2.2: Limitations

Before describing the convergence method, I would say a few words about image formation – words that are equally valid whether you choose to use the convergence method or to stick to conventional equations such as Equation 2.1.1.

We are assuming that a lens or mirror will form a point image of a point object, and that a parallel beam entering a lens will come to a point focus. You are probably aware – even if unfamiliar with all the fine details – that this is not exactly so, and you will be aware that if the diameter of a lens or mirror is comparable to its focal length or to the object or image distance, light will not come to a focus at a point, but the image will suffer from *spherical aberration*. Also, if the angular size of the object or image is large, so that light enters or leaves a lens or mirror at a large angle, additional aberrations such as *coma* and *astigmatism* appear. (It is not always realized that both spherical aberration and astigmatism also occur with refraction at a *plane* interface; neither are phenomena associated solely with curved refractive interfaces or curved reflective surfaces.) Although angles in this chapter are assumed to be small, I shall rarely draw them as small, because to do so would make for very cramped drawings.

In this chapter, I am going to ignore lens and mirror aberrations. I may possibly prepare a separate chapter on lens and mirror aberrations sometime, but that is not the topic of the present chapter. Thus, in this chapter, I am going to assume that all angles are *small*. How small depends on how large an aberration we are prepared to tolerate. Generally it means that I shall be satisfied with the approximation $\sin x = \tan x = x$. This approximation is known as the *paraxial* approximation. It means that none of the light rays make very large angles with the axis of the optical system.

You will also be aware that the refractive index varies with wavelength, and as a result lenses are affected by *chromatic aberration*. This, too, I shall ignore, except for a brief foray in Section 2.9, and if I say that the refractive index of a lens (or rather of the glass of which it is made) is 1.5, I am referring to a particular wavelength or color.

Initially, I shall also make the approximation that lenses are thin. That is to say, I assume that I can neglect the thickness of the lens compared with its focal length or with the object or image distance. However, in Section 2.11, I shall relax this restriction, and I shall deal with “thick” lenses.