Physics with neutrons 2

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Exercise sheet 3
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Exercise 3.1

Prove that the characteristic function of a homogeneous sphere with radius R is

$$\gamma_0(r) = 1 - \frac{3}{4}\frac{r}{R} + \frac{1}{16}\left(\frac{r}{R}\right)^3 \tag{1}$$

Calculate the form factor of a sphere using the radial Fourier transform.

Exercise 3.2

Download the four SANS datasets of polystyrene latex dissolved in a D_2O buffer from the lecture website `http://wiki.mlz-garching.de/n-lecture02:tutorials`. The polysterene latex rounds are almost perfectly spherical and uniform in size. The data are corrected for instrument-related effects, the first column is Q in nm^{-1}, the second column $I(Q)$ in units $cm^{-1}sr^{-1}$ and the third column its error. The scattering contrast of the particles to D_2O is equal $\Delta\eta = 6 \cdot 10^{10} cm^{-2}$ and the irradiated volume was equal $V = \pi\frac{1}{2}^2 \times 0.1 cm^3$. Determine the different concentrations of polysterene latex of the three samples

1. by determining the characteristic function

$$\gamma(r) = \frac{1}{V}\int Q^2 I(Q)\frac{\sin(Qr)}{Qr}dQ$$

   and using the definition of the scattering invariant

$$Q^* := V\lim_{r\to 0}\gamma(r),$$

   by finding a correlation of $\gamma(0)$ with the volume fraction of the dispersion;

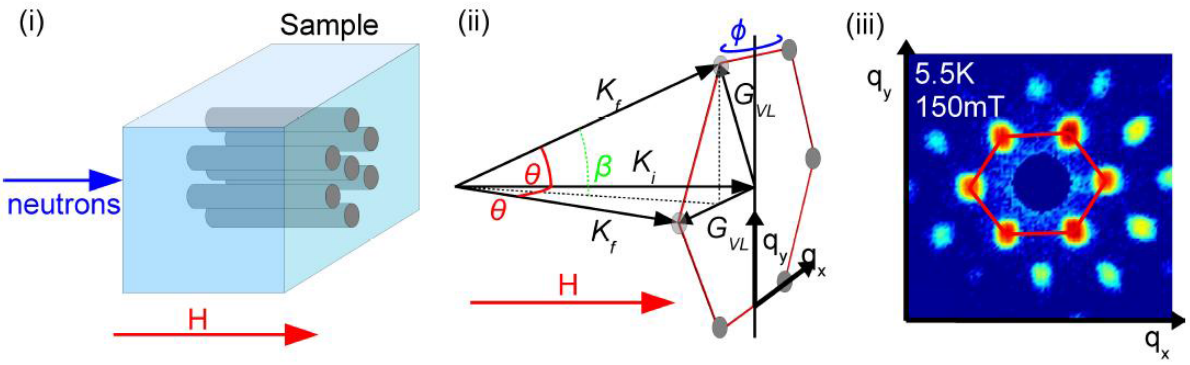
2. by performing a fit with the form factor of spheres

$$F(Q;R) = \frac{4}{3}\pi R^3 \Delta\eta\ 3\frac{\sin QR - QR\cos QR}{(QR)^3}.$$

Note: There is also incoherent scattering of the D_2O and the polysterene in the signal which should be taken into account first.

Exercise 3.3

In a neutron diffraction experiment, a vortex lattice can be considered as a long range magnetic diffraction grating for the neutrons. Are there Bragg peaks visible around the nuclear positions in a neutron diffraction experiment?


(i)
Sample
neutrons
H
(ii)
K_f
G_{VL}
θ
β
K_i
θ
K_f
G_{VL}
q_y
q_x
H
ϕ
(iii)
q_y
5.5K
150mT
q_x