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Optical Geometry Structure of Reflector Telescope

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ABSTRACT

The field of physics that focuses on light is called optics, which investigates the properties of light, and how those properties are used. Geometric optics and physical optics are two branches of optics. Geometric optics study the refractive and reflective properties of light. Optika has produced a variety of tools that help human activity in certain fields. For example, in astronomy, stellar binoculars are used to observe objects in space. The purpose of this article is to show the development of the history of geometric optics and to study the definition, structure, working principle, disadvantages, and advantages of a reflector telescope or reflecting star binoculars. This method of writing articles uses qualitative methods and conducts literature searches on relevant articles, journals, and libraries. The result is that the reader knows the history, definition, structure, working principle, weaknesses, and advantages of the reflector telescope in geometric optics. The reflector telescope basically has 9 main parts, has 5 reflex media and 3 main components, namely the main mirror, the secondary mirror, and also the positive eyepiece so that the reflector telescope is created. This telescope itself has the main task, namely collecting, focusing, and magnifying light on an object.

Keywords : *Astronomy , Optics , Telescopes*

1 Introduction

Curiosity is the basis of human existence, according to an astronaut named Gene Cernan during the Apollo 17 mission. People are always thirsty for new information. In an age when technology is such an important part of human life, the desire to know more about the outside world is beginning to emerge, not only to explore the beauty of the earth, but also to find answers to their questions in the vast universe. In this case humans have landed after several space trips to see space objects. However, in the era of modern technology, how can we explore the beauty of celestial bodies that are very far away and cannot be reached? To answer this question, finally humans developed optical science and always innovated in creating optical tools, namely telescopes or star binoculars.

The development of optics is inseparable from the shift in theory and history. The most advanced branch of physics is optical science that investigates the properties of light and how it interacts with matter.(Chandra et al. 2020) Geometric optics and physical optics are two subdisciplines of optics. Geometric optics explain the explanation of light-propagation vector rays. (Ray N Wilson 2004)One of the most important optical tools in astronomy is the telescope, Because a telescope is a tool intended to observe objects in the distant sky.There are now two types of telescopes: optical telescopes and radio telescopes.(June 2021) In the discussion of geometric optics, this time we will discuss the mirror telescope, or also known as the telescope *reflector* Then the development of how this optics can become a modern optical tool to this day.

Based on this background, the purpose of this article is as follows:

1. Demonstrating the development of optical science
2. provide accurate references so that readers clearly understand the history, definition, structure, working principles, as well as the weaknesses and advantages of the reflector telescope .

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2 Research Methodology

In 1041 AD Abu Ali al-Hasan bin al-Hasan, an Islamic astronomer inventor of the lens, opened the door to the history of the telescope. Then followed by the eyewear maker of Middleburg, the Netherlands, Hans Lippershey. Created the first instrument known as the telescope on October 2, 1608PAM Himastron ITB 2021 Dragon Army Group, (2021) 'Telescope: Early History and Development', Medium.. This telescope can magnify objects up to five times. Galileo Galilei created the first telescope devoted to celestial bodies in 1609, and by 1610, the telescope could be magnified to double, the theory justified "the universe centered on the sun."

The new telescope was invented by Isaac Newtoon in 1668, using a mirror as his lens, marking the turning point in the history of science.(Irvan and Hermawan 2019) In accordance with the discussion taken is a telescope *reflector* In accordance with the previous discussion, the telescope *reflector* has a history of this type of star binoculars. Henry King mentions the designs of Marin Mersenne (1588–1648) and Niccolò Zucchi (1586–1670), but this is too late and it seems that the designs were never practiced; No actual telescope has ever been built. The design proposed by the mathematician Bonaventura Cavalieri in 1632 (1598 1647) suffered the same fate, and the idea of René Descartes (1596 1650) was created seven years later. Moreover, there does not seem to be any evidence to support Luigi Campe delli's idea that Zucchi's idea may have been used by James Gregory and Isaac Newton.(Ronan n.d.)

Telescopes are the most important astronomical observation instruments. Telescopes, also known as miqrab. Telescopes, also called optical tubes or optical tubes, can magnify and clarify distant objects by collecting more light into the eyes.

The two components of an optical telescope are, the objective lens centralizes the light of the object at a single point of fire or focus, and the eyepiece that welcomes the centralized light.

