Vector Potential Photoelectron Microscopy: Short overview.

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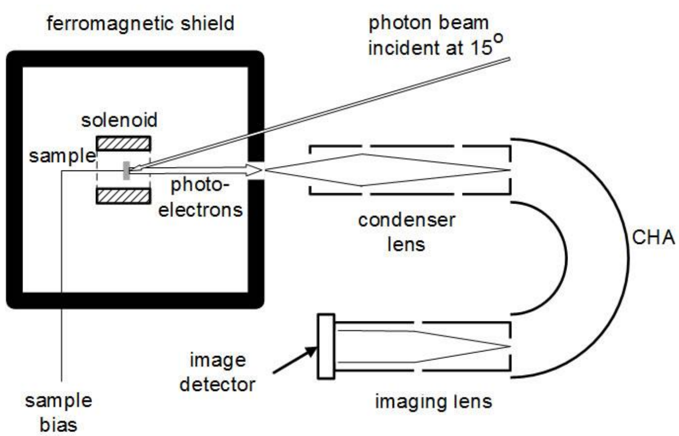
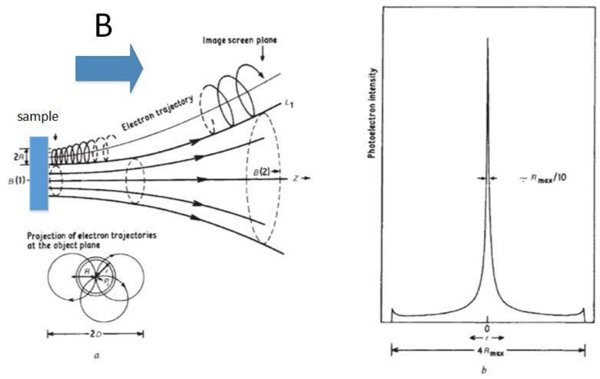
A superconducting magnet (a solenoid) with a uniform field region sits inside a ferromagnetic shield (a mild steel box) that has an aperture in it. The uniform magnet field is in fact created by the quantum mechanical vector potential field of the rotating current in the solenoid, and it is the vector potential that we use. The vector potential field from a uniform magnetic field is a circularly symmetric two dimensional vector field. The field has momentum derived from the electrons moving in the solenoid. We can use the two dimensional vector field as a spatially resolved reference for image formation.



The sample sits in the middle of the vector potential field (the middle of the solenoid), and is irradiated with photons. Photoelectrons are emitted into the field, and travel down magnetic field lines to an aperture in a ferromagnetic shield where the field is terminated. The electron momentum from the vector potential field is conserved when the field is terminated, and the photoelectrons diverge into an angular image. The resultant angular photoelectron image is energy analyzed using a concentric hemispherical analyzer (CHA). The energy analyzed angular image is projected onto an image plane detector using electrostatic lenses.

The action of the magnetic field in directing the electrons is shown in the diagram below. As can be seen the cyclotron orbits of the electrons form a complex distribution at the end of their travel in the field. This shape, the point spread function (PSF), is very peaked in the center but with wide wings that reduce the edge spatial resolution.



The test edge 20-80% spatial resolution is $3\sqrt{E/B}$ microns, where E is the photoelectron energy in electron volts, and B is the magnetic field in Tesla, but a much higher resolution can be obtained by image deconvolution.

A very high effective depth of focus results from the vector potential being a cylindrical shape along the magnet axis. In the case of the present instrument the depth of focus is very large, of the order of millimeters. The energy of the imaged photoelectrons is changed by biasing the sample. In the strong part of the field, photoelectrons from the sample can be accelerated, and decelerated without distorting the image, or altering the magnification. The electrostatic focusing, and energy analysis is set to a fixed energy so that the transmission, and the magnification of the electrostatic optical system is also constant. The energy of the imaged electrons can be changed by simply biasing the sample. Because they are entrained along the magnetic field lines while being accelerated very low energy electrons can be imaged. The advantage of very low energy electrons for imaging with VPPEM is they have the highest spatial resolution.