

Field Cycling Relaxometry in the Earth's magnetic field

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An Earth's field nuclear magnetic resonance apparatus based on the design presented in [1] and applying the method of Packard and Varian [2] is used to measure ^1H relaxation times. The device is built in a way that it can be used in a normal laboratory environment with its natural occurring interfering influences such as electric wires and metal from reinforced concrete or furniture. Self compensation against external alternating fields is achieved by a construction of two identical coils that are wound in opposite directions with respect to each other and connected in series (first order gradiometer). In this way external magnetic field noise common to both coils is cancelled out and the signal from the 20ml sample in one of the coils can be detected with minimal interference. Furthermore a 4mm thick aluminium shielding around the coils protects against low frequency alternating electrical fields. Three pairs of gradient coils (Maxwell pairs) are placed around the aluminium shielding to homogenise the Earth's magnetic induction in the sample volume. To keep the sample at a constant temperature the coils and the sample are cooled by air. By means of varying the polarising current, the apparatus can be used as a field cycling relaxometer.

The NMR device is still in a set-up phase, but from the first test measurements it can be concluded that this apparatus is able to measure transversal relaxation times in the Earth's magnetic field from about 10ms up to several seconds. The transversal relaxation time is directly derived from the digitised free induction decay (FID) signal with a signal to noise ratio of about 100. The ^1H Larmor frequency ($\gamma B_0/2\pi$) in the laboratory of the University of Bremen was determined to be 2058Hz, corresponding to a magnetic field strength of 48 μT . A single ^1H free induction decay signal measured by this apparatus and obtained from the protons of a 20ml water sample at room temperature is shown in Figure 1. Longitudinal relaxation times longer than about 20ms can be measured in a range from about 70 μT to 0.07T, corresponding to Larmor frequencies from 3kHz to 3MHz.

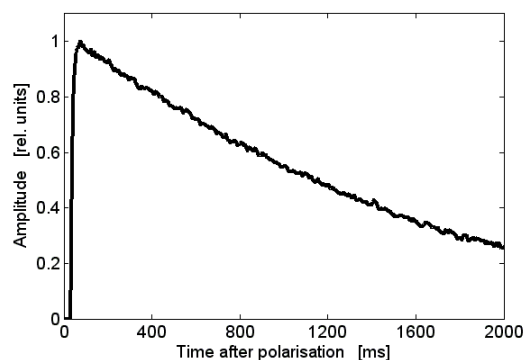


Figure 1: A single ^1H FID signal in the Earth's magnetic field from a 20ml water sample at 22°C

The planned application of the apparatus is the investigation of saturated and unsaturated porous model systems and soils by determining longitudinal and transversal relaxation times. Furthermore, the influences of large molecules in porous systems such as organic substances in soil will be explored by studying the longitudinal relaxation time dispersion.

- [1] Goedecke, R. *Ph.D. Thesis, University of Bremen* (1993)
- [2] Packard, M. and Varian, R. *Phys. Rev.* **93**, 941 (1954)