Devin Morin 2019-10-09

Advanced Research Project

Handheld Unilateral Magnet for Flow Measurements using Large Constant Gradient

The purpose of the research project is to measure flow velocity noninvasively with the use of a unilateral magnet and RF probe. Flow measurements have been done in the past, using magnets with a much larger field and gradient. However, the SA3 magnet has a much lower magnetic field (530 Gauss at 2.26MHz), which will impose some problems on the physical setup of the apparatus. The project takes a large influence from T.M. Osán and his paper on "*Fast measurements of average glow velocity by Low-Field NMR*". The goal of this project, as stated in Osán's paper is to develop a method of measuring flow velocity in both laminar and turbulent regimes. The use of LF NMR makes practical sense, as flow measurements give an abundance of signal from the hydrogen nuclei in water, as well as the application of the device to industry use (low cost and easy portability).

The project makes use of a Carr-Purcell-Meiboom-Gill (CPMG) sequence, which is composed of a 90-degree RF pulse, followed by a period T and then a train of 180-degree pulses separated by the time 2T. If the liquid is stationary and we neglect the effects of diffusion, then it's expected that the echo train intensity has the form of :

$$I(t) = \beta M_0 e^{-t/T_2}$$

The resulting NMR signal for flows has different characteristics compared to stationary liquid signal. For example, odd-numbered echoes have a greatly decreased amplitude. The overall signal intensity for flow data will decrease will greater flow velocity. As such, the first 7 peaks are fitted to the equation of the line:

$$I(t) = A + Bt$$

The ratio of -B/A turns out to be proportional to flow velocity. As such, multiple measurements will be taken of flowing liquid (Doped water would most likely be the best choice), and the relationship between -B/A and flow velocity will be shown. Doing this gives the means for flow velocity to be obtained from a flowing liquid. As long as the relationship was previously determined, one could gather NMR signal from a flowing tube of liquid and refer to the relationship between -B/A, and flow velocity.

Advanced Research Project Timeline

1.Wednesday, Oct 16, 2019 – Proposal Submission

2.Mid November – Fully Function NMR Device / Flow Setup

-This would involve testing the signal to make sure it's reliable. Previously, the signal had anomalies and would vary from day to day. The time during mid November should be spent preparing for collection of flow data. Of course, this includes a function flow setup.

3.Mid December – Gathering the Bulk of Flow Data

-By this time, most of the flow data should be taken. This would leave time to go back and retake data if problems arose.

4.Friday, January 10, 2019 – Mid-Project Report

-As stated in the original expectations document "prepare a short report on how the project has gone so far and how you anticipate the project will progress from here. Submit the report to your supervisor, who will read it and write comments giving you feedback on your progress by Friday, January 17, 2020."

5.Tuesday, March 31, 2020 – Submit Thesis

-As stated in the original expectations "in advance of this date, your supervisor(s) should have read and made corrections and suggestions to a complete draft of your thesis. Allow yourself a number of weeks to compose the document! Instructions regarding formatting and contents of your thesis will be available on the Department of Physics website. Submit your draft to the Department's Chair or Administrative Assistant in PDF format in a single file. This draft will then be circulated to the readers of your thesis.

6.Wednesday, April 9, 2020 – Presentation

-As per expectation "prepare a presentation on your work of about 20 minute duration, and review it with your supervisor(s). On the presentation date, you will give your presentation, and will then be questioned on your work by the readers, your supervisor, and then the rest of the audience."

7.Make corrections and write to your reviewers (end of term)

-As per expectation "the people who have evaluated your work will have almost certainly suggested changes and revisions to your thesis. Make all revisions that you (and your supervisor) agree are necessary. Write a brief response to your reviewers, addressing their concerns and explaining to them anything that"