PD Dr. Martin Jourdan, Institut für Physik, Universität Mainz

Exercises Condensed Matter Physics (Experimentalphysik 5c), WS16/17

1) **Raman scattering** (2 credits)

Inelastic scattering of light is used for the determination of the dispersion relation of phonons. Based on momentum and energy conservation it is possible to determine $\omega(\mathbf{k})$.
In Raman scattering, laser light ($h\nu$ = 4eV) is scattered by a solid sample. The maximum momentum is transferred, if the photon is backscattered. Which part of the Brillouin zone is accessible by this method, if the lattice constant amounts to 0.3nm?

2) **Measuring the Phonon dispersion relation** (3 credits)

Inelastic scattering of light or matter waves is used to determine the dispersion relation of Phonons:

a) Using X-rays with the energy $h\nu = 10^4$ eV a sufficient momentum transfer is possible. However, an energy resolution of 1 meV is required. Thus, the X-ray beam needs to be monochromatized, e.g. by Bragg scattering on a single crystal. Estimate based on the Bragg formula the necessary precision of the lattice constant Δd and aperture $\Delta\Theta$ of the monochromator crystal. Is Phonon spectroscopy with X-rays possible?
b) What is the wave length of neutrons, which are at T = 300K in thermal equilibrium and which maximum momentum transfer can be realized? Which precision $\Delta\lambda/\lambda$ of the monochromator is required in this case?

3) **London Equations** (3 credits)

Already 1935 the brothers London proposed two phenomenological equations.

a) Derive the 1st London Equation starting from the Drude model and assuming an infinite relaxation time.
b) The 2nd London equation is $\mathbf{B} = -\mu_0 \lambda_L \, rot\, \mathbf{j}$
Show that this equation includes that an external magnetic field parallel to a superconductor surface decreased exponentially within the superconductor (Meißner-Ochsenfeld effect).