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Generating neutron orbital angular momentum

There is growing interest in the generation of optical and neutron beams with orbital angular momentum (OAM) due to their numerous unique and useful properties [1]. An OAM beam is defined by its phase singularity $e^{i\ell\phi}$ where ℓ is the integer OAM quantum number and ϕ the azimuthal angle defined about the beam's direction of travel.

We present two neutron spin-echo experiments that demonstrate the generation of neutron OAM, one using magnetic Wollaston prisms (MWPs) and the other using a 2D array of forked diffraction gratings (FDGs) etched from a silicon wafer. MWPs generate OAM by using strong magnetic fields and high-temperature superconducting films to ensure sharp transitions between the field regions [2]. In addition to OAM, MWPs in the 2D spin-echo modulated small-angle neutron scattering (SEMSANS) configuration can also produce high-polarization spin textures when properly focused on the detector [3]. We have demonstrated the ability to produce a wide variety of neutron spin textures, and from these textures we can indirectly verify the production of neutron OAM.

On the other hand, FDGs are non-magnetic and can thus be used with techniques such as spin-echo small-angle neutron scattering (SESANS) that require non-depolarizing samples [4]. We demonstrated the production of OAM from FDGs using radio-frequency (rf) neutron spin flippers with SESANS. These experiments show that both MWPs and FDGs can generate high-fidelity states of neutron OAM which may have future application in the measurement of spin-textured and topological materials.

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[2] F. Li et al., Rev. Sci. Instrum. 85, 053303 (2014)
[3] Q. Le Thien et al., Phys. Rev. B 107, 134403 (2023)
[4] D. Sarenac et al., Sci. Adv. 8, eadd2002 (2022)

Topical Area

Emerging research and multimodal techniques

Author: Dr MCKAY, Sam (Indiana University)

Co-authors: Dr BAXTER, David V. (Indiana University); Dr LI, Fankang (Neutron Technologies Division, ORNL); Dr FUNAMA, Fumiaki (Neutron Technologies Division, ORNL); Dr ORTIZ, Gerardo (Indiana University); Dr KRAVCHENKO, Ivan I. (Center for Nanophase Materials Science, ORNL); Dr BURRAGE, Kaleb (Neutron Technologies Division, ORNL); Dr LAVRIK, Nickolay V. (Center for Nanophase Materials Science, ORNL); Mr LE THIEN, Quan (Indiana University); Dr DALGLIESH, Robert M. (ISIS Neutron and Muon Source); Dr PYNN, Roger (Indiana University); KUHN, Steve (Neutron Technologies Division, ORNL); Dr PARNELL, Steven R. (ISIS Neutron and Muon Source)

Presenter: Dr MCKAY, Sam (Indiana University)