Remote Observing and Beyond: Student Research and Analysis Programs at the Dark Ridge Observatory

Thomas C. Smith
Director, Dark Ridge Observatory
701 NM Highway 24, Weed, New Mexico
tcsmith@darkridgeobservatory.org

Abstract

Students that utilize remote observatories to conduct their scientific research are often at the mercy and whims of the observatory owner/operator. In today’s growing arsenal of remote observatories, many have provided the use of their equipment for both research and astrophotography but for most remote sites the support ends there. At the Dark Ridge Observatory students are made a part of the entire observatory and observing process including data reduction, analysis and incorporation into scientific papers in refereed journals. At the Dark Ridge Observatory the student is guided through the nuances of the host equipment to achieve scientific accuracy for their measurements. The process provides mentoring for the student in the collection, reduction and understanding of the use of astronomical images in science.

1. Introduction

For the two class semesters in 2006/7 students from Cuesta Community College C and California Polytechnic University in San Luis Obispo in California have been engaged in astronomical research utilizing observations made remotely at the Dark Ridge Observatory in Weed, New Mexico. The Dark Ridge Observatory’s contributions to the research, data analysis, and resulting published papers can serve as a model on which efficient use of remote telescopes and near real-time interactions with the students plays a very important role in learning opportunities. Communications before, during and after image data is collected and analyzed along with having “the” expert on the observatory equipment being a major collaborator and contributor are the keys to a very successful relationship that results in valuable scientific research papers that students can cite reference to in future endeavors.

2. The Dark Ridge Observatory (DRO)

Dark Ridge Observatory is located in the Sacramento Mountains of New Mexico at an elevation of 7100 feet. This area has a nominal weather pattern of clear crisp skies in the winter and spring months and monsoon-type weather in the summer and early fall. The sky conditions during most clear nights provide seeing between 1.5 and 0.7 arc-seconds. The Dark Ridge Observatory is a non-profit 501(c)(3) charitable organization that currently utilizes the privately owned faculty and equipment of the Dark Ridge Ranch.

Figure 1 shows an artist’s rendition of the planned DRO facilities where at least three roll-off roof observatories will house telescopes and cameras that are controlled from a separate warm room. Figure 2 shows the current status, with one of the three observatories in place.

Figure 1. The proposed rendition looking at phase 1 of the DRO construction effort.
3. Equipment at the Dark Ridge Observatory

Currently in operation are two Meade 14” LX200GPS/R telescopes and one Meade 8” LX200R used mainly for public outreach and star parties. Each 14” telescope is equipped with an SBIG ST series (7XE/8XME) CCD camera with “UBVReC” photometric filters and a 5” Orion f/5 refractor mounted parallel to the main telescope as either a wide-field imaging system or as the more common case as a guide scope configuration with either an ST-402 CCD camera (ST-7 format CCD) or the external guide head from the ST-8XME. Additional equipment available are two SBIG spectrographs, the DSS7 low-resolution and the SGS high resolution with 1800 rules/mm grating (high resolution) and 600 rules/mm grating (low resolution). The telescopes can be operated at their deigned f/10 focal ratio or at f/4 utilizing a f/3.3 focal reducer/field flattener, there are two Meade Deep Sky Imaging (DSI) CCD cameras (DSI, and DSI Pro II) available for imaging or autoguiding purposes.

Additional telescopes to be installed are a 20” Ritchie-Chrétien Alt-Az telescope with an Apogee AP-8 CCD with “UBVReC” photometric filters and narrow-band filters Ha, Hb, OIII (already in hand but currently in storage) and several other “to be built” Alt-Az systems that are being designed, constructed and tested by students at California Polytechnic University in San Luis Obispo, California under the guidance of an oversight group consisting of many individuals with various technical backgrounds and areas of interest.

4. Current Collaborations and Opportunities at DRO

There are currently several projects that are utilizing the Dark Ridge Observatory facilities and mentoring support, those being in the research areas of double star measurements, exoplanet follow-up, variable star work including some newly discovered variable stars that need classification work done as part of the GNAT project, headed by Dr. Eric Craine. Many papers have either been published in or are in the final processes of review and publication in journals, both refereed and non-refereed. These papers directly add valuable astronomical data to the scientific community and are a vital part of the student’s holistic view of the scientific process.

In addition to student research the Dark Ridge Observatory is conducting an on-going investigation of several over-contact eclipsing binary stars, spectroscopic analysis of the Oxygen Triplet feature of Cepheid variable stars in the near infrared, and exoplanet follow-up studies.

