Eliminating first echo transient from CPMG in inhomogeneous magnetic fields

Shin Utsuzawa[1]
[1]SLB, Sugar Land, USA

In NMR well logging, NMR signal amplitude is proportional to the formation porosity filled with ^{1}H-containing fluids, such as oil, gas, and water. This makes NMR a lithology-independent porosity tool. However, signal amplitude at t = 0 (which is proportional to porosity) cannot be measured due to ringing. Therefore, it must be inferred from an echo train measured with the CPMG sequence.

However, CPMG echoes obtained in inhomogeneous magnetic fields (which are found on NMR well logging tools and other inside-out NMR equipment) exhibits a transient [1]. In particular, the first echo is ~25 % smaller than the rest of the echoes. Therefore, it must be corrected before applying an inversion to obtain porosity. Because the size of the transient depends on signal bandwidth, which changes due to temperature and borehole/formation conductivity, this process is error prone.

Here, we propose a method to mitigate the CPMG echo transient by using two-step phase cycling. Figure 1 shows two measurements, one with the regular CPMG with the refocusing pulses phase shifted from the excitation pulse by 90 degrees, and another with a modified CPMG with the first refocusing pulse phase shifted from the rest of the refocusing pulses by 90 degrees (therefore, this first refocusing pulse is phase shifted from the excitation pulse by 0/180 degrees). The latter is like generating a CP echo and keep refocusing it with CPMG pulses. By combining these two measurements, we obtain the same amplitude and shape throughout the echo train.

However, there is one caveat; amplitude of this "combined" echo train is the same as that of the first echo, i.e., ~25 % smaller than the regular CPMG echoes. This makes it a hard choice when signal-to-noise is limited. A solution is to infer the amount of necessary correction from a short sub-measurement (Figure 2) and apply corrections to the main measurement based on regular CPMG. This will ensure robust porosity measurement with minimal increase in the total measurement time.

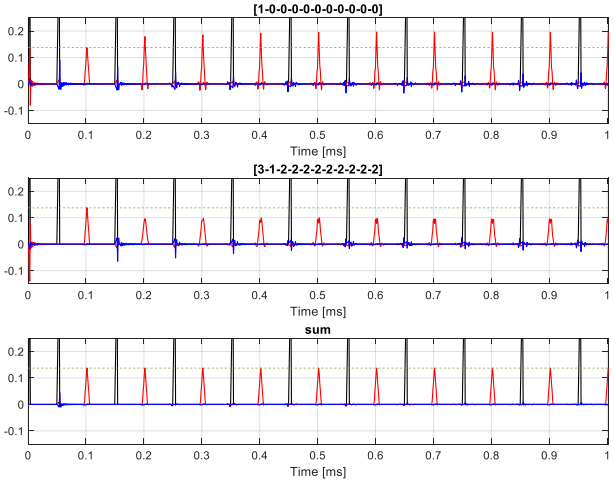

Figure 1. Two-step phase cycling to obtain an echo train with constant amplitude and shape. (top) Regular CPMG with the second and the following echoes ~25 % larger than the first echo. (middle) Modified CPMG with the second and the following echoes ~25 % smaller than the first echo. (bottom) The sum of steps 1 and 2.

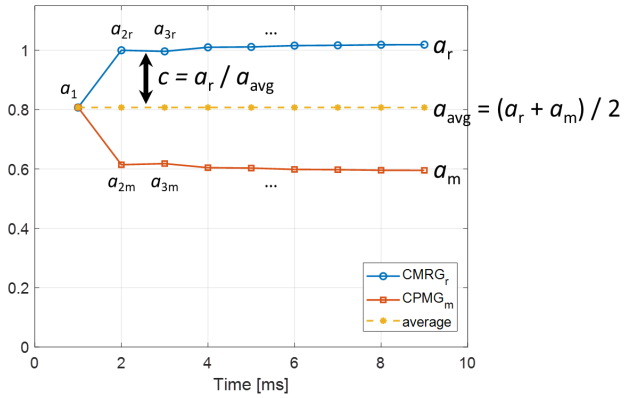

Figure 2. Correction of the first echo transient. The necessary correction factor c may be obtained as the ratio of the regular CPMG (a_r) to the average of the regular CPMG and modified CPMG (a_m).

Reference:

[1] M. D. Hürlimann and D. D. Griffin, *J. Magn. Reson.***143**,120-135 (2000).