Water and ^{3}He Polarimetry

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Motivations

• The aim of this work was to obtain a good signal for water using an Earth's field NMR kit, Terranova, made by magritek, and then use this to calibrate the degree of polarisation in our hyperpolarised ^{3}He sample.

• At earth's field the magnetisation of protons in a water sample is low and so the corresponding NMR signal is not very strong. In order to boost this signal a polarising pulse was applied for a particular duration by applying a current through the coil. The effect of using different strengths of polarising pulse can be seen in the FIDs in Fig. 1.

• The maximum current we applied to the polarising coil was 6A, and this corresponded to a magnetic field of 181G. We compared this to a pulse of 0.957A which equates to a field of 28G. The field values obtained are plotted in Fig. 4.

• The magnetic field strength of 28G was of interest as it is this strength of field we planned to generate for the hyperpolarised work using the Helmholtz coils illustrated in fig. 5.

Advantages of Polarising Field

• By applying a polarising pulse at low field we can temporarily generate a much higher magnetic field and so increase the polarisation of the sample, resulting in an improved FID.

a) b)

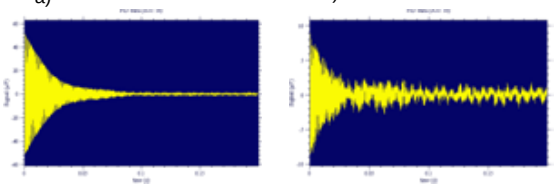

Fig. 1: Comparison of the FID obtained for a water sample with a) a polarising field of 6A corresponding to 181G, and b) a polarising field of 0.957A corresponding to 28G. Data was collected over 16 averages.

• Our experiments also showed that at 6A the FID signal varied by approximately 3.5%, compared with 23.2% at 0.957A, demonstrating that the observed signal improves as the magnetic field is increased.

• We can see that without this polarising pulse, Earth's field NMR is a very limited technique due to the poor signal generated. However, as the NMR signal for a hyperpolarised sample is greater by approximately 5 orders of magnitude, a polarising pulse is not required, and a good quality FID can be obtained at low field.

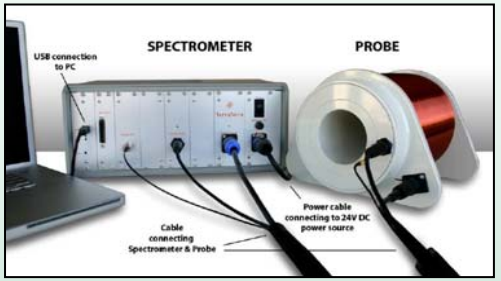

Fig 2: Earth's field NMR system by magritek [1]

Signal/Noise

• As is suggested just by looking at the FIDs in Fig. 1, increasing our polarising current improves the S/N, and this improvement can be quantified.

• By measuring the peak height in the frequency spectrum to obtain a value for the signal, and dividing this by the standard deviation of the noise, we obtained a measure of the s/n at both 181G and 28G, and so were able to quantify the quality of the signal:

Polarising Field (G)	Signal Amplitude	Standard Deviation in noise values	Signal/Noise
181	4.58×10^4	1050	**44**
28	7.43×10^3	419	**18**

Water Results

• The FIDs obtained for a water sample can be seen in Fig. 1, and the corresponding spectra in Fig. 3 below. Values for T_1 and T_2 of the sample were obtained by using the more complex pulse sequences spin-echo and CPMG.

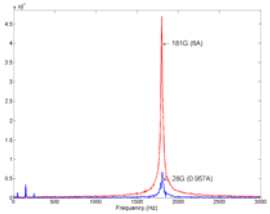

Fig. 3: Spectrum obtained for a water sample using a polarising field generated by a 6A current, compared with that obtained using a current of 0.957A. Data was collected over 16 averages.

References

1. 'Terranova Earth's field NMR system User's Manual', by magritek.
2. Data obtained by John Owers-Bradley and team.

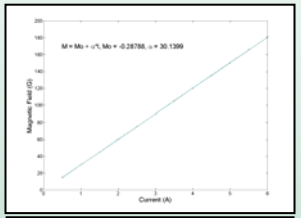

Fig. 4: Variation in magnetic field of polarising pulse with current applied

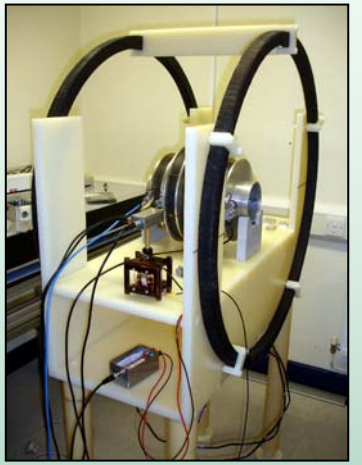

Fig. 5: MEOP kit for hyperpolarised work

Hyperpolarised result

• In order to obtain a ^{3}He NMR signal at low field we need to hyperpolarise our sample. This is done using the MEOP method, the apparatus for which is illustrated in fig. 5. A polarising pulse is no longer required as the polarisation of the sample is already high.

• For the hyperpolarised work we use a field of 28G as opposed to Earth's field, and so the corresponding frequency range is much higher. For this reason we use the Aurora system by magritek rather than Terranova.

• From these results we plan to calibrate the degree of polarisation of ^{3}He by comparison with our water results.

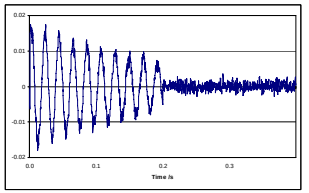

Fig. 6: FID of hyperpolarised ^{3}He cell at 3mbar. This data was not obtained using our magritek and MEOP kit, but is what we expect to obtain when fully operational [2].