SOCIETY OF PHYSICS STUDENTS
An organization of the American Institute of Physics

SPS Chapter Research Award

Proposal

Project Proposal Title	Observational Astronomy
Name of School	Old Dominion University
SPS Chapter Number	5311
Total Amount Requested	$1974.90

Abstract

The Society of Physics Students at Old Dominion University seek to build an observational astronomy setup. This setup will be used to perform nightly observations. These nightly observations following the completion of the set up will expand ODU's community outreach and present students with hands-on experience in astronomy research.

Proposal Statement

Overview of Proposed Project

Late 2019 saw the noticeable dimming of the star Betelgeuse, the star that makes up the left shoulder of the constellation Orion [1]. The dimming of supergiant stars such as Betelgeuse can be indicative of large-scale destructive events taking place [2]. This presents the need for observational research more than ever with such a momentous event on our horizon. It is necessary that students be trained to make such observations in order to better understand the importance of these events and provide observational data for theorists to discern the specific astronomical mechanisms at work. Our proposed research aims to observe variable stars such as Betelgeuse among other astronomical phenomena and collect images and data on them.

Recently, Old Dominion University (ODU) launched a new astrophysics major and will soon be opening a brand new planetarium for classes and public shows. The addition of an observational astronomy component would jumpstart undergraduate research opportunities for degree-seeking astrophysics students and offer practical experience for Society of Physics Students (SPS) members. It also has the ability to provide beautiful images for informal education purposes in the Planetarium. The setup will also set the stage for future joint projects between the Engineering and Physics departments at ODU in order to automate the telescope in a rooftop observatory. Naturally, this would bring recognition to both departments and the ODU chapter of SPS as a whole for taking steps to reinvigorate Old Dominion University's astronomy research. Previously, a radio telescope was used to perform research on campus, but it was dismantled 15 years ago.

The ODU Chapter of SPS aims to construct an observational astronomy setup so that nightly observations may be conducted at the University. This is to be completed through the purchase and installation of filters and a filter wheel, a primary mirror focuser, an off-axis guider, and appropriate adapters. The University's has already dedicated a Celestron CPC 1100, 11-inch telescope and an Apogee 8300 camera. Upon completion of installation, images will be processed using software such as MaximDL. Future projects include software developed by SPS members to auto-detect anomalies within our astronomical data in order to locate objects of interest.

The goals of this project are as follows:

- Construct an observational astronomy setup such that nightly observations can be carried out
- Make observations on variable celestial objects such as Betelgeuse, transits, and supernovae
- Provide the opportunity for SPS students to gain practical research experience analyzing data through image analysis and coding
- Provide a method by which members of the local community may see astronomical phenomena

Upon completion of this project, SPS chapter members will gain the experience necessary to carry out observational research in the field of astronomy. The grant offered by the National Society of Physics Students will provide great benefit to our chapter and allow us to construct a setup for observational research at ODU that will be enjoyed by the chapter, the Department and, the community as a whole. The research also allows ODU's SPS chapter to present findings during ODU's Celebration of Hubble event in April.

Background for Proposed Project

The earliest occurrence of sophisticated astronomy dates back to the Ancient Greeks, a time when ancient mathematicians aimed to describe the motion of the planets based on astronomical observations. Since then, mathematicians and scientists alike have aimed to describe the world around them by looking toward the stars with a more technologically advanced method of collecting data. Today, scientists use telescopes with digital cameras and filters to "hone in" on specific wavelengths of light and use programs to filter images and extract meaningful data [3]. More recently, however, observational efforts have been focused on the research of variable stars such as Betelgeuse whose magnitude has been fluctuating [1]. This is an indication that the star may go supernova soon, the result of which would be an apparent magnitude so low that the event would be visible to the naked eye during the daytime [4]. Our research aims to contribute to the pool of data surrounding variable stars and supernovae. The presence of a planetarium on our campus also allows us the opportunity to present results to the local community, providing the opportunity for local citizens to gain knowledge about an active area of research in the scientific community.

Expected Results

By the end of this project we expect to have constructed an observational setup consisting of a telescope with proper equipment and a camera. This setup will be used to gather images from the night sky over the duration of the research project using both visible band and red band filters. This will allow us to "hone in" on specific wavelengths of light and garner more useful data. In the future, we plan to purchase more filters to further expand our observational capabilities. Future research opportunities includes developing software to filter data based off of desired criteria and report anomalies in images. For instance, developing an algorithm to detect supernovae or planetary transits in images collected from the telescope. Later, the setup could be automated and installed in the University's rooftop observatory to allow for remote access.

