The Otter Creek Astronomical Observatory

The Observer

February 2007 (#7)

On July 1, 2006 the observatory closed for overhaul and installation of new equipment. We are removing our 10-inch Meade SCT and its mount and replacing it with a large refracting telescope with a custom-fabricated mount. We will also be installing new computer equipment. The observatory re-opened for Daytime (Solar) programs in October 2006. Night programs will not be offered while the work continues. This is being done both for the safety of our visitors and for the safety of equipment which may currently be partially installed or sealed against dust.

Upcoming Observatory Programs

February 10, 2007 – 11:00 am – 1:00 pm EST
March 10, 2007 – 11:00 am – 1:00 pm EST
April 14, 2007 – 11:00 am – 1:00 pm EDT
May 12, 2007 – 11:00 am – 1:00 pm EDT

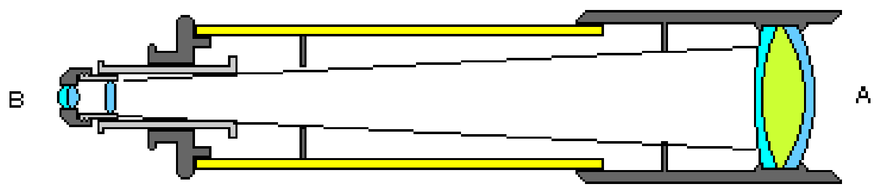
Daytime programs are held "rain or shine"--the observatory is open regardless of weather.

Visit the Otter Creek Observatory web page at

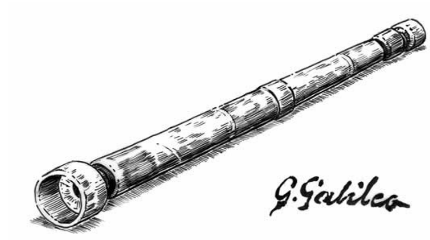
www.ottercreekpark.org

Since the Otter Creek Observatory is being renovated, this might be a good time to talk about telescope design. The thrust of our current renovation progress is really ‘retro’ in that we are incorporating a traditional instrument design by adopting a high-quality, long-focus refractor in our equipment suite. Come with us as we take a brief tour of some of the various types of telescopes to get an overview of the variety of instruments used to process light as it comes to us from space.

Telescopes are instruments that process light signals from the Sun, Moon, and planets and of course, from the stars themselves. The first telescopes were “refractors” -- telescopes that process light by refracting (bending) it with lenses. All refractors have the basic design shown below -- the telescope design that most people probably think of when they think “telescope”. The “objective lens”, A, receives the light transmitted from

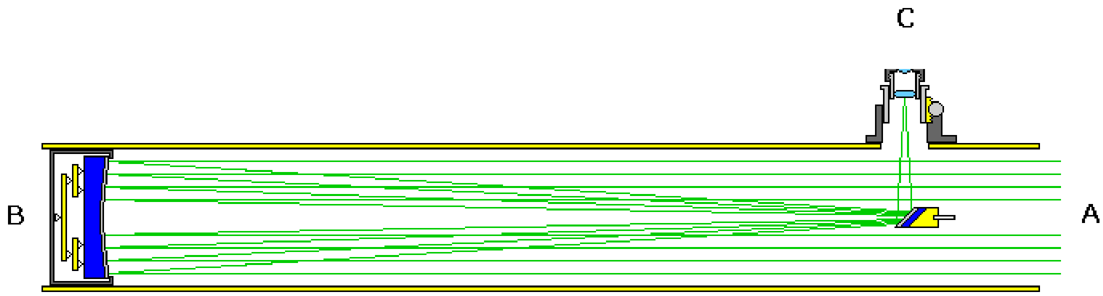


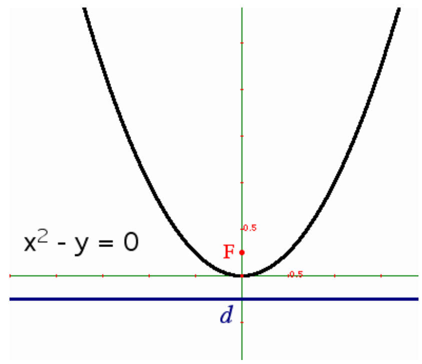
a source like a planet, star or some terrestrial object like a tree. The image is focused to an “eyepiece lens”, B. The eyepiece brings the image to a final focus where an observer can actually see the object that the telescope is pointed toward. Galileo was one of the first to use such an instrument to observe the Moon and Jupiter and its satellites. The refractor was developed because of eyeglasses! Eyeglasses use a lens to bend light so as to improve people’s vision. Around the time of Galileo people discovered that the lenses used in eyeglasses could be combined to produce a device that would make objects appear closer -- the device which we now call a refracting telescope.



