SOCIETY OF PHYSICS STUDENTS

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SPS Chapter Research Award Proposal

Project Proposal Title	Speckle Imaging for Fun and Outreach
Name of School	University of North Alabama
SPS Chapter Number	4815
Total Amount Requested	$1,379

Abstract

The principle way that we can obtain the masses of stars is through observations of binary stars. When A binary is close enough, both components can be imaged, and an orbital solution can give the masses. What is required is astrometric observations of these stars to observe the elliptical path of the secondary around the primary star. The proposed project will involve setting up a system to do speckle imaging of close double stars. The speckle imaging technique uses high speed imaging (100s frames per seconds) to “freeze” the effects of seeing on images (Labevrie 1970). Speckle imaging has been used to obtain diffraction-limited images of close double stars to allow astrometry of the components. The time to take the required observations is about ten minutes per pass-band, and so this makes a good first observing project. The group has been doing outreach to high schools students and publishing the results. Here we propose to emulate this work. The funds requested here will obtain the photometric filters and equipment to conduct the observations.

Proposal Statement

Overview of Proposed Project

Double stars are very fascinating and fun to learn about. They are a pair of stars in orbit around each other where each component is visible. These double stars are important because we can get the masses of stars this way. Studying binary stars is the only way we have of obtaining stellar masses. Being able to determine the mass of a star can tell someone a lot about that star, including how it will evolve. Now, the measurements that are needed to get double stars orbits is the position of each component. Speckle imaging is high-speed imaging that freezes the seeing effect of atmosphere, which allows the measurement of very close pairs (Labyrie 1970). This allows people to study double stars that are very close together. Because the data can be taken in a relatively short period of time, these studies make good choices for amateurs and for relatively inexperienced high school students. The Institute for Student Astronomical Research (InSTAR; Freed et al. 2020) has been conducting research with high school students for outreach and for introducing them to astronomy. The objective of this project is to implement a program to observe double stars using speckle imaging, with the aim to do an outreach program with local high school students, mimicking the InStaR program locally. This will both provide useful data for double stars, but also help encourage students to pursue STEM careers. This will be conducted by UNA SPS members using the UNA Observatory.

Background for Proposed Project

The evolution of stars is determined largely by their masses. More massive stars evolve faster than less massive stars, and some eventually explode as supernovae (e.g. Carroll & Ostie 2017). To model stars, we therefore need good statistics of the mass of stars of different types. To obtain these data we use binary stars – stars that orbit one another. The two stars in a pair will orbit their common center of gravity, the center of mass. The less massive star (star B) will orbit farther from the center of mass than the more massive component (star A). The projection of the orbits on the sky will be ellipses. The masses may be obtained from Kepler's third law, since its constant depends upon the sum of the masses of the stars. If the two stars are seen as separate objects on the sky, we call them a double star, which are the key to stellar masses. If we measure the orbital motion on the sky, then star B moves in an ellipse around star A, the time for which is the orbital period. If the distance and the apparent semi-major axis are measured, geometry gives the semi-major axis in km. This then allows the determination of the sum of the stellar masses. Combining this with the relative separation of the two stars from the center of mass as determined from the orbit, gives the masses of both stars. What is needed are observations of positions of the two stars over time, sometimes decades or hundreds of years. What is recorded is the separation in arcseconds and the angle from north, to trace out the path of star B.

This makes a good project for amateur astronomers and a good first project in astronomy for beginners because the time on the telescope is relatively short and software is mature to measure the images. This project will set up a program to observe very close binaries whose measurement is limited by seeing – the blurring of images created by the atmosphere. Once these techniques are mastered, we will set up an outreach program to train high school students to do the measurements. Measurements will be published in the Journal of Double Star Observations and JURP.

Expected Results

As an SPS project, we intend to use this research project as an outreach opportunity by creating a remote research experience. Our students have been interested in creating a series of videos to provide to the public, and recording parts of this research project would be an excellent opportunity. Using either zoom, or in person, we plan to create workshops where students can work alongside us as to process data collected during the project.

As an outreach opportunity, our chapter has a particular interest in reaching out to local high schools. Plans have been discussed about helping any high school student who has expressed interest in participating in the Alabama Academy of Science GORGAS competition. Although our university's STEM camp has been postponed due to COVID, we intend to work with high school students who wish to participate in research experience. Our chapter will work to provide educational opportunities that enhance the science curriculum, as many students are unaware of what scientists really do for a living. We wish to provide an example of what real research looks like. We want to demonstrate that science is less daunting and more rewarding than many people perceive. Our chapter believes that this research project is best suited to serve our purposes to perform such tasks.

