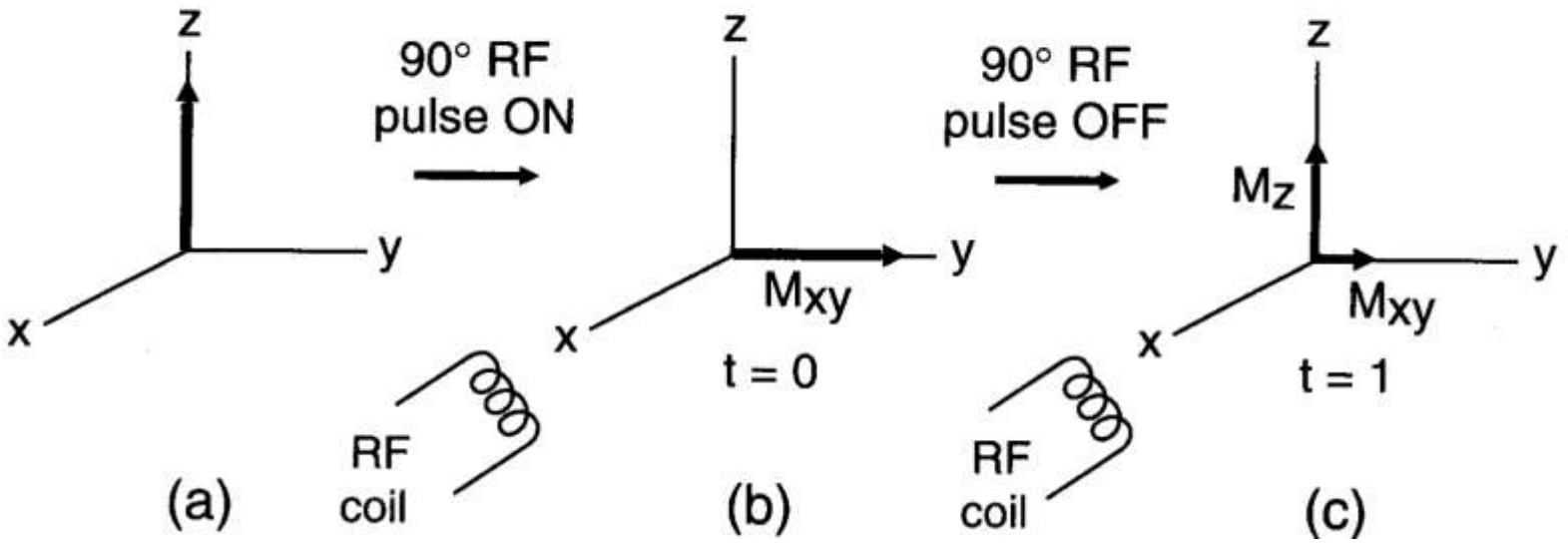
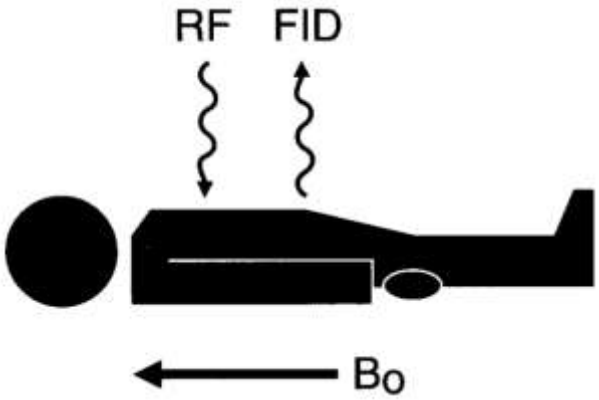
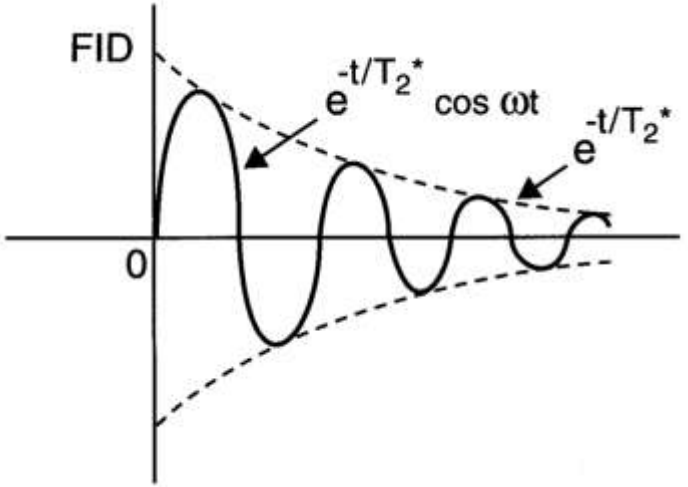
Web: http://ymk.k-space.org/courses.htm

Sequence of Events

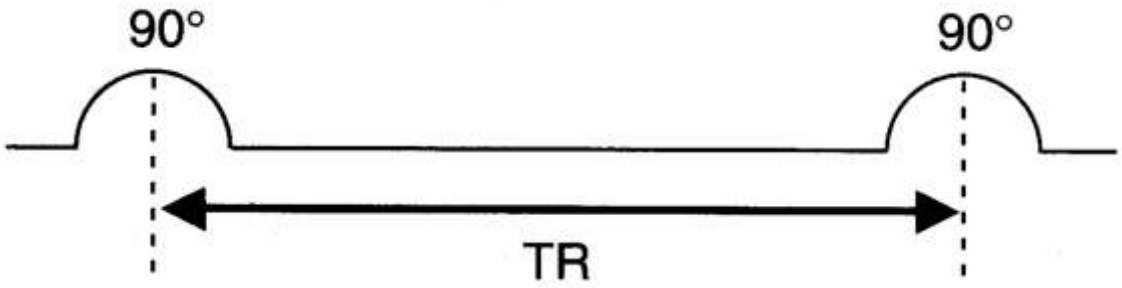






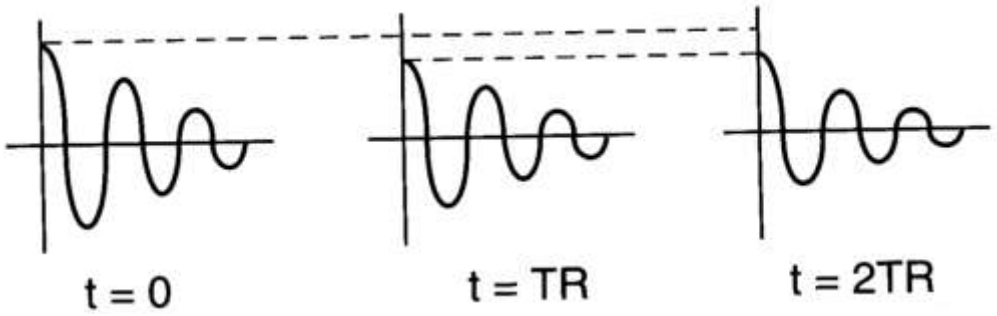
Pulse Repetition Time (TR)

