PARABOLIC MIRRORS

You have probably noticed that certain rays in ray diagrams do not intersect exactly at the image point. This occurs especially with rays that reflect at the mirror's surface far from the principal axis. The situation also occurs with real light rays and real spherical mirrors.

If light rays from an object are near the principal axis, all of the reflected rays pass through the image point. Rays that reflect at points on the mirror far from the principal axis converge at slightly different points on the principal axis, as shown in **Figure 14.** This produces a blurred image. This effect, called *spherical aberration,* is present to some extent in any spherical mirror.

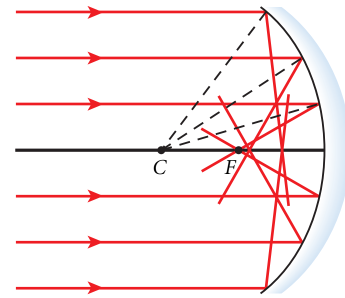

Figure 14
Spherical aberration occurs when parallel rays far from the principal axis converge away from the mirror's focal point.

Parabolic mirrors eliminate spherical aberration

A simple way to reduce the effect of spherical aberration is to use a mirror with a small diameter; that way, the rays are never far from the principal axis. If the mirror is large to begin with, shielding its outer portion will limit how much of the mirror is used and thus will accomplish the same effect. However, many concave mirrors, such as those used in astronomical telescopes, are made large so that they will collect a large amount of light. An alternative approach is to use a mirror that is not a segment of a sphere but still focuses light rays in a manner similar to a small spherical concave mirror. This is accomplished with a parabolic mirror.

Parabolic mirrors are segments of a paraboloid (a three-dimensional parabola) whose inner surface is reflecting. All rays parallel to the principal axis converge at the focal point regardless of where on the mirror's surface the rays reflect. Thus, a real image forms without spherical aberration, as illustrated in **Figure 15.** Similarly, light rays from an object at the focal point of a parabolic mirror will be reflected from the mirror in parallel rays. Parabolic reflectors are ideal for flashlights and automobile headlights. (Spherical mirrors are extensively used because they are easier to manufacture than parabolic mirrors, and thus are less expensive.)

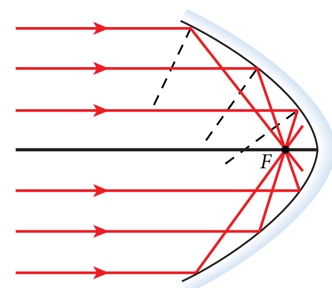

Figure 15
All parallel rays converge at a parabolic mirror's focal point. The curvature in this figure is much greater than it is in real parabolic mirrors.

Reflecting telescopes use parabolic mirrors

A telescope permits you to view distant objects, whether they are buildings a few kilometers away or galaxies that are millions of light-years from Earth. Not all telescopes are intended for visible light. Because all electromagnetic radiation obeys the law of reflection, parabolic surfaces can be constructed to reflect and focus electromagnetic radiation of different wavelengths. For instance, a radio telescope consists of a large metal parabolic surface that reflects radio waves in order to receive radio signals from objects in space.

There are two types of telescopes that use visible light. One type, called a *refracting telescope,* uses a combination of lenses to form an image. The other kind uses a curved mirror and small lenses to form an image. This type of telescope is called a *reflecting telescope.*