5. Making the Difference

When a student or group of students begins their research project one of the first things done is to decide on what type of science is to be obtained. This can include discussions of the type of astronomical object that is to be studied, the expected results from observing the object, and the many details about how the object is to be imaged for further analysis.

Having the “expert”, or subject matter expert (SME) on the specific telescopes and equipment mentor the students makes choosing many of the observing details and instrument selection a much richer experience for the students without them needing to learn all the instrument specific details and nuances and then how best to utilize the system for the intended function. This doesn’t mean that the student just picks the target and that all the rest of the details are laid out for them but rather a recommendation is made by DRO, explaining why the choices were made in detail, discussing the pros and cons of each choice suggested, and the student is then free to make the final decisions about the setup to be used.

Once a set of equipment choices and imaging parameters is decided upon, test images of the target providing representative results are made and presented to the students for their review. If the results are not as the student intended then adjustments are made to the selected setup and imaging parameters and further testing is performed until a satisfactory result is obtained. The test image and some resulting preliminary data can be immediately sent to the stu-
dent(s) involved via the Internet and then a real-time discussion can be conducted.

Following this discussion the data is collected by taking images, in raw form, for the specified period of time and then the images are subsequently reduced using either a library of calibration frames or, if needed, from calibration frames taken as part of the imaging session. The resulting “reduced” images are then used to begin an iterative analysis and discussion of results, with many of the analysis being performed at the Dark Ridge Observatory. This is usually done via email and phone conversations at a later time.

When the resulting data is in a form that the student feels correct for presentation or publication Dark Ridge Observatory will transmit all analysis data and resulting plots or charts to the student(s) such that they may begin preparing draft papers covering the science subject and project. Often times the Dark Ridge Observatory will simply pass on to the students the rough analysis results in raw numerical format so that the students can themselves perform further analysis and make their conclusions based upon their own work. This is the desired method provided the student has the necessary software to perform the analysis themselves.

6. Recent Student Activities

As part of a research class (Physics 93) held at the Cuesta Community College in San Luis Obispo California, the Dark Ridge Observatory worked closely with students and instructor in obtaining the astronomical imaging data needed to produce several publications that were presented to the following organizations:


American Association of Variable Star Observers (JAAVSO) for the following title; “Exoplanet Observations Suggest Early Ingress”, and ““Flare Star” Near WASP-1b 2007.10.15” data sent to the AAVSO VSX database.

Journal of Double Stars Observations (JDSO) for the following titles; “CCD Magnitude Limits of double stars”, “DRO CCD of Double Stars”,

7. Examples of student-DRO work

Many student projects have been conducted at the Dark Ridge Observatory in its previous location utilizing some of the same instrumentation as is currently available at the new site in New Mexico. Some examples of the work include the following:

"An Experiment in Relating CCD Differential Photometric Precision to Varying Degrees of Image Focus", presented by Eric Strum as a poster publication at the 2005 American Astronomical Society meeting held in San Diego California as well as a published paper at the Society of Astronomical Sciences (SAS) meeting. In this case data collection and analysis resulting in published posters, papers and presentations were conducted at the Dark Ridge Observatory.

"A Compact, Off-the-Shelf, Low-Cost Dual Channel Photometer", presented by Christine Heather in both written paper and oral presentation at the 2006 Society of Astronomical Sciences (SAS) meeting. In this case, construction of the hardware, data collection through imaging and analysis with resulting papers were conducted at the Dark Ridge Observatory.

"Light Curves of Two GNAT MG1 Survey Stars a One-Semester Community College Pilot Research Project", presented by Noll Roberts, Casey Milne, and Neelie Jaggi, a three student project, for publication in the Journal of the American Association of Variable Star Observers (JAAVSO).

Figure 3. The three-student team working at the Orion Observatory.

8. Conclusion

Dark Ridge Observatory and the interactive work that is conducted between the students and the on-site SME really makes a significant difference in the way the students both learn about science through astronomy as well as the way they get energized for all

© Society for Astronomical Sciences, Inc. • Provided by the NASA Astrophysics Data System
their future endeavors. It takes a lot of work and patience to accomplish first-rate astronomical science and in the production and presentation of their work in journals and speaking at recognized conferences and it is here where Dark Ridge Observatory and student collaboration is really making a difference.

9. Acknowledgements

The Dark Ridge Observatory would like to offer special thanks to Dr. Russell Genet and the students of his Research Seminars for being the subjects of this paper. Additionally I would like to thank Cindy Foote, Jim Carlisle and Bruce Gary for the collaboration on the exoplanet follow-up studies and the serendipitous discovery of the “Flare Star” near WASP-1b.