THE SCHOOL OF GALACTIC RADIO ASTRONOMY

A. Project Description

Introduction

The School of Galactic Radio Astronomy (SGRA) takes its name from the source SGR-A, the center of the Milky Way Galaxy. SGRA is based at the Pisgah Astronomical Research Institute (PARI) and is being proposed as an experience-based school room for regional use by elementary, middle, and high school teachers and their students. Their scientific educational experience at SGRA relies on Internet access to our remote-controlled radio telescope. The remote-controlled radio telescope is a 4.6-m antenna. We are developing as part of this project the pointing and tracking capabilities typical of any other astronomical telescope. The antenna is designed to detect 21-cm radio waves emitted for example by the center of our galaxy and its spiral arms, supernova remnants, and regions of star formation. Students and teachers make the observations from source selection, to pointing the telescope to taking the measurements. PARI is committed to making the radio telescope available to schools over the Internet and providing up to 20% of their astronomer’s time to the project. PARI is requesting start-up funding from the STScI IDEAS program to support the SGRA.

I. Goals and Objectives

The School of Galactic Radio Astronomy (SGRA) enhances science, mathematics, and technology education of students in grades 8-12. The purpose of SGRA is to teach the basics of scientific inquiry, which includes methodology, critical thinking, and communicating of results. Also, SGRA is designed to adhere to the State of North Carolina and national education standards in science, mathematics, and technology. The Basic Education Program (BEP) of North Carolina’s Public Schools, NC State Board of Education, 1994, emphasizes five major program skills in Science education for Grades K-12. From the NC State Board of Education BEP: “These goals address the nature of science, process skills, manipulative skills, positive attitudes towards science, and scientific concepts and principles in the areas of earth, life, and physical science.” High school courses are to stress doing science through the use of laboratory work and hands-on experiences. Science is presented as a practical and relevant subject. The basic philosophy of the NC BEP reflects an attitude that science is understandable and is a process of finding out about the universe with emphasis placed on using current technology as students investigate real problems. SGRA is a model program to meet these goals.

To facilitate the excitement of science and discovery, teachers and students will use the Pisgah Astronomical Research Institute (PARI) 4.6-m radio telescope (sentimentally called “Smiley”, see Fig. 1) via the Internet. Teachers and students, in the roles of scientists and discoverers, will control the telescope and data acquisition. The radio telescope operates in the same way as any other astronomical telescope, with the capability of pointing and tracking celestial objects. The telescope is currently equipped with a 21-cm wavelength detector. Analysis and interpretation of the collected data will be guided by activities supplied on the SGRA web page.

SGRA is similar to the Goldstone Apple Valley Radio Telescope (GAVRT) program in its goals. The GAVRT program is operated by a partnership between the Lewis Center for Educational Research (LCER), NASA, Jet Propulsion Laboratory (JPL) and the Apple Valley Unified School District. It is a program that emphasizes the promotion of scientific literacy by student involvement in the operation and remote control 34-meter radio telescope. The GAVRT Program webpage states “By the end of 1998, 22 teachers from 17 schools and more than 1,500 middle and high school students will have participated in GAVRT programs through the Lewis Center.” We think the SGRA has the potential to be as successful in reaching a large number of students and educators.

