World's First 1.5 GHz, 1 ppm NMR Magnet: Now Operating at the NHMFL

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The MagLab's new 36T Series-Connected Hybrid (SCH) magnet has reached its performance specification of 1 ppm stability and homogeneity! This has enabled the world's first two-dimensional (2D) NMR spectrum at 1.5 GHz to be obtained. Prior to this milestone, the previous record was set at 1.0 GHz.

Traditional NMR magnets employ single strands of superconducting wire carrying a few hundred amps and persistent joints and switches. In contrast, this magnet incorporates a 20kA superconducting cable in a steel conduit for the outer part of the magnet and copper-alloy sheet metal for the inner part of the magnet. To attain 1 ppm uniformity, current density grading was employed in the copper-alloy coils, while ferroshims and resistive shims were installed in the bore of the magnet [1]. The voltage across the resistive coils is 640V, which means it is impossible to operate the superconducting coil in the usual persistent mode. As such, an advanced Bruker magnetic-field lock with MagLab modifications [2] was utilized to stabilize the magnetic field to <0.1 ppm ripple, as shown in Figure 1.

Figure 2 shows the ^{17}O spectrum of isotopically-labeled benzoic acid at 1.5GHz (a magnetic field of 35.2T) under field-locked conditions. The exquisite resolution, resulting from a sophisticated NMR pulse sequence, demonstrates that a broad range of experiments for quadrupolar nuclei in biological and materials samples will be possible on this magnet. *The MagLab's vision of unlocking the periodic table using the Series Connected Hybrid magnet is hereby demonstrated by this two-dimensional NMR spectrum of oxygen.* Oxygen atoms sit at the sites that nucleate many chemical reactions in novel materials and biological systems.

Facilities: DC Field Facility, Cell 14.

Citations: [1] M.D. Bird, I.R. Dixon, J. Toth, *Large, High-Field Magnet Projects at the NHMFL*, **Transactions on Applied Superconductivity, vol.25**, no.3, 4300606 (2015).

[2] M. Li, J.L. Schiano, J.E. Samra, K.K. Shetty and W.W. Brey, *Reduction of Magnetic Field Fluctuations in Powered Magnets for NMR Using Inductive Measurements and Sampled-Data Feedback Control* **Journal of Magnetic Resonance 212,** 2, 254-264 (2011).

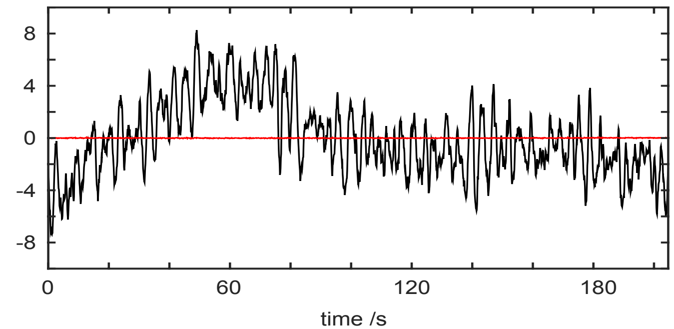

Fig. 1: Stabilizing the magnetic field at 35.2T. Black line records the way the magnetic field changes in the original configuration of the magnet at one point in space as time passes (16 ppm variation). **The <0.1ppm red trace is the resulting stability after employing the temporal stabilization system.**

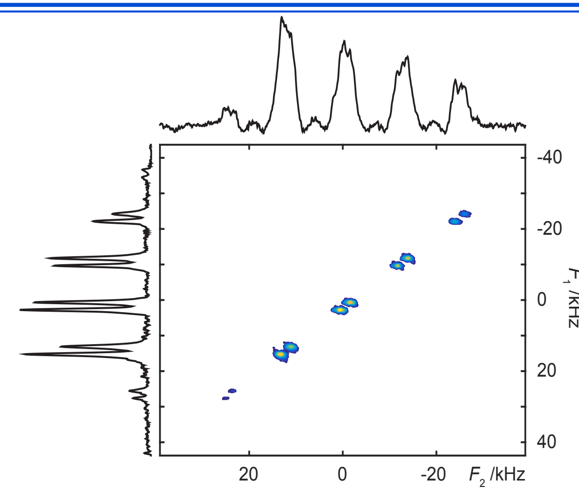

Fig. 2: Two dimensional triple quantum Magic Angle Spinning (MAS) spectra of ^{17}O benzoic acid at 35.2 T. This spectrum correlates the triple quantum signal (F1 axis) with the single quantum spectrum (F2 axis).