PHY327 Lab 3 Summary: NMR

Benjamin Humer

December 1, 2022

Nuclear Magnetic Resonance (NMR) in magnetic nuclei was first observed by both Carl Purcell and Felix Block independently in 1946. Since then, many technologies that exploit NMR have been developed for a variety of purposes; but the most common is for medical imaging. Doctors can use Magnetic Resonance Imaging (MRI) to take non-invasive scans of sensitive areas of the body.

NMR can be used to identify substances based on the characteristic relaxation times of the substances, T_1 and T_2. T_1 is the characteristic spin-lattice relaxation time, and T_2 is the spin-spin relaxation time. In this experiment, the values of T_1 and T_2 are measured for both light and heavy mineral oil to see what the impact of the increased number of cyclic (saturated) molecules, and the resulting lower density (when comparing heavy and light mineral oils), had on their respective spin-spin and spin-lattice relaxation times.

There is no method of direct measurement for either T_1 or T_2. To obtain both of these values there are two detailed procedures on pages III-14, and III-15/16 of the Pulsed/CW NMR Spectrometer PS2-A/B/C Instructor's Manual for T_1 and T_2 respectively.

$$\frac{dM_z}{dt} = -\frac{M_o - M_z}{T_1}, M_z(t) = M_o(1 - e^{-\frac{t}{T_1}}) \tag{1}$$

The second part of Equation 1 must be fit to the raw data collected with the method on page III-14 to obtain the value of T_1.

$$\frac{dM_z}{dt} = -\frac{M_o}{T_2}, M_z(t) = M_o e^{-\frac{2t}{T_2}} \tag{2}$$

The second part of Equation 2 must be fit to the raw data collected with the method on pages III-15 and III-16 to obtain the value of T_2.

In this experiment, a TeachSpin Pulsed/CW NMR Spectrometer was used, and all of the data was taken in pulsed mode rather than CW (Continuous Wave) mode. The data was recorded in tables on pages 33, 36, 38, 39 of my lab notebook, and the plots corresponding to those tables are on pages 41 and 42. The raw data is in my github repository. The experimentally determined values were $T_1 = 22.4 \pm 3$ ms and $T_2 = 21 \pm 3$ ms for heavy mineral oil, and $T_1 = 45.2 \pm 3$ ms and $T_2 = 40.2 \pm 3$ ms for light mineral oil.