

The **Lab-Tools Mk3 NMR Relaxation Spectrometer** is built around a credit-card sized Field Programmable Gate Array module for the digital RF, with attached custom surface mount low-noise receiver and linear transmitter. The extreme compactness and lightness of this precision research grade NMR relaxation spectrometer make it ideal for use in the field. The prototype has just been certified to international standards BS EN 61 326-1: 2013 & IEC 61326-1:2012.



Far more than just another liquids spectrometer, this device is targeted at samples that may be liquid, waxy, porous, polymer, tar , and is also capable of measuring T_2 s and mobilities in rigid materials like brittle ice. There are many applications in Material Science where measurements of mobility / stiffness / viscosity / rigidity are very useful parameters, providing data on the physical state of the sample, particularly as a function of temperature. A compatible Peltier thermo-electrically cooled variable temperature probe is also available.

Please see the following two links regarding the NMR Relaxation Spectrometer and a few example test measurements that have been made using it, and also two published papers :

http://www.lab-tools.com/instrumentation/pdf/Lab-Tools_NMR_Relaxation_Spectrometer-Instrument.pdf

http://www.lab-tools.com/instrumentation/pdf/Lab-Tools_NMR_Relaxation_Spectrometer-Example_Measurements.pdf

References :

1. *Credit-card sized Field and Benchtop NMR Relaxometers using Field Programmable Gate Arrays.* J. Beau W. Webber, Pavel Demin, Magnetic Resonance Imaging Volume 56, February 2019, Pages 45-51, DOI: 10.1016/j.mri.2018.09.018 <https://doi.org/10.1016/j.mri.2018.09.018>
2. *Biological, Medical and Nano Structured materials - NMR done Simply.* J Beau W Webber. Archives in Biomedical Engineering & Biotechnology 1(4): 2019. ABEB.MS.ID.000517 <https://irispublishers.com/abeb/pdf/ABEB.MS.ID.000517.pdf>

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Lab-Tools NMR Relaxation Spectrometer - Example Measurements

Dr. Beau Webber – 2019-09-04

Figure 1. The Spectrometer is here shown with the included HP i5 All-in-one Windows 10 PC with screen and simple NMR probe, being used to measure an NMR $\pi/2 - \tau - \pi - \tau - \text{Echo}$ sequence on a sample of hexadecane. The extreme compactness and lightness of this precision research grade NMR relaxation spectrometer make it ideal for use in the field. A range of nuclei can also be studied using this spectrometer.

Figure 2. Top Left : Graphical User Interface
 Top Right : Single-Shot capture of a Free Induction Decay and Echo from a 119mg hexadecane at 24 MHz.
 Bottom Right : Averaged echo peak, polynomial fitted, polynomial solved to obtain echo peak amplitude.
 Bottom Left : Fit parameters listed to screen, also logged to file with experimental parameters including sample temperature.

Figure 3. Carr-Purcell-Meiboom-Gill chain of Echoes in hexadecane in C60 sol-gel pores at +6.6 C. The echo peaks are then fitted with an exponential, of $T_2 = 8.4$ ms.
 Note : Hexadecane bulk melting point is +15C, the Gibbs-Thomson melting point depression in the pores results in the hexadecane still being liquid at +6.6C.

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Figure 4. Bulk brittle ice is a difficult sample for many spectrometers. Brittle ice FID at -5C, with Gaussian $T_2 = 14\mu\text{s}$.
 Figure 5. On the right is a plot of the Gaussian T_2 from -22C (10 μs) to just under 0C (20 μs). This provides information on the dynamics/mobility/stiffness/rigidity of the brittle ice as a function of temperature.

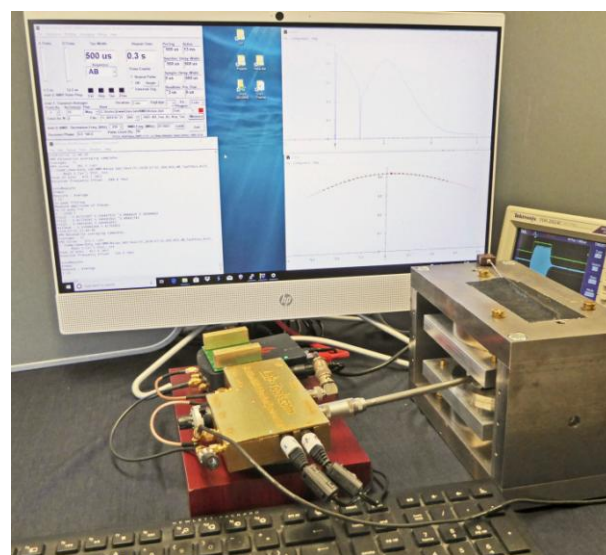


Fig. 1. Lab-Tools NMR Relaxation Spectrometer.

