New Day

(MRI)

Spectroscopy $\qquad \omega_0 = \gamma B$

$$\vec{\omega} = \gamma B_z \hat{k}$$

B_z is very homogeneous $1 : 10^7 - 10^{10}$
$\Rightarrow B_0 \hat{k}$

At the i^{th} nuclide, $B_i = B_0(\underbrace{1-\sigma_i}_{\text{chemical shifts}})$ + coupling constants (J_{ij}'s, D_{ij})

These are generally small effects. We will ignore them.

There is no function of coordinate here
We want to add this. $\rightarrow$ magnetic field gradients

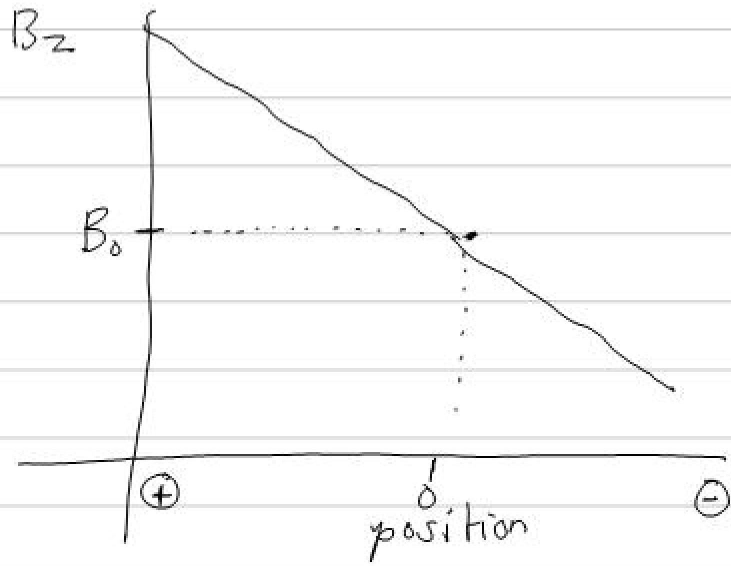
$$\underset{\text{gradient}}{G_z} = \frac{\Delta B_z}{\Delta z} = \text{constant}$$

(B_z is a linear function of position
– z coordinate.)

$$G_x = \frac{\Delta B_z}{\Delta x} = \text{constant}$$

$$G_y = \frac{\Delta B_z}{\Delta y} = \text{"}$$

One dimension



$$B_z = B_0 + G_x x$$

$$B_z = B_0 + G_y y$$

$$B_0 \approx 10^4 - 10^5 \text{ gauss}$$

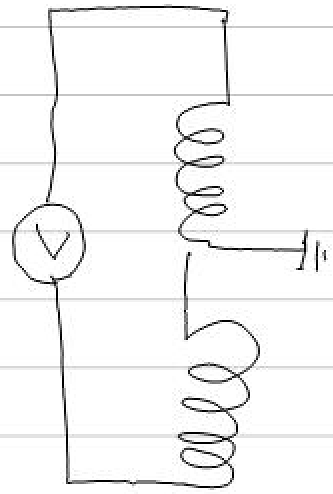
$$1 - 10 \text{ Tesla}$$

$$G_q \cdot q \approx 0 - 10^2 \text{ gauss}$$

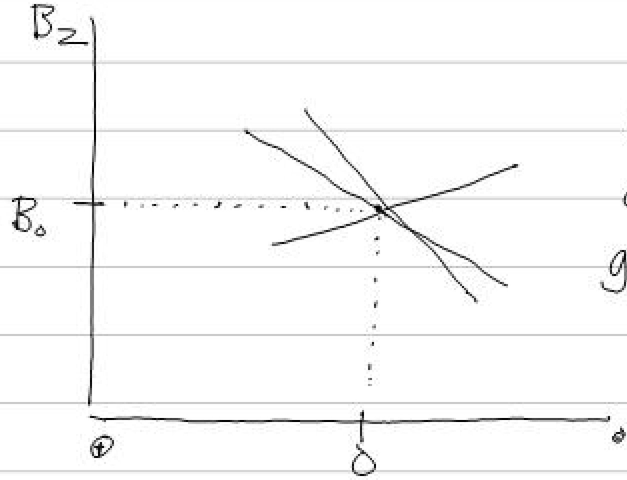
$$0 - 10 \text{ mT}$$

$G_{max} = 3-100$ gauss/cm clinical

$= 30-1000$ mT/m research



How gradients are generated.



Can control steepness and direction of gradient.

$G_{x,y,z} = fn(time)$

$$\left.\begin{aligned} \cancel{B_z} = B_z(z,t) &= B_0 + z \cdot G_z(t) \\ B_x(x,t) &= B_0 + x \cdot G_x(t) \\ B_y(y,t) &= B_0 + y \cdot G_y(t) \end{aligned}\right\} \omega = \gamma B$$

$$\omega(z,t) = \omega_0 + \omega_{G,z}(z,t) \Big] = \gamma z G_z(t)$$

$$\omega(x,t) = \underbrace{\boxed{\omega_0}}_{\text{ignored}} + \omega_{G,x}(x,t)$$

Frequency is now a function of position

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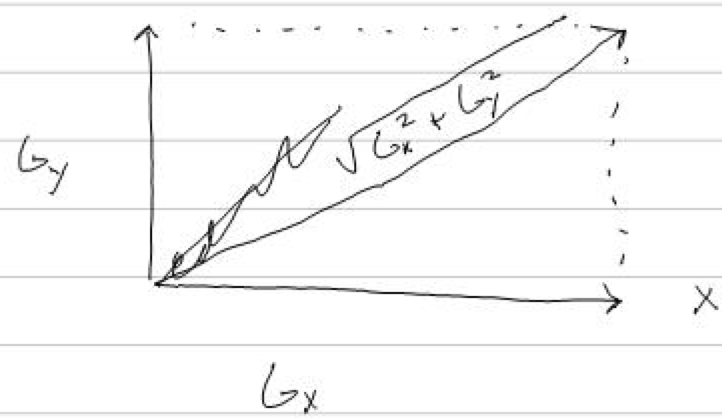
"Frequency Encoding"

ω is a linear function of position.

· Paul Lauterbur

But, perhaps we could encode all directions at once.



Gradients are vectors.

This would not give us encoding on both directions at the same time. We can only encodo along a single directions at any given time.

Good news is that you can choose any axis to do the encoding.

Can also use phase encoding.

$$\varphi_G(q,t) = -\int_0^t \omega_G(q,t')\,dt'$$

convention since counter-clockwise is positive

$$= -\int_0^t \gamma \cdot q \cdot G_q(t')\,dt'$$

$= -\gamma q G_q t$, if gradient is not a function of time