Microscopy is more informative without lenses: ptychography with X-rays, visible light, and electrons

by

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If you think of a transmission microscope, you generally think of focussing lenses. The trouble with lenses is that they can have aberrations and, in the case of atomic-scale wavelengths (X-rays and electrons), they are restricted to a very small numerical aperture: both of these effects can radically limit resolution. Coherent diffractive imaging (CDI) disposes of all lenses, instead using a computer algorithm to solve the phase problem in the diffraction plane. Ptychography is a very robust form of CDI that can solve for an indefinite field of view at (in principle) wavelength-limited resolution. It also delivers a very sensitive high-contrast phase image. It is now being quite widely adopted by the X-ray synchrotron community.

In this talk I will briefly describe the history and principle of ptychography and then present some recent results we have obtained using X-rays and electrons, as well as from some model experiments using visible light. Unlike conventional CDI (which uses only one diffraction pattern), I will show that the 'oversampling' condition, a central tenet of CDI, does not apply to ptychography. The massive redundancy in ptychography can be used to solve for 3D objects (without rotating the specimen), super-resolution, and for separating incoherently-superposed states. We can also measure the phase of X-ray absorption edges.