Description of Proposed Research - Methods, Design, and Procedures

The observing runs will consist of 10-minute observations of each double star using the ZWO CMOS camera. Observations in three filters will be obtained, in the B,V ad R band of the Johnson cousins system, and an H-alpha narrow-band filter supplied by UNA observatory. In addition to the target stars, doubles of know position will be observed in a similar manner to obtain the orientation of the images with respect to the cardinal directions on the sky. These images will then be input into the REDUC software, developed by Florent Losse, which is freely available. This will produce the autocorrelations, which will be used to measure the positions of the doubles to obtain the separations and position angles. The results will be disseminated in the Journal of Undergraduate Reports in Physics (JURP), the Journal of Double Star Observations (JDSO) and presented at the American Astronomical Society (AAS) meeting and the 2021 SPS Zone 6 meeting if that should be possible. We will also write up a popular article for the SPS Observer.

Plan for Carrying Out Proposed Project

Personnel: The project it will involve freshman student Emelia Abts, and senior students Charles Harville, and Hannah Miller, who will be doing it in part for her senior research. Other chapter members may become involved but have not committed yet.

Expertise: Both Charles Harville and Hannah Miller have done a senior-level observational astronomy course, and have done astrometry of double stars as a part of that course, and used the observatory to collect data. Emelia Abts is a freshman and amateur astronomer who has used telescopes before. Charles has a strong interest in promoting science, and has organized outreach projects with the SPS and done tutoring of middle and high school students on a volunteer basis.

Research Space: The observatory consists of a 0.36m Celestron SCT telescope mounted on a Paramount MEII mount. The control software is the Sky X, and MaximDl software for camera control. The observatory director is Dr. Mel Blake, who is the SPS Chapter adviser. He will make as much time available for this project as required for it to be successful. He has also arranged for the purchase of a ZWO CMOS camera to be used in this project.

Contributions of faculty advisors: Dr. Mel Blake, Chapter adviser and observatory director will help in all aspects of this project. His research specialty is binary and variable stars.

Project Timeline

January – February 2021: We will first use the Washington Double Star catalog to select a list of close double stars that have been neglected – not observed for at least ten years. This will provide an input list of targets. The first step in the project will be to learn the speckle imaging process ourselves, by obtaining data on double stars of known position and separation. We will also obtain the required equipment for the project.

February-May 2021: We will do observing runs to take speckle data of double stars and use these runs to learn the techniques. At this time we will present first results at AAS meeting.

Summer 2021: Write up first results for JURP, JDSO. Publicize project to local schools. Recruit two groups of four students to conduct first observations.

September – November 2021. First two workshops for students. Observations for two stars collected. Present results at Zone 6 meeting if possible. Data collected reduced collaboratively with student teams. Observations submitted to JDSO. Report to SPS written.

Budget Justification

The speckle imaging requires the use of standard filters, such as the Johnson-Cousins filters used in photometry. We require the purchase of three filters, the B, V and R-band filters. These will allow us to report the relative brightnesses of the stars in the binaries in addition to the positional measurements. The resolution depends upon the inverse of wavelength, better resolution will be obtained when observing at shorter wavelengths, and so the B-band filter will improve this result. These filters will cost $250 each, from the Custom Scientific website (http://www.customscientific.com/astronomy.html), for a total of $750. In order to acquire the images, we also will need the flip-mirror. UNA observatory had only a traditional CCD camera which is not capable of doing rapid imaging. To support the project the UNA Observatory has obtained a ZWO ASI1600MM Pro CMOS camera with filter wheel for this project, at a cost of $1799. This is the same model used by Wasson et. al. (2020). We also require a flip mirror for target acquisition. For this we will use a Vixen 2'' flip mirror at a cost of $129, from the Adorama website (https://www.adorama.com). The spring 2021 AAS meeting is Anchorage Alaska. While the meeting is currently planned for in-person attendance, it is not clear if that will really occur, but registration costs will need to be paid regardless of the format. We include $250 for registration for this meeting, based upon the costs for the Winter 2021 meeting registration. For two students' registration will be $500. Our total budget comes to $1379.

Bibliography

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