- Distance between successive RF pulses



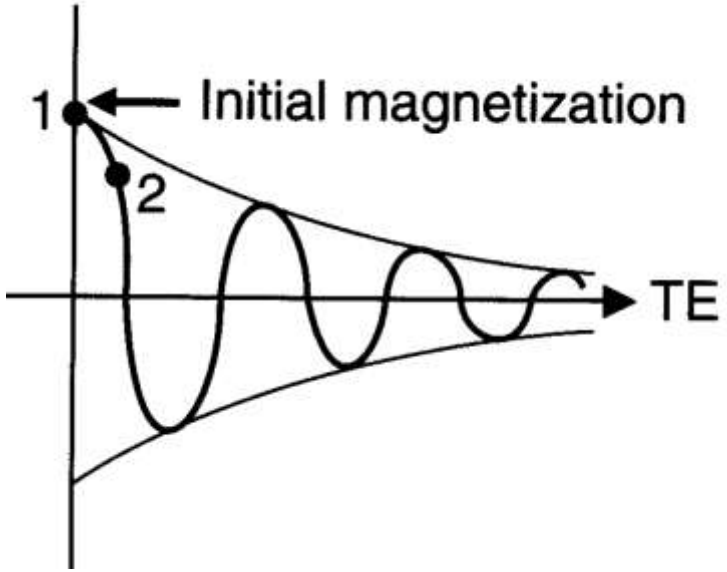
- At t=TR,

$$M_z(TR) = M_0 (1 - e^{-TR/T1})$$



Echo Time (TE)

