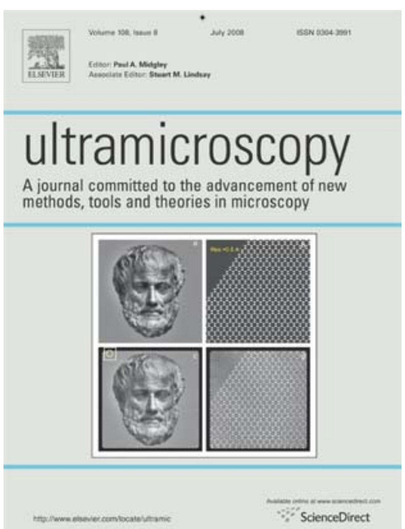
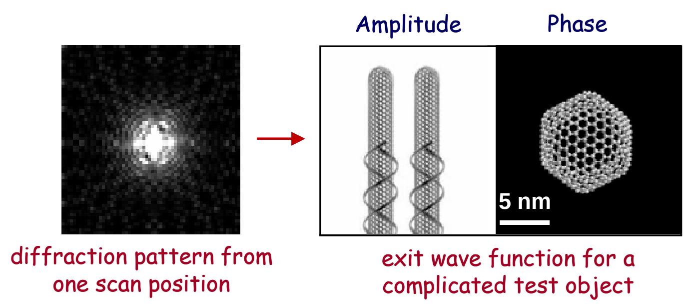
Imaging Without Lenses for the Physical and Life Sciences

Lens-less, or diffractive, imaging is a novel technique that eliminates imaging elements in an optical system relying instead on a coherent-source probe and phase-retrieval algorithms to obtain structural images of arbitrarily complicated objects. It is well suited for neutron, x-ray and electron probes, and removes aberrations and artifacts normally associated with imaging lenses. With this approach, spatial resolution can be substantially improved down to the diffraction limit of the probing technique. For modern electron microscopes this limit is easily sub-Angstrom in diffraction space. It is difficult to achieve such a limit for real-space imaging instruments even with aberration-corrected lenses. Practical use of this method for imaging complex objects requires fast, robust and reliable phase-retrieval algorithms. We have recently developed a generic and effective algorithm (Automatic Chaining Diffraction Algorithm) for fast phasing and inversion of diffraction data to retrieve real-space images. The robustness of the method has been experimentally demonstrated with a scanning transmission electron microscope by moving a highly collimated electron beam over complicated periodic and non-periodic objects. Lens-less imaging with our chaining algorithm can be applied to x-ray and neutron beams as well as sound- and radio-wave imaging systems including magnetic resonant imaging, and is suitable for both inorganic and organic (or biological) samples.





Top: using the automatic chaining diffraction algorithm we developed for a scanning electron probe we were able to retrieve the amplitude and phase of the electron wave based on diffraction data alone to solve real-space structure for arbitrarily complex objects.
Left: the journal cover. Two images at the bottom show an object exit-wave function recovered from diffraction data to be compared with reference complex-object images above.

V.V. Volkov, Y. Zhu, J. Wall (Brookhaven National Lab)

Reference:

V.V. Volkov, J. Wall and Y. Zhu, *Ultramicroscopy* **108**, 741-748 (2008)