OAOG

June & July 2006

The Royal Observatory - Greenwich England

Your sister group the “Greater Sudbury Amateur Astronomers” hosted what we believe was our best attended FBSP ever! There were at least 45 people gathered at the Beaver Lodge for the buffet on Saturday. We couldn't do a group photo, there were too many people to try and organize, so we took several images of groups of people, and I will be putting them up on our discussion group site over the next few weeks.
(sudburydeepskygroup@yahhogroups.com)

The weather did cooperate for one night and a few of us went on a tour of scopes. I loved Pierre's PortaBall. The rotatable tube is a plus for me. Pierre was able to adjust the tube for my height very quickly, then re-adjust for a taller person. I'm definately going to check the website! The view of Jupiter was breathtaking. I forget the magnification, but we could see the GRS and also its little brother- both quite visible on the eastern limb of the planet, slightly north of the equator (as viewed through a reflector scope). This was the first time I had seen the red spot, never mind its little brother.

A group of us went over to Mike's MallinCam set up, to check out the live views. There were a lot of ooh's and aaah's of course. This was a first for several people, so they were suitably "blown away" with how the object develops on the screen. Donna Bonnett and I have had a few opportunities to observe this, since we've been to Ottowa a couple of times. We even spent some time at Rock's observatory and had a chance to do some observing in colour! All I can say is....WOW!

Pierre entertained us after the dinner on Saturday with a beautiful fireworks display for the enjoyment of all. It certainly was appreciated, you really know how to set up for the best effects, Pierre.

The "Potluck" on Friday night was superb. Even although no one knows what anyone is bringing, there is always enough variety that we meet all the food groups! I must say I was impressed with the number of desserts though. Astronomers have sweet tooths I think :).

Mike made a few of us breakfast on Sunday morning before he left...scrambled eggs and peameal bacon...yummy.

I managed to capture NGC 3422, a beautiful face on spiral in Leo Minor with a couple of Milky Way stars in front of it. It looked just like the drawing in Night Sky Observer. That's number 46 on my list of 110 for the RASC NGC certificate, so I was happy with that.

There were several big Obsessions in the field this year, which I was quite pleased to see. If you want an "aperture hit", you can climb the ladder and get your fill. My observation is that there must be more people willing to invest in these big guys. Either that, or the financial arrangements are easier..haha. However, we've had Brian's "gentle Ben" for years. This is the first year where there were three or four of these big guys instead of just one.

That's it folks, see you in the fall hopefully.

Lynn Chetwynd, Volunteer coordinator for the Sudbury Amateur Astronomers group.

Telescope Types

By: Andre Tremblay

There are three basic types of telescopes:

1) Refractors
2) Reflectors
3) Catadioptric or combined lens-mirror systems:
   - and these are divided into subgroups.Catadioptrics are a combination of a refractor and reflector telescope, using both mirrors and lens to focus the incoming light. There are two popular catadioptrics designs: the Schmidt-Cassegrain and the Maksutov-Cassegrain; both are similarly designed.

They all have their different advantages and disadvantages and they are used in different areas of astronomy.

Short History of the Telescope

Galileo and his Refractive Telescope
Newtons Reflective Telescope

For thousands of years men and women sought to discover the mysteries of the night sky, but the quantum leap from naked-eye observation to instrument added vision was one of the great technological advances of mankind. It began with the lens. It's origin is unknown, but spectacles were being worn in Italy as early as 1300. The inventor was probably making glass disks for leaded windows; he probably tested the clarity of a disk by looking through it and discovered that he could see better.

Lippershey

The telescope was the first optical instrument and its origin is surrounded by controversy. The most likely story puts it in the shop of an obscure Dutch spectacle maker named Hans Lippershey, about 1600. Two children were playing with his lens, put two together, peered through them at a distant church tower and saw it wonderfully magnified. Lippershey looked for himself and soon mounted lenses together, creating his "looker." In 1608, Lippershey tried to sell it to the

Dutch army, but his offer was eventually turned down because of claims from others that they had invented it. New of the invention spread rapidly. That same year the French ambassador at the Hague obtained one for King Henry IV, and in the next year, they were being sold in Paris and Germany under the name of "Dutch Trunks," "perspectives" and "cylinders." They soon appeared in Milan, and Venice and by end of the year, they were being made in London.

