STAR Workshop 2007

Small Telescope Astronomical Research Technology, Science, and Education

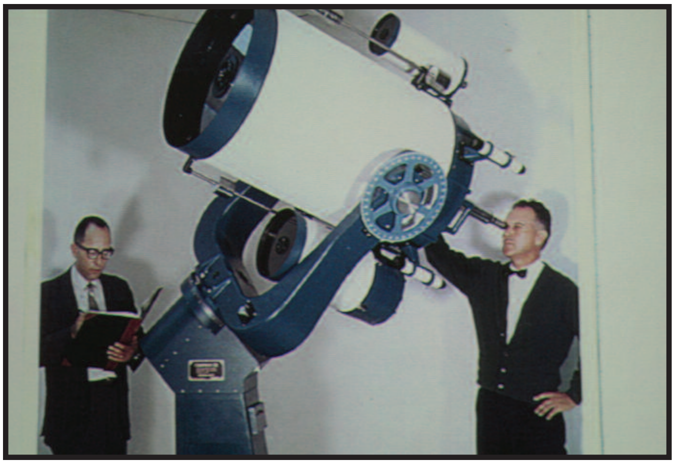
By Russ Genet

The trio of transportable Schmidt-Cassegrain equatorial telescopes, go-to telescope control systems, and affordable CCD cameras has revolutionized small telescope science, not to mention astrophotography. These portable systems – thanks to the high quantum efficiency of their CCD cameras – are, from a research point of view, the equivalent of yesteryear's massive mountaintop telescopes equipped with low efficiency film cameras.

Comprehensive robotic surveys are uncovering thousands of new pulsating stars, eclipsing binaries, asteroids, and potential transiting exoplanets every year. What are the periods of these objects? Which of the potential exoplanets are the real things, regularly transiting their parent stars? To answer such questions, each of these newly-discovered objects requires the dedicated hours, nights, and even weeks of follow-up observations that only modest-aperture telescopes can provide. Automation of, and remote access to, smaller telescopes is facilitating observations both locally and remotely, while global robotic networks are being formed to observe objects round-the-clock, passing them, as the Earth turns, from one longitudinal location to the next.

Low cost alt-az control systems, instrument rotators, and high-quality thin-disk mirrors are just now beginning to be incorporated into portable alt-az telescopes with apertures approaching one-meter. Similar to their huge mountaintop alt-az cousins, these new portable alt-az systems can precisely track and de-rotate objects, thus allowing long CCD exposures. Compared to equatorial telescopes of the same aperture, these new alt-az telescopes are not only lower in cost and more compact, thanks to their vertical/horizontal structural simplifications, but they are truly portable. Although they are never polar aligned, facilitating fast set up, their precision instrument rotators allow long CCD exposures of many of the much fainter objects uncovered by the new surveys, and with recently available off-the-shelf spectrographs, their superior light-gathering power will enhance both time-series and classification spectroscopy.

High school and undergraduate students with an interest in engineering and science are, in increasing numbers, joining the ranks of amateur and professional astronomers in developing and utilizing small telescopes for astronomical research. Whether developing new telescopes, instruments or software, or conducting astronom-



One of Tom Johnson's slides of the founding and early days of Celestron. A somewhat younger Tom is on the right, peering through a large-aperture Celestron Schmidt-Cassegrain telescope.

ical research, students gain invaluable hands-on experience in engineering and science while, as coauthors of published papers, their academic careers are given a boost. Assuring that students complete a research project within the confines of a single semester – including writing, reviewing, and submitting a paper for publication – is a challenging undertaking for educators. The Small Telescope Astronomical Research (STAR) Workshop not only provided a forum for instructors to exchange their insights and experiences, but to do so with a range of students.

