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Polarised neutrons and polarisation analysis at the ESS instrument MAGIC

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The instrument MAGIC is a neutron diffractometer currently under construction at the European Spallation Source (ESS) in Lund, Sweden. The instrument is dedicated to studies of magnetic properties in both applied and purely fundamental systems, ranging from magnetic structure refinement to magnetic diffuse scattering from single crystals and powder samples.[1,2]

MAGiC has been designed with polarisation in mind and will deliver a permanently polarised neutron flux on both thermal (0.6-2.3 Å) and cold (2-6 Å) spectra. For the thermal spectrum, reversal of the incident polarised beam in an 8T vertical magnetic field at the sample yields diffraction terms related to nuclear-magnetic interference. For the cold spectrum, longitudinal XYZ-polarisation analysis will allow for separation of all individual scattering terms arising for magnetic diffraction. Examples of simulated experiments are given. In particular, we present the design of a novel concept for the handling of neutron polarisation, which will offer a superior figure of merit P^2T, with very high degree of polarisation P and high transmission and transport T of neutrons through its optical polarising elements and magnetic fields.

The incident thermal beam is polarised in the middle of the neutron guide by FeSi supermirror reflection with a polarisation rate P>0.98; the cold spectrum is polarised by a solid-state bender assembled from Si-wafers, using also an FeSi supermirror coating, with a polarisation rate P>0.96. The RF (radio-frequency) flipper ensures a highly efficient spin-flip for the whole wavelength band. Guide fields >6 mT preserve the incident polarisation along the neutron guide.

For $\lambda > 2$Å, we apply a 120° wide-angle polarisation analyser made of FeSi coated Si-wafer stacks, which are placed in a saturating field of >0.1T. The performance of the analyser is characterised by a figure of merit $P^2T > 0.3$, which gives an improvement of up to a factor 4 (at 2Å) compared to existing polarisation analyser devices.

Near the sample position, the XYZ-magnetic field design allows for a rotation of the magnetic field into an arbitrary direction and subsequently, the rotation of neutron polarisation with high adiabaticity (>60 for 2Å). This was possible to achieve without any blocking of the solid angle of detection in the horizontal scattering plane. One may note further that the XYZ-fields are optimised for minimal field strength at the sample position in a trough-like field shape.

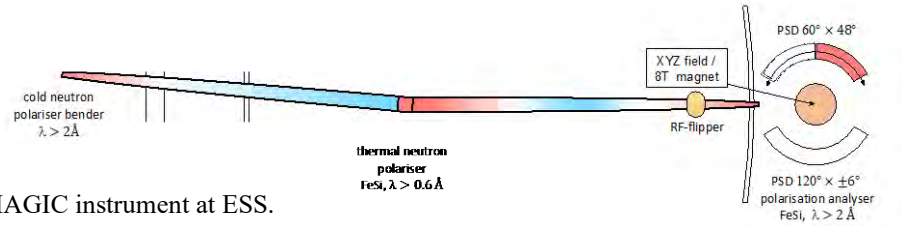

Figure 1. Scheme of the MAGIC instrument at ESS.

[1] https://europeanspallationsource.se/instruments/magic#instrument-description

[2] K.H. Anderson et al. The instrument suite of the European Spallation Source, (2020), *Nuclear Inst. and Methods in Physics Research* A**957**, 163402.