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Digital Darkfield Analysis of Lattice Fringe Images with ImageJ

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Digital-darkfield analysis involves the spatial mapping of selected frequencies across a digitized image, much as analog (e.g. electron-optical) darkfield-imaging allows one to locate crystals responsible for a given diffraction spot. This analysis involves a type of image decomposition which, like wavelets, is intermediate between direct and reciprocal (spatial-frequency) space [1]. Digital-darkfield analysis is of particular use on images that have well defined spatial-frequencies in them, like lattice-fringe images of atomic-planes encountered edge-on by high-energy electrons in crystalline materials [2-10].

A set of java plugins is posted on the ImageJ wiki at http://imagejdocu.tudor.lu/, along with macros for putting them to use. The java plugins include routines for quantitatively converting complex-number arrays to and from RGB images with pixel-intensity proportional to coefficient log-amplitude and pixel-hue linked to coefficient phase. These plugins may also be used by hue-maximization routines, to be described elsewhere.

Some of the routines allow the user to place a circular aperture in the power spectrum of an image, from which periodicity amplitude and phase-gradient (strain) maps are calculated, labeled, and displayed. A periodicity-amplitude map is shown (top right panel) in Fig. 1, for one of the many periodicities in the power spectrum (top center panel) of an electron phase-contrast image of some WC_{1-x} nanocrystals [11] (top left panel). Fig. 2 shows periodicity amplitude banding (left) with twice the frequency of ordinary thickness fringes, as well as the periodicity phase-reversals (right) expected to occur therewith.

Other routines let the user tile frequency space with an array of tiny darkfield (plus one brightfield) images, yielding a tableau containing one direct-space image formed by the spatial-periodicities found in each frequency-space tile. This darkfield-tableau strategy has helped find patterns, like icosahedral twin"bow-ties" and "butterflies" in images of randomly-oriented nanoparticles [12-13].

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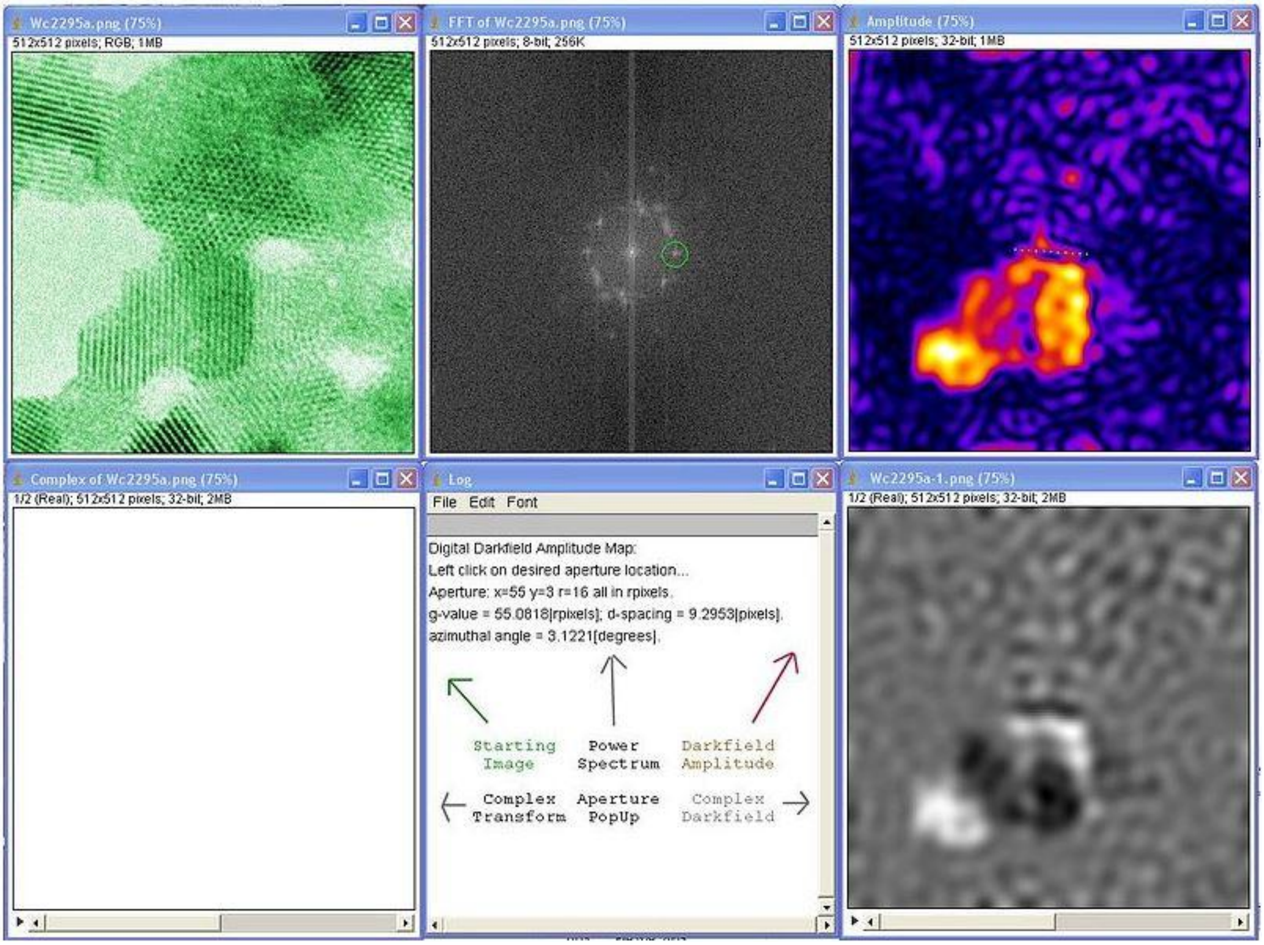

