



## News from NIST Center for Neutron Research

### Polarized $^3\text{He}$ neutron spin filters for NCNR instruments

Polarized neutron scattering (PNS) is a powerful probe for a wide range of research fields from physics to biology. Although it is useful for many applications, the lack of optimal polarizing and analyzing devices still precludes many PNS experiments. Nuclear spin polarized  $^3\text{He}$  gas, produced by optical pumping, can be used to polarize or analyze neutron

broadband and can polarize cold, thermal or hot neutrons effectively; 2) they can polarize large area and large divergence neutron beams without adding beam divergence; and 3) they can efficiently flip the neutron polarization by reversing the  $^3\text{He}$  nuclear polarization. This last capability can be performed using the adiabatic fast passage nu-

devices have been applied to diffuse reflectometry [2], small-angle neutron scattering (SANS) [3], and to a thermal triple-axis spectrometer (TAS) having a double focusing monochromator [4].

For thermal TAS, the  $^3\text{He}$  spin filters can provide significantly better neutronic performance and greater versatility in the selection of energy and polarization compared to Heusler crystals.

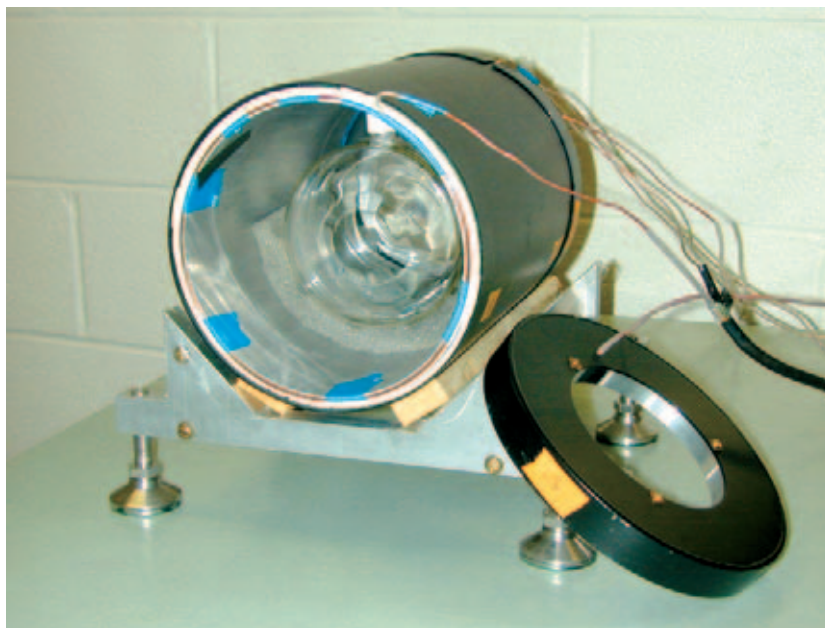
We have successfully performed several polarized beam experiments on the BT-7 TAS using  $^3\text{He}$  polarizers and analyzers. A  $^3\text{He}$  NSF in conjunction with a large double focusing pyrolytic graphite monochromator on the BT-7 TAS has yielded an initial polarized beam intensity about a factor of 20 higher than the recently decommissioned BT-2 TAS that used Heusler crystals.

For polarization analysis in diffuse reflectometry, the  $^3\text{He}$  spin filter allows much more efficient collection of off-specular scattering for a broad range of reciprocal space.

The use of a  $^3\text{He}$  spin filter makes polarization analysis practical in SANS. As a long-term goal, we plan to implement wide-angle polarization analysis for some other instruments.

User-friendly data reduction software is also under development to interface with these  $^3\text{He}$  NSFs. There exist two optical pumping methods to polarize the  $^3\text{He}$  gas, spin-exchange (SEOP) and metastability exchange (MEOP). Both SEOP and MEOP techniques can routinely provide polarized  $^3\text{He}$  gas at a polarization of 75%.

For our current  $^3\text{He}$  NSF applications, the  $^3\text{He}$  gas is polarized off-line by the SEOP method, transported to neutron scattering instruments, and stored on the beam line using a uniform magnetic field provided by a magnetically shielded solenoid



**Figure 1.** A compact  $^3\text{He}$  spin filter device (20 cm in diameter and 25 cm long) used for a thermal triple axis spectrometer.

beams because of the strong spin dependence of the neutron absorption cross section for  $^3\text{He}$ . Due to significant improvements in their performance during the last several years, polarized  $^3\text{He}$  neutron spin filters (NSF) have been of growing interest to the neutron scattering community worldwide. Compared to commonly used polarizers such as supermirrors and Heusler crystals, NSFs have the following advantages: 1) they are

clear magnetic resonance technique [1], thus integrating the polarizer and the flipper into a single device. The NIST Center for Neutron Research (NCNR) initiated a polarized  $^3\text{He}$  neutron spin filter program in 2006. The goal is to polarize and/or analyze neutron beams for neutron scattering instruments where other neutron-polarizing techniques are inadequate.

At the NCNR, polarized  $^3\text{He}$  NSF

(Fig. 1). The development of online optical pumping of  $^3\text{He}$  gas to maintain time-independent neutronic performance is underway for a few instruments.

The key technical challenges in applying  $^3\text{He}$  spin filters to neutron scattering are 1) producing a large volume of highly polarized  $^3\text{He}$  gas and 2) minimizing the  $^3\text{He}$  polarization decay.

We have constructed two SEOP systems capable of producing 75 % polarized  $^3\text{He}$  gas at pressures of (1 to 2)  $\times 10^5$  Pa in cells having volumes

approaching 1 L. To reduce polarization relaxation arising from field gradients inside magnetically shielded solenoids, we have optimized the field homogeneity by modeling and mapping the field, and most usefully, by measuring the polarization relaxation of the sealed low-pressure MEOP cells.

We have built a few compact magnetically shielded solenoids that yield field-gradient induced relaxation times up to 3000 h for a  $^3\text{He}$  pressure of  $10^5$  Pa over a cell volume of 1 L.

#### References

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## News from SNS ORNL Neutron Sciences Update

Both Oak Ridge National Laboratory neutron scattering facilities completed safety reviews in April 2007.

These successes enable the High Flux Isotope Reactor (HFIR) and the Spallation Neutron Source (SNS) to continue preparations for users to perform neutron scattering experiments. A recently developed web-based proposal submission process enables both facilities to coordinate beam time on the neutron scattering in-

struments through a combined user program. The Integrated Proposal Tracking System is undergoing beta testing. It will track proposals throughout the experimental process, including proposal submission, safety and science reviews, and beam time scheduling. The High Flux Isotope Reactor passed a formal review assessing readiness for restart of operations. Neutron production is expected to begin again in early May

2007. It is anticipated that the initial cycles will be devoted to testing of instruments and operational parameters, with general users arriving later this summer. Four HFIR instruments will be initially available following restart of the reactor: three triple-axis spectrometers and the residual stress diffractometer. Future capabilities at world-class levels will be enabled by a new cold source for two small-angle neutron scattering



**Figure 1.** A 24-ton portion of the 65m<sup>3</sup> ARCS scattering tank is lifted into position.  
*Photo credit: Mark Loguillo/ORNL.*



**Figure 2.** The POWGEN3 powder diffractometer team has completed installation of neutron guide.  
*Photo credit: Luke Heroux/ORNL.*