The STAR Workshop was sponsored by the Research Scholar in Residence Program at California Polytechnic State University (Cal Poly), and was held June 22-24 on Cal Poly's campus in San Luis Obispo, California. Late June was chosen as a time when schools were out but summer vacations had not started in earnest. The workshop provided a forum where high school and undergraduate students, amateur and professional astronomers, educators, and the commercial designers and manufacturers of small telescopes, could share their ideas in the rapidly expanding arenas of small telescope engineering development, scientific research, and undergraduate education. A larger STAR Conference will be held next year (2008) June 19-23, again in San Luis Obispo. Readers of *Astronomy Technology Today* are welcome at this conference. See www.STARConference.org for details.

Astronomy Technology Today

Tom Johnson, the founder of Celestron, opened the workshop's astronomy technology session with a historical sketch of how his development of a technique for manufacturing low-cost Schmidt corrector plates revolutionized the commercial production of small telescopes. Tom's son, Greg Johnson, described his involvement with the development of Celestron's computerized go-to capabilities.

A significant portion of small-telescope astronomical research consists of continuous time-series CCD photometry of pulsating or eclipsing stars, tumbling asteroids, and suspected transiting exoplanets, as well as sputtering matter spiraling onto white dwarfs, distant microlensing events, and fading supernovae. Hundreds or thousands of exposures are taken of the same object, often all night long, night after night – a task which is an obvious candidate for automation. In the early 1980's, Lou Boyd and I developed robotic telescopes controlled by low-cost PCs, achieving our first fully automatic operation in 1983. Within a few years, the Fairborn Observatory featured a number of Internet-accessible telescopes at a normally unmanned observatory located on Mt. Hopkins in southern Arizona. Our split-ring, friction-drive, 32-inch telescopes were designed from scratch for dedicated robotic photometry. They had no eyepieces.

Automated split-ring equatorial telescopes dedicated to photometry have advanced considerably since these early Fairborn Observatory telescopes, thanks very much to the advent of CCD cameras (the Fairborn systems used aperture photometers equipped with photomultiplier tubes). At the workshop, Jerry Foote described the 16-inch telescope at the Vermilion Cliffs Observatory he recently designed and built for his wife, Cindy Foote. This equatorial telescope features friction drives in both axes. A primary mirror made of low expansion substrate and carbon fiber trusses allow exposures to be made all night long without having to stop for focus adjustments. A Paracorr coma corrector, filter wheel, and SBIG ST-7 camera are located at prime focus.

Tim Brown described the 20- and 40-inch split-ring equatorial telescopes being developed at the Las Combres Observatory (LCO) for their global network. The 20-inch utilizes a modified Meade 20-inch Schmidt-Cassegrain optical assembly, while the 40-inch system is configured as a reflecting Ritchey-Chretien (R-C) system. Rather than using two stages of friction drive reduction, the LCO telescopes use high-torque "cartridge" servomotors and a single stage of friction drive. LCO is building 12 of their 20-inch systems and 6 of their 40-inch systems. These telescopes will be used, in LCO's global network, to provide follow-up observations of objects discovered in robotic surveys. Initial concentration will be on near-earth asteroids.

Automation requires carefully devised procedures, software, and equipment. Jerry Foote, in a one-hour overview, spelled out the basics of automated photometry. Jerry Horne overviewed the software available for automation, such as Doug George's Maxim DL and Bob Denny's DC3 scheduler and observatory controller.

As Schmidt Cassegrain telescopes become larger, their portability falls off while their prices rise rather sharply. After 20 or so inches of aperture, thin-mirror reflectors with R-C figures or paraboloids with corrective optics near the focal plane begin to dominate "small" science telescopes. Parabolic mirrors, which are significantly less expensive than R-C mirrors, can be used with correctors such as Tele Vue's 2-inch Paracorr or the 3- and 4-inch Keller Wynn correctors to provide wide, undistorted fields. David Rowe described a corrected Dall Kirkham (CDK) optical system he developed that utilizes a prolate ellipsoid primary, a spherical secondary, and two spherical corrector lenses near the focal plane. Being spherical, the secondary mirror is relatively insensitive to misalignment. This combination provides crisp, undistorted images across a 2-inch diameter field, fully supporting the latest large-format CCD cameras. Utilizing David's optical design, Plane Wave Instruments is manufacturing 20-inch CDK optical tube assemblies that employ carbon fiber trusses. David and several of his friends ground and figured a set of 42-inch CDK optics that employed a lightweight, cellular mirror blank. They plan on installing these optics in a folded, portable, alt-az CDK telescope.