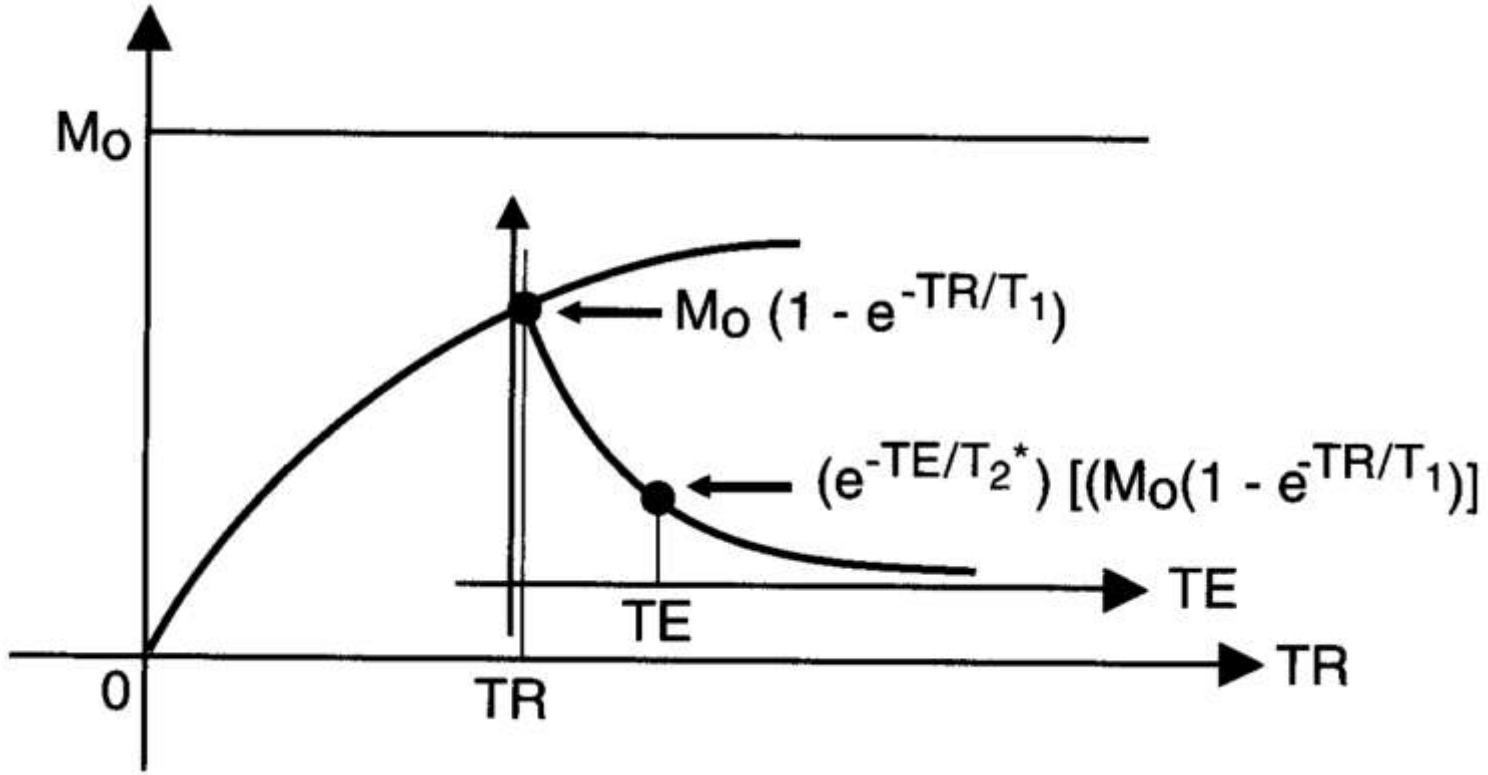
- Time sampling of FID starts



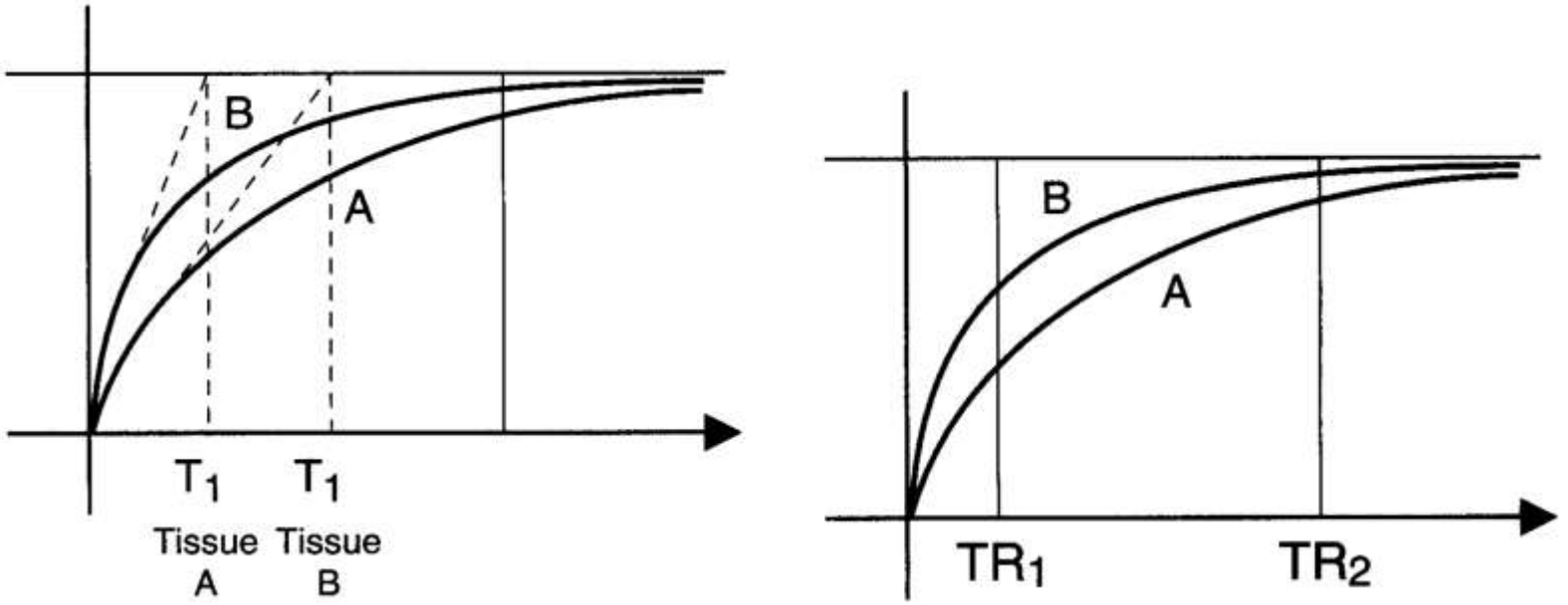
$$M_0 \cdot (e^{-TE/T2^*})$$

Tissue Contrast

$$\text{Signal Intensity} = SI \propto N(H)(e^{-TE/T2^*})(1 - e^{-TR/T1})$$

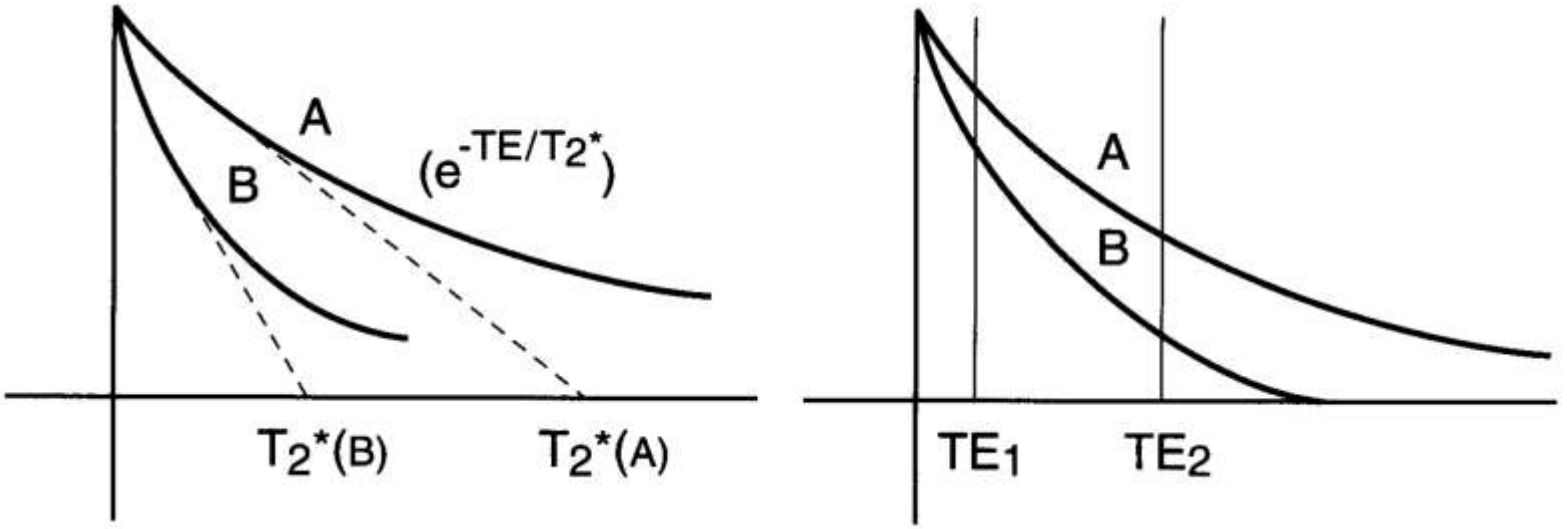


