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New polarized neutron diffraction setup for precise investigations of magnetic structures up to 8 T at the MLZ

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Polarized neutron diffraction (PND) is a powerful method for investigating magnetic structures. It gives unique access to contributions from nuclear and magnetic scattering, their interference terms, and their magnetic chirality, and permits to distinct between them. In contrast to non-polarized neutron diffraction, where the scattered intensity depends on the square of the magnetic structure factor, PND has a linear nuclear–magnetic interference term as part of the scattered intensity. This increases the precision in the determination of the ordered magnetic moment by at least one order of magnitude. Recently, a first PND setup using a compact high Tc superconducting magnet and a 3He spin filter polarizer has been successfully implemented [1,2] on the hot neutrons single crystal diffractometer POLI at Maier-Leibnitz Zentrum (MLZ) in Garching b. München. Although this setup performs well and first scientific output from the measurements performed using it starts to appear [3], it suffers from the relatively low maximal available field of only 2.2 T. For studying many modern-topic (e.g quantum, topologic order, complex frustrated, etc.) magnetic materials with small ordered magnetic moment, the field-limit of about 2 T is insufficient in order to produce significant measurable signal, even for PND. To overcome this limitation, a new 8 T split-coil superconducting magnet has been procured and implemented for measurements on POLI. Although, this new magnet is actively shielded, reducing the stray field by an order of magnitude compared to the classical design, its fringe fields are still too large to be used with the sensitive 3He polarizer of the previous setup. To overcome this issue, a new large-beam-cross-section solid-state supermirror bender (SB) polarizer has been developed for POLI. It was realized by a Fe/Si multilayer coating on both sides of the thin Si wafers (m=3) by the NOB company. An additional Gd oxide layer is deposited on the convex side of each wafer to absorb the neutrons with the wrong polarization. An existing shielded Mezei-type flipper is used between the magnet and SB. A dedicated guide field construction was numerically simulated, optimized and built to link the magnetic field of the SB to the flipper and to the stray field of the magnet. The neutron beam path between the monochromator drum to the sample magnet is shown in the Fig. 1. The new setup was successfully tested using a 3He spin filter as analyzer at low fields (< 1 T), and a high quality Cu2MnAl single-crystal at high fields (> 2T). An almost loss-free spin transport within the instrument for the complete field range of the new magnet was achieved. A high polarization efficiency of above 99% even for short wavelength neutrons could be experimentally reached using the new solid-state bender (Fig.2). The new high–field PND setup is now available for precise magnetic structure investigations on POLI for the internal and external user communities.

[1] H. Thoma, H. Deng, G. Roth, V. Hutanu, "Setup for polarized neutron diffraction using a high-Tc superconducting magnet on the instrument POLI at MLZ and its applications", J. Phys.: Conf. Ser. 1316, 012016 (2019)
[2] H. Thoma, W. Luberstetter, J. Peters & V. Hutanu, "Polarised neutron diffraction using novel high-Tc superconducting magnet on single crystal diffractometer POLI at MLZ", J. Appl. Cryst. 51, 17-26 (2018)
[3] J. Jeong, B. Lenz, A. Gukasov, et al. "Magnetization density distribution of Sr2IrO4: Deviation from a local jeff = 1/2 picture", Phys. Rev. Lett. 125, 097202 (2020)

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