Polarized ^{3}He spin filters for neutron science

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The large spin dependence of the absorption cross section for neutrons by ^{3}He gas provides a method to polarize neutron beams. For certain applications, such polarized ^{3}He-based neutron "spin filters" have advantages over conventional neutron optical polarizing methods. Spin filters operate at all neutron wavelengths, can cover a large angular range and/or a large energy range, and decouple neutron polarization from energy selection. Both spin-exchange optical pumping (SEOP) and metastability-exchange optical pumping (MEOP) are currently being employed to polarize ^{3}He spin filters at various neutron facilities worldwide. I will focus on the development and application of SEOP-based neutron spin filters at the National Institute of Standards and Technology, Center for Neutron Research (NCNR) [1]. The combination of long relaxation time spin filter cells, high power diode lasers spectrally narrowed with chirped volume holographic gratings, and the use of Rb/K mixtures have allowed us to reach ^{3}He polarizations up to 85 % in spin filter cells ≈1 liter in volume [2]. Studies have revealed limits to the achievable polarization from temperature-dependent relaxation [3] and unexplained magnetic field dependence for relaxation in SEOP cells [4]. Applications include neutron scattering methods such as triple-axis spectrometry and small angle neutron scattering [5], and fundamental neutron physics. A measurement of the spin-dependence of the neutron-^{3}He scattering length was performed with a small, polarized ^{3}He cell in a neutron interferometer and a ^{3}He spin filter for accurate neutron polarimetry [6]. Use of spin filters in high flux neutron beams have revealed beam-induced alkali-metal relaxation and long term effects on SEOP spin filter cells [7]. A recent focus has been application to wide-angle neutron polarization analysis [8], for which we have obtained nearly 80 % ^{3}He polarization in unique "horseshoe" shaped cells to analyze a 220° angular range. We are also currently pursuing application to polarized neutron imaging [9].

References

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