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Conceiving a Backscattering Spectrometer at the European Spallation Source to Bridge Time and Length Scales

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Abstract

Neutron backscattering spectroscopy has been proposed by Maier-Leibnitz nearly 50 years ago. This method improved the energy resolution of neutron spectrometers pushing it into the µeV range. The prototype BS spectrometer built at the FRM in the 1960s yielded an energy resolution of 0.6 µeV (FWHM). Two experiments were then carried out successfully in a completely new energy transfer window: quasi-elastic scattering in viscous Glycerol and nuclear spin excitations in V_2O_3.With this experimental breakthrough the term 'microeV' was coined in neutron scattering.

The development of the neutron backscattering technique follows the basic idea to use Bragg angles near 90° with moderate collimation for both beam monochromatisation and analysis, in order to obtain very high-energy resolution. Since the early experiments backscattering spectroscopy has largely progressed.

Nowadays the need to study systems involving longer length scales, which in turn require an increase of the corresponding time scale, i.e. higher energy resolution, is pressing. Moreover, the rapid rise in computer power, coupled with multi-processor computers and better simulation algorithms has led to significant improvements in the capability of molecular dynamics simulation for aiding the understanding of dynamic molecular order on various time scales. These factors lead to a strong scientific demand for neutron spectrometers with high energy resolution, balanced by the need for a broad dynamic range also including shorter timescales, which can be achieved by varying not only the energy resolution, but also the incident neutron wavelength.

Here we discuss a broadly conceived neutron backscattering spectrometer for the European Spallation Source, covering a wide range of time- and length scales in between those probed with time-of-flight (TOF) chopper spectrometers and neutron spin-echo (NSE) experiments. The specific conditions related with the long-pulse time structure of the ESS will be taken into account explicitly.