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The upgraded neutron grating interferometer at ANTARES – Design, Performance and Applications -

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Neutron grating interferometry (nGI) is a relatively new neutron imaging technique which is the adaption of a Talbot-Lau Interferometer for neutrons [1]. It simultaneously delivers information about the transmission (TI), phase shift (DPC) and the scattering (DFI) inside a sample [1].
In particular the DFI has generated high interest, due to its ultra-small-angle neutron scattering (USANS) contrast mechanism, allowing to indirectly resolve structures which cannot be directly resolved by an imaging instrument [2],[3].
For instance, nGI is sensitive to magnetic domain walls and consequently allows to measure the effect of induced stress in a sample onto the mobility of its magnetic domains [4]. Moreover, the distribution of flux domains within type-I and type-II superconductors has recently been visualized [5],[6]. Also there have been strong efforts to use nGI and particularly the DFI as tools for quantitative measurements of microstructures in materials. A theory has been proposed, which directly links the DFI contrast within the material to a Fourier back transform of its scattering function evaluated at a correlation length ξGI~λ [7].
A prerequisite for such quantitative measurements is a high signal-to-noise-ratio (SNR). For DFI measurements it has been shown that the main reasons for statistical uncertainties are (i) low DFI signal and (ii) low visibility [8]. Here, the visibility is the quotient between the amplitude and the mean value of the oscillation during an nGI scan and is an indicator for the performance of an nGI setup.
While the DFI signal is, as mentioned above, connected to the correlation length which can be tuned during the experiment, the visibility is strongly dependent on the quality of the gratings. Especially the quality (absorptivity) of the analyzer grating (G2) is a great concern here, as it is generally the grating with the smallest period (several µm). Current fabrication techniques cause the grating to strongly deviate from an ideal binary absorption profile. As has been shown in [9] this strongly degenerates the visibility. Furthermore, tuning the correlation length either lowers the achievable real space resolution or results in a change in neutron wavelength which also causes a decrease in visibility.
Hence a high visibility is an essential basis for quantitative measurements. In our contribution we will present the upgraded nGI setup at the ANTARES beamline at FRM II. This nGI setup has been heavily redesigned, compared to its precursor [10]. The redesign allowed to optimize the distances between the gratings, as well as the grating periods. In particular, the source and analyzer gratings, which are both absorption gratings, have been improved towards binary absorption profiles. With these changes in the improved ANTARES nGI we have achieved a visibility of 75% over the whole detector area (76mm x 76mm) at the design wavelength of 4 Å. It is worth noting that this visibility is very close to the theoretical limit imposed by the spatial coherence generated by the used G0 grating.

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