doi:10.1017/S1431927622001921
Microsc. Microanal. 28 (Suppl 1), 2022

Neutron Dark Field Tomography of Hierarchical Structures

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Neutrons are a unique probe of matter, readily penetrating metals, while scattering strongly from light elements. Neutrons provide valuable insight into a wide range of material science areas including electrochemical electrodes (batteries and fuel cells), polymer blends, flows in geological and porous media, structural biology, etc. Neutron dark field tomography measures the pair correlation function, averaged over a voxel, to provide multiscale information spanning many orders of length scales, nm to cm. Such data can map changes in the microstructure as a system evolves, for instance variation in electrode structure as a function of battery wear. One challenge to obtain a neutron dark field tomogram is the intrinsic neutron flux, which is nominally a billion times weaker than modern synchrotron X-ray sources. We are exploring dose reduction, sparse angular sampling, and machine learning methods in the hopes of collecting about 100 tomograms per day, about 100-fold increase in capability. Analyzing the microstructure presents a separate challenge, in which automated methods to determine appropriate fitting models is required. We have begun preparing data-driven simulations to guide this learning. We demonstrate our progress towards our final goal of tomography by applying the analysis to phantoms comprised of polystyrene.