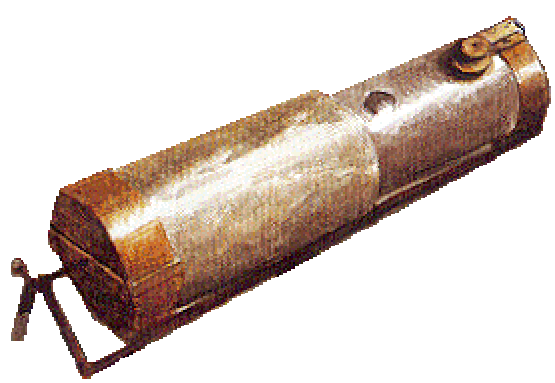
Galileo

The most influential person connected with the telescope in its early days was the Italian scientist Galileo. Within a month of Lippershey trying to sell his looker to the Dutch Army, word of the invention reached Venice when an unidentified stranger tried to sell one to the Senate, who referred the matter to its scientific adviser Paolo Sarpi, who examined it. But then the stranger and his instrument disappeared, so Sarpi went to see Galileo, the city's most respected instrument maker, who had just invented a new calculating device and described it. Galileo then "reinvented" it. The instrument was met with criticism and controversy as many felt that it did nothing other than create optical illusions and the image could not be trusted. In March of 1610, he published a description of his night sky observations as *The Starry Messenger (Sidereus Nuncius)*,. Although it contained only twenty four pages, it astonished and troubled the learned world. He reported that the moon was not smooth, as previously believed, but rather rough and covered with craters; that the Milky Way was composed of millions of stars and Jupiter had four moons. The latter led him to challenge the long accepted geocentric view of the world system (the universe revolves around the Earth) and accept the heliocentric (the solar system revolves around the Sun) proposed some fifty years earlier by Copernicus. Galileo had proof!

On the night of April 14, 1611, a banquet was held in his honor outside Rome. Galileo showed the guests his instrument and let them see his discovered. An unidentified Greek poet-theologian happened to be present and he proposed a name for the instrument, one borrowed from ancient Greece. It was quickly accepted and the host, Federico Cesi, then officially christened Galileo's instrument, "the telescope."

These first optical instruments were what the average person identifies with the word "telescope," a long thin tube where light passes in a straight line from aperture (the front objective lens) to the eyepiece at the opposite end of the tube. These have come to be called refractive telescopes, because the objective lens bends, or refracts, light. They were used by all the great early astronomers - Galileo, Kepler, Huygens, and Hevelius.

Newton



Some seventy years later, Isaac Newton, inspired by Kepler's work on optics and Robert Boyle's recent experiments with color, explored the way a prism refracts white light into a array of colors. He recognized that a lens was a circular prism and concluded that the separation of colors, known as chromatic aberration (see below) limited the effectiveness of existing telescopes. He created a new telescope design, one that used a parabolic mirror to collect light and concentrate the image before it was presented to the eyepiece. This resulted in the Reflective Telescope.

In optics, an image-forming optical system is a system capable of being used for imaging.

The two traditional sytems are mirror-systems (catoptrics) and lens-systems (dioptrics), although in the late twentieth century, optical fiber was introduced.

Isaac Newton is reported to have designed what he called a catadioptrical phantasmagoria, which can be interpreted to mean an elaborate structure of both mirrors and lenses.

Catoptrics and dioptrics have a focal point, whilst optical fiber transfers an image from one plane to another without an optical focus.

Catoptrics and optical fiber have no chromatic aberration, whilst dioptrics need to have this error corrected. Isaac Newton believed that such correction was impossible, because he thought the path of the light depended only on its color.

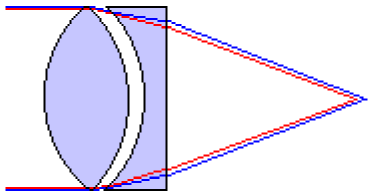
In 1757 John Dollond was able to create an achromatised dioptric, which was the forerunner of the lenses used in all popular photographic equipment today.

Refractors (Dioptrics)

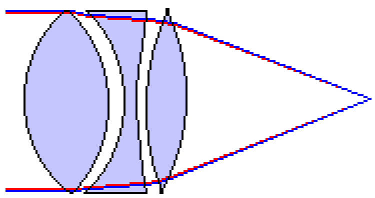
Dioptrics are simple telescopes using two convex lenses. The first lens has a longer focal length and is bigger in aperture. The second lens has a shorter focal length and serves as an eyepiece. The image focused by the first lens converges at the focal point and then is enlarged by the eyepiece. Focusing is achieved by adjusting the distance between eyepiece and point at which the image is formed.

A refracting or refractor telescope is a type of optical telescope that refracts or bends light at each end using lenses. This refraction causes parallel light rays to converge at a focal point; while those which were not parallel converge upon a focal plane. This can enable a user to view the image of a distant object as if it were brighter,
clearer, and/or larger. These are similar to microscopes. The monocular is a type of refractor. A typical refractor has two lenses, an objective lens and an eyepiece lens. The objective lens has two pieces of glass (with different dispersion), "crown" and "flint glass". Each side of each piece is ground and polished, and then the two pieces are -sometimes- glued together. The curvatures are designed to limit the effects of chromatic and spherical aberration.

