Physics with Neutrons I

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WS 17/18
26.01.2018

Exercise sheet 7

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Due on 26.01.2018

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1 Dynamical range of neutron spectrometers

We are interested in $\mathbf{Q}$, but we measure $\mathbf{k_i}$ and $\mathbf{k_f}$ (all measured in Å^{-1}) which are connected via

$$\mathbf{Q} = \mathbf{k_f} - \mathbf{k_i} \ . \tag{1}$$

1. Draw some possible scattering triangles for both elastic and inelastic scattering. What is the meaning of the direction of the $\mathbf{k}$ and $\mathbf{Q}$? Which experimental constraints do you expect?

2. Which absolute values $|\mathbf{Q}|$ can be reached in a scattering experiment as a function of $|\mathbf{k_i}|$, $|\mathbf{k_f}|$, and the scattering angle 2θ?

3. Show that this relation reduces to Bragg's law in the case of elastic scattering.

4. Basically, there are two classes of spectrometers: some fix $\mathbf{k_i}$, others $\mathbf{k_f}$ during an experiment. (It can also be varied which however requires a reconfiguration of the instrument.) Two examples at the FRM II are the time-of-flight spectrometer TOFTOF which works with a fixed $\mathbf{k_i}$ and the triple axis spectrometer PUMA which fixes $\mathbf{k_f}$. What are the consequences for the scattering triangles that can be realized during an experiment?

5. The energy change of the neutron is defined as $\Delta E = E_f - E_i$ (all measured in meV) with

$$E_{i,f} = \frac{\hbar^2 k_{i,f}^2}{2m_n} \ .$$

   Which are the limits of ΔE for TOFTOF and PUMA, respectively?