T1-Weighting



Long TR reduces the T_1 effect.

T2-Weighting



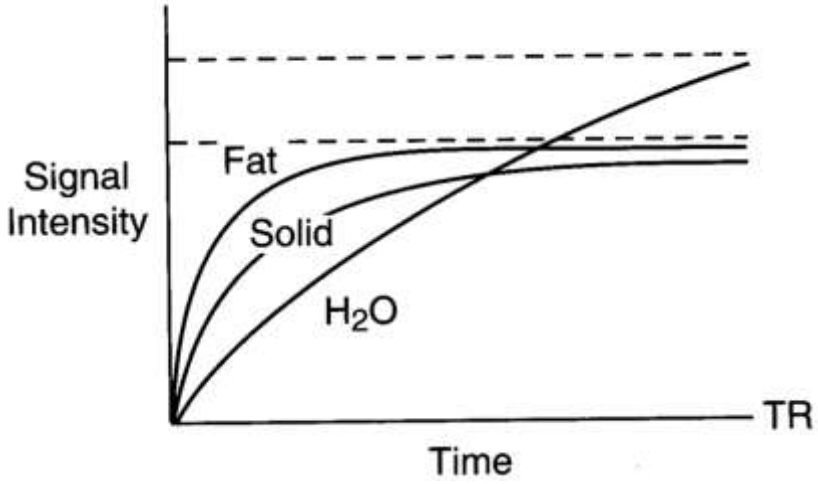
Short TE reduces the T_2 effect.*

Tissue Contrast

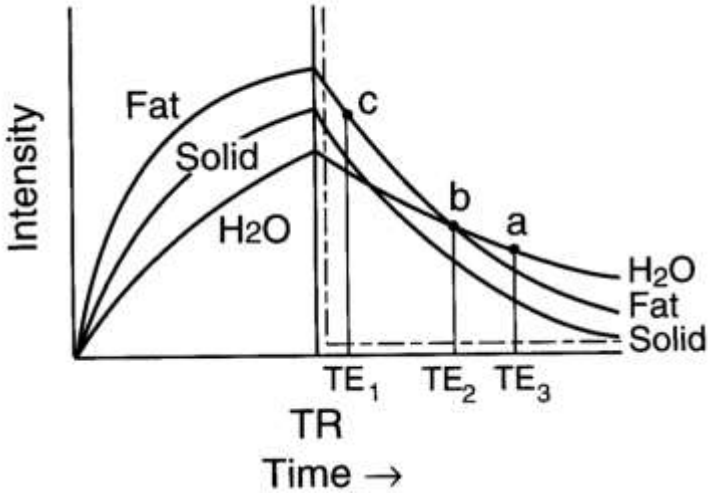
Tissue	T_1 (ms)	T_2 (ms)
H_2O	2500	2500
fat	200	100
CSF	2000	300
gray matter	500	100

