# Physics with Neutrons I

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WS 18/19
17.01.2019

**Exercise sheet 10** https://wiki.mlz-garching.de/n-lecture06:index

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## Due on 23.01.2019

## 1. Reverse engineering 'real' data

The following exercise should illustrate, how various effects affect the scattering data and how difficult it can become to interpret data, even for simple models.

Start by considering very dilute spherical particles with a radius $R = 100\text{nm}$. The scattering length density has its maximum value $\Delta\rho_b(0)$ at the center of the particle and falls off linearly to $\Delta\rho_b(R) = 0$ at its edge. (a smoothly varying distribution like this might happen in magnetic particles with a corresponding field distribution).

- Calculate the scattering cross section and take a look at the Guinier and Porod regime. Are they different from a homogeneous sphere?
- Now we introduce polydispersity: the particles have a certain distribution of various sizes. Assume, e.g. a Gaussian distribution centered around $R$, with a standard deviation $\sigma = 2\%$. (also test how the signal is changing when increasing the size distribution to 10% or higher)
- Additionally, the instrumentation degrades the obtained signal. assume a Gaussian shape of the direct neutron beam with a standart deviation $\sigma = 4 \cdot 10^{-4}/\text{Å}$ and perform a convolution on the signal.
- As a last step, we implement a 'real' detector, by assuming discrete pixels. For this, bin the data up to $q = 5 \cdot 10^{-2}/\text{Å}$ into 100 equally spaced data points.

Even though we only look at the radial dependence of the scattering cross section, in a standard SANS setup one obtains a 2D image which is later radially averaged for data treatment. If we are interested in even smaller scattering angles, a common setup is the Bonse-Hart camera, which uses two monochromators (before and after the sample) to increase the angular resolution. However, this technique reduces the 2D data to a 1D data by integrating the radial scattering data over the direction of monochromator rotation axis. So all scattering with the same q component perpendicular to the axis is summed up into a single value. This effect is called slit smearing.

$$\left(\frac{d\sigma(q_x)}{d\Omega}\right)_{slit} = \int \frac{d\sigma(\sqrt{q_x^2 + q_y^2})}{d\Omega} dq_y$$

- Take the scattering curve from step one and calculate, how the obtained signal will change. Again, take a look at the Guinier and Porod regimes.