The emerging class of portable alt-az telescopes requires constantly changing

Workshop participant Tom Smith stands beside Tom Mathis and the Plane Wave Instruments 20-inch optical assembly on a Mathis fork mount. Dave Rowe gave a talk at the workshop on his development of the corrected Dall Kirkham (CDK) optics. Photo taken by Russ Genet at RTMC a few weeks before the workshop.

The complete Sidereal Technology telescope control system was engineered and tested by amateur astronomers, for amateur astronomers. The full control system includes one or two Dual Servo Telescope Controllers, two or four servo motors (Alt/Dec, Az/RtAsc, Focuser, Rotator), and an FCC approved wireless handpad transmitter, with receiver complete with a built in auto-guider port. In addition, Sidereal Technology manufactures and sells "Dob" kits for easy control system installation. This system allows one to navigate the skies with amazing precision and ease with any ASCOM compliant planetarium software. There are over 100 installations of the Sidereal Technology Dual Servo Telescope Controller. It is a fully developed, easy to use system.

The Sidereal Technology Dual Servo Controller is economical, very small, and packed with many features. It connects to two D.C. servo motors with integral encoders, and to two high resolution telescope encoders. It will track and/or guide your telescope without any computer connected, or provide tracking, guiding, Go-To, etc. when connected to either a computer or an Argo Navis. The system is compatible with equatorial, German Equatorial, or alt/az mounts. It is versatile and easy to install on scopes of all sizes.

drive rates and instrument rotation and, consequently, a sophisticated control system running complex software. Therefore, special attention was given in this work shop to alt-az control.

A short historical diversion is in order here. My involvement with microcomputer control systems began with the robotic telescopes at the Fairborn Observatory in the early 1980's. I coauthored a book with Mark Trueblood, *Microcomputer Control of Telescopes*, published by Willmann-Bell in 1985, that gave a complete set of equations for alt-az telescope control. (A revised version, *The Telescope Control Handbook*, was published in 1997 and is still in print). In 1994, Mel Bartels' article, "How to Build a Simple Computerized Altazimuth Drive System" appeared in *Observatory Techniques*, inspiring a number of other amateurs, such as Rusty Fletcher and Chuck Shaw, to build portable, computer-controlled alt-az telescopes. Mel supplied software and populated boards for stepper control systems from his BB AstroDesigns.com and was also working on a servo system. Dan Gray started a new company, Sidereal Technology, and designed, fabricated, and programmed a new D.C. servo telescope controller. Mell Bartels now sells these, along with his telescope control software.

