ITERATIVE MODEL-BASED TOMOGRAPHIC RECONSTRUCTION OF 3D MAGNETISATION DISTRIBUTIONS USING ELECTRON HOLOGRAPHY ON THE NANOSCALE

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Abstract

Off-axis electron holography is capable of recording the phase shift of a high-energy electron wave passing through a thin specimen in the transmission electron microscope. The phase shift in turn contains information about the electromagnetic field within and around the specimen.

An iterative model-based reconstruction algorithm has been developed to allow the retrieval of the projected in-plane magnetisation distribution from a single phase image or a complete three-dimensional tomographic reconstruction of the magnetisation from two orthogonal tilt series of phase images recorded with electron holography.

The approach employs an optimised, fast and accurate forward model for simulating phase images from a given magnetisation distribution. The model utilises sparse matrix multiplications and FFT-based convolutions, with pre-calculated kernels representing the phase contributions of simple magnetised geometric objects.

The ill-posed nature of the inverse problem of magnetisation retrieval necessitates the use of regularisation techniques such as exchange energy minimisation and the use of masks to determine the magnetised volume and trustworthy regions in the experimentally acquired phase images.

Reconstructions for two- and threedimensional distributions are shown and discussed with regard to the influence of regularisation on the solution, obtaining the best solution in the presence of noise and dealing with artefacts such as magnetisation distributions outside the field of view and the perturbed reference wave.