Neutron Transmission through Sapphire Crystals  
Experiments and Simulations

Rantsiou, Emmanouela; Filges, Uwe; Panzner, Tobias; Klinkby, Esben Bryndt

Publication date:  
2013

Document Version  
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):  
Sapphire crystals are excellent filters of fast neutrons, while at the same time exhibit moderate to very little absorption at smaller wavelengths. We have performed an extensive series of measurements in order to quantify the above effect. Alongside our experiments, we have performed a series of simulations, in order to reproduce the transmission of cold neutrons through sapphire crystals. Those simulations were part of the effort of validating and improving the newly developed interface between the Monte-Carlo neutron transport code MCNP and the Monte Carlo ray-tracing code McStas.

Experiments

Our experiments were performed at the BOA testing beamline at PSI (Figs. 1-3). In total, 12 crystals were used, all with same dimensions of 26mm×26mm×10mm, and with the 10mm edge parallel to the beam direction. The crystals were obtained by three different commercial providers (four crystals from each provider). We have measured the dependence of both fast (>0.1eV) and cold (<1eV) neutron transmission to the crystals’ thickness, and also we have tested for potential performance differences, due to e.g. inherent impurities (quality check), among the three types of sapphire crystals from our three suppliers.

-- Figs. 4-6 show our results for fast neutron transmission through sapphire crystals of varying thickness: after 120mm-thick crystal, the integral intensity is reduced by a factor of ~6 (i.e. ~17% of fast neutrons go through; Fig 5), while the peak intensity is reduced by factor ~13 (or ~7% transmission; Fig 6).

-- Fig. 7 show our results for cold neutron transmission through sapphire crystals of various thicknesses for wavelengths between 0.7-10Å. The minimum transmission for a 120mm sapphire crystal is around ~30%. This goes up to ~50% when considering wavelengths between 1.5-6Å.

Simulations

We used the codes MCNP and McStas to simulate the transmission of cold neutrons through sapphire crystals. For the MCNP simulations, we have used newly acquired sapphire cross section libraries [1]. McStas on the other hand, uses a semi-analytical formula [2] to calculate neutron absorption by sapphire crystals (the relevant component file is Sapphire_Filter.comp within the regular McStas distribution).

We performed a series of simulations, reproducing our experimental set up, in order to: a) test the performance of a newly developed interface between the two codes, b) compare experimental results to the sapphire cross sections for MCNP and the semi-analytical formula used by McStas.

-- Fig. 8 shows the comparison between our experimental measurements and MCNP simulations. We observe a good agreement between the two, particularly in the range 2-6Å and for crystals of thickness ≥30mm.

-- Fig. 9 shows the comparison between our MCNP and McStas simulations. The agreement is good for crystal thickness <30mm (up to ~4% difference) and it improves for bigger thickness.

References

[1] Canare F et al. (2013); (to be published)