VIII. MAGNETIC RESONANCE*

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A. HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE IN SOLIDS

An eight-pulse, four-phase cycle of RF field pulses, mentioned in Quarterly Progress Report No. 89 (page 47), has been successfully tested in experiments at 55 MHz carrier frequency on the ^{19}F resonance of a CaF_2 crystal. In this experiment (the eightfold way) the following cycle of 90° pulses is indefinitely repeated:

$$P_x-2\tau-P_{-x}-\tau-P_y-2\tau-P_{-y}-\tau-P_{-x}-2\tau-P_x-\tau-P_{-y}-2\tau-P_y-\tau-,$$

where the subscripts refer to the direction of the effective pulse field in a reference frame rotating about the z-axis at the Larmor frequency. The freely precessing magnetization signal is sampled and held between pulses once during each cycle, and the resulting staircase smoothed by one stage of RC filtering, digitized, and stored in a Fabri-Tek signal averager. A typical transient of this kind, read out from the core on an X-Y plotter, appears in Fig. VIII-1. Figure VIII-2 is its Fourier transform, which corresponds to the unsaturated steady-state absorption spectrum of the ^{19}F spin system.

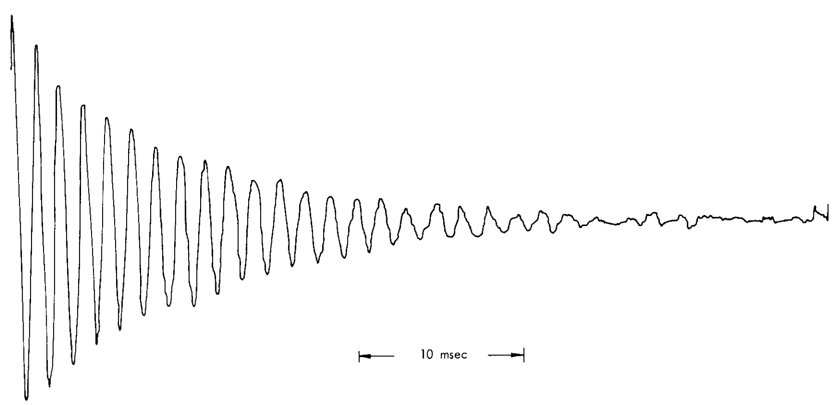

Fig. VIII-1. Eight-pulse experiment – CaF_2 crystal.

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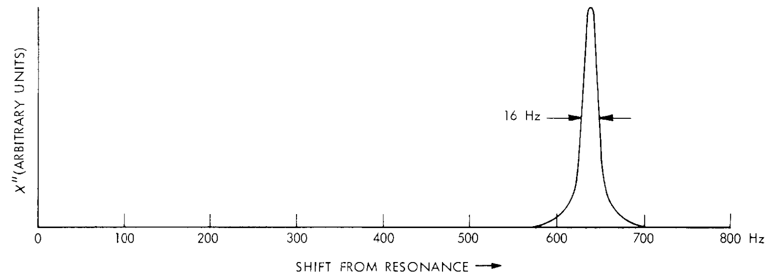

Fig. VIII-2. Fourier transform of Fig. VIII-1.

The effective linewidth is 16 Hz, compared with the "true" dipolar width in CaF_2 of ~30 kHz. The 640-Hz displacement from the origin corresponds to a $3 \times 640 = 1900$ Hz shift of the resonance from the spectrometer operating frequency.

The resolution shown is limited by several experimental factors, apparently the most important being connected with small transients of RF field in effective phase quadrature with the main carrier and occurring during the (~100 nsec) rises and falls of the main (~1.5 μsec) pulses. A higher powered, more heavily damped final RF amplifier is being constructed to minimize this problem, and a phase-switching and gating system having more variability of adjustment of pulse widths and phases is being built to permit compensation of the residue. Changes in pulse width of ~50 nsec and in phase of $<1°$ are critical in this regard. With these changes, and more careful attention to probe materials and geometry, we expect a further appreciable improvement in effective resolution.

A detailed theoretical analysis of these experiments has been submitted for publication to the Physical Review.

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