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TOWARDS ELECTRON HOLOGRAPHY OF 3D MAGNETIZATION DISTRIBUTIONS IN NANOSCALE MATERIALS USING A MODEL-BASED ITERATIVE RECONSTRUCTION TECHNIQUE

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Abstract

Off-axis electron holography is a powerful technique for recording the phase shift of a high-energy electron wave passing through a thin specimen in the transmission electron microscope. The phase shift is, in turn, sensitive to the magnetic field and the electrostatic potential within and around the specimen.

We have developed an iterative model-based approach that can be used to reconstruct the two- or three- dimensional magnetization distribution in a specimen from one or more phase images recorded using electron holography. Our approach makes use of an optimized forward model, which provides fast and accurate simulations of phase images based on successive guesses for magnetization distributions in the specimen. The forward model utilizes pre-calculated phase images of simple geometrical objects, which are processed using fast convolutions in Fourier space and sparse matrix multiplications. As the retrieval of the magnetization distribution is ill-posed and the solution is in general non-unique, a regularization term is used to select a solution that satisfies additional constraints, such as minimization of the exchange energy of the optimized magnetization distribution in the specimen.

We begin by illustrating solutions for reconstructed two-dimensional projected magnetization distributions, which are retrieved by application of the algorithm to both simulated and experimentally acquired phase images. We also illustrate preliminary three-dimensional reconstructions of magnetization distributions in materials obtained from tilt series of phase images.