

# Physics with Neutrons I

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## Exercise sheet 7

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[wiki.mlz-garching.de/n-lecture05:index](http://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 ( $T \rightarrow 0$ ).

Note: Quasi-elastic scattering shall be represented by a Gaussian of the form  $e^{-\frac{\omega^2}{2\sigma^2}}$ ,  $\sigma = 1$  meV.

Inelastic scattering shall be represented by a Gaussian of the form  $e^{-\frac{(\omega \pm \omega_0)^2}{2\sigma^2}}$ ,  $\sigma = 0.1$  meV,  $\omega_0 = 1$  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  $\omega_0$ . 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  $\rho(t) = r(t) - r(0)$ .