In most cases, the light beam from the celestial object is received by the lens at the focal point of the objective lens (*Fob*)(Paul A. Tipler; transcribed, Lea Prasetio, Rahmad W. Adi; eds. 1998), resulting in a real, reduced, and inverted shadow, with the equation:

$$\frac{1}{Fob} = \frac{1}{Sob} + \frac{1}{Sob'} \qquad (1)$$

The distance between the object and the objective lens is called Sob, and the distance between the object and the lens is called the shadow. Sob′. Because of Sob Equation (1), which is located far away (~), can be written as follows (David 1984):

$$\frac{1}{Fob} = 0 + \frac{1}{Sob'} \qquad (2)$$

indicates that Sob′ = Fob, distance (fob > fok).

The object on the eyepiece is the shadow formed on the objective lens. If the accommodation does not occur in the observer's eye, the eyepiece will be set at an infinite distance so that the end of the shadow lens becomes (Sok′ = ~) , dot (*Fob*) intersecting with the point (*Fok*). Thus, the distance between the two lenses (d) :(Sehah, Aziz, and Effendi 2015)

$$\frac{1}{Fok} = \frac{1}{Sok} + \frac{1}{Sok'} \qquad (3)$$

Sok = *Fok*, until :

$$\frac{1}{Sok'} = 0 \rightarrow Sok' = \infty \qquad (4)$$

Based on equation (2) and equation (4), the binocular length requirement (d) is as follows:

$$d = Fos + Fok \qquad (5)$$

According to Equation (5), the point (*Fob*) and the point (*Fok*) are located or close to each other.

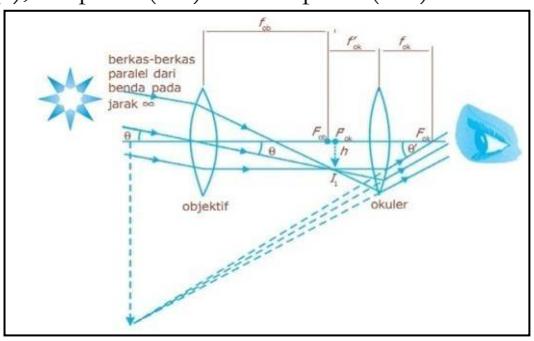

Figure 1 Schematic shadow of binoculars

The total magnification of the binocular shadow can be seen through the light beam travel diagram. Angle θ There is an equation that can be used to show whether a lens is objective () tinnginy is smaller than Fob and θ ≈ θ for very small angles. Before falling through the eyepiece The shadow of the objective lens falls $h1$(*Fok*) to the observer, means the angle θ':(Giancoli 2001)

$$\theta \approx \frac{h1}{Fob}$$

$$\theta' \approx \frac{h1}{Fok}$$

Enlargement of the angle of binoculars:

$$M = \frac{\theta}{\theta'} = -\frac{Fob}{Fok}$$

This research method is qualitative. The focus of research is to find the truth or stronger evidence. Practitioners, philosophers, and researchers, according to Lexy J. Meleong, use a certain model to pursue the truth. A paradigm is a model or pattern of how something is structured or functions. The term "paradigm" usually refers to this model. Emzir argues that this research is descriptive. The research is in the form of data collected containing explanations of words or pictures rather than numbers. The results of this study are shown and proven through citations from the data. In the search for this article, the literature study or literature research approach is used. This method collects data from previous research, notes, books, articles, and relevant journals.(Deswita and Saputri 2021).

3 Results and Discussion

3.1 Optical Telescope

Judging from the path of light, there are three types of optical telescopes, one of which is a reflector telescope. The main functions of the telescope itself are:

1. collecting light from objects
2. Focusing Light
3. Magnifying Light

Optical telescope requirements, in order to achieve an unobstructed collection area of 25 m2, a large primary mirror aperture is required. This area operates in the spectral range of 0.6–27 μm. The metrics used to measure the performance of coatings, contamination, and damage to micrometeoroids are known as x-optical area transmission products.(Caini et al. 2023) The telescope's image quality was measured using Strehl's ratio metrics at 2 μm 22 and 5.6 μm, with a diffraction-limited image quality value of 0.8 on the NIRCam and MIRI field of view, respectively. For these large apertures, the energy variation is less than 2.3% rms in an aperture of a radius of 80 mas at a wavelength of 2 μm cete The observatory's radiometric sensitivity requires a low background to detect dim sources. Zodiac light accounts for most of the components of the near-infrared background. Due to the longer wavelength of the central infrared channel, thermal emissions from observatories are more dominant in the background.(Zhou et al. 2023)

3.2 Reflector Telescope

Telescope *reflector* is a star binoculars using a mirror.(Braham 2005) The concave (objective) primary mirror at the lower end of the telescope tube collects light and is reflected to a smaller (secondary) mirror.(Kawachi et al. 2018) The smaller mirror is hung much higher above the tube, sending light to the side of the tube, where the eyepiece magnifies the image.

