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Authors:	André Kusmin, Jeroen Plomp, Michel Thijs, Catherine Pappas (TUD)

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1. Introduction

Larmor labelling uses the precession phase of the neutron beam polarization $\vec{P}$ around a magnetic field $\vec{B}$ to directly measure the energy or the momentum transfer at the sample. Thus, the performance of the instruments is a function of the homogeneity and geometry of the magnetic field over the areas, where the precession takes place. In our previous deliverable [1] we showed that the important parameter for the design of Larmor labelling instrumentation is the magnetic field integral $\int B(\ell)\, d\ell$, taken over all possible trajectories of the neutron beam. Ideally this integral should be the same for all trajectories for (NSE) or vary in a well-defined and controlled way (for SESANS). The stringent requirements on the magnetic field homogeneity lead to relatively long instruments, a design that ultimately collimates the neutron beam and reduces the neutron flux.

The aim of this work package was to investigate the effect of the ESS flat pancake moderators on the design of Larmor labelling instruments. These moderators deliver high intensity neutron beams, which are confined in a small cross-section and are well-adapted to small samples and compact instrumentation. On the basis of extensive analytical calculations and simulations [1], we have shown that the geometry of the ESS neutron beams improves significantly the performance of Larmor labelling setups. However, we found that the overall dimensions of the resulting instruments do not shrink substantially. In the following we provide recommendations for the two compact configurations investigated: a Neutron Spin Echo (NSE) Spectrometer and a SEMSANS add-on for SANS and Imaging.

A Compact Neutron Spin Echo Spectrometer

The magnetic field configuration considered is schematically shown in Fig. 1. This is the first arm of an NSE spectrometer, where the neutron beam exits a polarizing neutron guide. The precessions start at the $\pi/2$ flipper, which is positioned at a distance a_1 from the blue rectangular shape representing the main coil of length L and radius R. A π flipper between the main coil and the sample, at a distance a_2 from the end of the coil, marks the reversal point of the precessions. Additional coils, modeled by current loops, lower the magnetic field at the positions of the π/2 and π-flippers. In the calculations the efficiency of the flippers was assumed to be 100% and thus their intrinsic adiabaticity was ignored.

The results [1,2] show that there is a clear gain with the “pancake moderator” beams. Indeed, rectangular beam cross-sections with a height over width ratio, e.g. 1:4, that mimic the ESS “pancake moderator” beams lead to the best results, and improve the homogeneity of the magnetic field integrals by at least 30 %. On the other hand, because relative inhomogeneities become worse for shorter coils, in order to reach high resolution, i.e. long Fourier times, the length of the instruments cannot be reduced. Consequently, NSE spectrometers will perform better at the ESS, as the required magnetic field integral corrections (through Fresnel coils) will be weaker, but they will not be more compact than e.g. at the ILL or FRM2.

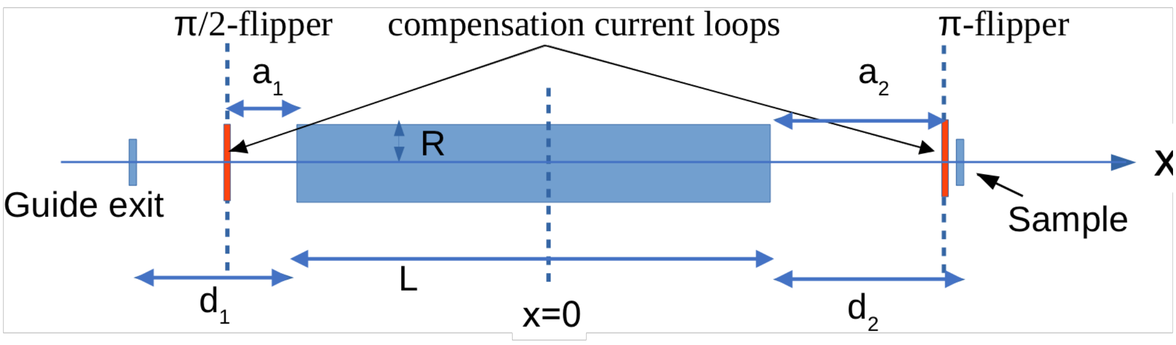

Fig. 1: Schematic representation of the configuration considered for the first arm of a NSE spectrometer. The layout is characterized by the lengths L, a_1, a_2 and R. The blue rectangular area represents the main precession coil.

B Compact SEMSANS add-on for SANS and Imaging.

The configuration used for the magnetic field calculations is schematically shown in Fig. 2. The setup had an overall length of 3.1 m and reproduced a test arrangement used for an experiment at the HZB, on the V20 ESS test beamline [3]. The magnetic field configuration has been calculated and optimised using the Infolytica MagNet software. All major components were included in the model, such as the guide field, Vcoils, DC magnets, field stepper. The dimensions were chosen such as to correspond to a standard setup and may be easily scaled to investigate the effect of a compact beam size.

The results show that one can change the dimensions while keeping the optimised [x,z,y] ratios for the components. For the setup investigated, this implies that when considering the beam geometry of the ESS pancake moderators, the overall length can be reduced from 3.1 m to 1.1 m, which can be considered as the minimal length for such an add-on setup. Such a compact design could be easily implemented as an add-on. It could be installed and removed, according to the experimental requirements and would substantially extend the capabilities of the ESS. A possible host instrument would be the polarised neutron SANS, SKADI, where the add-on would allow simultaneously SANS and SEMSANS measurements. Another host instrument candidate is the neutron imaging instrument ODIN, where the add-on could be used for high resolution dark field imaging [4].

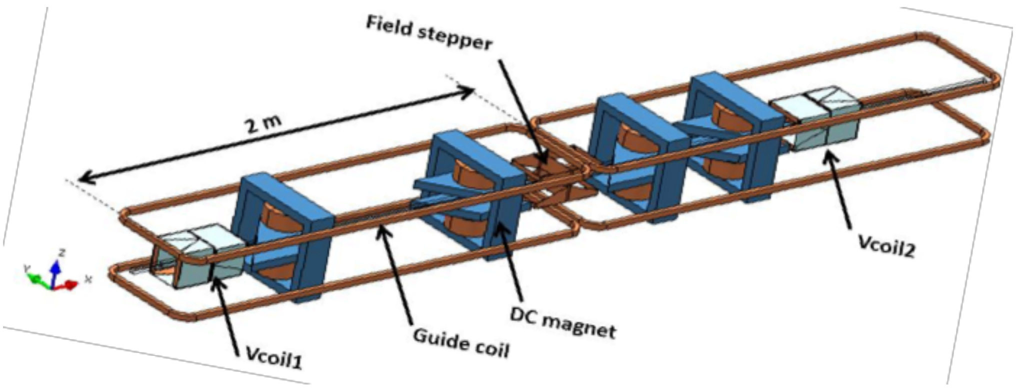

Figure 2: Schematic drawing of SEMSANS arrangement considered for the magnetic field calculations. The white boxes illustrate the Vcoils, which act as π/2 flippers, the blue components are DC magnets with parallelogram shaped pole shoes, the central coil is a field stepper. The long upper and lower create a homogenous magnetic field, which guides the beam polarisation.

References

[1] deliverable Nr. D8.7

[2] *A. Kusmin and C. Pappas, to be published at the Journal of Neutron Research*

[3] J. *Plomp et al. to be published*

[4] *M. Strobl, et al. Nature Scientific Reports* ***5,*** *16576 (2015).*