Improved efficiency of Kepler's model of refractor telescope Using MSWord

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The Keplerian model telescope's efficiency has been improved by fixing the problem of chromatic aberration using an achromatic doublet ,adding a distance calculator using parallax method (attached to the telescope) and a navigator to locate celestial bodies and to know where the apparatus is focussed with most of the parts detachable.

***Keywords*:** Chromatic aberration, Parallax method of distance calculation, Exit pupil, True field of view, Aperture, Barlow lens, Eyepiece, Objective lens and Magnification.
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1 Introduction

The development in field of astronomy depends on the development and advancements in astronomical instruments. Astronomical Instrumentation generally deals with tools used for observation. Observation is an important segment when it comes to science related fields like astronomy or space science. Telescopes have played a great role in discovery of new celestial objects like stars, galaxies, black holes, quasars etc. More the development or invention of these instruments more we get to know about celestial objects. The base instrument, the telescope is used to view celestial objects that are invisible to the naked eye (due to their distance) by using the properties of light like refraction or reflection. The first telescope to get a patent invented by Hans Lippershey in the year 1608 had a magnification of 3x. When Hans Lippershey saw two kids holding two lenses made a distant weather pane appear closer, he tried the same mechanism and made a simple refracting telescope. Usual telescopes consist of two lenses, the objective lens and the eyepiece lens. The one near the eye is called the eyepiece lens and the other lens which is comparatively larger is called the objective lens. Lippershey's model had a convex objective and a concave eyepiece lens. Then came Galelio's model with 20x magnification followed by the Kepler model.Galelio was the first person to use his telescope for Astronomical observation (point his telescope towards the sky). He was able to observe the mountains in moons, rings of Saturn and so on.Kepler's model used two convex lenses which ultimately provided an inverted (upside down) image. The formation of upside-down image did not pose a problem for Astronomical observation as there is no up or down in space but posed a problem for terrestrial observation. The upside-down image was difficult to see and understand the landscapes. Moreover, the refracting telescope had the defect of chromatic aberration. This is caused due to dispersion of light and reduces the clarity of the image. In order to increase the magnification, we have to use more powerful lens with smaller eye relief. This makes the observation difficult. The refractor telescope had flaws and was gradually replaced with reflector telescope which was later invented by Newton.A good telescope is a telescope which has a descent magnification along with some additional useful features. These additional features are provided by the Astronomical Instruments attached to the telescope. The Kepler's model of refracting telescope's efficiency has been increased by correcting defects and giving it add on features which helps us to study more about the celestial object we are looking at. This will be highly efficient for on the spot observations as well as for beginners who are new to the field of astronomy. This telescope with instruments can be made with locally available materials at a comparatively lesser cost.

2 Abstract

Science related fields like space science require observation as an important process of learning and discovery. To observe celestial objects that are light years away (1 light year= 9.46 x 10^15 meters) we need an instrument called the telescope. The telescope was first invented by a lens shopkeeper in the year 1608. Telescopes help us to see celestial objects that are so many light years far away. This is possible due to the phenomenon of refraction (when comes to refractor type telescopes). A good telescope is a telescope with good magnification, lesser defects and added features. The added features refer to the astronomical instruments which help the observer to learn more about the celestial object he is looking at.The improved version uses double achromatic objective lens for better clarity, Barlow lens for higher magnification, display screen for navigation, laser lights for distance calculation and a spectroscope to analyse the element, density and temperature by observing the spectral lines. These features make the telescope unique, multi-tasking and highly functional. Moreover the structure makes it detachable and compact making it easy to carry anywhere making it apt for on spot observations. Therefore telescopes are considered an important part of Astronomy or space science due to their role they play in the process of observation without which the field of space science wouldn't have developed. Therefore to improvise the learning or the process of discovering there should be a significant effort laid in discovering and developing astronomical instruments.

