Synthetic incoherence: Gaussian confinement of the mutual coherence function (Part A) and Dynamical diffraction: diffraction with energy loss in the plasmon regime of crystalline silicon (Part B)

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Part A. An incoherent signal is often desirable for imaging and tomography, but available sources in electron and synchrotron x-ray microscopy are often highly coherent. Here, I discuss theoretically a method to achieve a mutual coherence function with Gaussian confinement. The length scale of the region significantly different from zero is in the nanometer range for a typical application in transmission electron microscopy. Two schemes are presented: in one, a flood beam is scanned over the sample using a 2D rectilinear Gaussian pattern; in the other, a flood beam is scanned over the sample using "tapered-cone illumination", a term introduced here. Tapered-cone illumination is a 2D generalization of hollow-cone illumination in which the cone angle is varied and weighted with a Gaussian. Analytic and numerical results are given in all cases; the mutual coherence function in tapered cone illumination is seen to be much more confined that hollow-cone illumination, which has a 1/sqrt(R) tail, where R is the separation of the two points.

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Part B. Dynamical diffraction refers to the process of simultaneous energy loss and diffraction in transmission electron microscopy. In the present work, the classic formulation of Kohl and Rose is implemented numerically. A wave functions of a 50 keV electron entering and exiting a silicon crystal via the (111) face are found. The crystal potential is represented as a linear combination of Hartree-Fock atomic potentials. The incoming and outgoing electrons interact via the mixed dynamical form factor of the crystal, which, in turn, is given in terms of the nonlocal, energy-dependent dielectric function. The dielectric function is computed within the local-density functional formalism using the Random Phase Approximation. Figures are presented representing the diffraction patterns with energy losses of 10 eV to 25 eV in 2.5 eV steps, i.e., across the plasmon regime. If the incident beam is in the [111] direction, i.e., normal incidence, six-fold diffraction spots are predicted to be reasonably intense right at the plasmon energy, but much less intense away from the plasmon energy. For oblique incidence directions, lower symmetry diffraction patterns are predicted, with diffraction spots arising in a minority of cases.