Fringe Visibility Maps

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The phrase "*fringe visibility map*" here refers to high-resolution images of uniform-thickness single crystal foils showing locally hemispheric deformation (i.e. bent into the shape of a watchglass), and to various mathematical analogs thereof. As the availability of "diffraction information" in direct-space form increases, for example with the availability of HREM and z-contrast lattice images, fringe visibility maps may serve as the direct space analog to *Kikuchi maps*, i.e. to diffraction pattern maps of Kikuchi line pairs as a function of specimen orientation, and their various cartoonifications.

Figures 1 to 3 are schematic Mathematica-generated fringe visibility maps for face-centered, body-centered, and diamond face-centered cubic lattices, respectively. Here we have turned the "locally hemispheric" concept around and drawn fringes visible when one is viewing a spherical particle of the appropriate thickness, along varying beam directions (rather than lattice orientations) parallel to the local radius vector on that sphere.

As you can see, the global structure of these maps is identical to that of Kikuchi maps. In other words, the lattice fringes cross at zone axes which are identical to those orientations in reciprocal space at which Kikuchi lines cross. Hence the information on how far one has to tilt to go from one zone to the next is identical for both types of map. The similarities end there, however, because the widths of the bands (and of the fringes within) is proportional to the lattice spacing. In the reciprocal space case, of course, the width of Kikuchi bands is proportional to the Bragg angle and hence (to first order) inversely proportional to the lattice spacing. Unlike Kikuchi maps, the width of the visibility bands (but not the lattice fringe spacings themselves) depends on the thickness of the specimen. As shown in Figure 1, the visibility of fringes is also quite sensitive to microscope contrast transfer as well.

So far, we have found these maps useful for the following purposes[1-2]:

(i) Given any particular lattice, they tell which direction (and how far) to tilt with respect to a given direct-image cross-fringe pattern, in order to get to another desired location in orientation space.

(ii) For randomly-oriented particles with any given lattice, they allow one to assess visually and quantitatively the probability of seeing any given fringe type, and any given cross-fringe type.

(iii) With extremely thin particles, they allow one to visualize effects of lattice fringe foreshortening as one tilts away from the edge-on (or in-plane) beam orientation.

(iv) For very thick particles, they allow one to illustrate the "in-plane invisibility band" (or visibility band splitting) that one might expect with extremely parallel illumination.

(v) In conventional diffraction contrast, they illustrate the expected relation between the angular width of bend contours and specimen thickness. By using the distance between contour crossings to calibrate foil curvature, this would facilitate specimen thickness estimates directly from a single "sufficiently wide-angle" bend pattern simply by visual comparison with the corresponding map.

References:

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1. cf. Williams & Carter, Transmission Electron Microscopy, Volume 2, page 291.
2. W. Qin and P. Fraundorf, *Proc. Microscopy Society of America Annual Meeting*, 2000, p.1038-1039.
3. W. Qin, "Direct space (nano)crystallography via HREM" (Ph.D. Dissertation, UM-StL/Rolla, 2000)

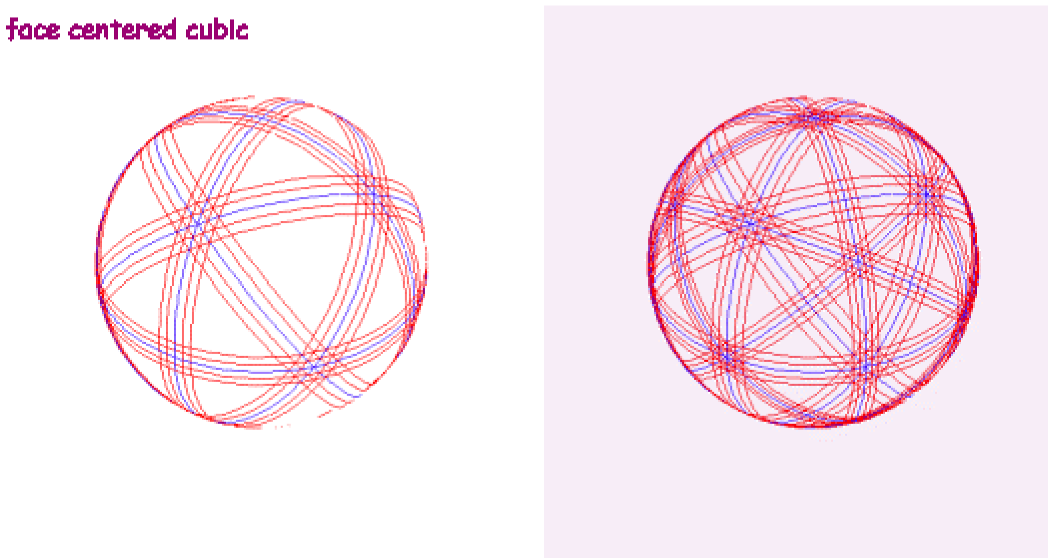

Figure 1: Tilt visibility maps for a face-centered cubic Aluminum foil 2 nm in thickness, showing locally top-down structure in HREM images as a function of specimen orientation. The first image assumes that only (111) and (200) fringes are detectable. The second image shows how this changes if the 0.14 nm (110) fringes are detectable as well.

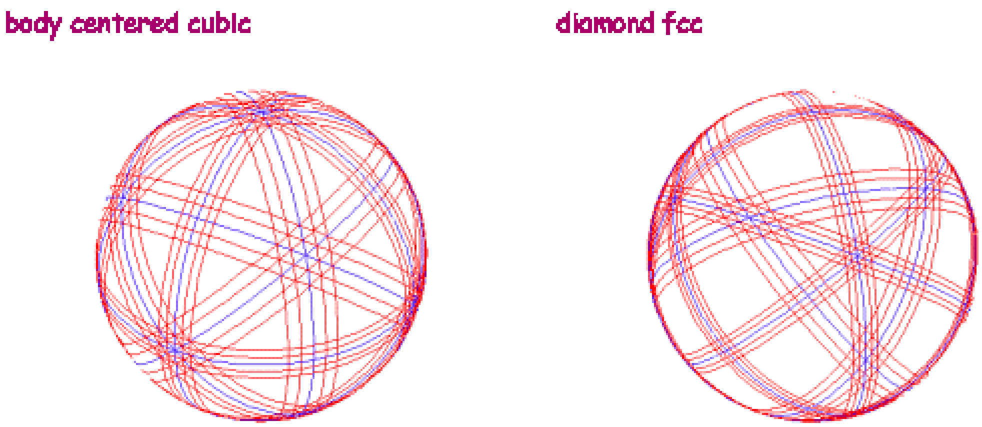

Figure 2: Tilt visibility maps of body centered cubic and diamond face centered cubic crystals, similarly oriented, for comparison to Figure 1.