Imaging Basics

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Imaging systems typically consist of

- a source of illumination,
- a specimen,
- the image forming system, and
- the image.

In the most familiar case the illumination is incoherent, the imaging system is some form of a lens, and a real image is formed on some detector, which may be a screen, or a detector, such as the retina of the eye.

In elementary optics one nevertheless treats plane or spherical waves incident on an object, and these are examples of coherent illumination. They give rise to interference and diffraction. While coherent illumination can give rise to speckle and other undesirable effects in imaging systems, it makes possible the following forms of imaging:

1/ Scanning microscopy, where the highest resolution is obtained when the probe-forming optic is coherently illuminated.

2/ Holography, where image formation takes place in two steps: A hologram is recorded, encoding the phase of the wave in the form of an interference pattern between the object-wave and a coherent reference wave. This hologram is then re-illuminated (in an optical set-up, or by computation) with another coherent wave to recover the image.

3/ Diffraction microscopy, where only the diffracted intensity is recorded. To create an image, the phase needs to be inferred from some form of additional information. Examples of additional information that have been used to recover the image are

- the specimen is isolated, the space around it is empty
- diffraction patterns are recorded at more than one distance from the specimen (transport of intensity)
- diffraction patterns are recorded from overlapping areas of the specimen (ptychography)

The image is generally reconstructed from the information available by computation, using iterative algorithms.