Three Decades of Small-Telescope Science

A Report on the 2011 Society for Astronomical Sciences 30th Annual Symposium on Telescope Science

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For three decades, the Society for Astronomical Sciences has supported small telescope science, encouraged amateur research, and facilitated pro-am collaboration. On May 24-26, more than one hundred participants in the 30th anniversary SAS Symposium heard presentations covering a wide range of astronomical topics, reaching from the laboratory to the distant cosmos.

From Planets to Galaxies

Sky & Telescope Editor-in-Chief Bob Naeye opened the technical session with a review of the amateur contributions to exoplanet discovery and research through monitoring of transits and micro-lensing events.

R. Jay GaBany described his participation as an astro-imager in the search for evidence of galactic mergers. His exquisite deep images taken with his 24-inch telescope displayed the diverse patterns of star streams that can be left behind when a dwarf galaxy is disrupted and absorbed by a larger galaxy. He also noted that not all faint structures are evidence of galactic mergers: the faint "loop" structure near M-81 is actually foreground "galactic cirrus" in our own Milky Way masquerading as a faux tidal loop.

Education and Outreach

Several papers related to education and outreach were presented. Debra Ceravolo applied her expertise in the generation and perception of colors, to describe a new method of merging narrow-band (e.g. Hα) and broad-band (e.g. RGB) images into a natural-color image that displays enhanced detail without glaring false colors. She is a strong advocate of using "natural" colors, rather than the potentially-misleading false-color display of astronomical objects in education and public outreach.

Richard Berry presented his investigation of an imaginative challenge: "Can the proper motion of Barnard's Star be detected in a project lasting only a few nights? Astoundingly, the answer is "yes". He showed how precision of a few hundredths of an arc-second in relative astrometry can be achieved with a small telescope and CCD imager.

Robert Buchheim described his project to replicate Tycho's use of diurnal parallax to determine the distance to the Moon by using a DSLR camera and its standard lens. He then applied a 0.28-m (11-inch) telescope and CCD imager to determine the distance to an asteroid, achieving respectable 15% accuracy.

Small-telescope science provides a wonderful adjunct to college classes, and not just for astronomy students. Doug Walker injected an astronomy project into his math class at Estrella College, giving his students a "hands-on" experience in conducting observations, making measurements, and applying mathematical analysis to their data. His students presented their project of measuring several visual binary stars, using both a reticle eyepiece and a CCD video camera. Their data will be submitted to the *Journal of Double Star Observations* for entry into the Washington Double Star Catalog.

While most small-telescope research is done with CCD imagers specially-designed for astronomy, the modern, inexpensive, commercial DSLR and "point and shoot" cameras have remarkable capabilities. John Hoot described the very advanced technology in these popular cameras, explaining how the advanced features can be used to conduct research and educational projects such as meteor parallax measurement, satellite tracking, and nova searches.

Optics, Instruments and Methods

Wide-field survey telescopes present unique challenges in optical design, but also offer the potential for making new kinds of observations. Peter Ceravolo explained his design of an instrument for detecting asteroid entry, which demands good image quality over a very large field of view. The keys to his optical system are its historical heritage (it is in some respects a folded, reflective version of a photographic lens), the importance of correct placement of the aperture stop (not at the primary optical element), and control of internal reflections (especially from the surface of the focal plane; front-illuminated CCDs are surprisingly reflective!)

Tom Smith presented a valuable description of the method for flat fielding CCD images that was developed for the AAVSO All-Sky Photometric Survey. This information will be useful to many small-telescope photometrists who want to ensure the highest quality and accuracy in their data. One surprisingly successful experiment was the use of Styrofoam insulation sheet as the reflective target. This material turns out to provide a wonderfully true white and Lambertian reflective surface.

Many variable star observers have struggled with determining their system's color transforms in order to achieve the best-possible consistency in CCD photometry. This struggle is partly mathematical, but mostly observational, since determining the transforms and second-order extinction requires observation of standard stars under near-photometric conditions on at least one or two nights per year (and these nights can be rare indeed for many backyard scientists). A new method of determining transforms and secondary extinction terms was explained by David Boyd. His method is less restrictive than previous approaches and offers great improvement in determining the night-to-night zero-points for asteroid lightcurves.

New Frontiers

Light pollution does not only impact astronomers. It has also been implicated in a variety of adverse ecological and physiological trends, including disruption of birds' migratory patterns and altering circadian rhythms. Unfortunately, as noted by Eric and Erin Craine, research into the effects of light-pollution is hampered by a paucity of quantitative data on sky brightness and its secular trends. They described their development of a portable light-monitor system and associated archive that can record both time-based and geographic variations in sky brightness. This system should be useful for both scientific investigations and policy assessments related to light control, such as demonstrating the impact of new property uses and assessing the light-control value of various regulatory regimes.