Tissue Contrast: Clinical Applications

- T1 recovery curve



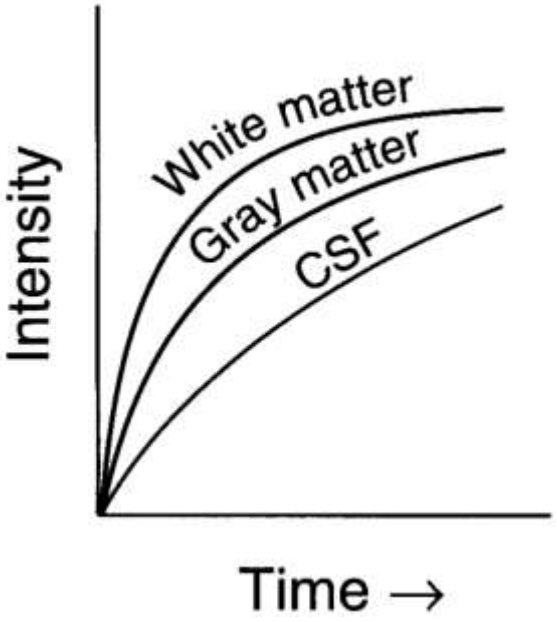
- T2 decay curves

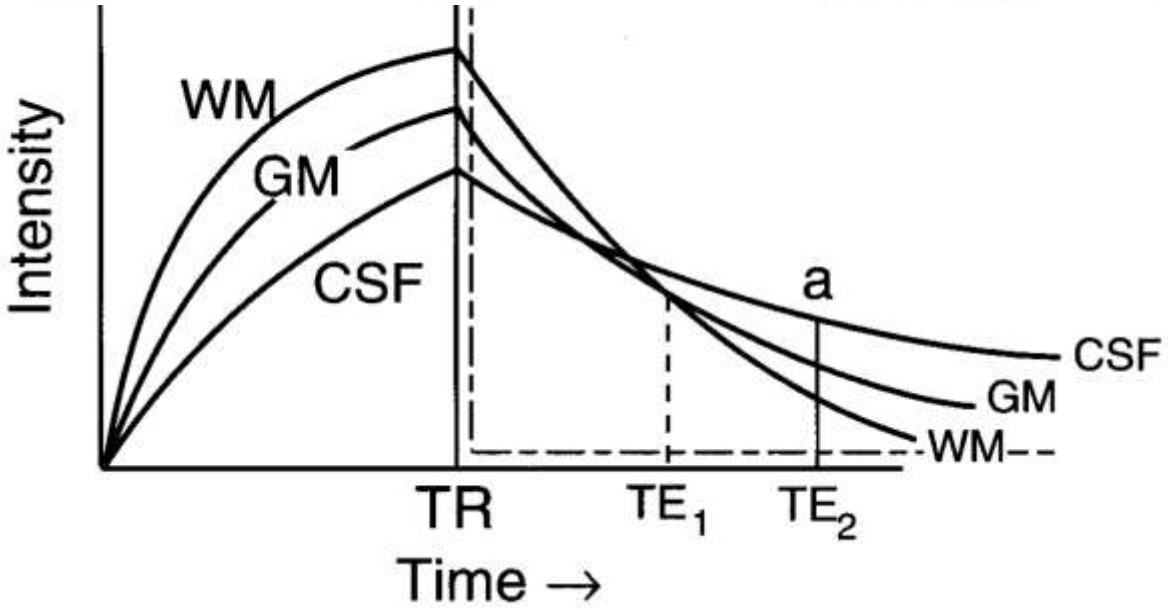


Tissue Contrast: Clinical Applications

- Brain imaging

	T_1 (msec)	T_2 (msec)	N(H)
White matter	510	67	0.61
Gray matter	760	77	0.69
Edema	900	126	0.86
CSF	2650	180	1.00





PDW, T1W, T2W

	T_1 (msec)	T_2 (msec)	N(H)
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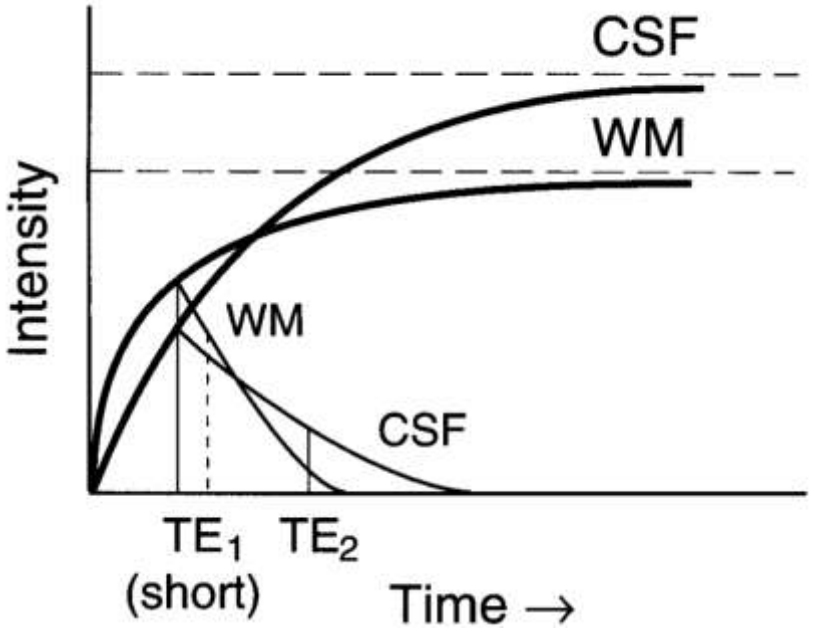
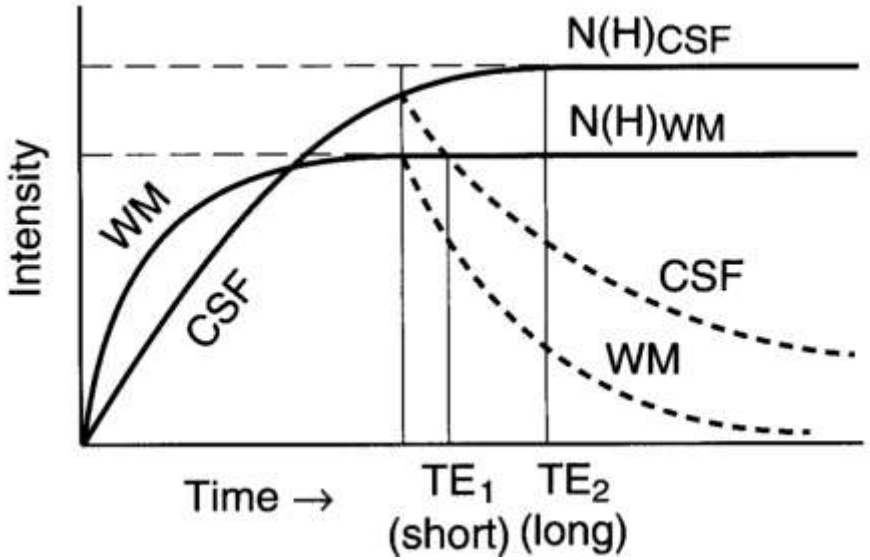




T1/T2 Values

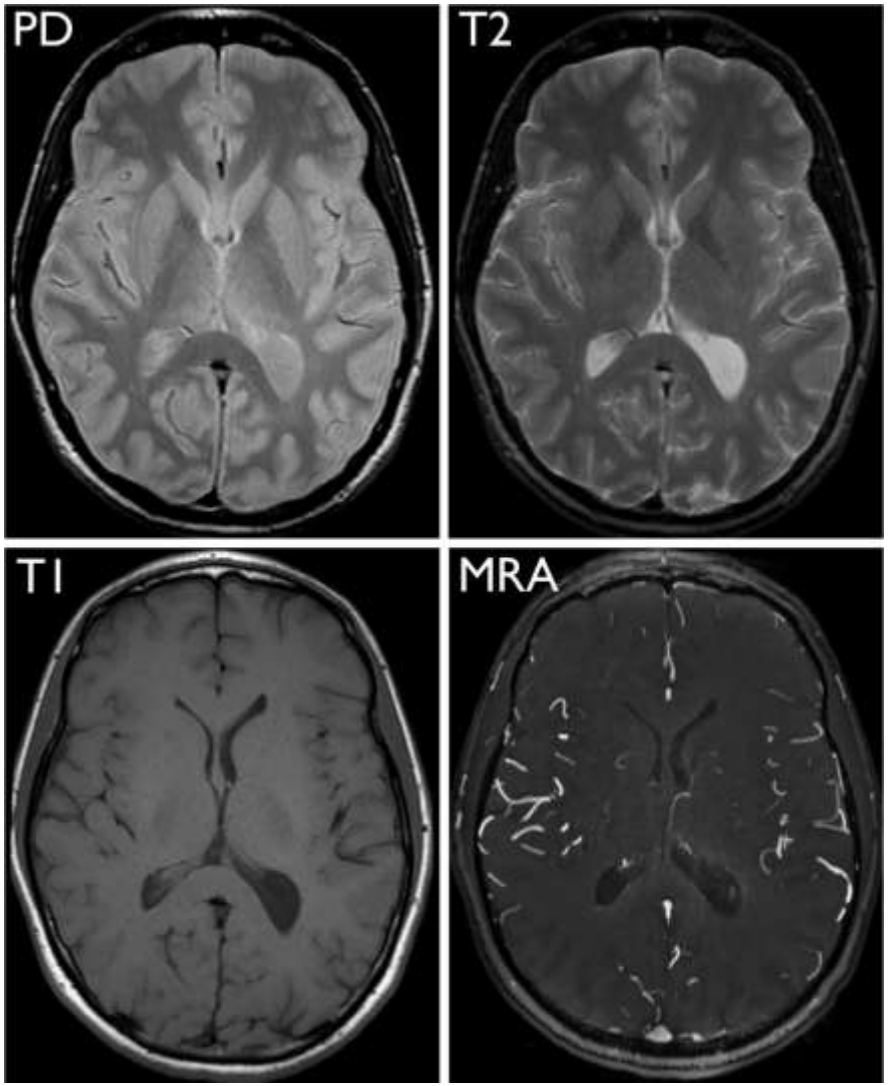
Table 6-2. T_1 and T_2 as a Function of Natural Motional Frequencies ω vs. the Larmor Frequency ω_0 for Different Tissues