Achromatic refractors use two lens elements to help minimize chromatic aberration, an optical effect which causes differing wavelengths of light to focus at different points.



Apochromatic refractors (often called "apos") use three or more lens elements, one or more having special properties, to eliminate chromatic aberration entirely.



Achromatic Refractor

Celestron C6-RGT

Uses a lens composed usually of two separate lenses, a convex and concave, of substances having different refractive and dispersive powers, as crown and flint glass, with the curvatures so adjusted that the chromatic aberration produced by the one is corrected by other, and light emerges from the compound lens undecomposed.

Apochromatic Refractor

TOA-130 by Takahashi©

An apochromat, or apo lens, is a photographic or other lens that has a high degree of color correction. Chromatic aberration is the phenomenon of different colors focusing at different distances from a lens. In photography, it leads to fuzzy images, and to color fringes at high-contrast edges, like an edge between black and white.

Astronomers face similar problems, particularly with telescopes that use lenses rather than mirrors. General purpose photographic lenses are corrected to bring two wavelengths (red and blue) into critical focus in the same plane.

Apochromatic lenses are designed to bring three wavelengths (red, green, and blue) into focus. They also generally correct for spherical aberration at two wavelengths, rather than one as in an achromat. Graphic arts process (copy) cameras generally use APO lenses for this reason. Classically designed process or APO view camera lenses generally have a maximum aperture limited to f/9. Recently high speed APO lenses have been produced for medium format, digital and 35 mm cameras.

Optical engineers can design lenses that bring several colors to a focus at the same distance from the lens. Such lenses can be apochromatic, and can give sharper images than uncorrected optics. However, it requires extra pieces of glass in the optical path, and additional kinds of glass. This makes apochromatic lenses heavier and more expensive than their uncorrected counterparts.

Technical Difficulties

Refractors are criticized for their relatively high-degree of residual chromatic and spherical aberration. This affects shorter focal lengths more than longer ones. A 4" F6 achromatic refractor is likely to show considerable color fringing. (generally a purple halo around bright objects) A 4" F16 will have little color fringing.

In very large apertures, there is also a problem of lens sagging, a result of gravity deforming glass. There is a further problem of glass defects, striae or small air bubbles trapped within the glass. In addition, glass is opaque to certain wavelengths, and even visible light is dimmed by reflection and absorption when it crosses the air-glass interfaces and passes through the glass itself. Most -or all- these problems are avoided by using reflecting telescopes, that can be made in far larger apertures.

However, modern designs using apochromatic optics built with special, extra low-dispersion materials essentially eliminate these problems. Such telescopes contain elements of fluorite or special, extra low-dispersion (ED) glass in the objective and produce a very crisp image which is virtually free of chromatic aberration. Such telescopes are sold in the high-end amateur telescope market. Apochromatic refractors are available with objectives of up to 553mm in diameter, but most are between 80 and 152mm.

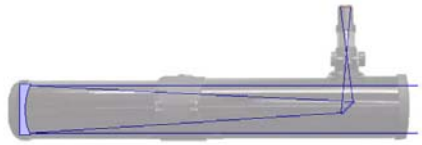
PROS:

- Erect image (right-side up) allows terrestrial use
- No collimation required
- Apochromatic refractors give best possible image quality
- Apochromatic refractors are excellent for photography

CONS:

- Easily available only in small sizes (less than 8" aperture)
- Physically longer than equal-aperture Schmidt-Cassegrain
- Most expensive per inch of aperture (especially apos)
- Achromatic refractors not well suited to photography

Reflectors (Catoptrics)



Newtonian telescopes use a curved mirror to focus incoming light to a second, flat mirror which directs the light to a convenient viewing position on the side of the telescope.

Looking down into the optical tube of a Newtonian you can see the large parabolic reflecting mirror at the bottom which sends light up to the "secondary mirror" located on the stalk sticking into the tube from the left.

Newtonian

The Newtonian telescope is a type of reflecting telescope invented by the British scientist Sir Isaac Newton (1643-1727), using a parabolic primary mirror and a flat diagonal secondary mirror.

Advantages of the Newtonian Design

Newtonians are usually less expensive for any given aperture than comparable quality telescopes of other types.

A high quality primary mirror can be made by hand by amateur astronomers

A short focal length can be obtained, leading to wide field, bright views.

Long focal length Newtonian telescopes can give excellent planetary views.

There is no chromatic aberration caused by lenses as in a refractor

The eyepiece is at the top end of the telescope, allowing for a shorter and more stable mount.

The heavy primary mirror is at the bottom allowing for large portable scopes. Dobsonian mounted Newtonians can have a 40" primary mirror.

Collimation is relatively easy.

