2019 Technology Fee Full Proposal

Title: Experiential Learning in Astronomy

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Purpose and Specific Objectives: This past year marked the 50th anniversary of Rosemary Hill Observatory (RHO), and the 55th anniversary of the Campus Teaching Observatory (CTO) at its current location. These two facilities are the core resources for experiential learning in astronomy at the University of Florida, with over 800 students using these observatories for coursework each year. This observing experience is central to the courses that we teach in our department, providing a perspective and experience that cannot be replicated with lectures alone. As we move towards more interactive courses, the importance of these facilities is only increasing with time. Our goal is to further expand student use of these facilities and improve these hands-on experiences. Towards this end, we are in the process of hiring a new lecturer in our department whose focus will be experiential learning. The department has also invested in modernization of the telescopes at both locations during the past few years, but we need support via a Tech Fee Grant to enable more complete integration of department observatories into undergraduate (and graduate) courses and to further expand experiential learning via inclusion of radio astronomy in undergraduate labs. There are two specific objectives for this Tech Fee request.

1. **Roboticization and addition of modern instruments for the Rosemary Hill Observatory**. At present, the Campus Teaching Observatory is the primary facility used for undergraduate course, with over 800 students from AST 1002, AST 1022, AST 3018, AST 3722, and AST 4723 all using it for classes. It is in operation every clear weeknight, often at (or beyond) capacity. RHO has larger telescopes at a much darker location (one of the darkest in the state, Figure 1), but use for undergraduate courses has been limited to AST 3722 and AST 4723 because it is a 45 min drive away (near the town of Bronson), and hence not easily accessible. The department has made significant effort in the past few years to upgrade RHO, including purchasing a new 14" telescope, and we have been working hard to refurbish the observatory buildings as part of our effort to modernize RHO. Repairs to the telescope domes have just been completed, fiber-optic internet access has recently been added, security for the buildings has been upgraded, and repainting of the domes is currently underway.

Figure 1: Image of the 30" Dome at Rosemary Hill Observatory, taken by an undergraduate major in our department. RHO is located in one of the darkest night sky locations in the state of Florida.

We request Tech Fee funds to enable remote operation of the new 14" telescope (Figure 2) and to add a new wide-area camera, including filters for obtaining color images and an adaptive optics module that results in sharper images. The 14" telescope is well-suited to automation in its current configuration, which is feasible now that we have a fiber-optic internet connection. We also have a new remote operations control room adjacent to the student study area in our department (Figure 4). These funds will enable students to run the

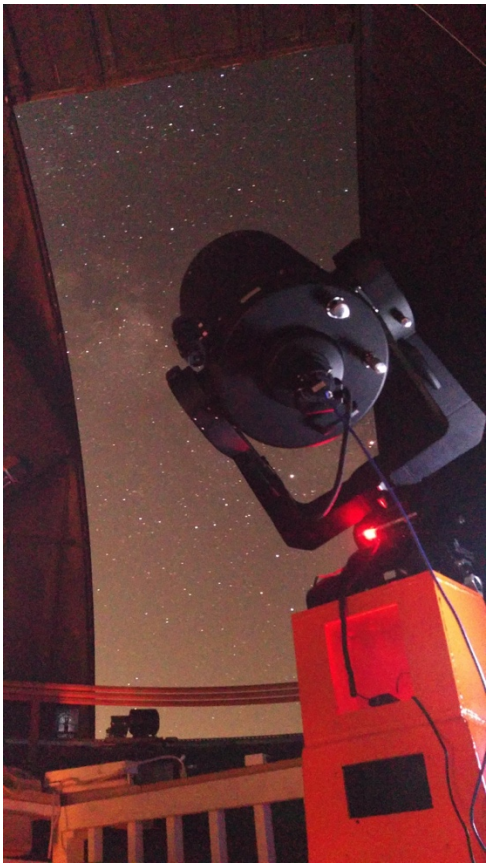

Figure 2: RHO 14" telescope, which will be roboticized for student use from campus.

Figure 3: AST 3722 students in the control room observing operation of a research telescope in Arizona. This is the room and setup that students will use to remotely operate the 14" telescope.

telescope from the remote operations room on campus at any time. This is a *significant* step in improving access to RHO, eliminating the hour and a half round-trip drive to the observatory and making it practical to schedule observing on nights when the weather forecast is uncertain (which is frequent). It thus becomes possible to have observing sessions using RHO from campus for AST 1002 in the same fashion as is currently done using the Campus Teaching Observatory, as well as regularly scheduled observing for the AST 1002 labs and the upper level courses AST 3018, AST 3722, and AST 4723. Moreover, with this remote access it becomes possible to integrate observing into the AST 1002 residential online courses, with the instructor controlling the telescope and students viewing objects in real time as the instructor shares image taken with the telescope.

The other improvement we request for RHO is the addition of a spectrograph to the 30" telescope. Spectrographs disperse light spatially as a function of wavelength (like a prism), and are a fundamental tool in astrophysics. The addition of this spectrograph will allow students to directly measure the temperatures, compositions, and velocities of stars. We plan to develop and implement labs for AST 3722 and AST 4723 in which students use this spectrograph to observe bright stars and derive the above properties for themselves. For AST 4723 students will also be able to design independent projects using the spectrograph.