	H_2O/Fluids	Solids	Fat and Proteinaceous Material
T_1	$\omega \gg \omega 0$ Non Efficient Energy Transfer **Very Long T_1**	$\omega < \omega 0$ Inefficient Energy Transfer **Long T_1**	$\omega \approx \omega 0$ Efficient Energy Transfer **Short T_1**
T_2	Less dephasing **Long T_2**	Most dephasing **Short T_2**	Intermediate dephasing **Intermediate T_2**

T1/T2 Values

	long T_1 (low SI)	intermediate	short T_1 (high SI)
long T_2 (high SI)	water/CSF pathology edema		**d (EC metHgb)**
intermediate		muscle GM **a (oxyHgb)** WM	
short T_2 (low SI)	air cortical bone heavy Ca^{++} **b (deoxyHgb)** **e (hemosiderin)** fibrosis tendons		fat proteinaceous solutions **c (IC met Hgb)** paramagnetic materials (Gd, etc.)

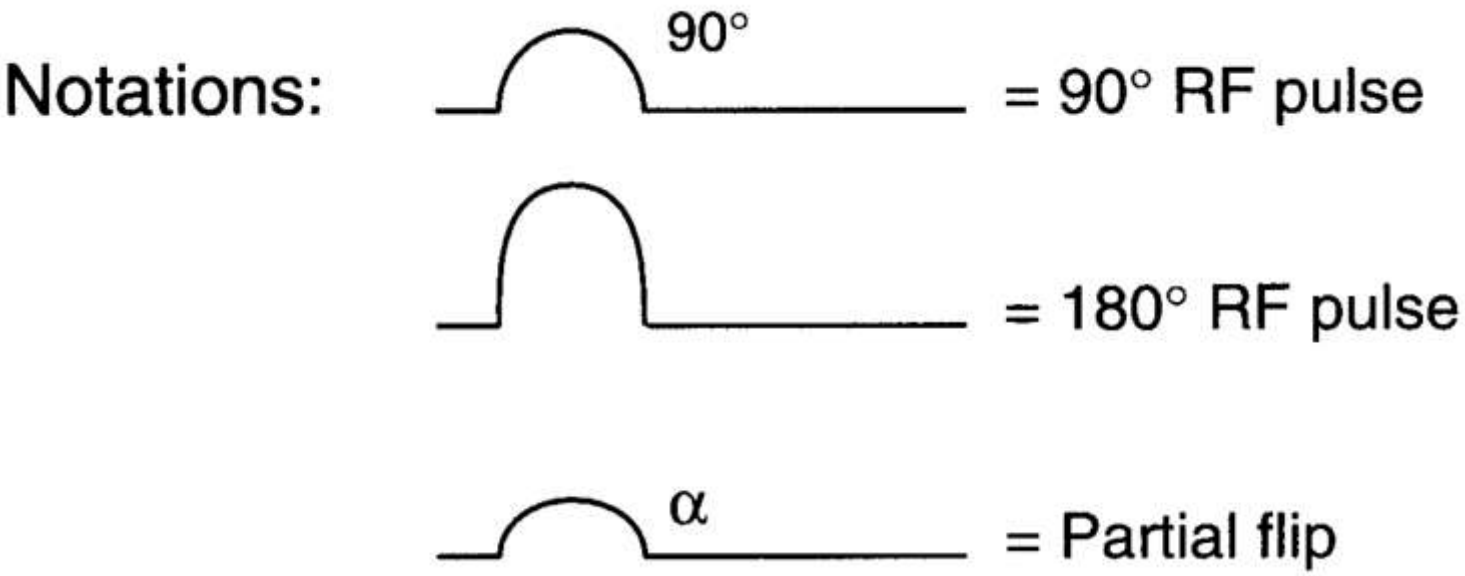
Example: Brain Imaging



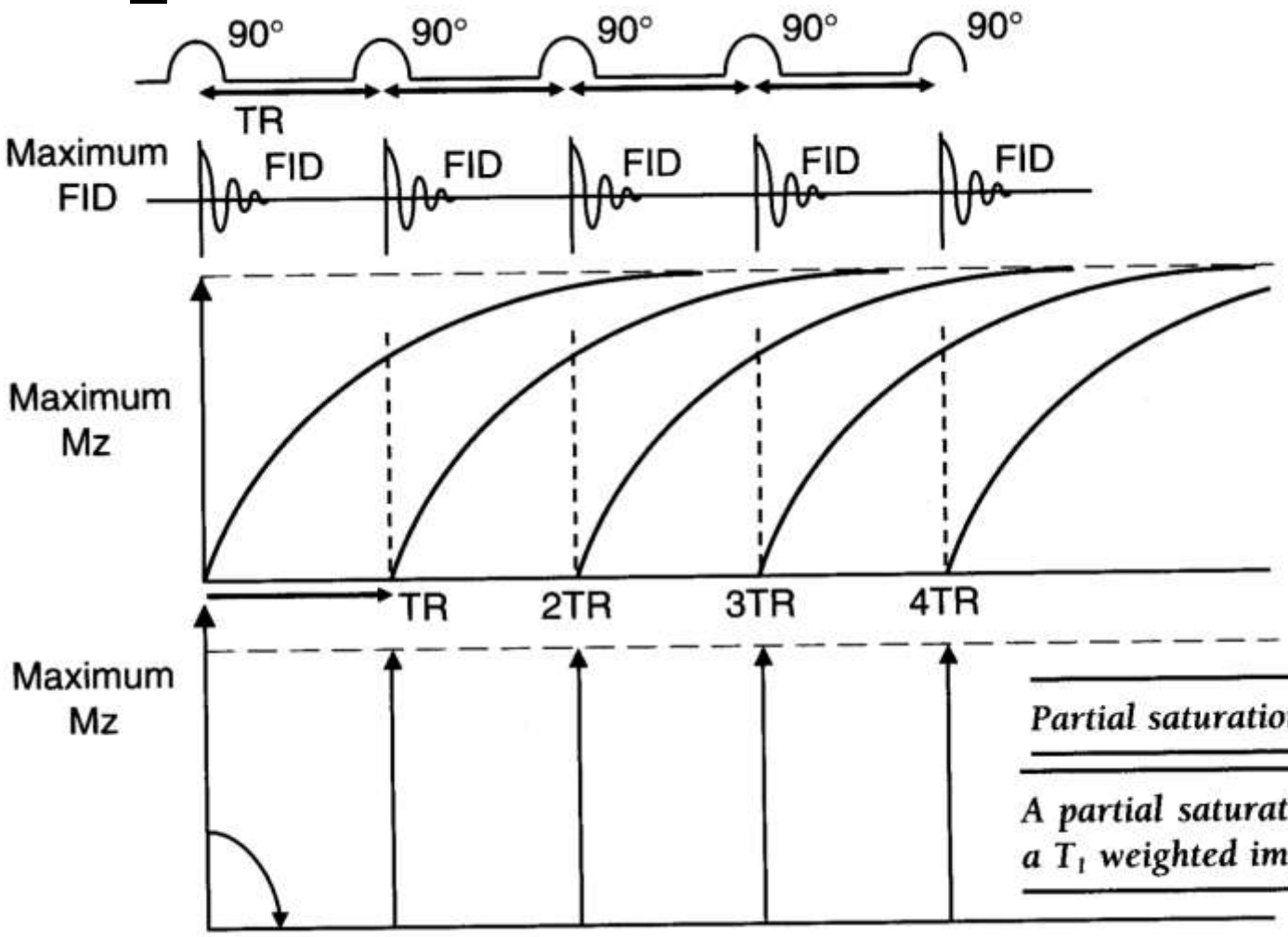
http://knol.google.com/k/brain-ct-mri#

Pulse Sequences: Saturation

- 90° pulse: saturation
- <90° pulse: partial saturation
- After T1 recovery: unsaturated



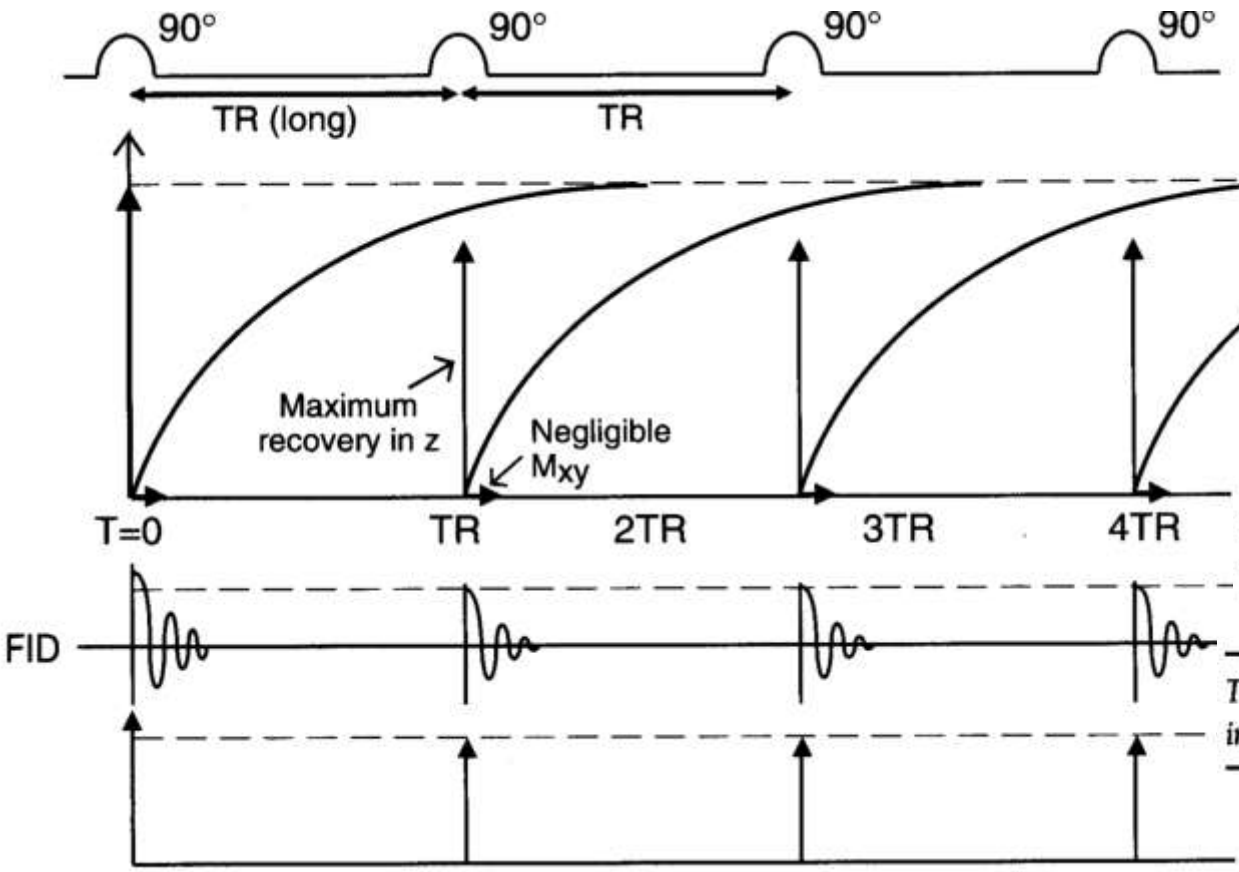
Pulse Sequences: Partial Saturation



Partial saturation: TR is short, TE is minimal.

A partial saturation pulse sequence generates a T_1 weighted image.