Disadvantages of the Newtonian Design

Newtonians have coma, which is blurring of images away from the optical center. This problem is worse the shorter the focal length. Newtonians with a focal length of f/6 or higher are considered to have little to no coma.

Newtonians of a focal length of less than f/4 are often considered to have too much coma.

Newtonians have a central obstruction due to the secondary mirror in the light path. This obstruction and the diffraction spikes caused by the support structure (called the spider) of the secondary mirror reduces contrast.

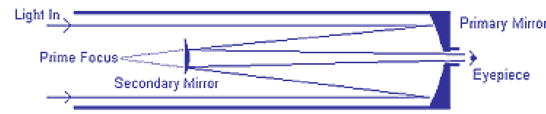
Visually, these effects can be eliminated by using a two or three-legged curved spider. Although a four-legged spider causes less diffraction than a three-legged curved spider, the three-legged curved spider often gives a more aesthetically pleasing view.

Gregorian Reflector

The form of reflecting telescope suggested by James Gregory (1638-1675) predates the familiar form of reflector which Isaac Newton (1642-1727) first designed and made in 1668. The problem with the reflecting telescope is how to view the image formed by the primary mirror. With a single concave mirror, this image is formed on the optical axis, and the head of the observer then gets in the way. Newton solved the problem by using a small diagonal mirror to deflect the image to the side, where it may be viewed through the eyepiece.

Gregory's solution was to place a small, short focal length, concave mirror along the optical axis. The rays reflect back toward the primary mirror and pass through a small hole in its center. The resulting image is then viewed with the aid of the eyepiece.

Classical Cassegrain



Primary: Concave Paraboloid Secondary: Concave Ellipsoid	Spherical Aberration	None
	Coma	Moderate
	Astigmatism	Moderate
	Field Curvature	Moderate
	Focal Plane Tilt	None
	Chromatic Aberration	None

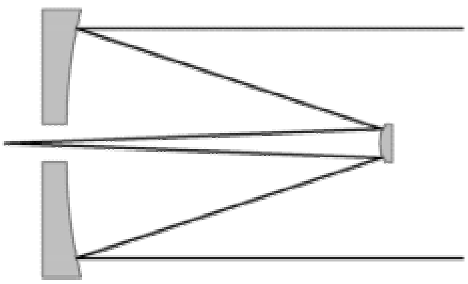
History

The Cassegrain Reflector is a combination of two mirrors used in some telescopes, which are then known as Cassegrain Telescopes. It is also used in very high gain radio antennas.

First developed in 1672 by Laurent Cassegrain, this reflector is a combination of a primary concave and a secondary convex mirror, both aligned symmetrically about the optical axis. The primary mirror usually contains a hole in the centre thus permitting the light to reach an eyepiece, a camera, or a light detector. The primary mirror is of paraboloid type, while the secondary mirror is of hyperboloid type.

Another descendent of the Cassegrain design is the Ritchey-Chrétien telescope, which uses a hyperboloid primary and secondary mirror, eliminating the corrector plate needed for the catadioptic telescopes. Most modern telescopes, including the Hubble Space Telescope, use the Ritchey-Chrétien design.

Dall-Kirkham



Primary: Concave Prolate Ellipsoid Secondary: Convex Sphere	Spherical Aberration	None to Slight
	Coma	Strong to Severe
	Astigmatism	Slight
	Field Curvature	Strong
	Focal Plane Tilt	None
	Chromatic Aberration	None

The Dall-Kirkham telescope design was created by Horace Dall in 1928 and took on the name in an article published in Scientific American in 1930 following discussion between amateur astronomer Allan Kirkham and Albert G. Ingalls, the magazine editor at the time. It uses an concave elliptical primary mirror and a convex spherical secondary. While this system is easier to grind than a Cassegrain or Ritchey-Chretien system, it does not correct for off-axis coma and field curvature so the image degrades quickly off-axis. Because this is less noticeable at longer focal ratios, Dall-Kirkhams are seldom faster than f/15.

Celestron produce a fast f/6.8 astrograph based on a modified Dall-Kirkham design which is said to address the off-axis coma problems of this design. Takahashi produce a folded Dall-Kirkham design called a Mewlon with apertures of 7" to 12" and focal ratios around f/12. Through the use of a field flattener they have achieved focal ratios as low as f/9.

Large liquid mirror telescope

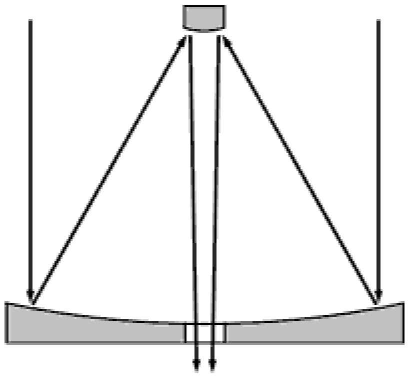
A liquid mirror telescope is a reflecting telescope whose primary mirror is a rotating pool of a reflective liquid, usually mercury.