Description of Proposed Research - Methods, Design, and Procedures

The research will revolve around the use of the University's 11-inch Celestron CPC 1100 telescope. The first step of its implementation will be to install the necessary components onto the telescope so that it may produce images of value (filter wheel, guider, camera, etc.). Upon completion of installation the telescope will be deployed nightly for observation, depending on weather conditions. Considering the current time of year, the telescope will be aimed at various patches of the night sky to observe variable stars, supernovae, or transits and collect images throughout the night. The following morning these images will be uploaded and backed up to ensure that they are not corrupted, image processing will occur, and data will be searched for anomalies. These anomalies will be catalogued and organized appropriately. In the future, the telescope will be stored and installed in the university's observatory to allow for automation of the project. This will necessitate installation of new equipment such as a wedge and motors for the dome of the observatory. We plan on having regular meetings where research participants will present their progress to faculty in order to facilitate the project and diagnose any ongoing problems. Students will be organized into subgroups based on their interests and areas of expertise. For example, students with a stronger background in programming will be assigned to develop software to detect anomalies.

Plan for Carrying Out Proposed Project

There are a total of 7 SPS members interested in this project. They will facilitate the project and see it to completion. Two of the participants are computer engineering majors with experience in both programming and entry-level automation. They will be able to assist in the future automation of the project. There are 3 non-SPS faculty members assisting in the project of which include, Dr. Balša Terzić: the coordinator of the newly established astrophysics track, Justin Mason: the Planetarium Director, and Josh Frechem: a physics PhD candidate with experience building his own backyard observatory. They will be assisting the development of the project and helping to diagnose any problems that may arise. They all have experience in the field of astronomy or experience in observational astronomy. Our SPS Chapter advisor, Dr. Matthew Nerem, will also participate. Dr. Nerem is to serve the role of advisor and mentor throughout the project. He has experience in programming and will be available for questions. The research itself will be conducted outdoors on ODU's campus. It will later be conducted in ODU's observatory atop the physics building.

Project Timeline

11/15/20	Submit SPS Chapter Research Grant Proposal
11/30/20	Assign self-study for group Assemble teams based off interest and skill set
1/10/21	Purchase necessary equipment for telescope
1/19/21	Start of ODU spring semester Regroup and assess any questions, concerns, etc. Go over spring term plan
1/29/21	Begin assembly/installation of telescope equipment Begin pseudocode/design of anomaly detection software
2/12/21	Finish assembly of telescope once all parts arrive -> Begin calibration/testing of equipment Delegate programming assignments based off pseudocode -> Begin initial prototyping of code
3/5/21	Test initial prototype of code Reassign roles if needed
3/19/21	Test redesign of prototype, make adjustments as needed
4/24/21	Present selected images at Hubble Celebration Event
4/31/21	Begin writing interim report Test second prototype of code Select summer observation group
5/15/21	Finalize program and test it Select images/tests for interim report
5/31/21	Submit interim report Break for summer Summer observation group -> Nightly observations Assign self-study
8/28/21	ODU Begins Fall ‘21 classes -> Reconvene and regroup Begin writing paper for final report -> assign roles for each person
10/31/21	Finish first draft and begin final draft of paper
12/31/21	Submit final report to National Society of Physics Students

Budget Justification

In order to conduct observational astronomy, the use of filters and accompanying accessories are required. Filters are used to observe specific wavelengths of light in order to examine the characteristics of a celestial object. For example, a V filter lets in visible light only, blocking out wavelengths in the infrared and ultraviolet spectrums. The magnitude of the star in multiple filters can be used to calculate the color index and determine characteristics of the star. To ensure that the telescope is stable and tracks objects correctly, guiders and focusers are also necessary. These ensure that the object remains in the focus of the telescope so that images can be taken of the same object throughout the entirety of the evening.

The telescope we will be using is provided by the Physics department. It is the Celestron CPC 1100. It is an 11-inch, computerized telescope. We will also be using an Apogee 8300 camera for capturing images during nightly observations. It is a research caliber CCD camera capable of capturing images of up to 8.3 megapixels in size.

Bibliography

[1] Hershberger, S. (2020, October 5). If Betelgeuse goes boom: How DUNE would respond to a nearby supernova. https://news.fnal.gov/2020/10/if-betelgeuse-goes-boom-how-dune-would-respond-to-a-nearby-supernova/

[2] Garner, R. (2020, August 13). Hubble Finds Betelgeuse's Mysterious Dimming Due to Traumatic Outburst. https://www.nasa.gov/feature/goddard/2020/hubble-finds-that-betelgeuses-mysterious-dimming-is-due-to-a-traumatic-outburst

[3] McDiarmid, F. (1915). The Evolution of Astronomy. Journal of the Royal Astronomical Society of Canada

[4] Siegel, E. (2020, January 23). This Is What We'll See When Betelgeuse Really Does Go Supernova. https://www.forbes.com/sites/startswithabang/2020/01/23/this-is-what-well-see-when-betelgeuse-really-does-go-supernova/?sh=39ac4a6743a2