

## Static Inhomogeneities

In the ideal situation, the static magnetic field is totally uniform and the reconstructed object is determined solely by the applied gradient fields. In reality, the magnet is not perfect and will not be totally uniform. Part of this can be addressed by additional coils called “shim” coils, and the process of making the field more uniform is called “shimming”. In the old days this was done manually, but modern magnets can do this automatically.

In addition to magnet imperfections, most biological samples are inhomogeneous and this will lead to inhomogeneity in the field. This is because, each tissue has different magnetic properties and will distort the field.

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## Static Inhomogeneities

The spatial nonuniformity in the field can be modeled by adding an additional term to our signal equation.

$$\begin{aligned} s_r(t) &= \int_V M(\vec{r}, t) dV \\ &= \int_x \int_y \int_z M(x, y, z, 0) e^{-t/T_2(\vec{r})} e^{-j\omega_0 t} e^{-j\omega_E(\vec{r})t} \exp\left(-j\gamma \int_0^t \vec{G}(\tau) \cdot \vec{r} d\tau\right) dx dy dz \end{aligned}$$

The effect of this nonuniformity is to cause the spins to dephase with time and thus for the signal to decrease more rapidly. To first order this can be modeled as an additional decay term of the form

$$s_r(t) = \int_x \int_y \int_z M(x, y, z, 0) e^{-t/T_2(\vec{r})} e^{-t/T_2'(\vec{r})} e^{-j\omega_0 t} \exp\left(-j\gamma \int_0^t \vec{G}(\tau) \cdot \vec{r} d\tau\right) dx dy dz$$

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## $T_2^*$ decay

The overall decay has the form.

$$\exp(-t/T_2^*(\vec{r}))$$

where

$$\frac{1}{T_2^*} = \frac{1}{T_2} + \frac{1}{T_2'}$$

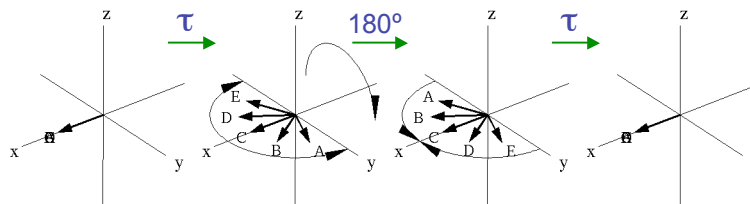
Due to random motions of spins.  
Not reversible.

Due to static inhomogeneities. Reversible  
with a spin-echo sequence.

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## Spin Echo

Discovered by Erwin Hahn in 1950.



The spin-echo can refocus the dephasing of spins due to static inhomogeneities. However, there will still be  $T_2$  dephasing due to random motion of spins.

*There is nothing that nuclear spins will not do for you, as long as you treat them as human beings.* Erwin Hahn

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Image: Larry Frank