Isaac Newton first realized that a rotating liquid forms a circular paraboloid and can therefore be used as a telescope, but he could not actually build one because he had no way to stabilize the speed of rotation (the electric motor did not exist yet).

The main advantage of using a liquid mirror is the cost. The University of British Columbia's 6-meter liquid mirror telescope cost about a fiftieth as much as a conventional telescope with a glass mirror.

Of course, because the shape of the liquid depends on gravity, the telescope can only point straight up. This is not actually as big a drawback as it sounds, because the part of the sky at the zenith changes with the season and time of day.

Ritchey-Chrétien



The Ritchey-Chrétien telescope or RCT is a specialized Cassegrain telescope with a hyperbolic primary and secondary mirror. It was invented in the early 1910s by American astronomer George Willis Ritchey (1864–1945) and French astronomer Henri Chrétien (1879–1956). Ritchey constructed the first successful RCT, which had a diameter of 0.5 metres, in 1927. The second RCT was a 1-metre instrument constructed by Ritchey for the United States Naval Observatory.

The Ritchey-Chrétien design is free of first-order coma and spherical aberration, although it does suffer from third-order coma, severe large-angle astigmatism, and comparatively severe field curvature (Rutten, 67). When focused midway between the sagittal and tangential focusing planes, stars are imaged as circles, making the RCT well suited for wide field and photographic observations. As with the other Cassegrain-configuration reflectors, the RCT has a very short optical tube assembly and compact design for a given focal length. The RCT offers good off-axis optical performance, but examples are relatively rare due to the high cost of hyperbolic primary mirror fabrication; Ritchey-Chrétien configurations are most commonly found on high-performance professional telescopes.

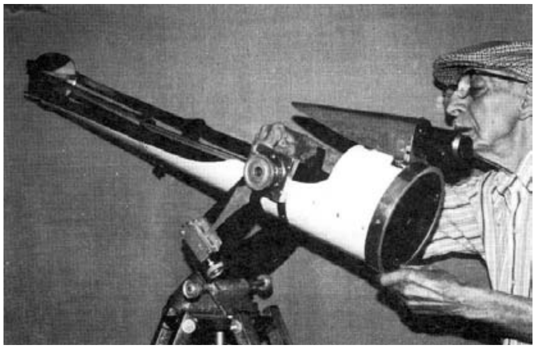
Schiefspiegler(Off Axis Reflector)

Conceived and brought forth in its modern form while Allied bombers dropped their deadly loads over Berlin, the Schiefspiegler, or leaning-mirror telescope, was the brainchild of the late Anton Kutter of Germany. Popular in Europe but much less so in the US, the Schiefspiegler resembles a Cassegrain of low amplification factor. The secondary is moved to one side so as not to shadow the primary mirror. Both mirrors are then tilted the right amount to produce a superb image of high contrast. The Schiefspiegler seems to be the most popular of the unobstructed reflecting telescopes.

Some Schiefspiegler variants are

- The **Kutter** system (the most widespread)
- The Yolo system

Yolo (Off Axis Reflector)



Named after a county in California, the Yolo was invented by Arthur S. Leonard of the University of California. It differs from a Schiefspiegler in that both mirrors are concave. The Yolo enjoys three advantages over the Schief with, (1) lower focal ratios possible, (2) lower image tilts, and (3) a more compact form. Its one major drawback probably accounts for so few Yolos built; it cannot correct for astigmatism without help. Three methods to do this have been successfully employed. Briefly, they are (1) the use of a warping harness, (2) polishing the correction into the secondary, and (3) adding a spectacle lens inside focus.

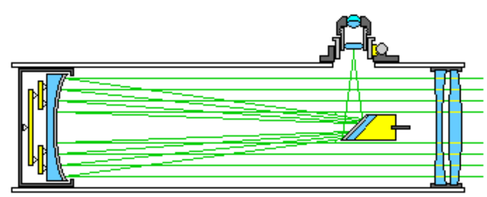
Write Schmidt Newtonian (Compound Reflector)

Schmidt-Newtonian (Compound Reflector)

A Schmidt-Newtonian uses a spherical primary and a corrector plate. Instead of using a convex secondary, a regular flat is used and the light is sent out like a regular Newtonian. This makes the system faster than an SCT.

