Physics with neutrons 2

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Exercise sheet 9
To be discussed 2017-07-11, room C.3203

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EXERCISE 9.1

Derive the Lorentz factor

$$L(\theta) = \frac{1}{\sin\theta \sin 2\theta}$$

The origin of the Lorentz factor is twofold:

1. The statistical distribution of the crystallites in a polycrystalline sample has to be considered.

2. The detector covers only part of the Debye-Scherrer cone, which describes the Bragg scattering from polycrystalline materials. As sketched in Figure 1, the wavevector $\mathbf{k}'$ of the scattered neutrons lies on a cone, known as Debye-Scherrer cone, where the axis of the cone is along the wavevector $\mathbf{k}$ of the incoming neutrons and θ is the Bragg angle.

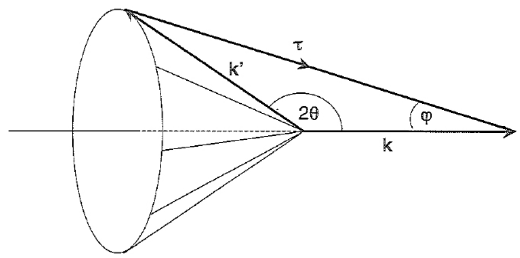

Figure 1: Debye-Scherrer cone for Bragg scattering from polycrystalline materials.

EXERCISE 9.2

Consider the localized ferromagnet EuO and the itinerant ferromagnet Ni with their properties given in the table. Calculate the intensity ratio of magnetic scattering and nuclear scattering from the (111) Bragg peak in powder samples.

	EuO	Ni
crystal structure	fcc	fcc
lattice constants	$a = 5.13\,\text{Å}, \alpha = 90°$	$a = 3.52\,\text{Å}, \alpha = 90°$
magnetic moments	$7\mu_B$	$0.6\mu_B$

EXERCISE 9.3

By comparing the intensity of the magnetic $\left(\frac{1}{2}\frac{1}{2}\frac{1}{2}\right)$ with the nuclear (111) Bragg reflection from

Shull and Smart, Phys. Rev. **76**, 1256 (1949).

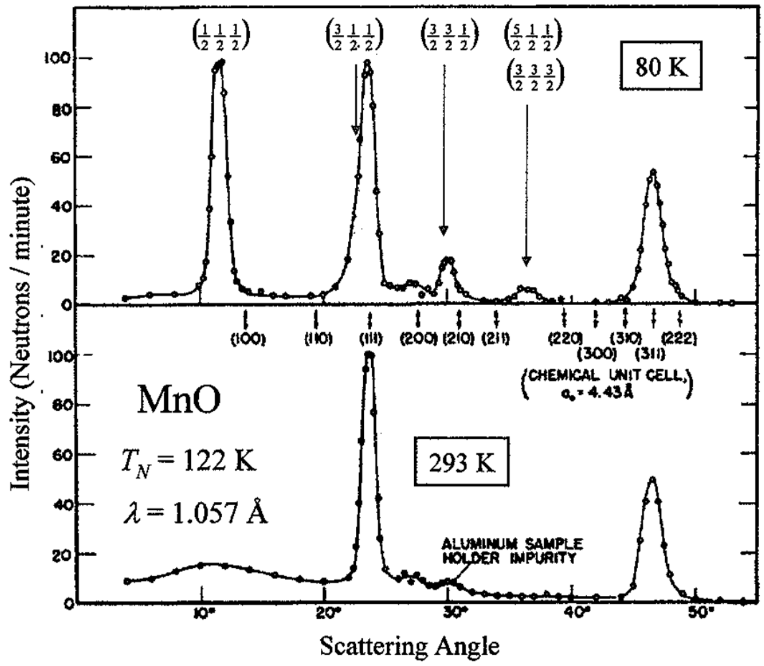

Figure 2: Neutron diffraction patterns for MnO above and below the Néel temperature.

power diffraction measurements estimate the magnetic moment of the Mn^{2+} ions in the anti-ferromagnet MnO. Do you need to take the Lorentz factor into account? As discussed last week, the magnetic form factors can be found at
`https://www.ill.eu/sites/ccsl/ffacts/`.

EXERCISE 9.4

From your solid state physics course you should remember the dispersion relation for phonons. Calculate the dispersion of an acoustic phonon of a linear chain of atoms with a lattice constant of $a = 2$Å. The measured velocity of sound is assumed to be 2300 m/s. Draw the scattering diagram for an inelastic neutron scattering experiment with $k_f = 2.57\,\text{Å}^{-1}$ at the boundary of the 2^{nd} Brioullin zone using energy and momentum conservation. Consider phonon creation and annihilation.