In this work paper the detail are shown for a lens telescope that gives a valuable amplification of between 263x and 88x. It has decreased image distortion in addition to giving a quality resolution, improving the quality of the product. A dual grayscale lens, which combines a concave and convex viewfinder constructed of tiara and pebble glassware, is used to correct this. The observatory is also useful for calculating distances using the offset technique with the aid of light shows. A straightforward spectrometer is also created with the use of spectroscopic, which enables the user to anticipate the components of a digital image. The observatory may also display the titles, locations, and architecture of stars, nebulae, and asteroids in the area it is looking towards. Due to the crucial role that telescopes play in the observational process—without which the study of aerospace engineering would not have advanced—telescopes are therefore regarded as a crucial component of astrophysics or planetary science.

3 Literature Survey

3.1 Geometrical and physical optics analysis for mm-wavelength refractor telescopes designed to map the cosmic microwave background

Two refractor designs are presented in which one is made up of silicon and another using a HDPE lens, which is capable of supporting 28-deg diffraction-limited field of view up to 280 GHz. Their performance is compared with geometric and physical optics and shown that the far field beam properties predicted are similar.

This section compares a smaller 2 different telescope to a comparable polycrystalline device that can accommodate a 28-degree light scattering peripheral vision at 1-mm wavelengths. Researchers contrast the 2 subsystems' optical characteristics with those that electrical and physical vision equally anticipates. According to the assessment, a polymer multiple magnifier machines can support similarly to a comparable semiconductor device over a large number of points and wavelength range up to 1 mm by reducing tele-centricity requirements. Then demonstrate that cool cut-off overflow substantially varies throughout the angle of vision for both observatory configurations, which is somewhat at odds with Gaussian composite beams and straightforward f-number scalability.

3.2 Tor vergata Synoptic Solar Telescope: preliminary optical design and spectral characterization

The Tor vergata Synoptic Solar Telescope (TSST) has the ability to acquire velocity and magnetic field maps of the solar atmosphere. These are important for space weather applications. Specifically the preliminary optical design and spectral characterization of the potassium MOF-based channel of the telescope is shown.

The geomagnetic and convective condition of the Heat can be deduced by ongoing multi-line observations of the heliosphere. Identification of potential antecedents of satellite meteorological conditions, such as flares and solar flares, is crucial. The TSST, a mechanical panoramic observatory with two major comprehensive sensors, an H camera and a potash magnetic properties filtering (MOF)-based observatory working at 769.9 nm, is described here, along with its formwork system. An additional MOF line can be added to TSST in the future. The first laser measurement, which was made in February 2020, is presented in this study along with a description of the TSST ideas. They demonstrate that Stripped - down version is a reduced autonomous laboratory capable of obtaining the data required for the investigation of antecedents.

3.3 The optical design of the LiteBIRD Middle and High Frequency Telescope

An overview is provided of the major optical studies and outstanding issues related to the Litebird MFT and HFT design. This has also described the baseline optical parameters along with the main design drivers which played an important role to define the current optical configuration of MHFT. Keeping in mind of the next generation optical studies it provides a more complete and realistic picture. LiteBIRD is a higher scores project that measures the Cosmology Background's polarisation. The Medium and Complexes Space probe is built on a combination of cryonic chilled Fresnel lenses. Considering the high destination responsiveness and cautious taxonomic classification required to meet the project's objectives, photonic modelling and portrayal are carried out with the purpose of capturing the majority of the physiological symptoms that could have an impact on the actual results.

3.4 Refractor telescope design using web camera

Based on discussion and analysis a refractor telescope is designed in such a way that it uses webcamera (webcam), and makes the observer to observe celestial objects from the laptop screen. The results of the assessment given by experts have stated that it has met the criteria of feasibility and can be used as a learning media.

