BIOE165, Fall 2013
Medical Imaging Signals and Systems

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HW10 Solution

Problem 1

a) PET resolution is limited by the following factors:

- The finite size of the detector
- Positrons travel before annihilation
- Annihilated photons are not strictly 180° apart

b) The most damaging factor is the finite size of the detector

c)

$$g(\theta, l)_{blur} = \delta[x\cos(\theta) + y\sin(\theta) - l] * \sqcap(\frac{l}{w})$$
$$g(\theta, l)_{blur} = \sqcap[\frac{x\cos(\theta) + y\sin(\theta) - l}{w}]$$

d) The detector width is proportional to the diameter of the ring if the detector number keeps constant. And the resolution is proportional to the detector width. Thus, if the diameter of the ring is scaled down by a factor of 4, the resolution will be improved by a factor of 4.

Problem 2

There are a lot more attenuation happening in SPECT than in PET because of SPECT's low energy gamma-rays. So in SPECT, we have a lot to correct. But in PET, all we care is 511 keV photons. We can reject the background by putting an energy windows.

Problem 3

Since the resolution is mainly contributed by the width of the detector. The 2D impulse response can be approximated as:

$$h(x, y) = circ(r)|_{r=\sqrt{x^2+y^2}}$$

Problem 4

a) The nuclear magnetization in water is:

$$M_0 = \frac{N\gamma^2\bar{h}I_z(I_z+1)B_0}{3kT}$$

we know that $\frac{N\gamma^2\bar{h}I_z(I_z+1)}{3kT} = 3.25 \times 10^{-3}\,A/m$ for protons in water at $37\,^\circ$

$$M_0 = 4.875 \times 10^{-3} A/m$$

b)

$$M = \chi H$$
$$M = \chi \frac{B}{\mu_0}$$
$$M = 1 \times 10^{-5}\,\frac{1.5}{4\pi \times 10^{-7}}\,A/m$$
$$M = 12\,A/m$$

c) Since there's no precession for molecular diamagnetic magnetization, we are not gonna be able to extract information of the object in frequency, like what we do in MRI.

Problem 5

$$\omega = \bar{\gamma} \cdot B$$
$$\omega = \bar{\gamma} \cdot (B_0 + G \cdot x)$$

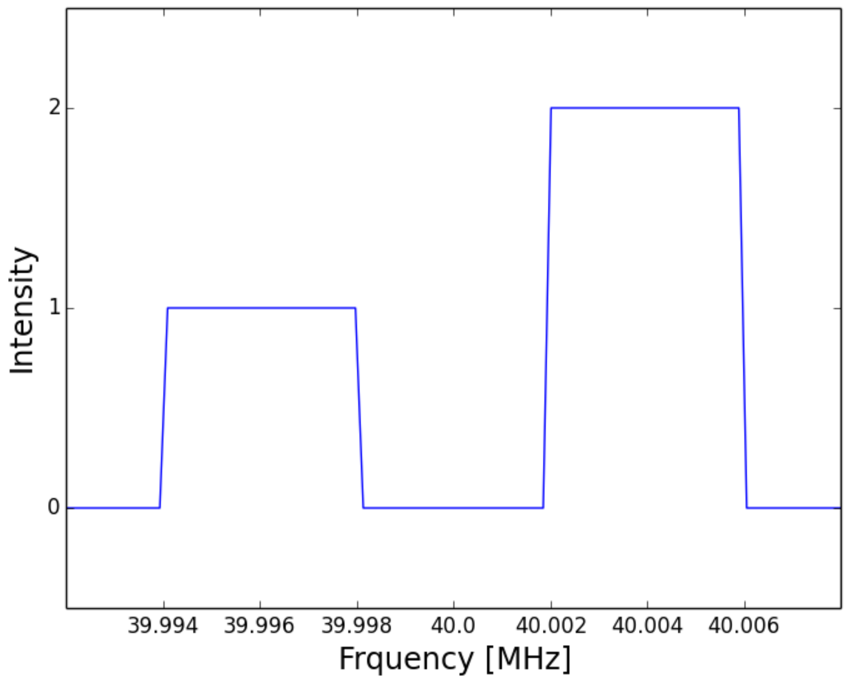

Figure 1: Spectrum of NMR signal

Problem 6

a) The two radio emitters have different frequency. So we can choose the channel by demodulating the signal at different frequency.

b) How we distinguish the radio emitters is exactly how we use MRI to image the nucleus density in our body. We are trying to resolve them in frequency rather than time.