With support from the IDEAS program, the first year of the grant period is intended to be development of three major areas: telescope capabilities (PARI’s commitment); development of Internet interactive use of Smiley (PARI and IDEAS support); and developing the science curriculum of SGRA (IDEAS support).
Telescope Capabilities
Currently, Smiley can point, but not track, celestial objects. PARI has made the commitment to develop the tracking capability of the telescope, and we do not request IDEAS support for this part of the project. We anticipate this to be the largest cost of the overall project. Smiley’s motion control was manually operated, in that it did not use a computer readout or pointing. For pointing and tracking a computer interface will be fabricated to allow computer control. The 21-cm detector is operational. The teachers and students can either study the motions of a Galactic source of 21-cm radiation, or map out the morphology of a source. For example, Figure 2 shows the 21-cm radiation from the Orion molecular cloud complex. The scans were made by letting the Orion cloud drift over the antenna beam (drift-scan method), while recording the velocity structure of the molecular cloud. Teachers and students can see the redshift and blueshift motions of the Orion molecular region. The drift-scan method is one way the telescope can be used. Another option will allow the observers to point the telescope and map the intensity of an interstellar radio source. We will include visible images of well-known astronomical sources such as planetary nebulae, or regions of star formation, so that comparison of the visible images can be made to SGRA radio measurements. Visible images will be kept on the SGRA webpage, but links to HST, and SKYVIEW, will also be included. In both cases of measurement (velocity or intensity), students will learn about detection of radiation and use mapping skills, while operating a sophisticated astronomical instrument.

Development of Internet Interactive Use of Smiley
Teachers and students will be able to select from the SGRA webpage, one of four areas: RADIO ASTRONOMY BASICS, OBSERVING, GUIDES, AND LOGBOOK. The RADIO ASTRONOMY BASICS section teaches the concepts of electromagnetic waves, detection of electromagnetic waves, sources of astronomical radio waves, and how astronomers use radio telescopes. Included in the RADIO ASTRONOMY BASICS section are several simple, relatively inexpensive experiments teachers and students can perform. The OBSERVING section is the link to controlling the radio telescope and making the measurements of celestial 21-cm radiation. The OBSERVING page is designed in the same way a control room at an observatory is designed. Controls include options of source selection, coordinate entry, slew, set, and guide selection, and tracking. We will use free software called Virtual Network Computing (VNC; http://www.uk.research.att.com/vnc/) to allow access to the telescope controls over the Internet. VNC is a password protected remote display system that allows the user to view and control a computing 'desktop' environment not only on the machine where it is running, but from anywhere on the Internet and from a wide variety of machine architectures. Download of VNC by teachers will be made available on the SGRA webpage. Astronomical observatories that are operated remotely commonly use VNC.

The radio measurements of a galactic source are stored at PARI, but options will be available for display and download of the data. The GUIDES webpage contains atlases of the astronomical sky, catalogs, examples of observing sessions, guidebooks for data reduction, and data reduction software that can be downloaded for analysis offline. The LOGBOOK page is primarily a guestbook, but we will request notes pertaining to use of the facility. The Logbook is one of our sources for evaluation of the project.
The timeline for development of the Interactive Internet use is one year, although the first generation is estimated to be ready in three months. After three months we will begin interaction with one or more local schools to study effectiveness and make appropriate adjustments to the program. We request partial support from the IDEAS Program to fund service to the Internet. Good Internet connectivity is essential to the project. For safety and hands-on experience, we plan to serve realtime video of the antenna via the Internet. The slower the connection, the more disassociated one feels when controlling remotely. Students and teachers would be prone to over compensation if latency is too high. It is essential that near full-motion video is available so that a student will know when to stop a motion as the target object comes into view on the data recorder. One video picture takes several minutes to transfer via our current dial up account. The goal is at least 6 frames per second. This corresponds to a continuous connection of at least 360 kbps or about one fourth of a T1 communication link. With inherent server processing delays, a T1 is needed to maintain this low latency data rate. Fiber optic lines are used extensively used throughout PARI. To begin and maintain the T1 communication costs about $900/month. We are asking the IDEAS program to support the T1 communication service. At the end of the two years, PARI will continue to support 100% of the T1 line. The Internet line is critical to success of the School for Galactic Radio Astronomy.

**Figure 2.** Scans on the vertical direction across the Orion Nebula. (a) Contour map shows the red and Blueshifted motions of the molecular cloud. (b) A surface plot showing the same data as the contour map.

**Developing The Science Curriculum Of SGRA.**

Development of the science curriculum of SGRA will be led by the educator with significant input by the two astronomers. We plan to emphasize the following: electromagnetic radiation, chemistry, math skills such as graphing, interpretation of graphs, contour maps, and trigonometry, computer skills, and technology.

