Neutron spin filter based on dynamically polarized protons using photo-excited triplet states

T.R. Eichhorn[a,b], **B. van den Brandt**[a], **M. Haag**[a], **P. Hautle**[a] and **W.Th. Wenckebach**[a]

[a]Paul Scherrer Institute
CH - 5232 Villigen PSI, Switzerland

[b]Laboratory of Functional and Metabolic Imaging, EPFL
CH - 1015 Lausanne, Switzerland

The use of polarized protons as a spin filter is an attractive alternative to the well-established neutron polarization techniques such as super mirrors and polarized helium-3 gases, as the large spin dependent neutron scattering cross section for protons is useful up to the sub-MeV region.
Nuclear spin order can be obtained by standard methods using dynamic nuclear polarization (DNP) through a coupling to highly polarized electron spins being at thermal equilibrium. This requires both low temperatures (ca. 1 K) and strong magnetic fields (2.5 to 5 T) in order to obtain a significant Boltzmann factor for the electron spin system. These rather strict conditions can be relieved by a more recent and very promising DNP method that uses short-lived electron triplet states in organic pentacene:naphthalene crystals. Photo-excitation of the triplet states provides a large electron spin order far beyond the thermal equilibrium. As a consequence the requirements for the cryogenic equipment and the magnetic field are relaxed significantly and technically simpler systems with open geometries are possible.
We have recently proven that the triplet DNP method can be used to build a reliably working neutron spin filter. It is operated in 0.3 T and about 100 K and has performed stably over periods of several weeks [1,2]. So far we can report on high proton spin polarization values of up to 0.5 corresponding to an analyzing power of ca. 0.5 obtained with a sample of typical 4 mm thickness [3].

References

[1] M. Haag, B. van den Brandt, T.R. Eichhorn, P. Hautle, W.Th. Wenckebach, Nucl. Instrum. Methods Phys. Res. A 87 91 (2012).
[2] T.R. Eichhorn, M. Haag, B. van den Brandt, P. Hautle, W.Th. Wenckebach, S. Jannin, J.J. van der Klink, A. Comment, J. Magn. Res. 234 58 (2013).
[3] T.R. Eichhorn, M. Haag, B. van den Brandt, P. Hautle, W.Th. Wenckebach, Chem. Phys. Lett. 555 296 (2013).

E-mail of the corresponding author: tim.eichhorn@psi.ch