Figure 2 Mirror on the Telescope Reflector

Reflector Telescope Structure :

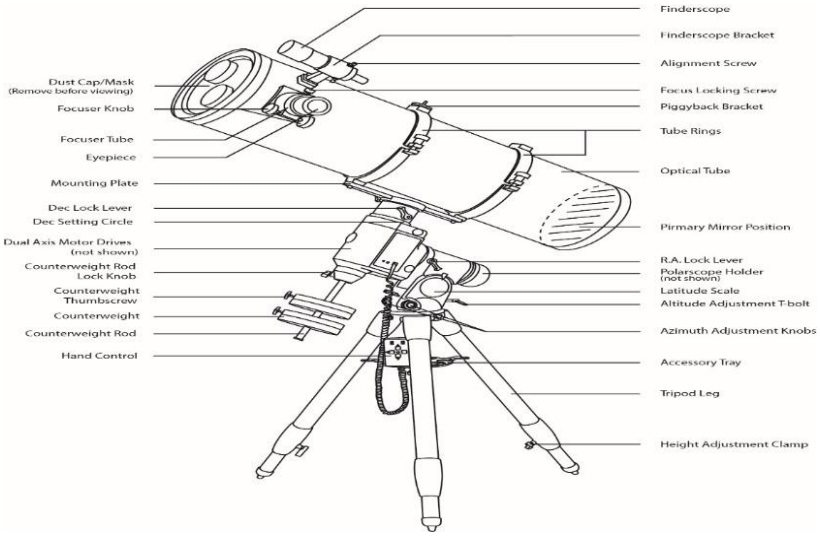

Figure 3 Component on a Telescope Reflector

In the past, telescopes consisted only of a lens and its frame, but now it has advanced to consist of the following parts:

a. *Optical tube*, main mirror holder. In a refractor telescope, the focuser is behind the main lens in front of it. In contrast, in a reflector, the focuser is above the main lens.
b. *Eyepieces*, eyepieces placed near the observer's position (eyepiece) to enlarge the image of the object.
c. *Focuser:* Each telescope has a focuser that varies in its style. It holds the telescope's eyepiece and is attached to the telescope tube. The shape of the telescope has buttons on the part (rack and pawn, Crayford) that move up and down until it reaches focus, when the internal tube is operating, for some force (helix) it can achieve focus both on the left and right.
d. *Finderscopes*, are the most important part of a telescope because they can track objects in space. When there is no finderscope, it will be very impossible for the observer to see distant objects, this is mounted on the side of the main telescope.
e. *Mounts*, called towers help keep the telescope in place. The two types of mountains are alt-azimuth and equatorial. Other mountains also exist, for larger telescopes. Mounting, also known as "telescope mounts", is divided into two types. Equatorial mounting uses three axes, namely the RA, Declination, and Equator axes.In altazimuth mounting, two axes are needed, these two axes X which signifies top and bottom and Y or azimuth signifies right and left. Equatorial mounting operations are difficult as compared to altazimuth mounting.
f. *The lens* , the main part of the telescope, is the lens, in essence the collar that attaches the primary lens to the telescope tube.
g. *The lens of the eye,* the part that a person sees, depends on the type of telescope, some have additional lenses in it.
h. *Barlow lenses* Barlow lenses are also in between the eyepiece and the focuser. The lens effectively increases the focal length of the telescope, which at a significant degree the magnification is usually doubled, but can be up to five times.
i. *Tripod*, a restraint consisting of three legs with a height at which the human stands.(Zhou et al. 2023)(Kuja and Wiid 2018)

Working Principle :

There are five refractive mediums in the eye, through which light and shadow will enter and reach the cornea, humor aquos, pupils, and vitreous of the body, before reaching the retina through the primary lens. The shadow is then sent to the optic nerve and then to the brain through the retina. Thus the image can be seen.(Eko Hadi G 2011)