Binoculars, often known as refractors, are exoplanets that utilise the optical quality of optics. The glasses of a telescope must be fairly large if it is to have a considerable bright sun capacity, which is necessary for observational data. In addition to being used for digital viewfinders, the lensed telescopic architecture was first utilised in espionage spectacles and celestial observatories. The specular reflection observatory has largely replaced the diffracting astronomy for scientific purposes, despite the fact that large convex lenses were quite successful in the mid - nineteenth century era. Reflection observatories cause different kinds of visual distortions, but its structure enables them to have focuses with very large diameters. Materials make up almost all of the large observatories used in astrophysics investigation.

3.5 Probing frequency-dependent half-wave plate systematics for CMB experiments with full-sky beam convolution simulations

The formulation of an extension of the harmonic beam convolution algorithm which was originally described by Wandelt and Gorski in 2001 which adds the ability of simulating systematics due to non-ideal half wave plates (HWPs). This generalised algorithm allows for numerically efficient generation of simulated time-domain data.

3.6 A feather on the hat: Tracing the giant stellar stream around the Sombrero galaxy

The paper presents new deep images of Sombrero galaxy (M104) outskirts. An 18-cm telescope was used in this process. The new data allows us to trace full path of the streams on the either side of the galaxy (disk of the galaxy). The path streams do not intersect with any of the two halo fields recently targeted by the HST (Hubble Space Telescope).

4 Working Principles / Methodologies

Improved features and add-ons

The new improvised version's additional features and corrections include the following.

4.1 Reduced chromatic aberration

Chromatic aberration or chromatic distortion is the inability of a lens to focus all colours to the focus. This phenomenon is caused by the physical property of dispersion of light where different colours having different wavelengths disperse at different angles. Due to this the image thus obtained is blurred and the clarity is reduced significantly. This defect is corrected with the help of an achromatic lens (achromatic doublet) which is a combination of concave element made up of flint glass and convex element made of crown glass. This combination creates a huge difference in the obtained image making it clear

Refracted light, which is produced by scattering, is the optical term for a lenses' inability to function all shades at once. Chromatic aberration appears as "outskirts" of shade along the lines dividing the black from the light parts of the screen. When feasible, you should use a grayscale glass or extend the viewing angle of the telescope to minimize blurring effect. Through merging more than multiple lenses with various proportions, as in an allred optic or apochromat, the amount of rectification can be further improved. Several different styles of spectacles have been created to lessen image distortion. Particles contain is a quality of certain materials, particularly those that include fluorine.

4.2 Parallax method of distance calculation with the help of LASERS

The distance from the point of observation (the place where the observer stands) to the point where the telescope is focussed can be calculated using the parallax method. The distance is calculated with the help of two powerful lasers (Light Amplification Simulation Emission of Radiation) from the telescope in such a way that they intersect at the point of observation making angles with the normal. The distance between the two lasers(basis) divided by the summation of the angles made by the laser lights with the normal gives us the distance between then celestial body and the telescope(where the observer stands). This additional feature is most helpful when attached with the telescope as we might be able to see the intersection of the two powerful laser lights through the telescope itself, moreover the scaling takes place automatically as we scale the telescope on the tripod. This can be used for terrestrial purposes also to calculate the distance from buildings or towers. To correct the image (turning it 180 degrees) we can use a diagonal which will make the observation better especially for terrestrial purpose.

A technique for determining proximity to an item is called refraction. The route to a faraway location is behavioral modification from two main viewing points, much as how our visual acuity aids us in determining range. It is a simple matter of arithmetic to detect the length to the item if the length seen between observations places is given and the tilt between them would be calculated. Although it is a fairly straightforward idea, it is one of the most crucial for scientific phenomena. The precession technique in astrophysics can be used to calculate the separation between our observable universe and a planet up to 1600 light - years from earth. This approach can be used in any circumstance that is similar in structure; it is not just confined to stargazing.

