Physics with Neutrons I

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Exercise sheet 3 https://wiki.mlz-garching.de/n-lecture06:index

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1. Python

Some exercises require the use of some program for numerical computation, such as Matlab, Mathematica or some programming language. Several exercises will require the use of a computer. The solutions will always be given in the language python. Although you are not forced to, it might be a good idea to install the requirements to run these programs on your computer:

- python, the language interpreter **http://www.python.org/download/**
- ipython, a nice command line **http://ipython.scipy.org/dist/**
- numpy & scipy, packages for numerical and scientific computing **http://www.scipy.org/Download/**
- matplotlib, a package for 2D-plotting **http://matplotlib.sourceforge.net/**

Personally, I use the ANACONDA distribution of python which comes with the developing environment SPYDER **https://www.anaconda.com/download/**

2. Coherent and Incoherent scattering cross section

In most cases, real materials do not have a single scattering length, but a distribution of several values. This could be due to different elements, isotopes or a non-zero nuclear spin. In case of a nuclear spin, the isotope has two scattering lengths, one for parallel spin alignment of nucleus an neutron b^+ and one for antiparallel alignment b^-

- In the experiment, we use cross sections σ instead of scattering lengths b to describe a sample and especially distinguish between coherent and incoherent scattering. How are those quantities related? Is there a fundamental difference for a mixture of elements, isotopes or spin-states?
- What extreme cases of scattering can happen in any system?
- Calculate the coherent and incoherent scattering cross sections for an element with n isotopes. Assume that each isotope has a relative abundance f_i
- Calculate the coherent and incoherent scattering cross sections for a single isotope with nuclear spin I.
- Determine the coherent and incoherent scattering cross sections of pure Hydrogen and Deuterium with the following values:

Nuclide	I	b (fm)	Nuclide	I	b (fm)
^1H	1/2	$b^+ = 10.85$	^1H	1	$b^+ = 9.53$
		$b^- = -47.50$			$b^- = 0.98$

3. Bragg Scattering II

Consider a similar setup of exercise 4 on sheet 2 (Bragg Scattering) with neutron wavelength $\lambda = 2.0\AA$, lattice parameter $d = 3.2\AA$ and $n = 100$ scattering planes. Assume, that each scatterer (scattering plane) has its own scattering length b_j and compute the scattering pattern for the following cases:

1. $$b_j = \begin{cases} 0 & \text{if } j \text{ is even,} \\ 1 & \text{if } j \text{ is odd.} \end{cases}$$

2. $$b_j = \begin{cases} 1 & \text{if } j \text{ is even,} \\ 2 & \text{if } j \text{ is odd.} \end{cases}$$

3. $$b_j = \begin{cases} -1 & \text{if } j \text{ is even,} \\ 1 & \text{if } j \text{ is odd.} \end{cases}$$

4. Choose b_j randomly for each scatterer (plane) : $b_j = 0$ or $b_j = 1$
5. Choose b_j randomly for each scatterer (plane) : $b_j = 1$ or $b_j = 2$
6. Choose b_j randomly for each scatterer (plane) : $b_j = -1$ or $b_j = 1$
7. Feel free to play around!