NEUTRON ENERGY ANALYSIS USING GRATINGS.

F. Ott, A. Menelle, P. Humbert, C. Fermon
Laboratoire Léon Brillouin CEA/CNRS, CE Saclay.

Gratings have become standard optical elements in the field of X-ray synchrotron radiation. The field of neutron instrumentation has not yet seen much use of these artificial structures. A noticeable realisation is however the use of gratings for neutron interferometry. At the LLB, we are evaluating the use of optical gratings in the field of neutron optics to perform an energy analysis of a neutron white beam in a reflectivity geometry. In a reflectivity geometry (grazing incidence) it is possible to perform highly efficient diffraction on gratings which have periods in the micron size range (see fig. 1). These gratings are easy to produce by standard UV lithography on large surfaces (several cm²).

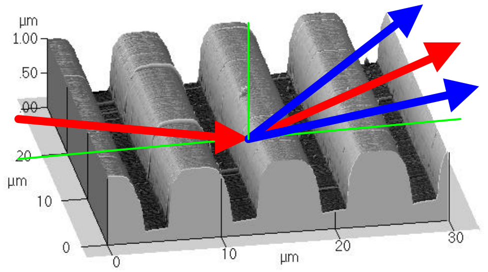

Figure 1 : diffraction on a grating: neutron incident beam and specular reflection (red) ; the beam is diffracted (blue) in the plane of incidence (green).

The use of gratings in neutron optics requires an increase in the diffraction efficiency. Several approaches have been tested in order to maximise this efficiency : use of high index materials, titanium coating, super-mirror coatings. We have shown that an appropriate coating can allow to reach a diffraction efficiency as high as 25%. We have also shown that these efficiencies can be obtained over a wide scattering wave-vector range (0.02 nm^{-1}) (with respect to a neutron reflectivity geometry) [1-2]. Figure 2 shows the example of the diffraction on a nickel grating.
These gratings could have a direct application in time-of-flight (TOF) neutron reflectometers built around steady state reactors and could lead to very large gains in measuring time. The sample is illuminated by a white beam (covering the whole guide wavelength spectrum available). After reflection on the sample, the neutron beam is diffracted by the grating (see figure 3).

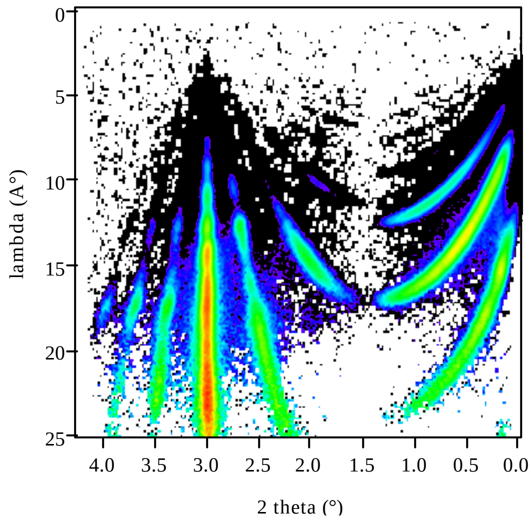

Figure 2: reflected and transmitted intensity on a nickel grating (the neutron beam incidence angle on the grating is 1.5°). The horizontal axis represents the position on the detector. The vertical axis represents the wavelength. The colour scale represents the neutron intensity. The measurement has been made on the D17 reflectometer at the ILL with the help of R. Cubbit. The diffracted intensities can amount up to 10% of the incident beam.

The diffraction direction is a function of the wavelength. By using a position sensitive detector, one can then instantly measure the whole reflectivity curve. Assuming a grating diffraction efficiency as low as 5%, this device could allow a gain of a factor 10 in measuring time (by avoiding the chopping stage).

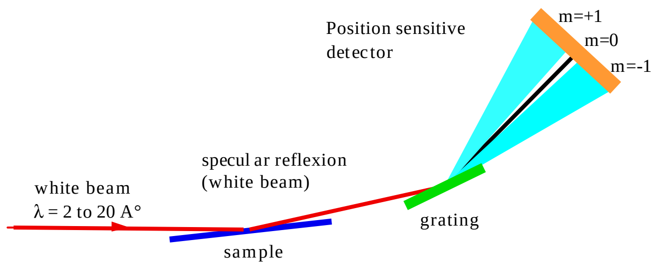

Figure 3 : principle of the energy analysis using gratings.

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[1] F. Ott, A. Menelle, C. Fermon, P. Humbert, Physica B **283** (2000) 418-421.
[2] F. Ott, P. Humbert, C. Fermon, A. Menelle, Physica B **297** (2001) 189-193.