# Determination the size and stability of geometric aberrations of a transmission electron microscope.

Master Thesis, Electron Microscopy Group of Materials Science, Prof. Ute Kaiser

## Background

Since the advent of the realizable hard-ware aberration correction [1], transmission electron microscopy (TEM) has undergone and is still undergoing revolutionary changes in its ability to image materials at the atomic level (see e.g. the review articles of Urban [2] or Rose [3]). Previously, the almost impossible tasks to image light atoms (boron, carbon, nitrogen or oxygen), light atom columns and light atom columns between heavy ones have now become feasible. However, the reduction of aberration $C_S$ that was previously limiting the resolution comes at the cost of increased occurrences of residual aberrations like coma and $2^{nd}$ order astigmatism. Therefore, those residual aberrations have to be considered during the daily work with aberration-corrected microscopes and must be removed as well.

Unfortunately, the aberration correction is not permanently preserved over the day. Reasons can be temperature drifts, stray fields, instabilities of the power supplies, hysteresis of the lenses and other instabilities that lead to varying conditions of objective lens and corrector.

## Aim

The task of this thesis is to establish protocols and evaluation procedures to determine the long time stability of aberrations parameters of TEMs such as the newly developed SALVE TEM [4,5,6]. Moreover, the effect of changing microscope parameters such strong changes of focus on the aberration correction have to be studied.

## Workplan

- introduction to high-resolution transmission electron microscopy
- introduction to information transfer in the TEM
- recording time-dependent image sequences with aberration-corrected HRTEM at different voltages
- data post-processing of recorded image sequences and determination of the shifts of corrections
- theoretical description of the long-time stability

## Requirements

- good physical and mathematical understanding
- high interest in laboratory work
- enjoying autonomous, scientific work in an international environment

**Supervisor:** Dr. Johannes Biskupek

Experiments are performed on the TITAN and SALVE instruments.


1] M. Haider, H. Rose, S. Uhlemann, E. Schwan, B. Kabius, K. Urban, A spherical-aberration-corrected 200 kV transmission electron microscope, *Ultramicroscopy* **75** (1998) 53-60.[2] K. Urban, Studying Atomic Structures by Aberration-Corrected Transmission Electron Microscopy, *Science* **321** (2008) 506-510.

[3] H. Rose, History of aberration correction, *Advances in Imaging and Electron Physics* **156** (2008) 1-36.

[4] www.salve-project.de

[5] U. Kaiser *et.al.* Ultramicroscopy **111 (8)**, 1239-1246 (2011)

[6] M. Linck et al. Phys. Rev. Let **117** 076101 (2016)