Physics with neutrons 2

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Exercise sheet 7
To be discussed 2017-06-20, room C.3203

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Exercise 7.1

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, $k_B T \gg E$) and (b) the quantum limit ($T \to 0$).

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

Exercise 7.2

Derive the intermediate scattering function, pair correlation function, and the scattering law $S(\mathbf{Q},\omega) = \frac{1}{2\pi\hbar}\int dt\, e^{-i\omega t} I(\mathbf{Q},t)$ for a single atom that oscillates harmonically in one dimension with a frequency ω_0. When you perform the Fourier transform, assume that the amplitude of the oscillation is very small.

Exercise 7.3

Estimate the energy scale of the magnetic interaction for

- two electrons,
- an electron and a neutron,
- an electron and a nucleus (for example Cu), and
- a neutron and a nucleus (for example In).

The respective particles are supposed to have a distance of 1 Å.