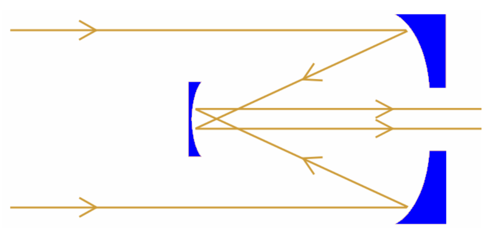
Refractors have the nice feature that little light is lost in the process of refraction. One big problem with refractors used to be color distortions, so that red and blue fringes would appear around objects giving a false impression of the true colors of the object. Opticians improved the quality of objectives over time. Today, very high-quality objectives, called apochromatic lenses, are routinely engineered. They are considered by some to be as near to telescope perfection as one can get. The downside to these lenses is that they are quite expensive.

Another big development in telescope design came during the 17th century with the notion of taking light and reflecting it to a focus with a mirror rather than refracting it with a lens. In this design the light enters an open tube at A as shown below, passes through the tube to a concave mirror, called the “primary” mirror, at B. The mirror then does the job of focusing the light rays to a flat “secondary” mirror which bounces the rays at a 90 degree angle up to an eyepiece at C. An observer looks down through the eyepiece and sees the image.



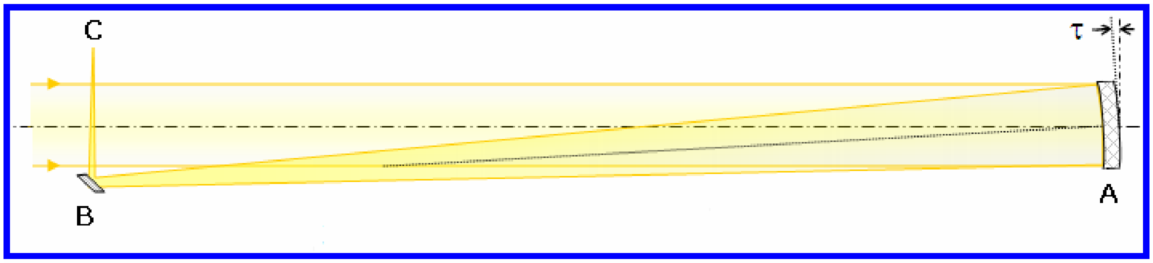


The curve of a reflector’s mirror is similar to the curve of satellite TV dishes. The principle of focusing radiation this way is the same for both. The mathematics and design is fairly simple. In fact, if you have ever taken an algebra course, you probably had to suffer through graphing a parabola like this one. The curve of the mirror in a modern reflector is a parabola -- albeit not as deep as this parabola shown. Isaac Newton, who invented the reflector, actually used a telescope (pictured at left) in which the curve of the mirror was just a segment of a simple circle. However, the parabolic shape produces better images than does the simple circular (or “spherical”) shape. This earliest type of reflector is called a “Newtonian” reflector.



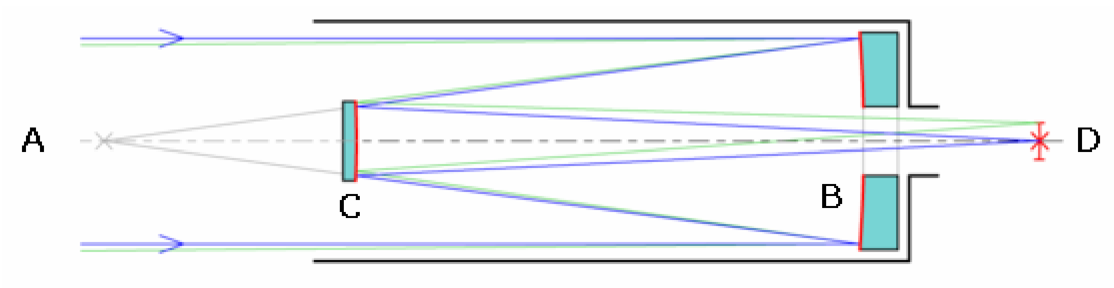
Another early reflector design was the “Gregorian” design, in which the secondary mirror was concave and reflected light back through a hole in the primary mirror. The early reflectors caused a stir because their tubes were noticeably shorter than refractors of the same aperture (width) while providing reasonably good images, and shorter telescopes were easier to handle.