4.3 Navigation

The position of celestial objects is to be known by the observer in order to view things properly. The observer must know where the telescope is pointed. In order to display what is being viewed by the telescope in the night sky (planets, stars, constellations, galaxies…) we attach a mobile phone with a holder in such a way that its backside is pointed towards the sky. With any sky navigation application installed in the phone (example: Google Sky Maps) we can get to know what is being viewed as we scale the telescope on the tripod. This is an efficient way (especially when we can't carry much equipment) for observations.

4.4 *Better eye relief*

When we try to increase the magnification of the telescope by using more powerful lenses of lesser focal lengths the size of the exit pupil decreases gradually which makes it difficult for observation (especially for those who wear spectacles). A more efficient way of increasing the magnification is using a Barlow lens. This is usually placed in between the objective and the eyepiece lens. It increases the magnification giving better eye relief. A barlow lens (concave) increases the focal length of the telescope making the light rays diverge and gradually increasing the magnification of the eyepiece. It is directly attached with the eyepiece of the telescope. A typical 2x barlow increases the magnification by two times.

4.5 *Spectroscopy*

A custom-made spectroscope is attached with the telescope. By breaking the incoming light into its various components, the made spectroscope produces a spectrum which is captured and observed. It helps us to analyse the elements the incoming light is interacting with and know its properties. The incoming light is passed through the spectroscope in which it passes through a tiny slit and the small amount of light is passed through a special grating called the diffraction grating which makes the incoming light to split into its various components (of the seven colours of the rainbow). Modern telescopes like the Hubble space telescope makes use of spectroscopy.

Spectroscopy is a technique of how beam and other cosmic rays are absorbed and emitted by material, and how this depends on the infrared spectrum. The research of contacts involving atoms like quarks, neutrons, and protons as well as their exchanges with other units that were chosen of their excitation energies has been added to the term more subsequently. The most basic science concepts, such as subatomic particles, the special and general hypotheses of relativistic and classical wave particle duality, have all benefited greatly by spectrophotometry. Academic comprehension of the electrostatic field as well as the strong and weak nuclear charges has been greatly aided by the use of spectrometer in elevated interactions.

4.6 Equations and Formulae

The following equations and formulae are required for the calculations involved in making of the telescope and the distance calculator.

$$M=f_o/f_e$$

Resultant magnification= magnification of telescope x power of Barlow lens

Where M is magnification f_o is focal length of objective lens and f_e is focal length of eyepiece lens.

To design the achromatic doublet lens we take two linear equation systems

$$1/f_{eq} = 1/f_1 + 1/f_2 \quad \text{------}1$$

$$1/f_1V_1 + 1/f_2V_2 = 0 \text{------}2$$

Solving for f1 and f2 from equations 1 and 2 we get,

$$F_1 = (V_1 - V_2)/V_1 \times f_{eq}$$

$$F_2 = -(V_1 - V_2)/V_1 \times f_{eq}$$

The formula for calculating the distance using parallax method is given by,

$$D = b/\theta$$

Where b stands for basis length and θ stands for the angle formed by the two lasers at the point of observation.