Figure 1. In this example, a crystal with lattice fringes in only one direction is shown (top right) to be responsible for the circled diffraction-spot in the image power-spectrum (top center).

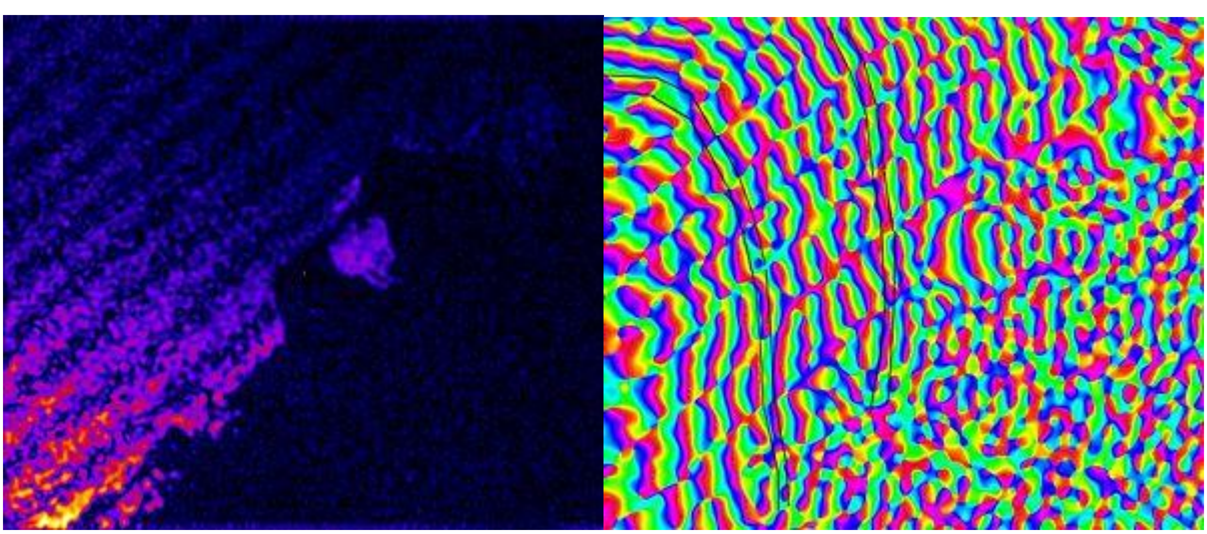

Figure 2: Si-111 darkfield amplitude map of a 4024x3443 pixel lattice image (left), is shown in the darkfield phase image (right) to have phase-inversions expected at thickness-fringe maxima & minima.

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