Physics with neutrons 1

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Exercise sheet 7
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Exercise 7.1

Insulating organo-metallic compound $NiCl_2 - 4SC(NH_2)_2$ (know as DTN) demonstrates magnetoelastic properties (Phys. Rev. B 77, 020404(R) (2008)). In an applied magnetic field its c-axis first shrinks by $6 \cdot 10^{-3}\%$ and then expands up to $2.2 \cdot 1^{-2}\%$ in comparison to the zero field value. Calculate whether it is possible to detect such a change in length of the c-axis using powder neutron diffractometer HRPT located in PSI (the instrumental resolution is equal to $\Delta\theta/\theta = 9.5 \cdot 10^{-4}$ for $Q = (002)$. The unit cell is tetragonal (space group I4 number 79) and the lattice parameters (zero magnetic field) are: $a = b = 9.558$ Å, $c = 8.981$ Å.

Exercise 7.2

Highly oriented pyrolytic graphite (HOPG) is used as one of the most efficient monochromators for thermal and cold neutrons. In addition, HOPG is used as a filter for neutrons. Graphite has a hexagonal crystal structure. Along the $[00l]$ direction, the crystal planes are regularly stacked thus exhibiting the properties of a single crystal. Within the hexagonal planes, the atomic sheets are oriented randomly, i.e. like a powder. Calculate the energies for the cut-offs of the first few reflections (002), (004), (006), (101), (102), (103), (104), (105) and (106). The lattice constants are $a = 2.4612$ Å and $c = 6.7079$ Å. The stacking along the c-direction is such that the peaks with $(00l)$, l odd, are extinguished.

Exercise 7.3

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.

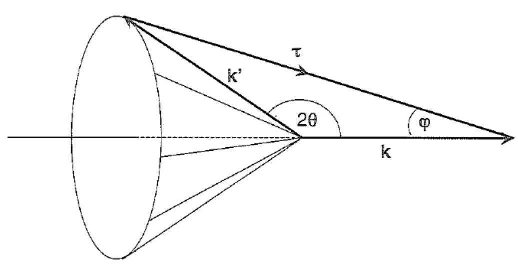

Figure 1: Debye-Scherrer cone for Bragg scattering from polycrystalline materials.