Schalck- Newtonian (Compound Reflector)

Maksutov- Newtonian (Compound Reflector)



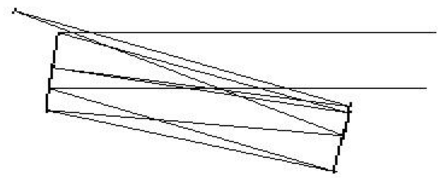
At first, this design looks like it offers the worst of both worlds; a doublet lens as the objective, and a mirror as well, so one is paying for the optics of both a Newtonian and a refractor. However, the main mirror is now spherical, not parabolic, and the corrector is made from two lenses both of plain crown glass, so one does not need to use flint glass. Also, even after this is recognized, it might be asked what advantage such a telescope has over a Maksutov-Newtonian, which requires just one corrector element, also with two spherical surfaces.

But for an amateur telescope maker, creating two corrector elements that are relatively thin lenses, rather than the steeply-curved meniscus of a Maksutov design, avoids the need to either work from a very thick piece of glass, and remove a lot of material, or somehow find a blank that has already been molded into an approximation of the desired shape.

In addition, the additional lens does allow an additional correction, for curvature of field. Remember, a Maksutov-Newtonian is essentially equivalent to the original Maksutov camera, which like the Schmidt camera avoids coma by being spherically symmetrical everywhere, including the surface on which the image is produced. As a result, a number of amateur astronomers have made themselves telescopes of this type, with focal ratios of f/5 or f/4. Of course, simple Newtonians with very fast focal ratios have been used as well, despite the coma, which can be corrected with commercial attachments at the eyepiece end of the telescope.

Tilted-Component Telescope

The tilted-component telescope (TCT) is a well-known approach to overcome the drawbacks originating from the central obstruction in conventional reflecting telescopes. In theory the image quality of a TCT can reach the physical limits for a given aperture.

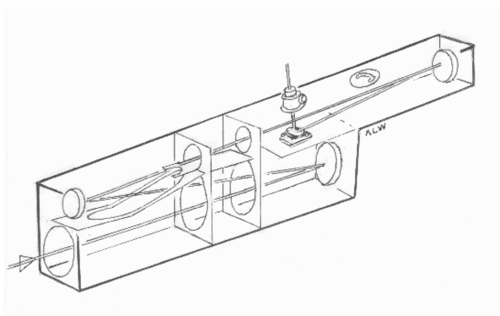


Because a TCT can be made for a fraction of the cost of an apochromatic refractor, a lot of different designs were developed. These range from the single mirror Herschelian telescope to the modern three and four-mirror designs. However, none of these telescopes can really compete with the apochromatic refractor especially for compactness.

Every mirror tilt results in additional optical aberrations. To make the telescope diffraction limited, all aberrations have to be compensated in a reasonable field of view. Depending on the particular type of TCT, this compensation leads either to a complicated system with respect to the number of components, or to the type of mirror surfaces (e.g. toroidal), or to an unfavorably long focal ratio of the telescope. In brief, the ideal TCT is an obstruction free, mechanically compact system with two simple mirror surfaces and a fast focal ratio. It should be diffraction limited at least in a half degree field of view. In this article a significant step forward to this goal is presented.

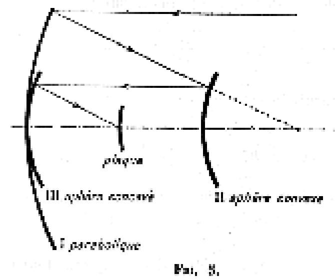
Herrig TCT Telescope
(This telescope can be made of two spherical mirrors)

Stevick-Paul Telescope



A remarkable design with inherent third-order optical perfection, this basic arrangement of mirrors has been rediscovered several times since M. Paul's 1935 paper. Despite the Stevick-Paul's superficial resemblance to a TCT, all mirrors are coaxial. The unobstructed view in this design comes from using the optics "off-axis".

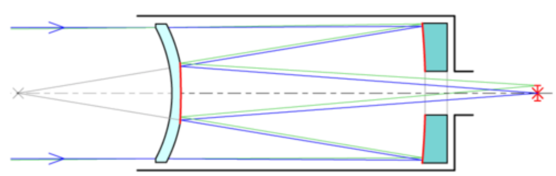
The system was first described in 1935 by Maurice Paul who presented it as a zero-power corrector for large astronomical telescopes. The two spherical mirrors are of mating curve. Paul showed the concave tertiary in contact with the paraboloidal primary. Because of the large obstruction of this axial arrangement, Paul considered the system of theoretical value only.



Combined Lens-Mirror Systems (Catadioptrics)

A catadioptric sensor is a visual sensor that contains mirrors (catoptrics) and lenses (dioptrics). The word catadioptric originally appears in telescope design, but the term catadioptric sensor has come to refer to panoramic sensors created by pointing a camera at a curved mirror.

