Towards a single resistive magnet 0.5 T Fast Field Cycled Magnetic Resonance Imaging System

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Motivation: The accessibility of novel image contrast mechanisms, through the use of field cycling, has been demonstrated by a number of groups [1,2]. We have previously employed a system in which the polarizing and detection magnetic fields were provided by a 0.45 T superconducting magnet whilst the evolution field, applied between the periods of polarisation and detection, was generated by a co-axial self shielded resistive field-offset magnet [3,4]. However it was felt that using a solitary resistive magnet would have a number of advantages: (a) allowing operator control of all the magnetic fields; (b) removing post field-switching field instabilities, caused by eddy currents induced in low temperature radiation shields; (c) no longer requiring cryogens; and (d) allowing a more compact geometry with improved accessibility.

Methods: Following decommissioning of the primary (detection field) superconducting magnet, we have used our existing 0.45 T resistive field-offset magnet as a test-bed for single-magnet FFC-MRI. In a preliminary study we investigated the effects of the magnet temperature on the field stability of the magnet. The system was programmed to acquire a series of 128 free induction decays after polarising the spins at 0.45 T for 500 ms with 500 ms at zero field between each acquisition. The temperature of the magnet's output cooling water was measured with a PT100 resistive thermometer. The output temperature of the Neslab HX2000 chiller, which supplied the cooling water, was also observed. Once it was established that some degree of thermal, and thus magnetic, equilibrium could be established spin echo (SE) imaging of an axial slice through a sample bottle containing $CuSO_4$ solution was attempted.

Results:

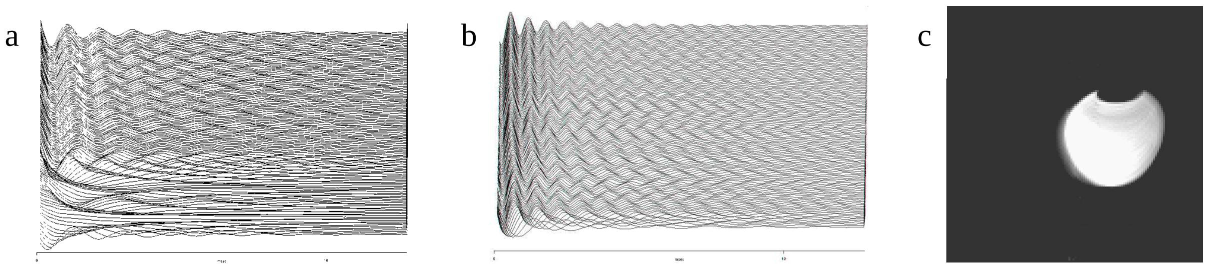

Figure: (a) and (b) show stack plots of 128 FIDs, with first acquisition at front (foot). Plot (a) shows the effect of starting the acquisitions with the magnet at 21 C. A significant change in the tuning of each successive acquisition can be seen as the temperature rose to 35 C. Plot (b) shows the comparative stability when the system was brought to 35 C before the acquisitions were started. There is still some degree of instability which can be traced to the hysteresis in the temperature of the water from the chiller, which hunted between 18 C and 25 C. On the right is a 128 by 128 pixel SE image of a 10 mm slice through a 60 ml bottle of 2.5 mM $CuSO_4$ solution acquired in about 2.5 minutes. A dummy acquisition had been used to raise the magnet temperature to 35 C before the image was acquired.

Conclusions: Field stability was sufficient in order to collect an image, which was remarkably free from ghosting artefacts. We are in the process of constructing a new single-magnet 0.5 T FFC-MRI system with a dedicated magnet.

References:

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[4] G. R. Davies and D.J.Lurie. Proc. Int. Soc. Mag. Reson. Med. **13** (2005) 2187.