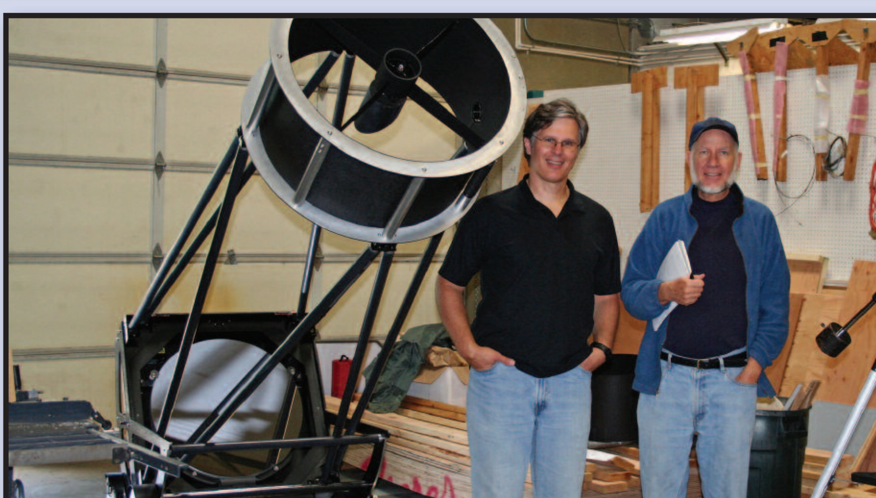
At the workshop, Dan described and demonstrated SiTech's low cost (around $1,000) four-channel servo system (altitude, azimuth, instrument rotation, and focus) that controls a complete alt-az telescope. Fully ASCOM compliant, it can operate stand alone via a wireless (RF) control paddle, or under the control of Sky Commander, Argo-Navis, or laptop computer via popular planetarium/telescope control software such as Maxim DL, The Sky, etc. Dan also described his 14-inch alt-az telescope and its instrument rotator, and the recently completed computer-controlled 28-inch alt-az telescopes he and Howard Banich built using mirrors from Mike Lockwood and Kennedy Optics, respectively. I saw both of these telescopes a couple of weeks before the STAR workshop at an impromptu one-day meeting on portable alt-az telescopes at Dan's shop in Portland. This meeting was also attended by Mel Bartels, Howard Banich, and Richard Berry.

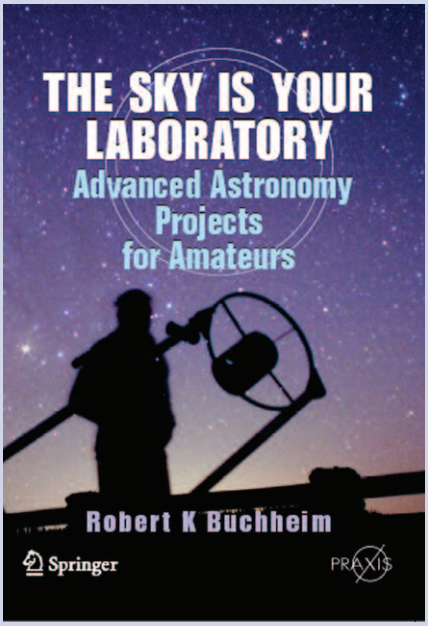
The development of an emerging class of portable, computer controlled, general purpose, alt-az telescopes was discussed at the workshop and in depth immediately thereafter. Plans are being formulated for a 20-inch technology demonstration system that will feature Sidereal Technology's control system, servos and encoders in both axes, focus control, and an instrument rotator at the Newtonian focus. Truss tubes will be carbon fiber, and every effort will be taken to make the system unusually stiff, lightweight, and resistant to wind gusts. We envision this type of telescope being used for both teaching (visual, astrophotography, photometry, and spectroscopy) and research,

Pictured Top: Russ Genet, Howard Banich, Richard Berry, Mel Bartels, Dan Gray, pose by Dan's 14-inch alt-az telescope at the one-day pre-workshop Portland alt-az meeting. The instrument rotator is on the other side of the telescope.

Pictured Left: Howard brought his 28-inch telescope to a one-day, pre-workshop meeting in the back end of his SUV. The portability of this large-aperture telescope is amazing. The f/3.6 primary mirror was made by Kennedy Optics.

Pictured Below: Howard Banich and Russ Genet stand beside Howard's portable 28-inch alt-az telescope, which uses a Sidereal Technology control system.





Today, telescope construction is funded by national budgets and instruments are launched into space to get clearer views of celestial objects. Is it still possible for amateur astronomers to contribute to astronomical science? Yes, indeed! Some research projects require the small telescope's flexability in observing schedule, and familiarity with the night sky that are attributes of the advanced amateur astronomer. These projects provide results that are valuable to the astronomical community, and publishable contributions to the professional literature. Meteor studies, occultations, CCD photometry and astrometry, searches for novae, supernovae and lunar meteor impacts are all being successfully pursued by amateur astronomers. Robert Bucheim's *The Sky is Your Laboratory: Advanced Astronomy Projects for Amateurs* describes 18 research areas including their value, the observational and data reduction procedures, and venues for publication of your results. It can transform you from a backyard stargazer to an amateur scientist.

including semi-automated, all night, time-series photometry. Emphasis will be placed on ease of setup and use, reliability, and transportability. Larger-aperture versions would employ a folded optical scheme such as the 42-inch CDK system described by David Rowe at the Workshop.

