A Modular Low Frequency EPR Spectrometer for Studying Objects with Cultural Heritage Significance

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Overview
Unlike X band EPR, Low frequency EPR (LFEPR) spectroscopy can be used to examine large objects with cultural heritage significance non-invasively and non-destructively. This capability is due to their large volume magnets and lower operating frequency (ν < 500 MHz). The former permits the placement of large intact objects in the spectrometer while the latter makes it easier to construct surface coil (SC) probes. In this poster we describe the features of our spectrometer while the latter makes it easier to construct surface coil non-invasively and non-destructively. This capability is due to their large volume magnets and lower operating frequency (ν < 500 MHz).

The spectrometer’s modular design allows us to easily change its frequency and capabilities.

Specifications

Magnet:
Type: Electromagnet
Size: 15 cm Diameter, 45 cm Length, 800 turn #10 Cu wire
Field Sweep Range: 0-34 mT
Frequency Range: 100-500 MHz
Modulation Frequency: 10 kHz

Modulation Coils:
15 cm ID Helmholtz, 1.8 Ω
10 cm ID Solenoid, 2.3 Ω
4.3 cm Saddle, 13 Ω

Sample Probes:
Single Turn Solenoid: 150, 205, 251, 299, 354, 400, 440 MHz
4.3 cm Saddle, 13
Largest Sample Diameter: 15 cm

Surface Coil Probe:
2 cm, 7 turn, spiral, inductively coupled

LFEPR Program

Three Spectrometer Control Programs
1. Spectrum: Conventional B₀ sweep and record lock-in signal
2. Field Cycle: Record lock-in signal while sweeping B₀ up and down
3. Time Domain: Fixed B₀ and record signal as a function of time

Example of spectral output from the field cycling program (#2). The sample is ferrimagnetic electrophotographic toner fused on paper. For comparison, a 299 MHz, field cycled x0.01 spectrum of paramagnetic DPPH is inserted.

Example of spectral output from the time domain program (#3). Sample is the barconde-39 of the letters RIT printed with ferrimagnetic electrophotographic toner fused on paper. Barcode was scanned under the 2.9 mm SC.

Summary
A modular LFEPR spectrometer design for operating at frequencies between 100 and 500 MHz is presented. The spectrometer can be easily reconfigured to utilize different volume and surface coil sample probes. Three different control programs allow the instrument to record field sweep, field cycled, and time domain spectra. For applications, see the other posters done by our lab.

References