The **second year** of the grant period is the introduction of SGRA to regional schools. SGRA will be online. We will organize a workshop for area teachers, and request support from the IDEAS Program to offset the cost of “Get Started” manuals (full manuals will be on the SGRA webpage), and floppy disks with samples of software available on the SGRA webpage. We plan two workshops, one in the Fall and one in the Spring. These workshops provide the linkage we need with area schools. We plan to visit interested teachers who are not able to attend the workshops, to present demonstrations to the teachers and students.

**II. The Target Audience: Grades 8-12**

The target audience includes teachers and students in Grade 8-12. Underserved/underrepresented students in western North Carolina at schools with the computer technology will be encouraged to access SGRA. With the help of the educator, the astronomers will identify and visit underserved/underrepresented schools, to encourage participation. For those schools without the computer technology, we will invite the teachers and students to PARI
to use SGRA on-site. Although we designed SGRA to be a remote-use facility, the importance of enhancing the education of every school group we can reach must be emphasized.

The excitement of exploration and discovery by participating in SGRA is not limited to Grades 8-12, although those are the target grades. As we gain experience, and after the initial two year period of operation, we plan to expand the availability to earlier grades and the public.

III. Roles of the PI and Co-I’s

The educator’s (Jay Case, Brevard High School) role includes development of the science curriculum, identifying a pilot school for the first year of development, identifying schools that are interested in participating in the second year, introducing the astronomers to schools, and participate in the project evaluation and dissemination.

PARI’s astronomer is the PI of this proposal and responsible for the SGRA. The PI will direct the SGRA webpage development. The webpage will be constructed by a web development consultant. The webpage will consist of an interactive telescope control panel, log book, and real-time communications capabilities. The telescope control panel will allow school groups to choose to use Smiley in real-time, or submit requests for observations to be done by the astronomers. The PI will also provide atlases, catalogs, links to other observatories such as HST, data reduction software, and options of presentation of data such as images or contour maps on the webpage. An important part of the telescope operation is scheduling the telescope based on observing requests made online by teachers and students. The PI will maintain the schedule that will be accessible online.

The radio astronomer (David Moffett) participating as a Co-Investigator on the team is responsible for science content in the RADIO ASTRONOMY BASICS page, and also provide answers to radio astronomy questions raised by the educators and students. The Co-I will read the LOGBOOK and respond to questions, and provide feedback to the PI for adjustments to the program or webpage interface.

Since this is a new interactive way to bring astronomy to regional students and teachers, the astronomers will maintain the webpages based on evaluation of the project. Also, the astronomers are responsible for operation of the radio telescope and its detector while a school group is using the facility. Success of SGRA depends on smooth operation, and enjoyable experiences by all users. Together, the educator and astronomers will develop the content of the Radio Astronomy Basics page for grades 8-12, and the options in observing capability.

The support from the IDEAS Programs plays a fundamental role in assuring the success of the SGRA. PARI has committed itself to the SGRA as a long-term project.

IV. The Pisgah Astronomical Research Institute

To help better understand the breadth and depth of the potential of the SGRA, a brief description of the Pisgah Astronomical Research Institute (PARI) is required. PARI is a not-for-profit foundation dedicated to providing educational and research access to optical and radio astronomy for a broad cross section of users. Located about 50 km west of Asheville, North Carolina, in the Pisgah National Forest, the PARI 200-acre site is relatively free of light and radio interference. There are 20 buildings on the site, providing more than 100,000 square feet of temperature controlled space. PARI maintains a radio observatory with two 26-m, a 12-m, and the 4.6-m radio telescopes, a log periodic pair antennae dedicated to the study of Jupiter-Io magnetic field interaction, and a 0.20-m remote controllable optical telescope dedicated to an all sky survey. PARI is a research lab open to all astronomers for on-site radio observations, project development, instrument development, and postdoctoral research. Visiting astronomers are expected to support their research conducted at PARI through public or private grants. Visiting astronomers are also encouraged to develop educational initiatives including K-12 teacher workshops, promote requests to develop summer outreach programs to pre-college and pre-high school teachers, and mentor undergraduate and graduate research. Furthermore, PARI will provide the staff needed to assist visiting astronomers’ initiatives, provide opportunities for the public to participate in general astronomy education, and provide remote access to 4.6-m radio telescope for schools.
B. Evaluation and Dissemination Plan