Jo Johnson, Russ Genet, and Darrell Grisham work through calculations for the separation and position angles of visual double stars for presentations given by Jo and Darrell at the workshop.

Small Telescope Science

Small telescope science enjoys a rich, four centuries long tradition that will be celebrated at the upcoming conference, Galileo's Legacy: Small Telescope Science 1609 and 2009. New Year's Eve fireworks and a five-day Hawaiian conference, 1-5 January 2009, will assess the state of small telescopes and the remarkable science they are producing, while also honoring Galileo who initiated the tradition of making fine small telescopes and using them to advance scientific knowledge. Readers of *Astronomy Technology Today* would be most welcome to attend and speak at the many special focus sessions – see www.GalileosLegacy.org for details.

Research projects suitable for small telescopes abound. They include: the separation and position angles of visual double stars; asteroid and comet positions; searches for asteroids, comets, nova, and supernova; photometric variations over time of asteroids, intrinsically variable stars, cataclysmic variables, eclipsing binaries, exoplanet transits, and microlensing events; high speed photometry of asteroid and lunar occultations; and, with the larger of the "small" telescopes, spectroscopy time series variability and classification. These many possibilities and more are covered in Robert Buchheim's recently released book, *The Sky is Your Laboratory: Advanced Astronomy Projects for Amateurs*. At the workshop, Robert kindly provided an overview of small-telescope science, followed by presentations from amateur, student, and professional astronomers in many research areas.

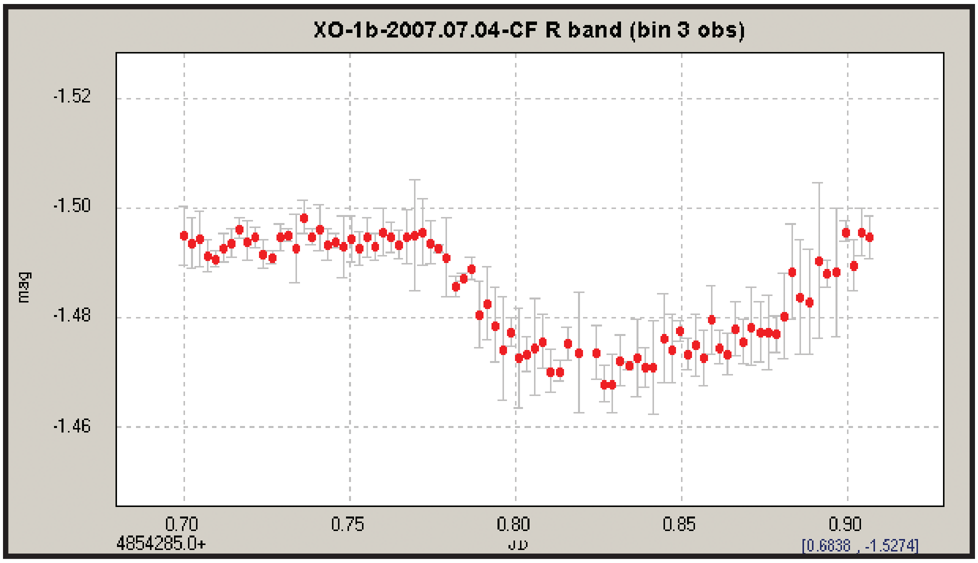
Darrell Grisham and Jo Johnson, both students of mine at Cuesta College, presented, in their first-ever scientific talks, the results of their visual observations of the separation and position angles of double stars, soon to be published as papers in the *Journal of Double Star Observations*. Both used

Greg Johnson looks on as Walt Morgan sets up to observe lunar occultations. Walt's system includes a GPS receiver, a "Kiwi box" time stamp inserter, and a camcorder as well as an 8-inch Meade LX-200 telescope.

