Physics with Neutrons I

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Exercise sheet 8

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wiki.mlz-garching.de/n-lecture05:index

1 Thermal occupation

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 an 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 shall be represented by a Gaussian of the form $e^{-\frac{\omega^2}{2\sigma^2}}$, $\sigma = 1\,\mathrm{meV}$. Inelastic scattering shall be represented by a Gaussian of the form $e^{-\frac{(\omega \pm \omega_0)^2}{2\sigma^2}}$, $\sigma = 0.1\,\mathrm{meV}$, $\omega_0 = 1\,\mathrm{meV}$.

2 Single-atom harmonic oscillator

Derive the intermediate scattering function, pair correlation function, and the dynamic structure factor $S(\mathbf{Q}, \omega) = \frac{1}{2\pi\hbar} \int dt\, e^{-i\omega t} I(\mathbf{Q}, t)$ 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.

Hint: Start with the intermediate scattering function in one dimension:

$$I(Q,t) = \frac{1}{N} \sum_{j,j'} \langle e^{-iQr_{j'}(0)} e^{iQr_j(t)} \rangle$$

and make the substitution $\rho(t) = r(t) - r(0)$.