4.7 Ray diagrams and photographs

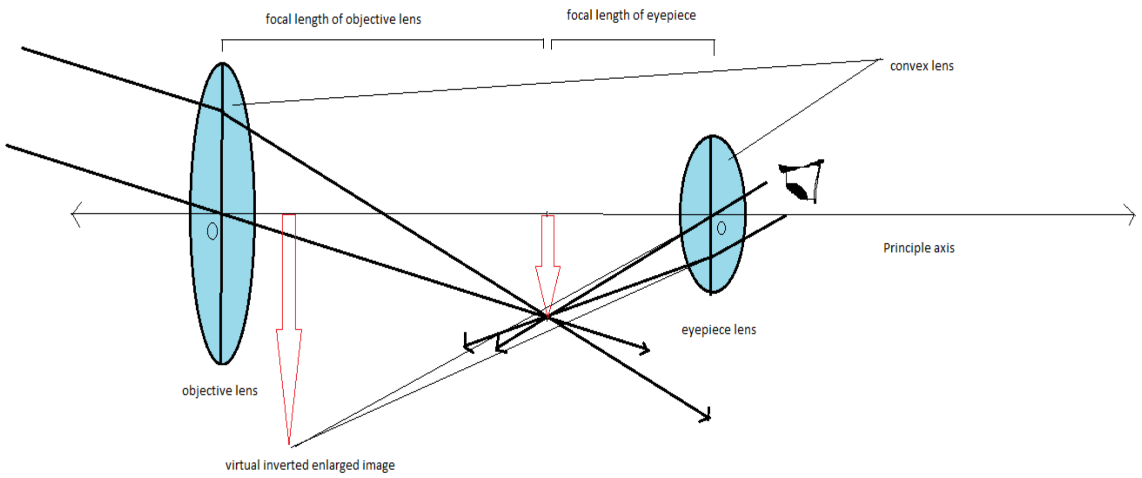


Figure 1

The lens placed in the front (objective lens) is a convex lens which has the property to converge light rays to a single point known as the focus. The refractor telescope is a combination of two or more lenses (minimum two), the objective and the eyepiece lens. From this combination we get a virtual enlarged but inverted image of the celestial object which can be corrected using a diagonal (diagonal of a telescope) to turn the image 180-deg by using a mirror or prism.

Figure explanation

A telephoto zoom lens projector is made up of 2 or even more frames in the image previous section. It projects an impression of the planetary body that is magnified but reversed. BY employing a dispersion screen, ocular viewfinder, pr mirror to rotate the view 180 degrees, the sight can be rectified.

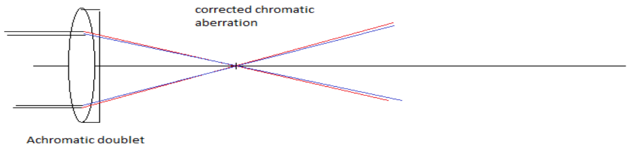


Figure 2

The double achromatic objective lens in generally a combination of concave and convex lens where concave lens (negative element) is made up of flint glass whereas the convex lens (positive element) is made up of crown glass. This is to prevent the phenomenon called as chromatic aberration. The necessary condition is given by Fr=Fv or 1/fr= 1/fv.

Figure explanation

In the above figure two circular lenses are combined to create the dual grayscale optical system. Pebble stone makes up the magnifying glass, whereas tiara crystal makes up the inverted lens. This is done to avoid a condition.

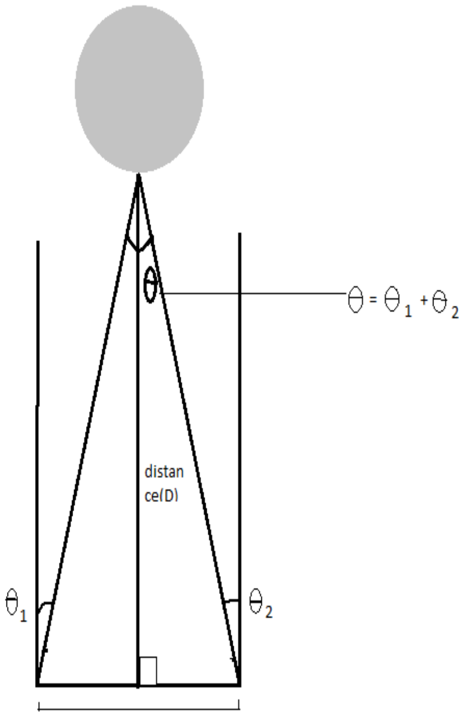


Figure 3

The parallax method of distance calculation uses a simple formula with very less calculation to find the distance from current location to the celestial object. This is done with the help of LASER lights by pointing them at the celestial object in such a way that both the lasers coincide to perform further calculation.

