Epithermal neutron spin filter with dynamic nuclear polarization using photo-excited triplet electron

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A neutron spin filter using polarized ^{1}H media can polarize the neutron beam passing through it because the cross-sections have a large helicity dependence. ^{1}H has a flat cross-section of 20 barn in the wide energy range. Therefore, the spin filter of ^{1}H media is suitable for epithermal neutrons. A polarized epithermal neutron beam is available, for example, in the T-violation search in a compound nucleus.[1)] The solid state of ^{1}H doped media is often polarized by Dynamic Nuclear Polarization (DNP). DNP is a technique of transferring spin polarization from electrons to nuclei by microwave irradiation. We applied DNP with photo-exited triplet electron spin (Triplet-DNP)[2)] because it can be used at a higher temperature (>77 K) and in a lower magnetic field (<1 T) compared to the conventional DNP method. The neutron spin filter with Triplet-DNP was first developed at the Paul Scherrer Institut (PSI) in Switzerland. They achieved ^{1}H polarization of 70% using a naphthalene crystal with a size of $5 \times 5 \times 5$ mm^3 in 0.36 T and at 25 K,[3,4)] and evaluated its performance using a polarized neutron beam in a meV region. We plan to prepare a 1-cm-thick sample because a thick sample is suitable for the polarization of epithermal neutrons. In addition, we need a large acceptance of the spin filter in order to obtain high statistics. Therefore, we prepared a setup of the neutron spin filter with Triplet-DNP to polarize such a huge sample, and it is shown in Fig. 1. The system is installed in the target chamber made of stainless steel, and the chamber is cooled with cold N_2 gas.

Triplet-DNP is carried out at 0.3 T and 100 K. A single crystal of naphthalene doped with pentacene is used as a filter. To polarize a huge crystal, a high-power laser was implemented into the target chamber. We measured the polarization build up time and relaxation time of the single crystal with a size of $\phi 15 \times 6$ mm^3 (Fig. 2). The values are longer than assumed. As the next step, we are planning to optimize the strength of the laser and microwave, and the filter thickness. Then, we will check the performance of the neutron spin filter at RIKEN Accelerator-driven compact Neutron source (RANS) in March this year.

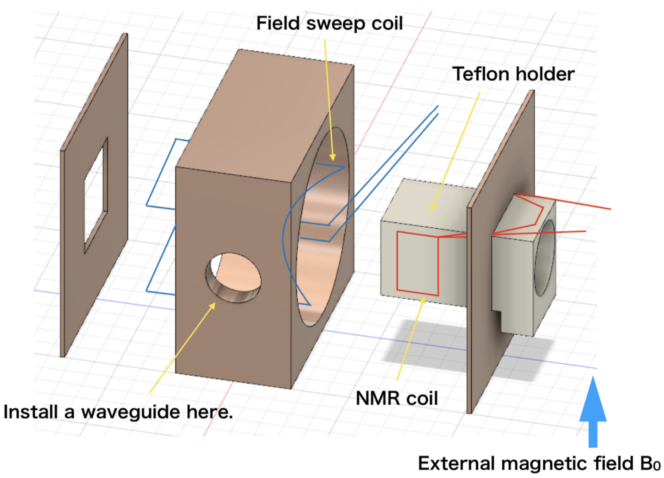

Fig. 1. Setup of the neutron polarization system using Triplet-DNP.

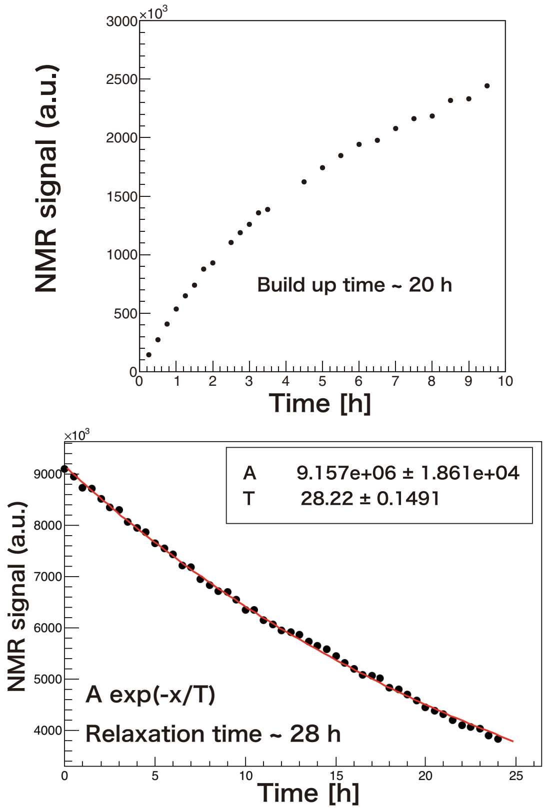

Fig. 2. Polarization build up time (upper) and relaxation time (lower) of the sample.

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