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Fakultät für Naturwissenschaften, Fachbereich Physik

Announcement

Basics of Structure Physics: Probing the atomic structure by electrons, (X-rays and neutrons) – including hands-on problem solutions

Prof. Kaiser, Prof. Rose

Description

The objective of this course is to teach fundamental principles and introduce the state-of the art instrumentation for probing atomic (and electronic) structure with electrons (X-rays, neutrons), along with the skill to transfer the theory taught during the course to practical computer code or talk. Each student will have to solve a dedicated problem related to one of the topics addressed during the lectures. These problem will be addressed in a student talk, along with a detailed explanation of the background of the implemented theory or a numerical solution. The student will also perform two experiments on our Cs-corrected TITAN80-300 on high-resolution TEM.

Content

1. Introduction into structure physics (Bragg and Laue, history, instrumentation)
2. The symmetry of crystals – space groups
3. Basics of geometrical optics – paraxial approximation, Scherzer theorem, aberrations, correction of aberrations
4. Basics of Fourier optics – Sommerfeld diffraction, basics for Abbe imaging theory
5. Basics of contrast in TEM – scattering amplitude, scattering cross section, electron optical refraction index, Born approximation, high energy approximation, multislice algorithm, propagation and image formation, image intensity
6. Basics of HRTEM imaging – experiment and calculation

Student's project: Evaluate one of the problems below, document the problem and the approach used to solve it. Present and discuss the project during the exercises.

- Generate atom positions within the unit cell from symmetry operators and replicate this unit cell a given amount of times, building a crystal – build in pre-defined space group numbers
- Calculation of the electron paths in a magnetic field
- Chromatic and spherical aberration, calculation of the influence and different accelerating voltages
- How a hexapole corrector works? Calculation of ray paths.
- Fresnel and Fraunhofer diffraction in TEM
- Calculation of the scattering amplitude and the scattering cross-section in first Born approximation and high-energy approximation
- Compute an electron diffraction pattern and the projected potential and the image contrast using the multislice algorithm for a defined structures
- Calculation of the amplitude and phase contrast transfer function of different objects and imaging conditions.

Prerequisites

Undergraduate physics and mathematics, some experience in programming would be helpful

Literature

Links to relevant literature and programming guides will be provided on the course website http://www.uni-ulm.de/einrichtungen/hrem/lehre/lehreteaching/

Additional information

Two block for 1 week each (corresponding to 3 hours per week)

Seminars/Exercises/Experiment (2 hours per week)

6 ECTS credits

Dates

First meeting:	Tue, 2.5.17, 16:00, N27/glas box
Introductory seminar:	Wed, 3.5.17, 16:00, N27/glass box
Lectures:	4.5. - 9.5.17, daily 9 – 12 and 8.6. - 13.6.17, daily 9 - 12
Lab course:	10.7. - 13.7.17

Assessment

The final grade will be composed as follows: 50% for the student's project + 50% for the exam.

Lecturer

Prof. Kaiser, Prof. Rose, Electron Microscopy Group of Materials Science