From this point, we begin to see an ever widening diversification of types of reflecting telescopes. For one, during the eighteenth century, Sir William Herschel experimented with the existing design of the reflector to modify the location of the secondary mirror. In the Newtonian and Gregorian designs this mirror is actually located directly in the path of incoming light. In what became known as the “Herschelian” type reflector, the primary mirror, A, would be tilted at a slight angle (τ) and the secondary mirror, B,

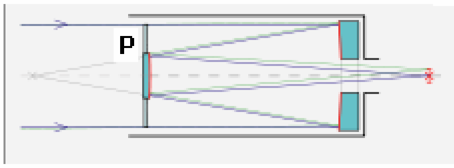


was removed further to the side of the telescope out of the path of the incoming light. This design is the first example of what has become known as “off-axis” reflectors, so-named because such telescopes reflect their light askew with respect to the optical axis of a traditional Newtonian reflector. It is also an “unobstructed” reflector because the light path is not obstructed by the secondary mirror.

Yet another design took the light path through the primary mirror in a manner somewhat like the Gregorian. This form, known as the “Cassegrain” reflector, bounces incoming light off the concave primary mirror at B, as before. But now, the light is returned back via a convex secondary mirror at C, to pass back through the primary via a hole. An eyepiece at D focuses the image for viewing.

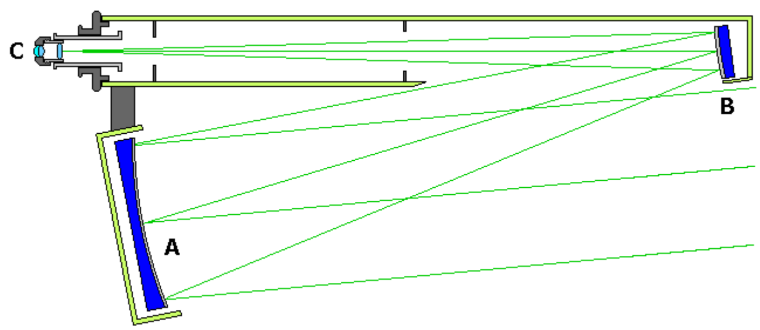


The Cassegrain had the advantage that it duplicated the long focal length (the distance the light travels between the mirror and the focus) of refractors without the long tube that was necessary for refractors. Long focal lengths are good for producing high magnifications desirable for viewing the planets, moon, and close groupings of stars. Unfortunately, there were image distortions that needed to be remedied, but this instrument led to a line of designs called folded-optic reflectors, because as the name implies, the light path is folded back on itself.



Two main variants of the Cassegrain design were developed to deal with image distortions in different ways. One design, called the Schmidt-Cassegrain has been widely popularized by telescope manufacturers like Celestron and Meade. This design uses a special corrector plate (P) on the incoming light to correct for distortions. The secondary mirror is attached on the back side of the corrector plate. A similar design called the Maksutov employs a more curved corrector plate and a spherical primary mirror. Other designs involve the same basic concepts but again, modify the type of curvature of the primary and secondary mirror and the type of correcting plates used. Such designs are all known as “catadioptric” -- a term applied to instruments which employ both lenses and mirrors. Continuing in this vein, Maksutov’s designs were coupled with the classical Cassegrain to produce a Maksutov-Cassegrain and also with a traditional Newtonian to produce a Maksutov-Newtonian. Essentially, the difference between these types of catadioptrics and those involving the Schmidt designs are in the shape of the correcting plates.

A separate branch of instruments uses two or more mirrors of different geometric configurations, such as elliptical or hyperbolic, in some combination. In this branch some very unusual designs have evolved. Among these are the schiefspieglers, which in German means a “skewed” or “oblique” reflector design. Essentially, these variants go to sometimes great lengths to produce a reflector that is both compact and unobstructed. One such design is shown below.



Well, we have taken a quick, although by no means exhaustive, tour of the development of some telescope designs. Each new design presented advances in solving problems of some preceding type, but usually requiring some additional expense or tradeoff. When the observatory’s renovation is complete, Otter Creek Observatory will feature telescopes of both the refractor and Schmidt-Cassegrain designs. We hope you will come see them.