Neutron spin precession in samples of polarised nuclei

B. van den Brandt[1], H. Glättli[2], H. Grießhammer[3], P. Hautle[1], J. Kohlbrecher[1], J.A. Konter[1], F.M. Piegsa[1,4,*], J.P. Urrego-Blanco[1,5] and O. Zimmer[4]

1. Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland
2. SPEC and LLB, CEA Saclay, 91191 Gif-sur-Yvette Cedex, France
3. Centre for Nucl. Studies, Dept. Physics, George Washington Univ., Washington, DC 20052, USA
4. Physics Department, Technische Universität München, D-85748 Garching, Germany
5. Dept. Physics and Astronomy, Univ. of Tennessee, Knoxville, TN 37996, USA

* florian.piegsa@psi.ch

The doublet neutron-deuteron scattering length $b_{2,d}$ is a crucial input parameter for novel effective field theories at low energies. The value of $b_{2,d}$ can be obtained via a linear combination of the spin-independent nd scattering length $b_{c,d}$ and the spin-dependent one, $b_{i,d}$. The latter is so far limiting the total accuracy and shall be determined in this experiment at the polarised cold neutron beamline FUNSPIN at PSI. The goal is to achieve thereby a relative accuracy of $b_{2,d}$ of better than 1%.

Neutrons see a spin-dependent potential passing through a target containing polarised nuclei. This pseudomagnetic effect causes a neutron spin precession with a precession angle φ^* proportional to b_i (Figure 1). An ideal method to determine this precession angle very accurately is Ramsey's atomic beam technique, adapted to neutrons (Figure 2).

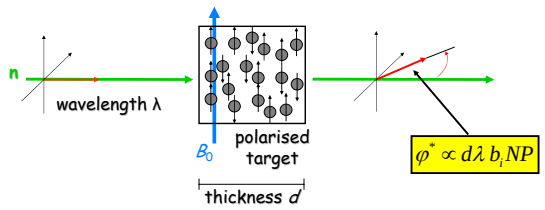
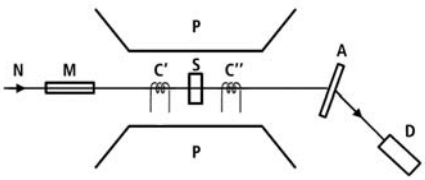


Figure 1: Polarised, cold neutrons with a wavelength λ precess in a target with polarised nuclei. The precession angle φ^* is proportional to the spin-dependent scattering length b_i and the target polarisation P.



N: polarised neutron beam
M: wavelength selector
S: polarised sample
P: pole pieces of the magnet
C',C'': π/2-RF-spin flippers
A: spin analysing bender
D: neutron detector

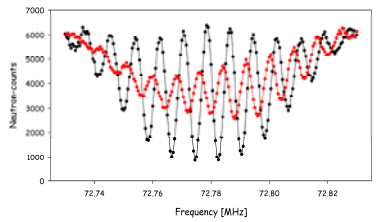


Figure 2: Scheme of Ramsey's technique of separated oscillating fields (above) and typical Ramsey patterns: frequency scan with an unpolarised target (black) and a polarised target (red).

The nuclear polarisation of the protons and deuterons in the sample is achieved using the technique of dynamic nuclear polarisation (DNP). The degree of polarisation is measured by cw NMR employing a Q-meter with a low temperature resonant circuit.

The targets are thin deuterated plastic discs matching the beam spot size. They are placed inside a target cell filled with liquid ^{4}He, which is thermally anchored to the mixing chamber of a ^{3}He-^{4}He dilution refrigerator which reaches a base temperature of about 100mK (Figure 3). This ensures long relaxation times of the nuclear polarisation in the sample.

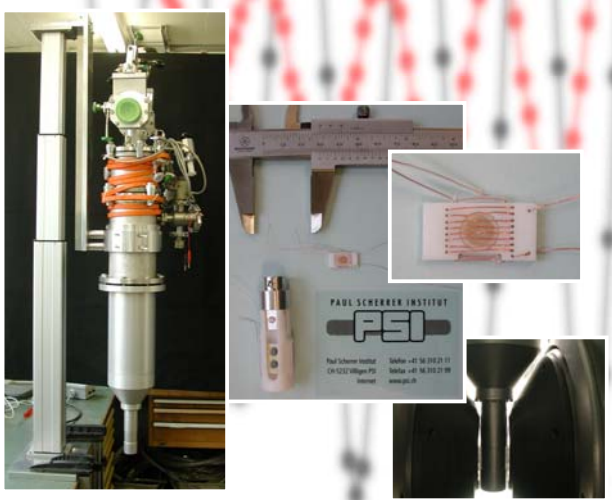


Figure 3: Dilution refrigerator, deuterated plastic target (ø=5mm) with NMR-coil in target-holder and vacuum nose of the cryostat between the pole pieces of the 2.5 Tesla magnet.

[B. van den Brandt et al., NIM A 526 (2004) 91-95]
[P. Hautle et al., Proc. SPIN 04, World Scientific (2005) 669-672]
[F.M. Piegsa et al., Proc. PANIC 05, AIP Conf. Proc. 842 (2006) 814]
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PAUL SCHERRER INSTITUT PSI