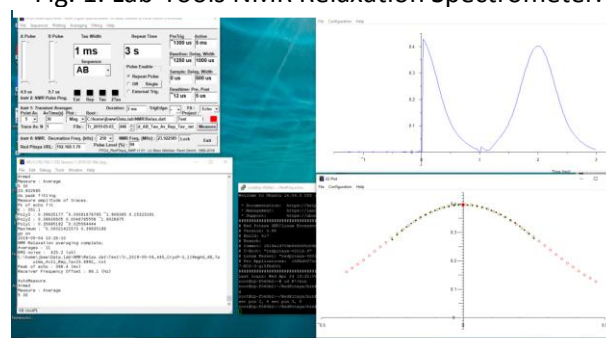


Fig. 2. Hexadecane FID and fitted Echo.

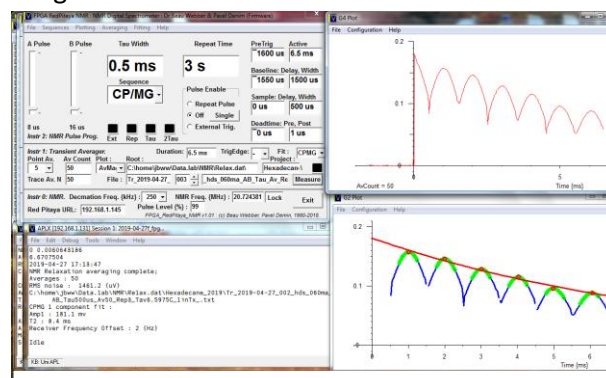


Fig. 3. CPMG echo sequence for a liquid in pores.

Ice Free Induction Decay : -5C

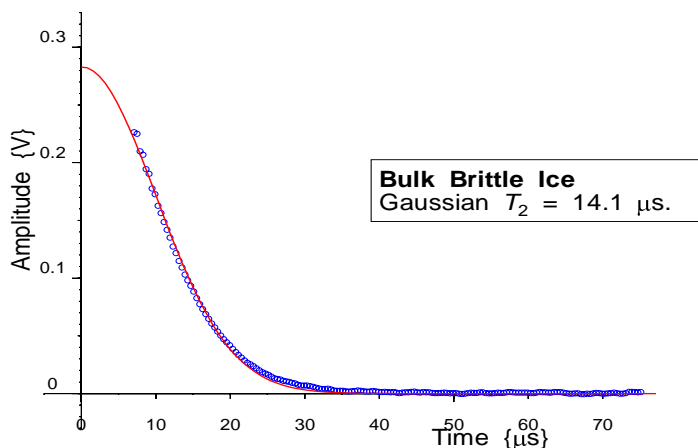


Fig. 4. Bulk brittle ice FID.

Brittle Ice Gaussian T_2 s

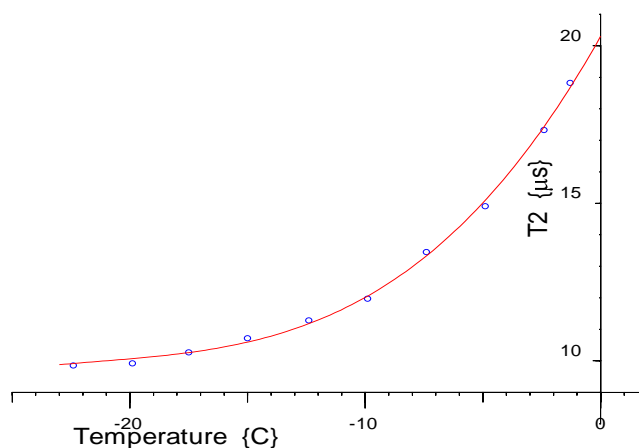


Fig.5. Plot of brittle ice mobility vs. Temperature.