Meade laser-etched astrometric eyepieces. Darrell, with a truly small telescope – a 3-inch, manually operated vintage Tasco refractor mounted on a 6-inch diameter steel pier embedded in a ton of concrete – has achieved amazing precision. Jo built his own position angle indicator, making his observations with a 12-inch Meade LX-200 telescope at my Orion Observatory.

Walter Morgan and Kent Okasaki, both long-time members of the International Occultation and Timing Association (IOTA), described their experiences with both lunar and asteroid occultations. Walter brought his 8-inch Meade LX-200 telescope, GPS receiver, Kiwi time inserter, and cam-recorder to the workshop's evening "star-b-que" at the Orion Observatory. He recorded several lunar occultations which he dutifully analyzed and presented at the workshop the following day. My Cuesta College research seminar students are looking forward to observing lunar occultations this fall, and also hope to form a "line" of telescopes to observe an asteroid occultation to help determine its size and shape.

Cindy Foote, an amateur astronomer for just two years – with her own 16-inch, research-grade, semi-automatic telescope situated at a very dark site – gave her first-ever science talk at the workshop. Cindy struck pay dirt as the co-discoverer of two transiting exoplanets with the Vermillion Cliffs Observatory's 24-inch telescope, which she was using while Jerry Foote built her 16-inch telescope. As a member of Peter McCullough's research group, she and several other amateur astronomers checked out potential transits from candidates generated by an array of 4-inch robotic telescopes located at Haleakala on Maui. For both of these discoveries, Cindy was the first member of the team to detect the transits. Their results will be published shortly in the *Astrophysics Journal*.



Light curve showing the dimming that occurred when the planet XO-1b passed in front of its parent star XO-1. The team has since discovered XO-2b and XO-3b that were announced at AAS in May.

Cindy Foote's 16-inch telescope at Vermillion Cliffs Observatory. Her CCD camera is mounted at prime focus. The telescope's truss is made of carbon fiber tubes.

John Keller, who teaches astronomy at Cal Poly, gave an overview of asteroids. John, a recent graduate in Planetary Sciences from the University of Arizona, is looking forward to working with Cal Poly and Cuesta students to make astrometric determinations of asteroid positions and to also obtain asteroid light curves with Cal Poly's 12-inch Meade LX-200 telescope and new SBIG CCD camera.

Michelle Ouellette, who also teaches astronomy at Cal Poly, provided an overview of pulsating stars. Similar to Cepheid variables, determination of the pulsation period of RR Lyrae stars provides an estimate of their luminosity and hence distance. A joint Cal Poly/Cuesta College student RR Lyrae observing program is being planned for this fall.

Cuesta College research seminar student Brittany McCrigler reported her observations of a pulsating star that she observed at Orion Observatory with other students this past spring. This star had been identified, in the MOTESS/GNAT survey of a

Cuesta College students Brittany McCrigler and Jolon Johnson at the workshop dinner. They gave their first ever science talks at the conference, and both have papers nearing completion.

Shown is the Martin Solar Polar Telescope at Helio Research. The optical bench is parallel with the Earth's axis of rotation. The Telescope tracks the Sun only by rotation of the optical bench around its long axis. The circular primary mirror appears as an oval-shaped mirror in the upper end of the telescope. Sunlight is reflected from the mirror through a 10-inch lens in the tube at the upper end. The solar disk is brought to prime focus at the upper end of the small tubes after passing through two dichroic mirrors to eliminate heat by restricting the part of the spectrum observed to red sunlight. A field aperture at prime focus limits the area of Sun to be photographed to 10x10 arc minutes. The solar image is then relayed by secondary lenses through a 1 Angstrom prefilter and a 1/10 Angstrom narrow-band filter to come to focus on a 1024x1024 CCD array in an Apogee 6 camera. A small guidescope maintains the pointing at a chosen location on the Sun. The electronics cabinet is shown near the lower end of the telescope. Once a target on the Sun is selected, images are automatically recorded on a large data disc in a computer (not shown) which also allows one to visually see the subject being recorded.

strip of sky near the celestial equator, as a likely short-term variable. Brittany used MPO Canopus along with the Peranso analysis program to determine the star's pulsation period. She plans on majoring in astrophysics at the University of California, Berkeley.