Figure explanation

The picture demonstrates how a simple equation and very little arithmetic may be used to compute the disparity separation between the actual location and the celestial body. This is done by directing laser beams at a planetary body so that they overlap and perform additional calculations.

Results and discussions

Figure 4

The first image is from another telescope where we can see chromatic aberration whereas the second one is from this telescope with reduced chromatic aberration. This gradually increases the clarity of the image and makes it easy for the observer to make note of minute details. The image of the moon has a magnification of 87.5x (without Barlow lens).

Figure explanation

In the figure above it is found that with the telescopic instrument of Barlow, the spectator may easily take notice of subtleties because the outer space appearance has amplification. The first frame, which shows image distortion, comes from a different scope. As a result, the picture becomes progressively clearer and it is simpler to discern details.

Figure 5

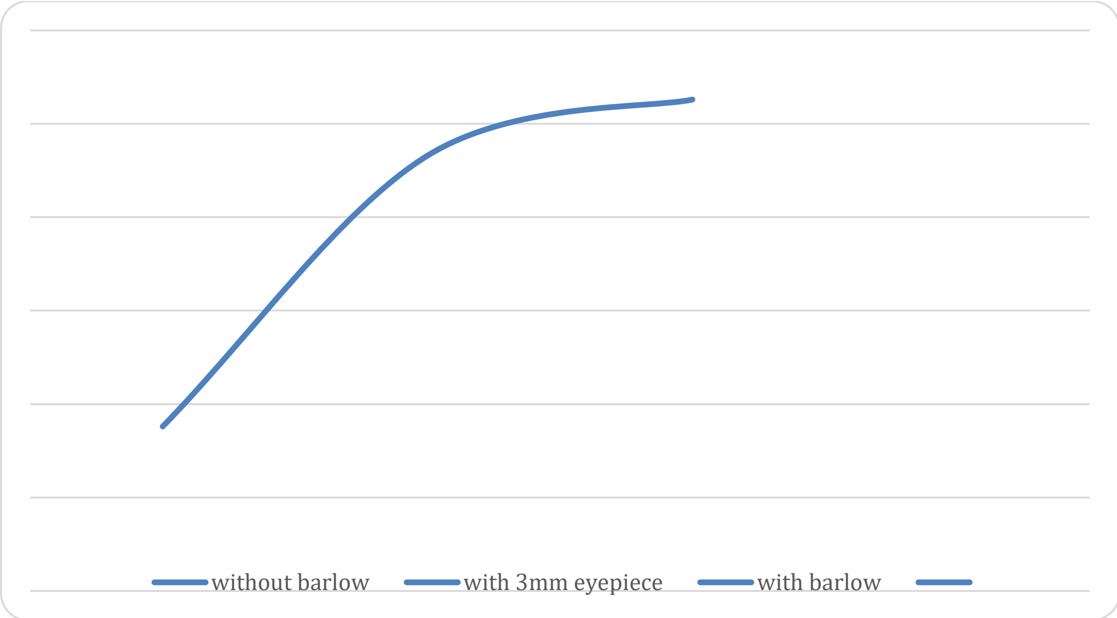
The image shows the magnified image of a nearby tower. The first photo was taken with 1x magnification (default magnification). The second photo is taken with 87.5x magnification of the telescope through it. The third image is with 262.5x (as a 3x barlow was used) magnification, i.e., with the barlow lens attached to the telescope.

