

## **Ptychography and Coherent Diffractive Imaging - X-rays and Electrons**

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Several ideas, developed over half a century, have now converged to provide a working solution to the non-crystallographic phase problem. These include Sayre's 1952 observation that Bragg diffraction undersamples diffracted intensity relative to Shannon's theorem, that iterative ("HiO") algorithms with feedback rarely stagnate (Gerchberg-Saxton-Feinup), producing an astonishingly successful optimization method, and that these iterations are Bregman Projections in Hilbert space. Modern algorithms based on these ideas have recently produced the first spectacular atomic-resolution image of a double-walled nanotube from experimental electron diffraction patterns (Zuo et al, Science, 300, 1419 (2003) ), and lensless X-ray images at 20nm resolution (Miao et al Nature, 400, p. 342 (199), He et al Phys Rev B. 67, p. 174114 (2003) ). In this talk two new ideas will be presented. First, recent experimental application of the "Shrinkwrap" HiO algorithm (Marchesini et al, (2003) in press) will be given. This algorithm inverts X-ray speckle patterns to images without knowledge of the object boundary. Experimental results are given with 20nm resolution. Secondly, the use of compact support along the beam direction in the transmission geometry for a thin diffracting slab will be described as a phasing method. Simulations for cryo-TEM tomography of protein monolayers shows that this use of the HiO algorithm greatly reduces the number of TEM images needed to provide known phases for the three-dimensional diffraction data (Spence et al, J.Struct Biol, in press, also Weierstall et al, Ultramic 90, 171 (2001) ). Finally, a conceptual connection between the HiO "oversampling" method (which requires diffracted intensity measurements at half the "Bragg" angle) and Ptychography (which uses interference between adjacent coherent diffraction orders) will be suggested.