Maksutov-Cassegrain



Invented by the Russian optician Dmitri Maksutov (1896-1964), the Maksutov reflecting telescope is a type of catadioptric telescope that uses a spherical primary mirror in conjunction with a meniscus-shaped corrector plate at the entrance pupil in order to correct spherical aberration. At the time of his invention, in the 1940s, Maksutov himself hinted at the possibility of a 'folded' Cassegrain-type construction. In 1957, John Gregory published in Sky and Telescope his landmark design for two f/15 and f/23 Maksutov-Cassegrain telescopes to be built by amateurs. The commercial use of the design was explicitly reserved for Perkin-Elmer, the company where Gregory worked at that time.

The key difference from the similar Schmidt telescope design is the meniscus-shaped corrector plate, that has easy-to-make spherical surfaces, and not the complex aspherical form of the Schmidt design.
Most Maksutov-Cassegrains manufactured today use only spherical surfaces. All-spherical 'Cassegrain' designs (as the Gregory telescope cited above) that use, as secondary, a small aluminized spot on the inner face of the corrector are, specially for apertures larger than 150mm, simpler constructions that cannot exploit the Maksutov principle to the full. They are, however, cheaper, and thus extensively used, specially by amateurs. By using the central spot of the corrector as secondary, the construction is easier, but a degree of freedom (the radius of curvature of the secondary) is lost, that radius being the same as that of the rear meniscus face. Gregory himself, in a second, faster (f/15) design resorted to aspherization of the front corrector surface (or the primary mirror) in order to reduce aberrations.

The best, high-quality makes have all surfaces laser-interferometer tested and even hand-figured to achieve excellent performance. The compact 'Maksutov-Cassegrain' telescope has been mass-produced since the mid-70s, and has proved to be a very convenient instrument for most amateurs. Low-cost Russian and -lately- Chinese mass-production has pushed the prices down to the point that the Maksutov-Cassegrain (and the Schmidt-Cassegrain too) has today become the 'instrument of choice' for the amateur astronomer, if not a 'telescope for the masses'. Something unthinkable in the 60s, when even a small Maksutov-Cassegrain, as the 'Questar', was quite expensive and within the reach of deep pockets only.

The Maksutov design also has excellent correction for off-axis aberrations such as coma, which is a significant problem in the simpler Newtonian reflecting telescope.

In 'folded', Maksutov-Cassegrain or Maksutov-Newton telescopes the diffraction generated by the arms of the 'spider' that holds in place the secondary mirror in 'pure' Newton or Cassegrain designs is eliminated, since the secondary is held by the corrector itself, even being integral with it in some cases, as mentioned above. Hence, image contrast is improved, and the image quality is very high, close to refractors of the same net aperture. This advantage, together with the fact that reflecting telescopes are almost free from chromatic aberration makes this telescope ideal for lunar, planetary and some deep-sky observations.

The chief disadvantage of the Maksutov design is that it does not scale up well to large apertures (>250mm/10 inches), since the corrector plate rapidly becomes prohibitively large, heavy and expensive as the aperture increases. However, specialist manufacturers do create models beyond 14 inches in aperture.

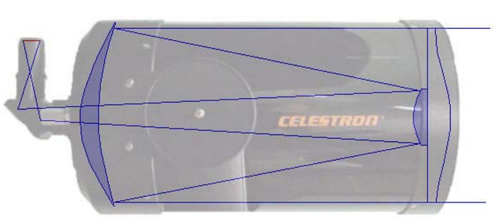
The focal ratio of the Maksutov-Cassegrain design provides high powers and a narrower field of view. This makes them unsuitable for wide-field Astrophotography but superb at lunar and planetary imaging. They are also very adept at imaging tightly packed formations such as globular clusters and at splitting double stars.

Schmidt-Cassegrain

The Schmidt-Cassegrain is a classic wide-field telescope. The first optical element is a Schmidt corrector plate.

The plate is figured by placing a vacuum on one side, and grinding the exact correction required to correct the spherical aberration caused by the primary mirror. Thirty inch Schmidt-Cassegrains are used for sky surveys at astronomical observatories and satellite tracking stations.

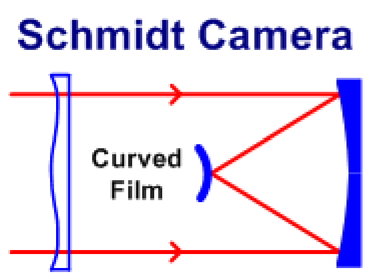
Schmidt-Cassegrains use a spherical primary mirror to focus incoming light onto a convex secondary mirror which sends the light back through a hole in the primary mirror to the eyepiece, located at the rear of the telescope. Spherical mirrors are less expensive to make than parabolic mirrors but introduce spherical aberration. By using a corrector plate at the front of the telescope, spherical aberration is corrected.



Looking down into the optical tube of a Schmidt-Cassegrain you can see the large reflecting mirror at the bottom which sends light up to the "secondary mirror" located on the far side of the black circle in the center of the glass corrector plate at the front of the scope.