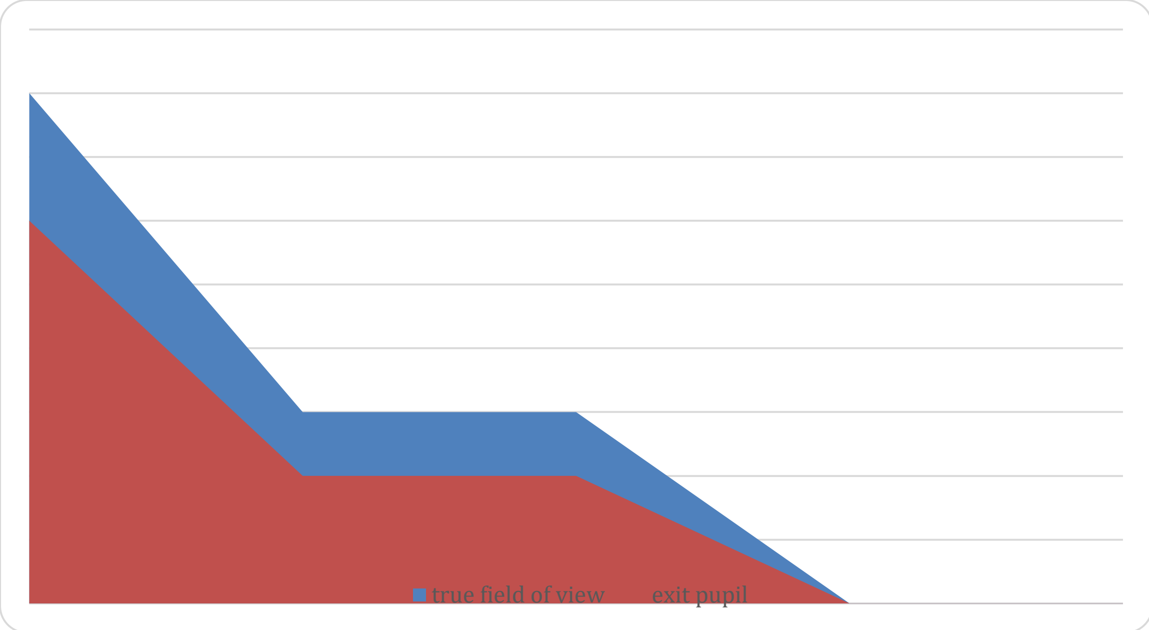
Figure explanation
In the above diagram of several picture which are compared as an adjacent structure which is visible in the photograph enlarged. Taken in default magnification to take a decent picture. The next image was captured with a telescopic at 87.5x resolution. The third photo has a 262.5x resolution, meaning that the Barlow optic was mounted to the observatory.

Tables

S.No	With or without barlow lens	Focal length	Magnification	True field of view	Exit pupil
1	Without	700mm	88x	0.8 degrees	0.6 mm
2	With	2100mm	263x	0.3 degrees	0.2mm
3	If a 3mm eyepiece is used	700mm	233x	0.3 degrees	0.2mm

From the table it is clearly understandable that using a barlow lens is better than using an eyepiece with lesser focal length. Even if we try to use a 3mm eyepiece which gives same true field of view and exit pupil, the magnification tends to be less than that of a telescope which uses a barlow lens.





The graph further explains us why we prefer to use a barlow lens over a eyepiece with shorter focal length. More than increasing the eyepiece collection it gives a better magnification than the 3mm eyepiece which had the same true field of view and exit pupil.

Conclusion

I have presented a refracting type telescope which gives a good magnification about 263x (with barlow lens) and 88x (without barlow lens). More than giving a good magnification it has reduced chromatic aberration which increases the clarity of the image. This is fixed by using a double achromatic objective lens which is a combination of a convex and concave lens made up of crown and flint glass respectively. The telescope is also capable of distance calculation using the parallax method of distance calculation with the help of laser lights. Further with the help of spectroscopy, a simple spectroscope is made which helps us to predict the elements referring the spectrograph. The telescope can also show where the telescope is pointed at (towards sky) showing the names, positions and structures of constellations, galaxies, planets and so on. The removable parts make it highly efficient for outdoor observations and made maintenance easy. This telescope has satisfied the necessary condition of feasibility as well as stand as a highly informative structure for learning process.

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Geometrical and physical optics analysis for mm-wavelength refractor telescopes designed to map the cosmic microwave background
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M A Karaeng[1], S Saehana[1] and U Wahyono[1]
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