Model-Based Analysis of Phase Images Reconstructed from High-Resolution and Medium-Resolution Off-Axis Electron Holograms

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Off-axis electron holography is a powerful technique for recording the phase shift of a high-energy electron wave that has passed through an electron-transparent specimen in the transmission electron microscope. The phase shift is, in turn, sensitive to the electrostatic potential and magnetic induction in the specimen, projected in the electron beam direction. We are currently working on several model-based approaches that can be used to provide quantitative interpretations of phase images recorded using off-axis electron holography.

FIG. 1 shows the result of iterative fitting of specimen tilt, absorption, image spread and aberrations up to 5th order by comparing an experimental phase image recorded from five monolayers of two-dimensional WSe_2 with simulations. The simulations are based on scattering potentials derived from density functional theory and include bonding effects, which are found to be necessary to achieve quantitative agreement between experimental and simulated phase images [1]. By removing residual aberrations from the experimental phase image, a quantitative description of the atomic structure of the material, including the detection of structural defects, becomes possible.

We are also developing a model-based approach for reconstructing three-dimensional magnetization distributions in materials from series of phase images recorded using off-axis electron holography as a function of specimen tilt angle. In order to perform such reconstructions, we generate simulated magnetic induction maps by projecting best guesses for the three-dimensional magnetization distribution in a specimen onto a two-dimensional Cartesian grid. This approach avoids many of the artifacts that result from the use of classical backprojection-based tomographic techniques, as well as allowing additional constraints and known physical laws to be taken into account [2].

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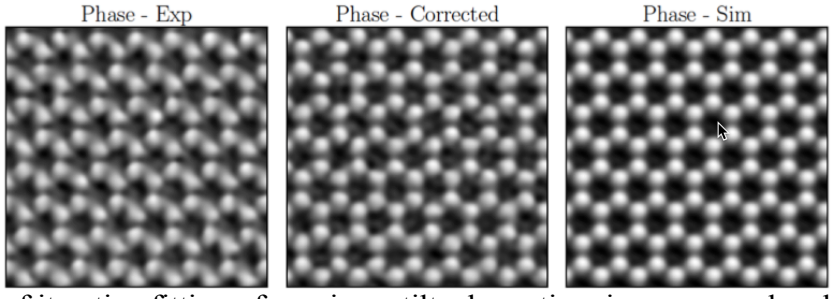

FIG. 1. Result of iterative fitting of specimen tilt, absorption, image spread and aberrations up to 5th order by comparing density-functional-theory-based simulations with an experimental phase image recorded from five monolayers of WSe_2 using off-axis electron holography.