Wide field range studies of nuclear magnetic relaxation using optically pumped magnetometers

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Recently, spin-exchange relaxation free (SERF) alkali-vapor magnetometers have been applied as detectors of nuclear magnetic resonance (NMR) in the zero to ultralow field (ZULF) regime [1]. In ZULF the reduction of spectral line broadening due to field gradients as well as the possible existence of long-lived coherences [2] may lead to spectra with high resolution. These can provide new chemical and physics insight into the sample, beyond the capability of existing analytical techniques. In recent work the technique has been used to provide chemical-specific insight into liquid mixtures after being imbibing into porous catalytic materials [3].

In this presentation, we discuss new methodology that extends the scope of ZULF NMR to study multi-phase materials, including liquids in porous catalytic materials and metals. One aim is to measure ^{1}H NMR relaxation rates T_1 and T_2 at magnetic fields between a few nanotesla and several hundred microtesla, to interrogate slow dynamics associated with surface-site diffusion. These methods are applicable even to materials that cannot be studied with conventional magnetic resonance, including highly paramagnetic, disordered materials.

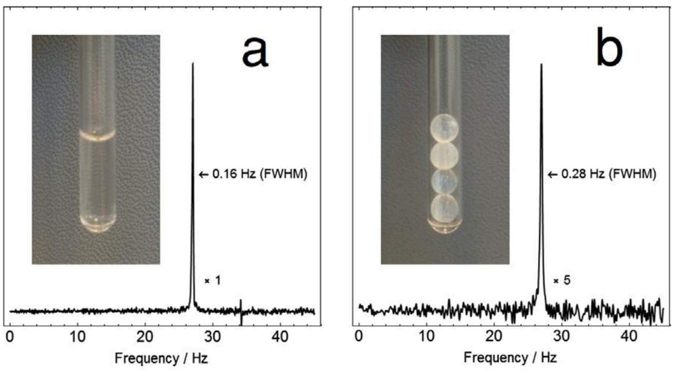

Fig.1. Detection of ^{1}H Larmor precession in bulk liquid (a) and porous silica (b). Both Fourier-transformed time-domain signals were measured with an optically pumped magnetometer. The low-field environment only leads to a slight increase in the resonance linewidth and allows detailed analysis of relaxation processes.

References

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[2] M. Emondts, Physical Review Letters **112**, 077601 (2014)
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