Supplementary Information

One-dimensional “ghost imaging” in electron microscopy of inelastically scattered electrons.

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S1. Resolution considerations

In order to discuss the resolution of the ghost imaging we can use that for a given wavelength the confined modes of light have a generic form in the x,y plane of a Helmotz-like equation

$$\nabla_{\perp}{}^{2}\overline{E} = -K_{\perp}{}^{2}\overline{E}$$

The relation between the $K_{\perp}$ depends on the materials and on the dispersion curve.

Regardless of it we can write the confined state

$$E = E_0 \exp\left(ik_x x + ik_y y\right)$$

With $K_{\perp}{}^2 = k_x{}^2 + k_z{}^2$ for normally in plane propagating states $|k_{x,z}| < K_{\perp}$ however as in the 3D cases it is possible to consider evanescent waves e.g.

$$E = E_0 \exp\left(-k_x x + ik_y y\right)$$

If we imagine a geometry as the one introduced here the dark area is the electron injection and the wave cross a small square particle and reach the bucket detector on the right.

We consider for simplicity a near “planar” geometry in 2D In absence of the object none of the evanescent wave would have a reasonable superposition to the backward propagating wave the E_{REV} .

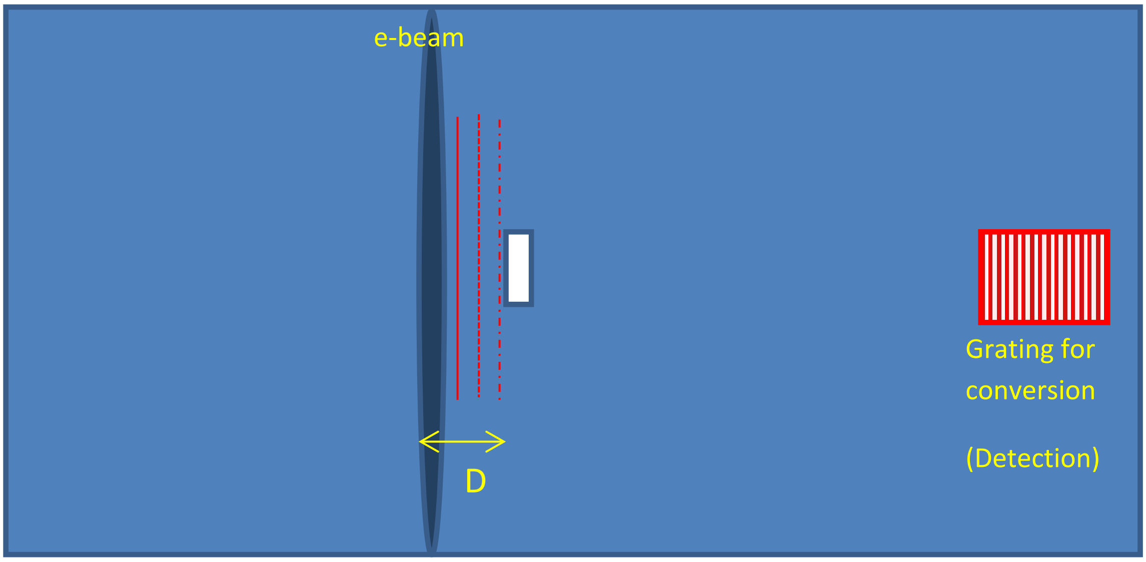

Figure S1. Scheme of how the joint measurement can use evanescent waves to obtain deep sub SPP-wavelength resolution. The SPP evanescent component are transformed by the object at a distance D into propagating waves and enter (through the grating) in the joint measurement process. The closest is D the easiest is the transfer of these high frequencies.

However the small object produces an approximatively multiplicative perturbation V that can be written in Fourier components $= \int V_g \exp(igy) dg$. The exchange of momentum with the object

$$k_y \rightarrow k_y + g$$

leads from an evanescent to a propagating wave that yields a reasonable superposition integral to the E_{REV} and therefore in the coincidence intensity. Therefore even the lengths smaller than 1/K can be give a contribution to the image as they scatter trough the evanescent waves from the beam.

In this process the leading parameter is the distance D between the injection and the object. It determines a dumping of the wave before they are converted into propagating wave.

A very rough approximation of the y-frequency modulation function is

$$H(k_y) = \begin{cases} 1 \; for \; |k_y| < |K| \\ \exp\left(-\sqrt{|K^2 - {k_y}^2|}\, D\right) otherwise \end{cases}$$

D therefore determines the cut-off frequency of the ghost imaging system.

In order to improve the resolution D can be strongly reduced potentially to few nm but care must be taken to avoid that the tail of the electron beam produce a direct damage. For this reason the resolution and D must be set within a range of 10-20nm and inverse method can be further used to push the resolution.