1.7: How can the nuclear spins be manipulated to generate the NMR spectrum?

The previous figure shows the system at equilibrium. In order to generate a NMR signal, we must do something to perturb the populations of our spin states. As in other spectroscopic measurements, this is done through the absorption of radiant energy (light) of the appropriate frequency. In NMR, this transition is in the radio frequency (rf) range, corresponding to the Larmor frequency of the nucleus we are interested in. We cause this transition by irradiating our sample at a single radio frequency. An AC current oscillating at the desired rf frequency is applied to a coil wound around our sample. This oscillating current creates an additional magnetic field (called the B_1 field) that acts upon our macroscopic magnetization vector and tips it away from its equilibrium position aligned with B_o. This B_1 pulse creates the signal that we detect in NMR. In order to excite all of the different types of a single nucleus in our sample (e.g. all of the different types of protons or carbons), this pulse of rf radiation is kept short (typically ~10 μs). By the Heisenberg uncertainty principle, a short pulse will excite a broad range of frequencies; $\Delta f = 1/\Delta t$.

Exercise 1.7.4

What range of frequencies would be excited by a 10 μs rf pulse?