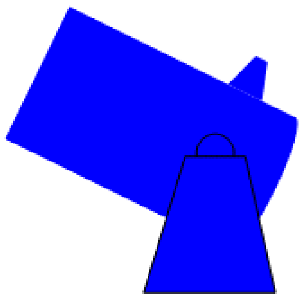
Thousands of amateur astronomers have purchased and used Schmidt-Cassegrain telescopes, with diameters from 20 cm (8 in.) to 48 cm (16 in.), since this type of telescope was introduced by Celestron in the 1970s. Now many companies mass-produce this type of telescope, at prices that make them quite affordable for many amateurs. One of the major advantages of the Schmidt-Cassegrain is that its folded light path makes the optical tube very short and squat, thus increasing its portability.

Schmidt camera



The Schmidt camera, invented by Bernhard Schmidt, is not technically a telescope since the light path does not exit to an eyepiece. This is because the image formed by the lens and mirror lies along a curved rather than flat focal plane, so it cannot be viewed with an eyepiece. Therefore it is strictly a camera, with a photographic plate, film or a CCD placed at the prime focus. The Schmidt camera corrects for spherical aberration by placing a correcting lens at the center of curvature of the mirror. The corrector, which is thicker in the middle and the edges, corrects the light paths so that the outer and inner parts of the mirror focus at the same distance. A simpler lensless

Schmidt can be made by placing an aperture stop at the center of curvature, stopping the aperture to f/8 or longer.

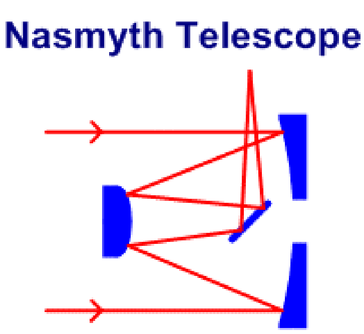


This degrades the light gathering ability of the telescope but produces a sharp image while preserving the wide field of the shorter focal length mirror. The 48" telescope at Palomar Observatory is actually a Schmidt camera.

A Schmidt Camera is not a telescope and cannot be looked through, - it will need an auxiliary finder scope fitting in order to aim it.

Nasmyth Telescope Optics

This is a derivative of the Cassegrain



and is a very clever and practical telescope design that is in our opinion very under rated and under used. The Folded Newtonian was introduced to lower the height of the eyepiece. With a Cassegrain, the converse can be a problem with the eyepiece sited too low for comfortable viewing?

The focal point of a Cassegrain is behind the primary mirror and if you intend viewing at high elevations, then the tube of the telescope would have to be supported high off the ground. It is of course possible to fit a 90 Degree bend on the focuser of a standard Cassegrain for use at high elevations, but if the telescope is above say 12" Diameter, you will still need a strong, tall and relatively expensive mounting.

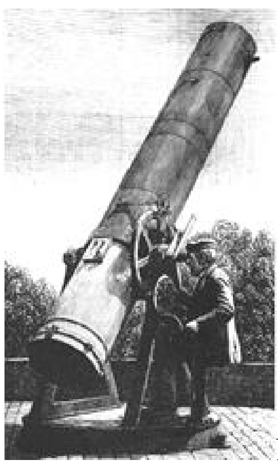
So if you are considering a Cassegrain of 12-24" or above, - then why not consider having the 90 Degree bend built into the design at the start? - This is the design credited to James Nasmyth. It is a Cassegrain optical system with an extra elliptical flat from a Newtonian bending the light out the side of the tube. The extra cost of the elliptical flat is not significant when the cost of the other two mirrors is considered.

The Nasmyth opens the possibility of using a much simpler and lower mount, as illustrated by the very basic design on the right which shows the focuser carried on the top of the tube.

The primary mirror does not need a central hole for optical purposes, but it is often there to provide a mounting point for the elliptical flat. If the elliptical flat is towards the primary end of the tube, there is no extra optical obstruction and as an extra bonus, the baffling needed in standard Cassegrains is not required as stray light has a lot more difficulty in reaching the focal surface.

Very large professional telescopes often have a "Nasmyth focus" deliberately aligned on a hollow axis of the telescope mounting so that the eyepiece and viewing position are always maintained in the same position and at the same height. This is illustrated by the original 20" Telescope built by James Nasmyth in 1845.

Some dictionaries suggest the feature of the hollow axis and fixed viewing position marks the "true" Nasmyth Telescope? - but there is no alternate name for the simpler version?



Note that a modern Nasmyth Telescope would have the same tube length as any modern Cassegrain or Schmidt Cassegrain. It would certainly not have the long tube of the original 1845 version illustrated on the left, - which looks more like it belongs to the Artillery than an Astronomer!

Rent a MallinCam

The OAOG Mallin*Cam II Observing System is available for rental for a period of two weeks at only $20.

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