# Supplemental material to the article

# Dynamics and relaxation of multiple quantum NMR coherences in a quasi-one-dimensional chain of nuclear spins $^{19}$F in calcium fluorapatite

The preparation and detection of multiple quantum coherences in solids impose strict requirements on the experimental equipment. Most importantly, stringent requirements apply to the NMR probes which should provide short 90 degree pulses $t_{90}$ (i), a broad and uniform excitation band of the magnetization $\Delta F$ (ii), the highest possible homogeneity of the radiofrequency field $B_1$ within the sample volume (iii), and also the shortest possible dead time $t_d$ following the successive pulses (iv).

The first condition (i) is satisfied by the generation of a high magnitude of the $B_1$ field since the rotation of the magnetization $M_0$ during the pulse duration $\tau$ in the rotating frame is proportional to $B_1$. In our case the implementation of the pulse sequence for the multiple quantum coherence excitation requires the width of the 90 degree pulses to satisfy $t_{90} < 1\ \mu s$. Commercially available NMR probes for 5 $mm$ samples allow obtaining pulses of the order of 3 $\mu s$.

The second condition (ii) is achieved by lowering the quality factor $Q$ of the resonance circuit. This, however, reduces the magnitude of the $B_1$ field. The improvement of the $B_1$ field homogeneity (iii) is achieved by the implementation of the solenoid coil with the length to diameter ratio of $3 \div 4$. Condition (iv) is also achieved due to a low $Q$-factor value.

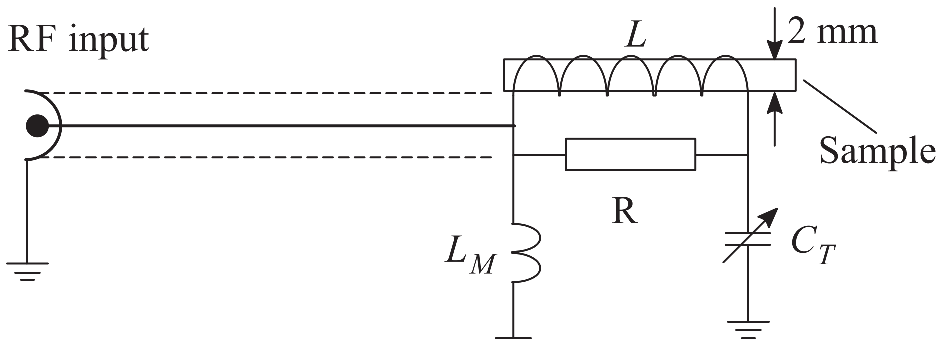


Figure 1: NMR probe scheme. $L$ transmit-receive coil, $L_M$ – matching inductance, $C_T$ – circuit tuning capacitor, $R$ – damping resistor

These common principles of NMR instrumentation became the basis for the design of the probe for the excitation and detection of $^1H$ and $^{19}F$ multiple quantum coherences in solids. A solenoid coil with the inner diameter of 2 $mm$ was used as a radio-frequency coil. This increases the $B_1$ field strength in comparison with 5 $mm$ coils and allows obtaining a sufficient winding length at the cost of a low inductance. Lowering the $Q$-factor for obtaining a satisfactory dead time $t_d$ was performed by matching a damping resistor. The electric circuit of the probe is presented in fig.1.

The 90 degree pulse length was determined by acquiring signals for incremented $t_p$. The duration of a 90 degree pulse at 400 MHz was 0.3 $\mu s$ at 400 W of the radiofrequency power. The equality of the signal amplitudes, following the 90 degree and 270 degree pulses, indicates high $B_1$ field uniformity.