Selective excitation with colored Frank sequences

A. Görges[a], S. Benders[b], M. Küppers[a], M. Adams[a], B. Blümich[a]
[a] ITMC, RWTH Aachen University, Aachen, Germany, [b] Department of Chemistry, NYU, New York, NY USA

Introduction: Inspired by the development of miniaturized NMR devices and the growing interest in their use in material science as well as for chemical and biological research, low-power rf excitation is explored to eliminate the transmitter amplifier. The lowest excitation power is achieved with sequences of phase-modulated, constant-amplitude rf pulses, whereby one pulse is applied each sampling interval. The earlier realizations such as maximum-length binary sequences rely on the Hadamard transformation [1-2] and hamper selective excitation for solvent signal suppression and slice-selective imaging [3]. Frank sequences [4] promise a new way out. They can be understood as being composed of packets of discrete phase wavelets arranged in such a way that one scan with a Frank sequence corresponds to a rapid frequency sweep through the spectral excitation window. This suggests that individual wavelets could be omitted to skip a narrow frequency region in the excitation spectrum. It could be shown that selective signal suppression in the low power regime is possible for NMR spectroscopy and imaging without resorting to more demanding schemes like SPREAD [3] or WURST [5].

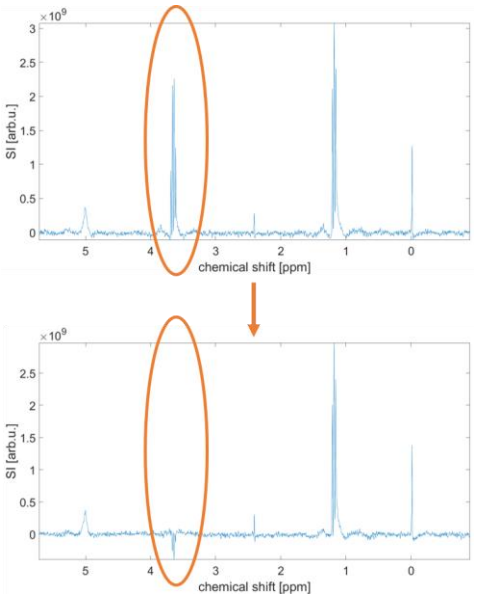

Figure 1: Selective signal suppression by colored Frank-excitation. Here the CH_2 signal of ethanol is suppressed by replacing an excitation wavelet with zero-amplitude pulses. The remaining spectrum is largely unaffected.

Methods: Frank sequence excitation with 3.8 µW and 16 k pulses was realized on a Bruker AV 300 MHz spectrometer. Data acquired with conventional pulse excitation are compared to those acquired with µW Frank excitation. Different approaches for selective signal suppression are tested in terms of applicability, spectral quality and efficiency. Additionally, imaging experiments with Frank excitation were tested, as the low-power excitation promises short dead time.

Results and Discussion: Figure 1 depicts ethanol spectra obtained with Frank excitation as mentioned above. The top one has been acquired with non-selective excitation, while the bottom one has been acquired with colored Frank excitation to suppress the signal of the CH_2 group. Figure 2 illustrates the application of Frank excitation in MRI.

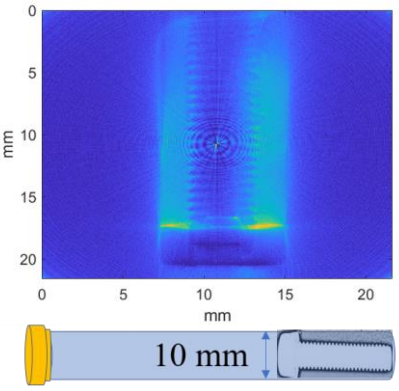

Figure 2: 2D image of a screw in a 10 mm water filled sample tube obtained with Frank excitation at 5 mW peak amplitude power.

References: [1] Ziessow, Ber. Bunsenges. Phys. Chem. (1974). [2] Kaiser, J. Magn. Reson. (1973). [3] Nielsen, Magn. Reson. Imaging (1996). [4] Blümich, J. Magn. Reson. (2009). [5] Laustsen, J. Magn. Reson. (2014).