3D Printed Outreach Parascope for Astronomy Open-Houses

Jacob Romeo

Abstract

Embry-Riddle Aeronautical University (ERAU) was equipped with a 1-meter Ritchey-Chretien Cassegrain telescope by DFM Engineering back in 2014. The 1-meter telescope has a focal ratio of f/8, where f is the focal length, and is composed of a primary and secondary mirror. These mirrors have little to no expansion under different climate conditions, meaning they have small expansion coefficients. This is currently the largest telescope in Florida available to students, thus, is a big attraction in the community (1). Because of this, the physics department in the College of Arts and Science (COAS) conducts 3 Astronomy open houses per semester for the public. Allowing not only the students to have amazing hands-on experience, but also for guests to come and observe the spectacle themselves. The *"Outreach Parascope"* allows the guests to observe what the 1-meter is pointed at. Giving them a similar feeling us Astrophysics seniors have during observations. The parascope also mitigates people tripping over wires and hitting their heads, due to the extension attached to it effectively extending the eyepiece. This allows for a fun, easy, and safe way for the public to visit and observe the night sky using the telescope. I wanted to thank Dr. Vikas Sudesh, the advising professor, for his help with the advancement of this project along with Dr. Stephen Gillam and fellow Astronomer Ryan Reynolds.

1 Introduction

1.1 Background

The physics department has been holding Astronomy open houses since before the 1-meter telescope was installed, back in 2014 (1). They have a lot of activities throughout the COAS, simulating classical gravity wells, topography of the moon and mars, observing with the Veranda telescopes, etc. Once the 1-meter was installed it became the pinnacle of the open-houses, where the volunteers gave tours of it. Talking about the student research involved and the technical components used for imaging and spectroscopy.

The only piece missing from this experience was observing with the 1-meter itself, rather, they were using a guiding telescope. This does not have the quality and magnification of the 1-meter, making it a less anticipated experience. This guider was attached to the side of the 1-meter. It was primarily used for astronomers to see approximately where they were in the sky. The original idea for making an eyepiece, or essentially a parascope, to be able to observe directly with the 1-meter came from graduate (enter name). This is the finished product of their work, making this concept into a reality.

1.2 The Assembly

The Summer Undergraduate Research Fellowship (SURF) stipend gave the resources to create the parascope. But before modeling the optical assembly, Dr. Sudesh and I had to find the components necessary for recreating the image made by the 1-meter. These components consisted of a mirror (on a pick-off mount, inserted into the telescope to reflect the incoming rays into the assembly) (Fig. 1), a lens for light collimation, and a lens for focusing the light into an eyepiece (Fig. 2).

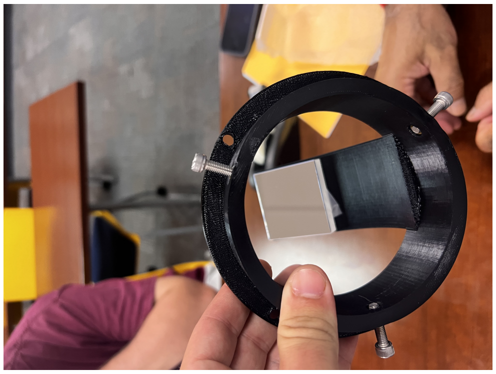

Figure 1: *Mirror on the pick-off mount.*

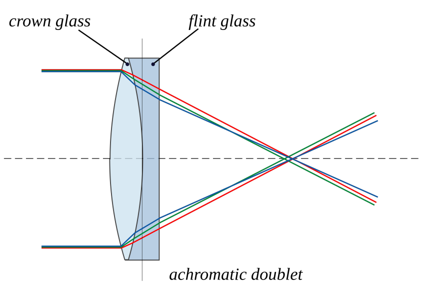

Figure 2: *The type of lens used (2).*

Computational analysis was used to calculate the approximate lengths of each part on the assembly. Once this was done, the assembly was modeled using Fusion 360, with the dimensions of the 1-meter and lengths derived taken into account. Once the parts of the apparatus were individually tested and eventually assembled (Fig. 3), the final product, including the mirror and lenses, were assembled and installed (Fig. 4). Allowing you to observe what the 1-meter is pointed at using the full power of the 1-meter itself.

Figure 3: *Prototype of the parascope.*

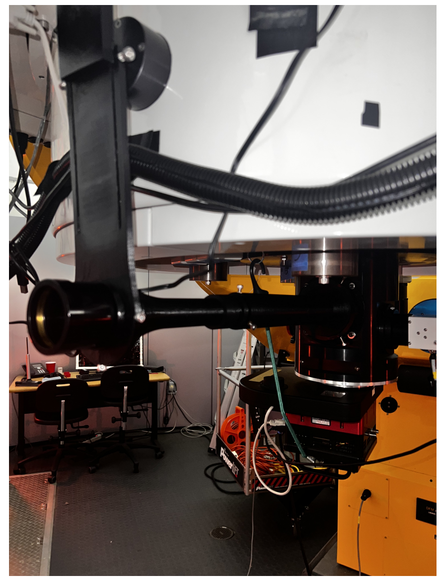

Figure 4: *Final version.*

2 Methods

2.1 Computations

The 1-meter has a focal ratio of $f\# = f/8$, putting the image, reflected from the pick-off mount, about 14cm away. This was found by installing the mount and measuring the distance from the mirror to the focused point. This gave us the approximate position the first lens needed to be placed. The incident light coming through the first lens is collimated, making the distance between this and the second lens arbitrary. The lenses are duplicates with a focal length of 200mm and diameter of 30mm. Though the focal length of the lens was known, you can see Dr. Gillam finding the 200mm focal length in Figure 5.

