Physics with neutrons 1

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Winter semester 2015/16
Exercise sheet 10
Due 2016–Jan–15

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Exercise 10.1

Calculate $\langle\zeta^2\rangle_T$ and f^2_{DWF} for lead ($\theta_D = 88\,\mathrm{K}$), copper ($\theta_D = 315\,\mathrm{K}$), and diamond ($\theta_D = 1860\,\mathrm{K}$) at $T = 10\,\mathrm{K}$ and $T = 1000\,\mathrm{K}$ with the low and high temperature approximations. Which material is most useful as a monochromator? What can be done to improve the reflectivity of copper monochromators?

Exercise 10.2

Derive the representation

$$G(\mathbf{r},t) = \frac{1}{N}\sum_{j,j'}\int \langle\delta\Big(\mathbf{R} - \mathbf{r}_{j'}(0)\Big)\delta\Big(\mathbf{R} + \mathbf{r} - \mathbf{r}_j(t)\Big)\rangle dR$$

from the expression for the intermediate scattering function

$$I(\mathbf{Q},t) = \frac{1}{N}\sum_{j,j'}\langle e^{-i\mathbf{Q}\cdot\mathbf{r}_{j'}(0)}e^{i\mathbf{Q}\cdot\mathbf{r}_j(t)}\rangle_T$$

using the substitution

$$e^{-i\mathbf{Q}\cdot\mathbf{r}_{j'}(0)} = \int e^{-i\mathbf{Q}\cdot\mathbf{r}'}\delta\Big(\mathbf{r}' - \mathbf{r}_{j'}(0)\Big)d\mathbf{r}'.$$

Exercise 10.3

Discuss and draw qualitatively the thermal occupation factors of $\langle n\rangle$ and $\langle n+1\rangle$ for a diffusion process leading to quasi-elastic scattering and a excitation, i.e. inelastic scattering. Discuss (a) the classical limit (high temperatures, $k_BT \gg E$) and (b) the quantum limit ($T \to 0$).

Note: Quasi-elastic scattering is represented by a Gaussian of the form $e^{-\frac{\omega^2}{2\sigma^2}}$, $\sigma = 1\,\mathrm{meV}$. Inelastic scattering is represented by a Gaussian of the form $e^{-\frac{(\omega\pm\omega_0)^2}{2\sigma^2}}$, $\sigma = 0.1\,\mathrm{meV}$, $\omega_0 = 1\,\mathrm{meV}$.