Calibration of a Fast Field Cycling Relaxometer for Ultra-Low Field Measurements of T_1-Dispersion

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In Fast-Field Cycling (FFC) MRI the field switches to different levels, allowing for the measurement of NMR parameters such as T_1 over a range of fields [1]. Extending the applied field and thus the acquired T_1 - dispersion curve below the region of mT will allow for the investigation of slow dynamic processes such as diffusion, protein folding and intermolecular interactions [2] and has already been applied in samples of liquid crystals, water with polymers of various concentrations, and water with ^{17}O [3,4].

For the successful implementation of the ultra-low FC techniques on a commercial bench-top FFC relaxometer (Stelar S.r.l., Italy) the paracitic magnetic fields coming from external sources need to be compensated. The magnitude and orientation of these fields are determined with the application of FC measurements in a range of fields close to zero. During this process the non-adiabatic behaviour of magnetisation is exploited. According to this when a field switches-off or changes direction non-adiabatically fast the magnitude and dierection of the magnetisation will remain along its initial orientation and precess around the new direction of the field with a frequency detrmined by the equation: $\omega = \gamma B(t)$ [5].

For the compensation of the longitudinal component of the paracitic fields FC measurements are perfomed with a varying longitudinal field applied by the relaxometer. In each measurement the magnetisation precesses around a resultant field composed by the transverse paracitic component and the result of the compensation of the longitudinal component, with the frequency of precession determined by the magnitude of the resultant field. The indication of succesfull compensation of the longitudinal parasitic field is the minimum frequency of precession because in this case the magnetisation precesses around the transverse paracitic field without any longitudinal fields contributing to its magnitude (Figure 1). Similarly, for the compensation of the transverse component of the paracitic fields a transverse field of varying magnitude and orientation is applied by the relaxometer, with the minimum frequency of precession being again the indication of the succesful compensation [5].

After the succesful calibration of the relaxometer the ultra-low FC methods can be applied, extending the T_1-dispersion curve acquired to the region of μT without any paracitic fields intefering (Figure 2).

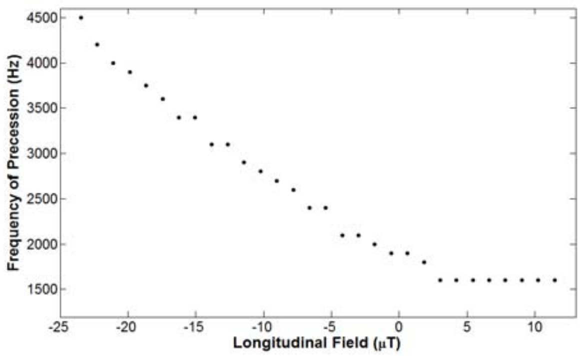

Figure 1. *Graph of the frequency by which the magnetisation precesses for each longitudinal field applied. The minimum is observed in the range of 3 to 12 μT.*

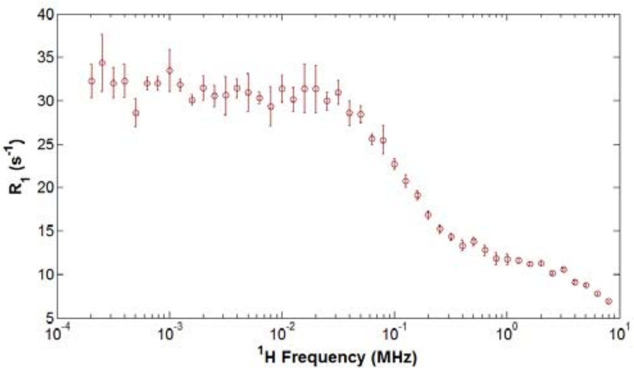

Figure 2. *T_1-dispersion curve of a sample of $MgCl_2$ acquired after the calibration, with the range of minimum ^1H Larmor frequencies extending to200. Hz(corresponding to a field of 4.6 μT).*

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