Finally, Sara Martin, a professional solar astronomer at Helio Research, described the Martin Solar Polar Telescope designed and built by her husband, Douglas Martin. After taking early retirement from Caltech and the Big Bear Solar Observatory, Sara and Douglas, together with colleagues, established the nonprofit Helio Research Corporation for research and education in the astronomical sciences. The Helio Research laboratory for data analysis and the Martin Solar Telescope are located at their residence in La Crescenta, California, which has proven to be a good site for solar observing.

With funding from research grants, Sara and Helio Research employees (including students) use special filters for recording the Doppler shifts of activated filaments, erupting prominences, solar flares and other dynamic features on the Sun. In practice, the observations are taken by tuning each of two filters to different wavelengths around the Hydrogen alpha line in the solar spectrum. The first is a 1A prefilter that tunes mechanically under computer control of a motor that tilts it in steps of a fraction of a

Star-b-que at the Orion Observatory. In the background are permanently-mounted 12- and 10-inch Meade LX-200 telescopes. In the foreground is Tom Frey's 18-inch Obsession he brought for the evening's star party. Orion Observatory and Sidereal Technology co-sponsored the Star-b-que.

degree. The second narrow-band filter is a special Fabry-Perot etalon that changes wavelength when high voltage is applied across the surfaces of a very flat, thin crystal of lithium niobate.

A good observing day consists of automated images typically recorded at 5 second intervals for periods of 5 or more hours. Measurements are made from "movies" of changing solar events, and research results are presented at professional meetings and published in conference proceedings and journals. Sara discussed several research projects on solar filament evolution and eruption which involved students in nearly all phases of the research.

Undergraduate Engineering and Science Education

Small telescope engineering development is particularly well suited to high school and undergraduate students. By designing and developing telescopes and robotic observatories, engineering students can hone their skills as they provide their schools with cutting-edge scientific research facilities.

Small telescopes science is also well suited to high school and undergraduate students and can be properly supported by telescopes and instruments that are affordable and useful in many areas of research. In one or two-semester research courses and summer camps, students have proven their ability to conduct high-quality, published research. Through hands-on research, these students develop an appreciation for the true exploratory nature of science.

I have been associated with student research since 1980, when Douglas Hall and I founded the IAPPP, an international society devoted to astronomical photometry. A number of years ago, while teaching astronomy at Central Arizona College, I initiated my first one-semester undergraduate astronomical research seminar. Using a robotic telescope at the Fairborn Observatory, students observed a number of Cepheid variables, determined their periods, and reported their results at a meeting of the American Astronomical Society. My firm requirement for this and my subsequent research seminars has been that students – either singly or in small teams – plan, conduct, and complete a research project by the end of the semester. Their projects must include the review and submission of a paper to an astronomical journal or, alternatively, they can submit an abstract for a poster or talk they give in person at an astronomical conference. Besides holding research seminars, I have enjoyed sponsoring senior projects at Cal Poly where, over a more generous two semesters, students (singly) plan, conduct, and report on their projects in published papers or as talks or posters at formal conferences.

The STAR Workshop featured an "educational roundtable" discussion of last fall's research seminar at Cuesta College. Students had obtained time-series CCD photometry of nine MOTESS/GNAT survey stars, found two to be continuously variable and had determined their periods. They had written and submitted a paper to the refereed *Journal of the American Association of Variable Star Observers*, as well as published abstracts/poster presentations at the American Astronomical Society and the Society for Astronomical Science. Student travel was funded by a local retired physicist, George Alers. The students had received awards, and had been featured in local newspaper articles and television news programs.