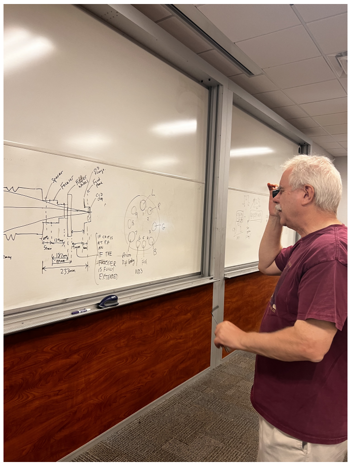

Figure 5: *Dr. Gillam measuring the effective focal length of the lens.*

Even though the distance from lens 1 to lens 2 is arbitrary, the distance from lens 2 to the eyepiece is not. This is because the second lens is focusing the collimated light, thus the eyepiece is displaced approximately 200mm away from lens 2. The eyepiece, with a 32mm focal length, then collimates the focused light so that the eye can see an image made by the 1-meter. This setup gives a clear, and focused image of what the telescope is pointed at. The telescope's image quality is mainly dependent on the atmospheric conditions. Since Daytona Beach is mostly cloudy and rainy, it is difficult to get a good observing night.

2.2 Fusion360 and 3D-Printing

Fusion360, a cloud based CAD software, was used to model each part for 3D printing. This was the bulk of the project, due to constantly testing and upgrading the designs. The pieces were designed and testing individually, then once functional they were assembled and projected in the CAD (Fig. 6) and printed individually. The assembly consists of printed threads for the larger pieces and threaded inserts for the smaller ones. The threaded inserts also give flexibility, allowing the observer to focus the image by slightly changing the lengths of each piece. In Figure 6, you can see a long extension that is mounted where the eyepiece goes. This is the support for the system, installed into the 1-meter. This puts less torque on the system allowing the parascope to be straight and not sag.

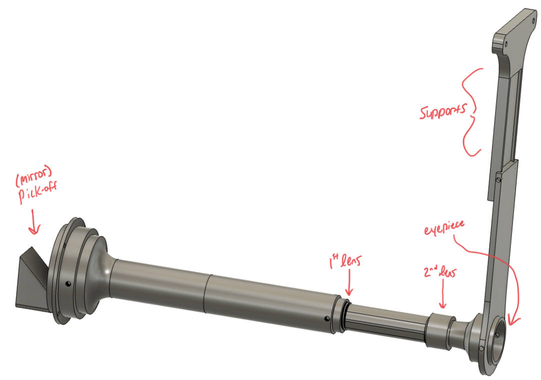

Figure 6: *CAD model of the parascope.*

Fusion360 has the ability to export the CAD file as a stl file, allowing you to slice it for printing. The slicing software which was used was prusa slicer, allowing flexibility on the printer used. Using the Engineering Physics Propulsion Lab's (EPPL), located in the COAS, 3D-printers to print the assembly. The selection of 3D-printers includes Prusa, Ender, and Modix brands. There were mainly issues with printing on the Enders, thus the Prusa printers were mainly used. The Modix printer, which is a 0.6 cubic meter printer, was originally being used for printing of the main tube, about 20cm long. But it was found that printing it in separate pieces which screwed onto each other was easier then one, long piece.

3 Results and Discussion

3.1 First Open-House

On September 27 of 2023, the COAS had its first open-house of the semester with nearly a thousand guests. The people who toured the 1-

meter got to observe the moon and Saturn with its satellites using the outreach parascope (Fig 7). This was the first official test run for the parascope, where the others took place during cloudy and humid nights. Not allowing us to fully test the functionality of the parascope.

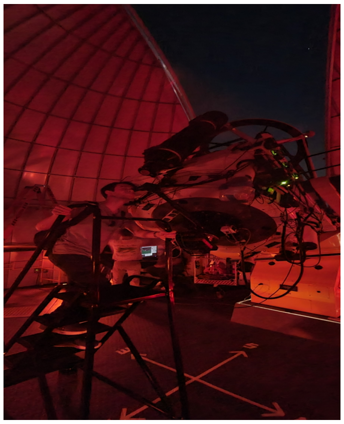

Figure 7: *One of the students observing.*

Though this was the first run with good weather, the parascope performed flawlessly, allowing the guests to comfortably view the objects with ease. The focus was nearly perfect and the setup allows anyone to change the focus in order for their eyes to adjust to see the image clearly. Figure 8 shows the northern hemisphere of the moon. Unfortunately images could not be taken of Saturn due to the intense magnification of the 1-meter telescope. The magnification de-focuses the image the camera receives, not allowing the camera to get a centered picture.

Figure 8: *Section of the moon through the parascope.*

3.2 Future Upgrades

When an object is low on the horizon, the telescope is high to reach. Meaning the parascope is also high and difficult to reach. To deal with this the team giving the tours must use a ladder so that the guests are able to reach the eyepiece. This position is still comfortable for the observer, though to get rid of the use for a ladder there must be an extension to be made. This extension would be adjustable and allow the observer to view the object without the use of a ladder. It would need another lens to be able to re-collimate the focused light so that you can extend the image. You would then be able to attach the eyepiece, that is currently being used, to the end. This would, in theory, give the same image you would see with the original setup.

When the outreach parascope is in use, the research camera, or charged coupled device, gets blocked and cannot be of use. So when we the researchers need to use the camera, they have to remove the parascope and re-install it for the next open-house. The solution to be able to use both simultaneously and receive equal amounts of light is to use a beam-splitter. This will direct the light so that it is delivered to both systems. This allows the camera and the outreach parascope to be in use at the same time, so that the parascope may stay installed.

4 References

(1) (2) $WikimediaFoundation.(2023, September30).Achromaticlens.Wikipedia.$
$https://en.wikipedia.org/wiki/Achromaticlens$