

Basic principles of MR imaging

Hoofdstuk 2: MR principe

Magnetische eigenschappen kern

Alle kernen met een ongelijke atomaire massa hebben een spin. Wanneer er een magnetisch veld aanzet wordt zullen deze spins ofwel parallel of antiparallel draaien. De spin vectoren draaien om een as met een specifiek frequentie => Larmor precessie. Er zullen net wat meer spins parallel aan het veld staan.

Larmor precessie

Door de spins aan te slaan met een RF puls van dezelfde frequentie als de spin, klapt de netto magnetisatie vector (M_z) om. Hierna draait de M_z met de Larmor frequentie in het magnetisch veld. Door het toevoegen van een ander magnetisch veld klapt de M_z om in de M_{xy} richting. Fliphoek = $\gamma B_1 t$. M_z is longitudinaal, M_{xy} is transversaal. Het maximale MR signaal ontstaat bij een 90° hoek. Een hogere veldsterkte leidt tot een hogere M_z en mogelijk een hoger signaal. M_z is statisch en geeft dus geen signaal.

Relaxatie

Na excitatie keren M_z en M_{xy} terug naar de evenwichtstoestand waarbij elektromagnetische radiatie uitgezonden wordt. Beide relaxatie processen zijn onafhankelijk van elkaar, maar wel afhankelijk van moleculaire structuur, fysische staat en temperatuur.

- Longitudinale relaxatie: T_1 is een tijdconstante welke de tijd beschrijft die nodig is om terug te groeien tot 63% van de originele M_z waarde. Grote en kleine moleculen hebben een relatief lange T_1 en medium moleculen een korte T_1 . De T_1 van vloeistoffen is over het algemeen korter dan die van vaste stoffen. De T_1 is afhankelijk van hoe efficiënt energie uitwisseling plaats kan vinden. De T_1 gaat omlaag in de aanwezigheid van macromoleculen. $5 \times T_1 \sim 100\%$ terug groei.
- Transversale relaxatie: T_2 is een tijdconstante voor spin-spin interacties om terug te vallen tot 37%. Door spin-spin interacties ontstaan er veld inhomogeniteiten, de spins defaseren en de M_{xy} neemt af. Vaste stoffen en grote moleculen hebben een korte T_2 . Kleine moleculen hebben een korte T_2 en de aanwezigheid van macromoleculen verkort de T_2 . De combinatie T_2 relaxatie en veld inhomogeniteiten wordt T_2^* genoemd.

Free induction decay, signaal detectie en Fourier transformatie

Na de 90° puls wordt een signaal gemeten in een ontvangstspool nadat de excitatie puls uit is gezet. Dit signaal wordt het "free induction decay" signaal genoemd omdat het in de loop van de tijd verval. Het signaal oscilleert rond de Larmor frequentie, de amplitude daalt met T_2^* en door het uitvoeren van Fourier transformaties ontstaat het NMR spectrum. Amplitude M_{xy} is afhankelijk van proton dichtheid. Fourier transformeerd een functie in het tijddomein naar een functie in het frequentiedomein door integreren. Een rechthoek in de Fourier is een $\text{sinc}(k)/mk = \text{sinc}(k)$.

Spin echo

De statische veld inhomogeniteiten kunnen teniet gedaan worden door de echo te meten i.p.v. het FID signaal. De 90° puls zorgt voor omklapping naar het XY-vlak. Door T_2 effecten treedt defasering op. Op $TE/2$ wordt een 180° puls gegeven waardoor de spins gespiegeld worden. De spins refaseren en vormen een echo. De spins zijn nu alleen nog van elkaar gescheiden door spin-spin interacties. Uiteindelijk wordt de echo hierdoor 0. De afname in amplitude is gelijk aan T_2 . Scan duur = $N_y \times TR$. Vullen k-ruimte: G_y en G_x tegelijkertijd dus diagonaal = 180° puls spiegeld in $x=y \Rightarrow G_x$ individueel zorgt voor horizontale lijn.

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SB Merriam



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Basic Principles of MR Imaging X. Philips, 2000 **Basic Principles of Nuclear Magnetic Resonance Imaging** J. Valk, C. MacLean, P. R. Algra, 1985

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