After last fall's research seminar a number of actions were taken to improve the upcoming fall seminar. These were discussed during the roundtable discussions. Student participation is being increased to include a team of advanced-placement physics students from Arroyo Grande High School advised by their physics instructor, John Baxter. A number of amateur astronomers from the Central Coast Astronomical Society were enlisted as both students and mentors. A spring astronomy research star-b-que and star party was held to bring the seminar's participants together well before the first class. Not willing to wait until fall, a number of students began their research, informally, in the spring, nearly completing three projects by the June workshop.

The greatest difficulty with last fall's research seminar was the need to operate within the confines of a single semester. The students had to obtain many thousands of

Tom Smith standing beside his Meade 14-inch LX-200 GPS telescope equipped with an SBIG ST-7 camera at its new Dark Ridge Observatory at 7,200 feet in New Mexico.

time-series photometric observations over dozens of nights, and learn how to and actually reduce this mountain of data. In addition, the students had to analyze and write up their results and send them off for outside review. Although they were successful, and submitted their final paper on the last day of class, it was a strain on both these students, their hard-working mentor, Tom Smith, and on me – their instructor and observatory director.

The roundtable discussion suggested two solutions to reduce the workload for students, mentors, and instructor. First, a larger variety of research projects should be encouraged, including ones that would be less time consuming. Students should only tackle advanced projects after they had gained experience with a more basic project and are assured of published results.

Second, a number of observatories, both local and remote, should be asked to provide reduced observations. Students would request the observations in an appropriate format, and would analyze and publish the results, including the observer as a co-author in their paper. While not making the observations themselves, students would be expected to understand how the observations were made and reduced. Several workshop participants kindly agreed to provide student-requested observations this fall, and three described their observatories at the workshop.

Tom Smith, a key mentor in last fall's seminar, will be supplying observations from Dark Ridge Observatory's (DRO's) new home at 7,200-feet elevation in New Mexico. DRO will, shortly, be installing its 20-inch alt-az and two Meade 14-inch LX-200 GPS telescopes on permanent piers.

Jim Carlisle will be working with students at his Hill House Observatory in Atascadero. His 14-inch Meade RCX-400 telescope and SBIG ST402 camera will be utilized for time series photometry of asteroids and variable stars.

Tom Frey, who teaches chemistry at Cal Poly, will be making visual observations with his 18-inch Obsession telescope. Tom purchased an astrometric eyepiece and devised a position angle readout for observing double stars.

Tom Frey assembles his 18-inch Obsession at the workshop star-b-que. Tom is measuring the separation and position angles of visual binary stars.

Finally, telescope development and construction projects suitable for one-semester seminars and full-year senior projects were discussed after the workshop. The design and construction of a "junior" version of the proposed 20-inch alt-az technical demonstration telescope may be an appropriate student undertaking.

Small Telescope Development and Research Today

Small telescope development is entering an exciting new era. With the emerging development of portable computer-controlled alt-az telescopes with instrument rotators and thin but high-quality mirrors, "small" is being extended to 32 and perhaps, eventually, 40-inches. Spectroscopy here we come! Small has come a long ways since Galileo's 1.5-inch telescope!

Small telescope research has never been better positioned or more in demand. The conjunction of highly capable telescopes, and the overwhelming outpouring of new objects to research from the automated, big-telescope surveys, bodes well for the future of small telescope research. Not only can backyard amateur astronomers help meet this urgent need for scientific observations, but so can undergraduate and even high school students, aided not only by local amateur astronomy mentors, but by observations provided from remote amateur observatories.

The advancement of smaller telescopes and their application to scientific research is enhanced by a technical understanding not only of available telescopes, instruments, and various accessories, but a feel for where small telescope technology is heading. *Astronomy Technology Today* provides a valuable forum for technical information exchange. It is my hope that many of the readers of this article will become sufficiently intrigued with small telescope engineering development and scientific research to attend next years STAR Conference. You can register now at www.STARConference.org. Feel free to email me with any questions at russmgenet@aol.com. ATT