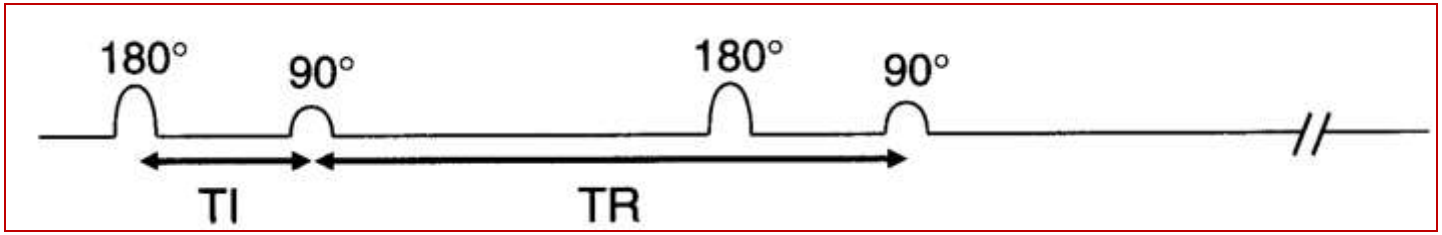
Pulse Sequences: Saturation Recovery

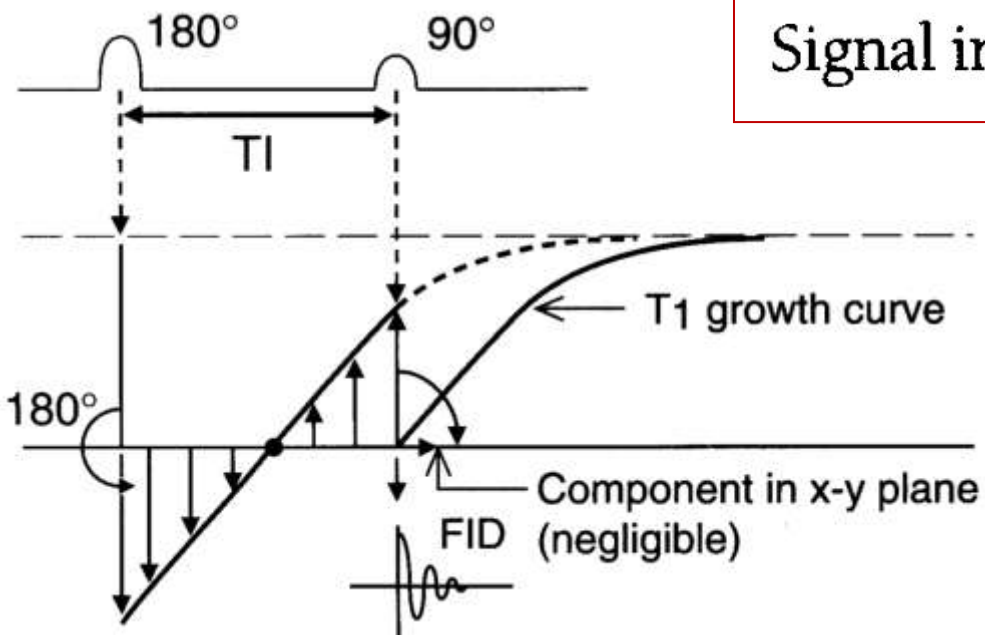


In saturation recovery, TR is long and TE is minimal.

The saturation recovery pulse sequence results in a proton density weighted image.

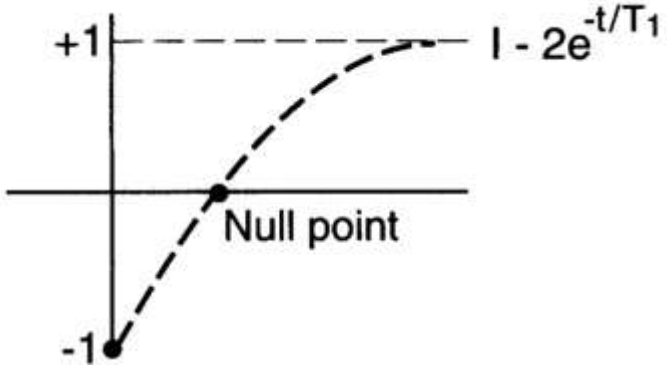
Pulse Sequences: Inversion Recovery





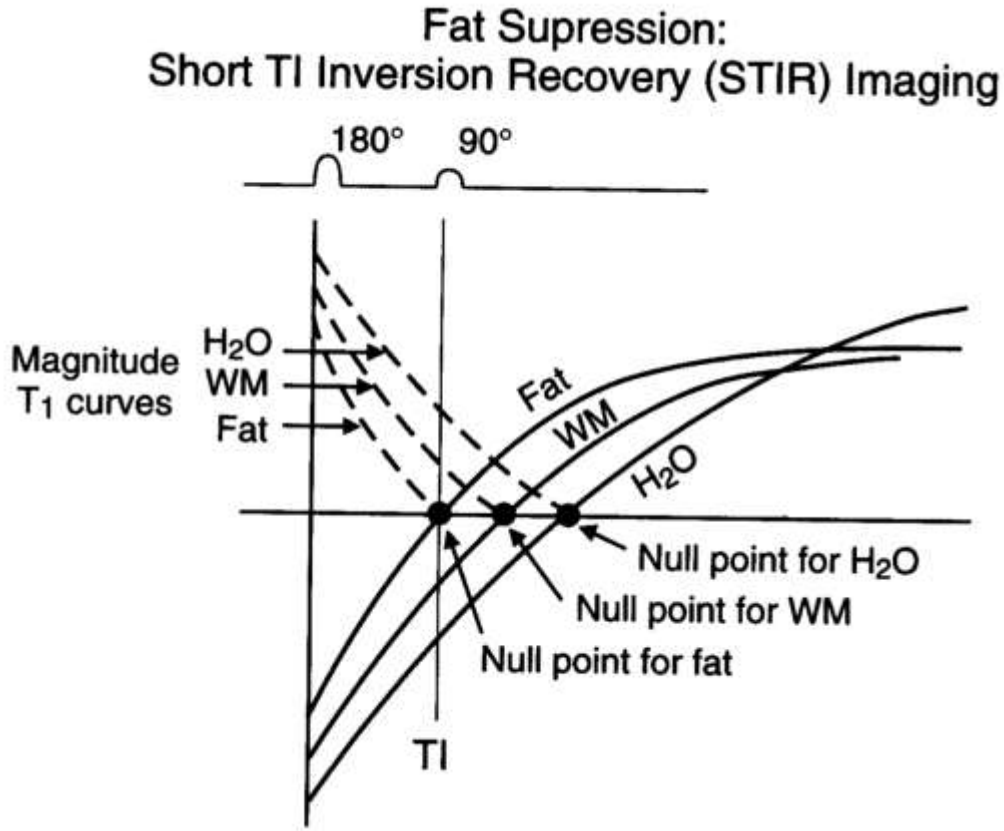
$$\text{Signal intensity} = 0 = 1 - 2e^{-TI/T1}$$