EVALUATION

Process and outcome evaluations of the SGRA will be instituted. The goals and objectives of the School for Galactic Radio Astronomy include the enhancement of grades 8-12 science education using a web-based school room with a 4.6-m radio telescope as the primary tool for exploration. Students entering the SGRA will be led by means of guides and simple experiments to learning science and technology by observing the Galaxy seen at radio wavelengths. Students will learn to use sophisticated technology (e.g. controlling a telescope remotely), critical thinking (e.g. data analysis and interpretation), and how one field of study relates to another (e.g. mathematics with science). Measurement of the goals and objectives can be achieved by both process and outcome evaluation. Comparison group methodology design will allow us to compare participants in one group with other groups in the program.

To conduct a process evaluation, we will have an SGRA webpage link to a Logbook. Each school group that logs in will record their name, dates of use, objects observed (if the telescope was used), what facilities they used on the SGRA webpage (a set of checkboxes, a checkbox for each item on the webpage), and a textbox for comments on ease of use. The checkboxes provide a tally of the frequency of use of different aspects of the SGRA webpage. The process evaluation must be a continuous process so we can make adjustments to the project. Aspects of SGRA frequently used will be enhanced; those aspects not used will be modified or removed. The school names provide demographic information. Schools in the area that do not use the site may not know about it, or may not be interested. Personal contact will be considered. The astronomers on the team for the SGRA project are experts in data statistical analysis and have committed their time to maintaining the data collection and analysis.

Outcome evaluation will be addressed to the teachers. They are best informed in the effect of the SGRA project on their students. The tools we will use are either questionnaire or interview, an option left to the teachers. We seek data that tells us if the goals and objectives have been met. Specifically, does access to SGRA enhance the science and technology education of students in grades 8-12? Is the SGRA website easy to use and intuitive? Does the technology always work? Is the experience enjoyable? What can the astronomer do to make the science more exciting? Questionnaire and interview questions will be the same and initially include:
1. How many students accessed SGRA?
2. What concept did the students explore?
3. Did the students use the radio telescope?
4. Did the students understand concepts presented on the RADIO ASTRONOMY BASICS page?
5. How many times over the previous 6 months have you accessed SGRA?
6. Are the concepts presented in an easy-to-understand way?
7. Are the concepts too difficult for your grade level?
8. Were the astronomers helpful?
9. Was the experience too time consuming?
10. Did your students remain attentive during the experience?
11. Would you access SGRA again?
12. If you had the opportunity, would you arrange a class visit to PARI to operate the Smiley telescope on site?

Experience will teach us what further questions need to be asked.

DISSEMINATION

The astronomers and educator team will disseminate and publish the program results. Dissemination will focus on implementation, results of evaluations, suggestions and comments for improvement, and we will also make recommendations. We plan to disseminate program results to both professional organizations and to the public.
Professionally, the astronomers will present results at national meetings of the American Astronomical Society. The project team will also contribute to the *Teachers' Newsletter: The Universe in the Classroom*, a free quarterly educational newsletter published by the Astronomical Society of the Pacific for educators. The National Science Teachers Association publishes *NTSA Reports!* (a newspaper of science education), *Science Scope* (a journal for middle school science teachers), and *The Science Teacher* (a journal for high school science teachers). We will seek publication in each of these publications. Publicly, we will seek interviews with local newspapers, radio, and TV stations. Also, we will produce a quarterly newsletter for distribution at meetings and in the area schools.