2 Some Common Terms and Definitions

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Abstract. This chapter presents a number of terms and definitions that are common to the instruments presented in Chap. 5 to Chap. 12. The most common forms of optical aberration are described followed by a discussion of microscope objective lenses. The concepts of magnification, numerical aperture, lateral resolution, spot size and depth of field are discussed in limited detail to allow the reader to use them throughout the rest of the book.

2.1 Introduction

This chapter will present some terms and definitions that are common to many optical instruments that measure surface texture. It is assumed that the reader has a basic knowledge of geometrical and physical optics. There are several good texts on basic optics that can be consulted where necessary (see for example, Born and Wolf 1997, Hecht 2003). The chapters in this book that describe the instruments will present their associated basic theory, but there are some concepts that are common to most instruments. For example, many of the instruments use objective lenses that are common to the simple compound microscope (see Murphy 2001).

2.2 The Principal Aberrations

Aberrations are departures of the performance of an optical system from the predictions of paraxial optics (Welford 1986). Aberration leads to blurring of the image produced by an image-forming optical system. It occurs when light from one point of an object after transmission through the system does not converge into (or does not diverge from) a single point. Most optical instruments need to correct their optical components to compensate for aberration.

Most of the optical components in microscope-based instruments have spherical surfaces that can lead to a number of aberrations. These aberrations are corrected by the use of further optical components or systems, examples of which include compound lenses, elements with different refractive indexes, aspherical lenses and tube lenses. It is impossible to remove all aberrations, and many of the
correcting components can also introduce further aberration, so optical design is always a compromise. This leads to a large array of different objective lenses.

The principal aberrations of lenses are briefly described below:

Chromatic aberration – This aberration, sometimes referred to as chromatism, is caused by a lens refracting light of different wavelengths by differing amounts (see Fig. 2.1). This causes blur in the image and, since each wavelength is focused at a different distance from the lens, there is also a difference in magnification for different colours. To compensate for chromatic aberration, compound lenses are made from glasses with different dispersion properties.

![Fig. 2.1 Effect of chromatic aberration](image)

Sperical aberration – This aberration occurs due to the increased refraction of light rays when they strike a lens (or a reflection of light rays from a mirror) near its edge, in comparison with those that strike nearer the centre. Hence there is not a well-defined focal spot for a point source and the sharpness of an image is affected. To compensate for spherical aberration, a compound lens can be used with concave and convex geometries of differing thicknesses.

Comatic aberration – This aberration, usually referred to as simply coma, is inherent to certain optical designs or due to imperfection in the lens, or other components which results in off-axis point sources appearing distorted. Coma causes a point object to appear as a comet with the tail extending towards the periphery of the field. Correction for coma is made to accommodate the diameter of the object field for a given lens.