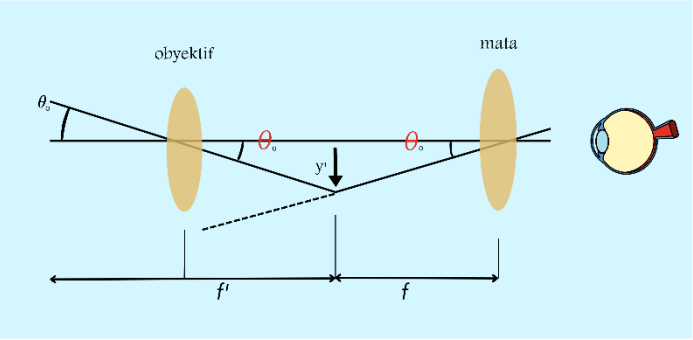

Figure 4 Eye reflect

The three main components consist of a reflector star binoculars. The first is the primary mirror, which is a concave mirror as a primary mirror that is near the object, or objective lens. The second is the secondary mirror, which is a flat mirror. Then, the positive eyepiece, which is a type of refractor, is near the eye and as a magnifying glass that allows the user to see the shadow produced by the objective lens.(An et al. 2023)

The light from the object will directly hit the concave mirror and then reflected to the secondary mirror. The secondary mirror focuses light that should be directly on the light shadow, but is reflected by the secondary mirror so that its focusing is near the eyepiece. The eyepiece is arranged so that the distance is right so that it produces a shadow that is clearly visible to our eyes. To achieve perfect shadows, the placement, not the concave mirror, must be precise against the optical axis of the eyepiece. To make the telescope bigger, namely:(Nature 2022)

$$M = \frac{\theta}{\theta'} = -\frac{Fob}{Fok}$$

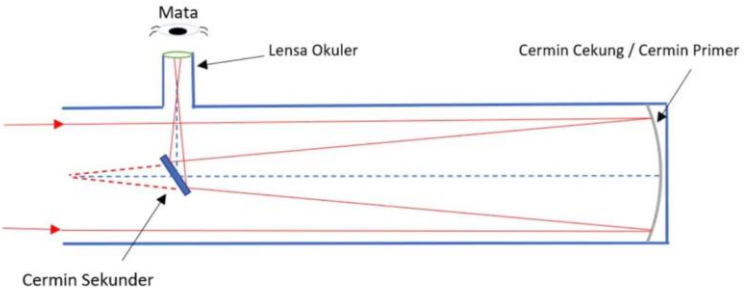

Figure 5 how the reflector telescope work

Objective focal length = Focal length of the concave mirror
Eyepiece focal length = Eyepiece lens focal length
Magnitude Limit = 6 + 5 logs

The maximum magnitude that can be observed through a telescope is called magnitude. According to this equation, the larger D (or the diameter of the mirror) the greater the magnitude, and conversely, the brighter the celestial object, the magnitude is written in smaller numbers. Thus, the larger the D, the greater the light collection will be, so the reflector telescope is better able to see fainter celestial objects.(bidin A 2018)

Disadvantages and Advantages :

The weakness of the reflector *mirror* needs to be checked periodically to ensure that the position is aligned. In addition, the mirror coating is damaged and needs to be replaced every few years *the reflector is* prone to coma, an effect in which the stars at the edges of the field of view appear wedge-shaped. The secondary mirror blocks the light propagating from the observed object to the primary mirror. This can result in the appearance of "spikes" that come from bright objects.

Excess Making telescope mirrors is easier and cheaper than lenses. This means that the reflector is less expensive compared to a refractor with the same aperture The eyepiece is positioned near the top end of the telescope tube, making the reflector easy and convenient to use on the mount. This type of telescope is great for looking at deep-sky objects, such as nebulae and dim galaxies. *Reflector* also free from chromatic deviations.(Dinwiddie 2012)

4 Conclusion

The Development of optics is inseparable from its theoretical and historical shifts. The most advanced branch of physics is optical science that investigates the properties of light and how it interacts with matter. (Chandra et al. 2020) Geometric optics and physical optics are two subdisciplines of optics. One of the most important geometric optical tools in astronomy is the telescope, also known as the stellar binoculars.

A telescope is a tool intended for observing objects in the distant sky. Judging from the path of the beam, there are three types of optical telescopes, one of which is a telescope reflector or reflective star binoculars. Telescope reflector is a star binoculars that using a mirror, where there is a concave primary mirror (objective) at the bottom end of the telescope tube collects light and reflects it back to a smaller (secondary) mirror. The main function of these stellar binoculars is to collcet, focus, and magnify light on an object. Structure of the telescope reflector basically there are 9 main parts, it has 5 media refraction and 3 main components, namely the primary mirror, secondary mirror, and also the positive eyepiece.

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