$$TI\ (\text{null}) = 0.693 \times T1$$



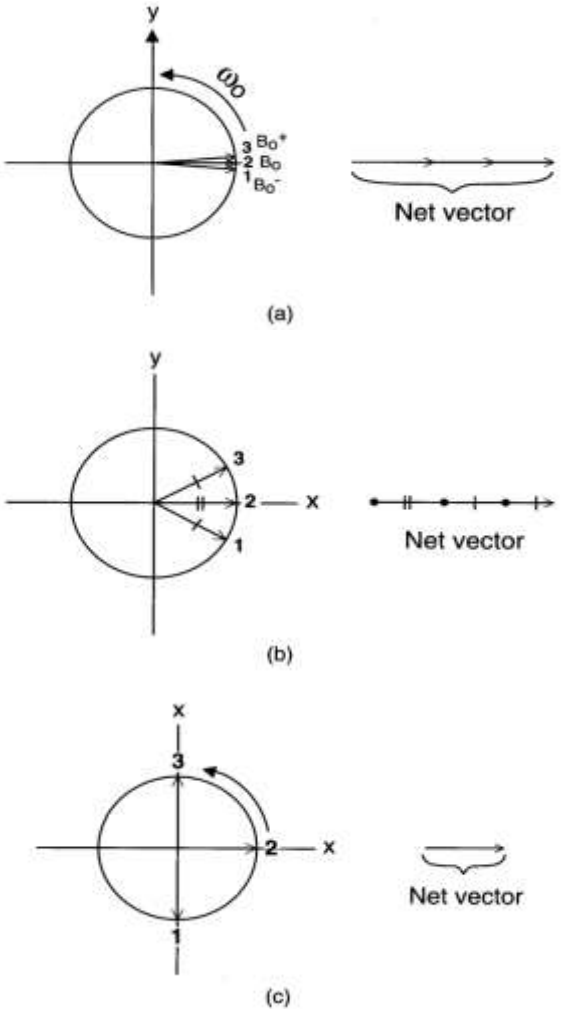
Fat Suppression using STIR Imaging

- STIR: Short TI Inversion Recovery

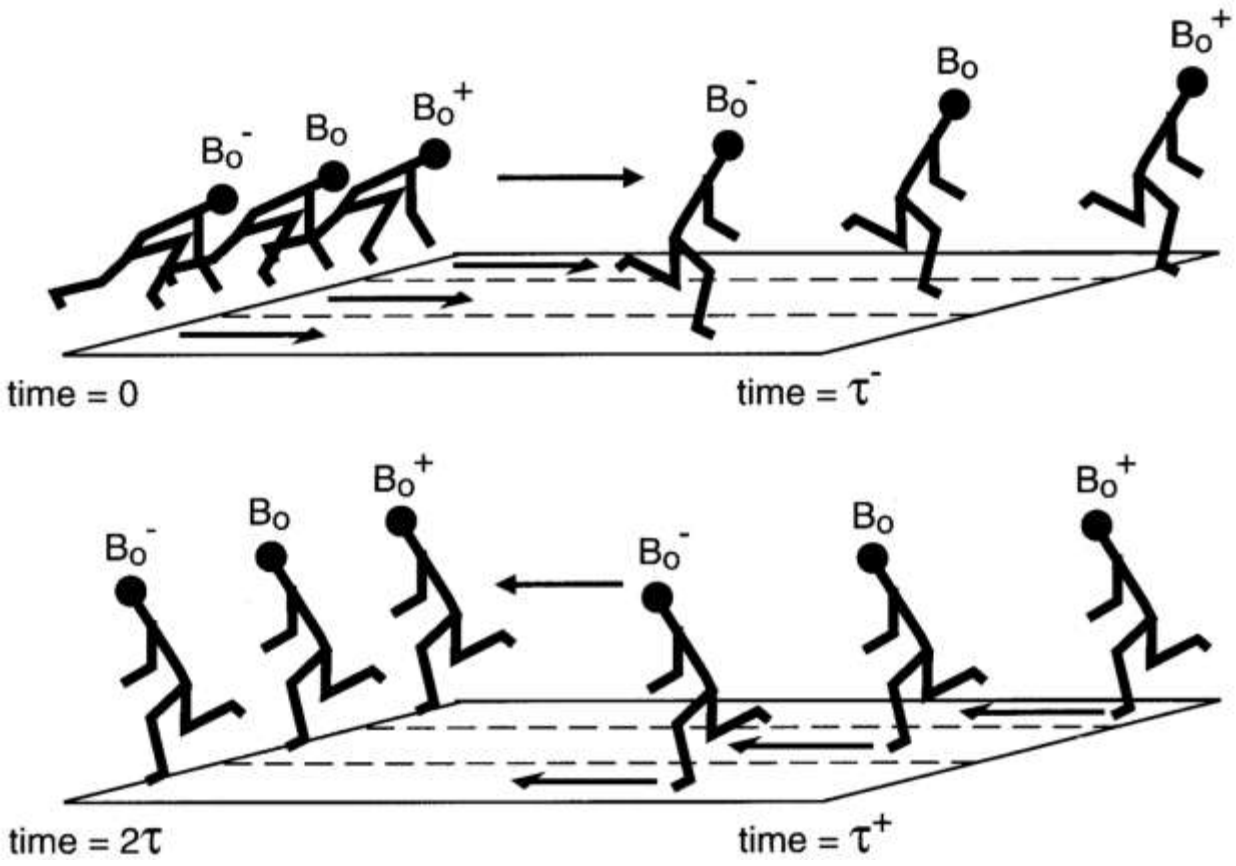


Pulse Sequences: Spin Echo

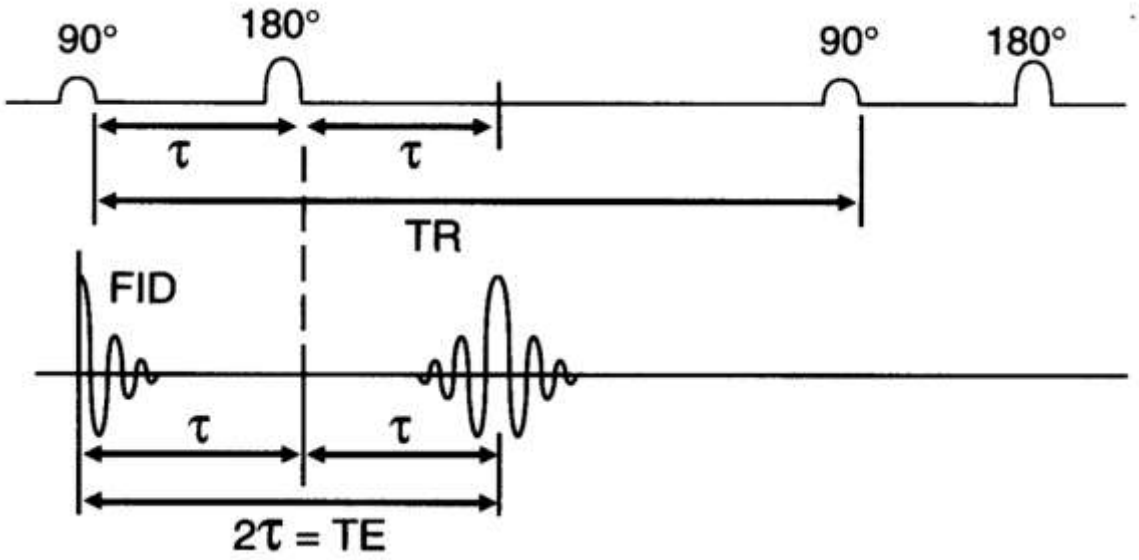
- Dephasing problem
  - External field inhomogeneity
  - T2* weighted FID

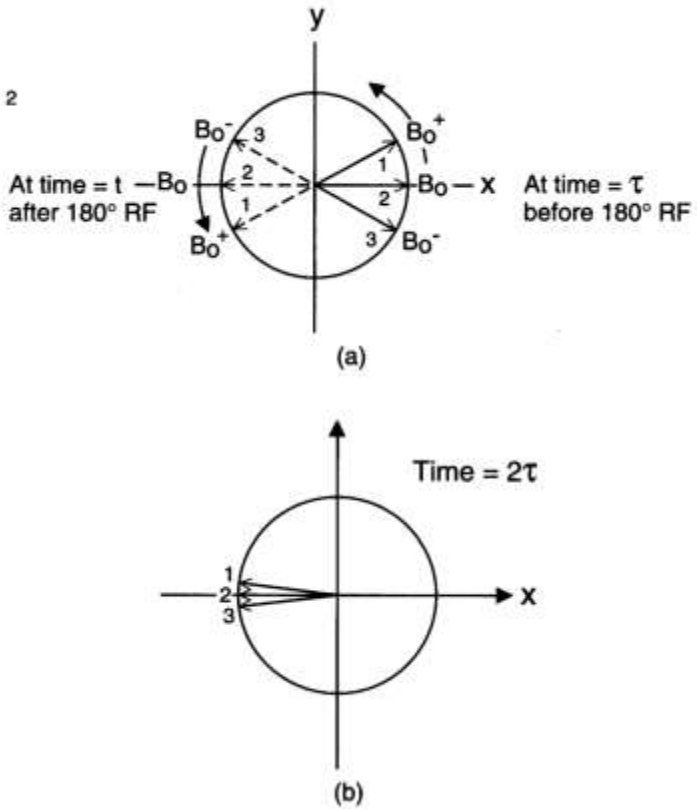


Pulse Sequences: Spin Echo



Pulse Sequences: Spin Echo





Tissue Contrast Summary

	TR	TE	Signal (Theoretical)
T1W	short	short	$N(H)(1 - e^{-TR/T1})$
T2W	long	long	$N(H)(e^{-TE/T2})$
PDW	long	short	$N(H)$

	Short TE	Long TE
short TR	T1W	mixed
long TR	PDW	T2W

Problem Assignments

- Solve the problems at the end of each chapter.