For both telescopes, we are requesting two monitors (one large and one small). For the 14" we will require students to be trained on site before remote operations, and these will be similar to the setup in our campus control room (which has one more small screen per station for analyzing the data). For the 30", we will also be matching this configuration, and the large monitor will be key to facilitating observing sessions for classes. We typically have 10-20 students in the 30" dome when we take classes out for training or group observing. In these situations, we currently end up with 10-20 students crowded around a single 27-inch monitor trying to see the images being acquired. With the new monitors, we will be able to have a few students controlling the telescope and spectrograph from the smaller screen while others can comfortably observe the images being acquired on the larger screen.

2. **Observing the Universe in the Radio**. Besides visible light, radio is the only other means by which we can observe the Universe from the ground, and provides a very different experience. To augment the optical observing from our teaching observatories, we propose to purchase two small, low-frequency radio antennas and associated receiver electronics for use with our AST 1022 and AST 4723 labs. Modest in cost, we can install these at our observatories and operate them from our remote control room on campus. The antennas that we propose to purchase are designed for student construction – we intend for the full installation to be a student-run experience. The planned labs are as follows. For AST 1022 we will implement a lab in which students explore the radio spectrum. The frequency range covered by these antennas will include the frequencies used for TV broadcasts, cell phones, and aeronautical communications, enabling students to observe both emission from astrophysical objects (e.g. the Sun) and human-generated signals. For AST 4723, students will use these antennas to learn the fundamentals of radio astronomy through observations of the Sun and Jupiter. We also plan to design a lab in which the students will construct a simple interferometer with the array of two antennas (improving the spatial resolution compared to a single antenna) and target the signal from either the Sun or a geosynchronous satellite to compare the signal from the interferometer with a single antenna. Using an array of antennas in this fashion is the same technique that was recently used to image a black hole for the first time – a technique that was originally developed at the University of Florida. This experiment gives the students experience that prepares them for cutting-edge research in astronomy.

Impact/Benefit: We will integrate use of the RHO telescopes into AST1002 (14"), AST 1022 (14") and AST 3018 (14" and 30") and expand their use in AST 3722 and AST 4723, which will relieve the current pressure on CTO. The radio antennas will enable us to add radio astronomy labs to our introductory and upper level lab courses (AST 1022 and AST 4723). Moreover, the automation of the RHO telescopes provides us with a means of integrating observing into the residential online sections of AST 1002 (200 students/yr, not included in the number of students currently using the facilities), with the instructor or TAs controlling the telescope to observe student-suggested objects, and sharing the images in real time online. ***This incorporation of experiential learning into our introductory residential online course is unique and novel.***

Additionally, these telescopes will become a valuable resource for undergraduate research projects. Once upper level students are trained on use of the telescopes and remote operations, it will be possible for them to schedule time on the telescopes and operate them from the department. Specifically, we will establish an online schedule and allow them to reserve time slots for remote observing with the 14". We will also establish protocols and training so that teams of undergraduates can reserve time at RHO using the 30" telescope (no students will be permitted to observe alone for safety). There are a number of upcoming large sky surveys that are designed to identify time-variable objects such as supernovae, variable stars, and transiting exoplanets. Access to these facilities will enable students to conduct cutting-edge, publishable research using the 14" RHO telescope from campus, and to obtain spectra of the most interesting objects with the 30". Such research experiences are central to our effort to make experiential learning integral to the education of our majors. These types of research experiences are also an important consideration for many graduate school admissions committees, and research with these telescopes will strengthen the applications of our undergraduates who are applying to graduate school.

Finally, we realize the importance of making these facilities accessible to all students. Remote observing itself is an important step in this direction. The remote observing room in the department is ADA accessible. We will also work to ensure ADA compliance of the web interface for remote observing.

Sustainability: Rosemary Hill Observatory has been in continuous operation since 1968, and the department budgets for yearly operating costs associated with the facility. For the telescope roboticization, the hardware is selected to be robust with a long lifetime, and the department will budget for eventual repair should elements fail. Similarly, the camera and radio antennas should have usable lifetime of >10 years (with a planned budget for eventual replacement). Well-built spectrographs can last for many decades, and our department is one of the world-leaders in designing and building astronomical spectrographs. Should any repair be needed, we have the expertise to do so. Lightning is the one potential key concern for sustainability, as a lightning strike to the 14" telescope

building can potentially destroy the assorted electronics associated with robotic operation of the telescope. This is not a theoretical concern, as RHO has been impacted by lightning strikes in the past. To mitigate this danger, the final item that we have budgeted for in this proposal is hardware for a lightning protection system that we will install on the 14" dome. This protection includes both surge protection and breakers, and also a grounding system designed to redirect surges away from the interior electronics.

Timeline: We will get started on this effort immediately upon award of the grant and have designed our timeline to have all phases of work complete well within a year. The timeline for the spectrograph is longest, as spectrograph construction will be student-driven and we want to ensure they have sufficient time to learn from the process and test out the spectrograph in the lab before installation at the telescope.