

January 15, 2015

## Modern Techniques in Biophysics

Topic: Nuclear magnetic resonance

### Exercise 1: Chemical shift

A reference sample containing certain nuclei was placed in a 9.4 T magnet and was found to resonate at 400 MHz. An unknown sample containing the same type of nuclei displays a resonance that is +20,000 Hz relative to the reference sample.

- (i) What is the nucleus being investigated? Explain.
- (ii) Draw a simple diagram containing the locations of the NMR signals from the two samples. Calculate the chemical shift of the unknown sample in ppm.

### Exercise 2: Larmor frequency and nuclear polarization

A bottle of water (mainly protons,  $^1\text{H}$   $\gamma=42.6$  MHz/T) was studied by NMR at ambient conditions at Earth's magnetic field ( $B_0=5$  G) and  $T=298$  K.

- (a) At what frequency do you expect to see the NMR signal?
- (b) Calculate the nuclear polarization in % of the sample under those conditions.
- (c) Assuming there are  $10^{25}$  proton spins in that bottle of water, what is the difference between the spin populations between the upper and lower Zeeman energy levels?