One of the difficult management challenges facing large professional observatories is the handling of transient "targets of opportunity" – should the telescope be diverted from an approved program in order to focus on a newly-discovered transient event? Private observatories can be supremely flexible in this regard. Near-Earth objects, supernovae, and other unpredictable events can be immediately put under intense, long-term observation on the owner's sole initiative. As Bob Koff described, opportunities abound for backyard scientists, as large surveys collect far more transient events than can possibly be studied by professional astronomers. He described the requirements for making credible observations of targets of opportunity along with sources of prompt notification of transients (one of the participants noted that "there's an 'app' for that!").

Automated and Robotic Telescopes

The very first robotic telescope may have been the pneumatically-operated mechanism that commanded multiple cameras to record a solar eclipse in 1901. Dr. Russ Genet described how this venerable heritage is being advanced, with progress on the development of low-cost, portable, meter-class telescopes for photometric and occultation studies.

Tom Smith and Tom Krajci presented a half-day workshop on various approaches (and potential pitfalls) in automating your observing equipment so that it robotically carries on observations and data collection, while the observer sleeps. Their lessons were useful for both "backyard" installations (such as Krajci's) and remotely-operated systems (such as Smith's).

Photometry:

Jerry Horne discussed an interesting example of data mining in which he re-examined his own data from several years ago that happened to coincide with the Kepler field. He found one probable Cepheid variable and some interesting changes in several stars, between his data epoch and Kepler's recent lightcurves.

Gary Vander Haagen noted that "there are probably astrophysical processes that generate high-frequency brightness variability, but we don't know about them because we don't have the ability to monitor very fast fluctuations". He described how the silicon photomultiplier can provide the needed sensor, with some important advantages over the conventional photomultiplier. The Silicon PM is rugged, inexpensive, immune to magnetic fields, and only about 5X less sensitive that a conventional PMT. With appropriate filtering of the signal, it appears that most atmospheric scintillation noise can be removed from the data.

Eclipsing Binaries

Dr. Dirk Terrell presented a half-day class on eclipsing binary stars, covering their characteristics and their main observational features. He then presented an example of determining the properties of an eclipsing system by matching a theoretical lightcurve to observational data, using the PHOEBE code.

Epsilon Aurigae's eclipse has generated many opportunities for small-telescope science, since it is far too bright for large observatories to deal with. Gary Cole presented new results from his ongoing campaign of polarimetric monitoring of the system throughout this eclipse. His data are of special value because his is one of only three known polarimetric data sets (one of which was largely clouded out during the critical period of third contact). His data show that the third-contact change in polarization during this eclipse is almost identical to the polarization observations made during the last eclipse – offering an important constraint for the theorists.

Spectroscopy

With the increasing availability of modest-cost, high-quality commercial spectroscopic instruments, amateur astronomers are contributing to several types of research activities. Olivier Thizy described the European scene in pro-am spectroscopic collaboration, which is both robust and energetic. He noted that one of the key elements to effective pro-am collaboration is for the professional astronomer to explain why the object/project is important and interesting. There are so many potential targets for small-telescope research that without such guidance, the amateur-research community might skim right over significant targets. He made particular note of the July 2011 periastron of delta-Scorpii, which should be a high-priority target for both photometric and spectroscopic observation. This system comprises a Be star with a companion in an eccentric orbit, and periastron may generate all sorts of interesting phenomena.

The "Be" stars are also the focus of California amateur Robert Gill, who described his home-made Littrow spectrograph. This inexpensive instrument should have sufficient resolving power to measure many of the features of the "Be" stars (e.g. high rotation speed of the circumstellar disk, and non-radial pulsations) with his 14-inch telescope.

Asteroids

Asteroids are an important area of solar system studies. A large majority of asteroid lightcurves are now generated by backyard scientists, and those lightcurves are being used for an expanding array of studies (including rotation period, shape modeling, and evidence of subtle non-gravitational forces). This emphasizes the need for an archive of asteroid photometric data. Brian Warner described the Asteroid Lightcurve Data Exchange Format (ALCDEF), and noted that the Minor Planet Center has agreed to host the archive, thereby ensuring its long-term sur-

vival and easy availability to current and future researchers. All asteroid photometrists were encouraged to submit their data to this archive.

Dr. Lance Benner described the current status and recent results of radar observations of near-Earth asteroids from Arecibo and Goldstone. There is important synergy between radar observations and optical lightcurve data to fully characterize these objects. He particularly highlighted the case of 2005 YU55, which will pass inside the Moon's orbit this coming November, reaching 13th magnitude. The rotation period of this asteroid is currently unknown. Small-telescope photometrists were encouraged to put this event into their observing plans.

Richard Kowalski provided an overview of the Catalina Sky Survey and Catalina Real-time Transit Survey. The CSS is the most efficient search for near-Earth objects, having accounted for 65% of the NEO discoveries in 2010. One feature of the CSS is that its data are publicly available within minutes of each new discovery, which facilitates immediate follow-up and more detailed study by other observers, including amateur researchers. He noted that many of the supernovae that CSS discovers every night are in need of spectrographic follow-up, which might be within the range of some advanced amateur researchers. He also shared the story of his discovery of the Earth-impacting asteroid 2008 TC3, setting the stage for the after-dinner lecture.

The Symposium was capped by the Keynote lecture given by Dr. Peter Jenniskens, who described the observations of 2008 TC3's atmospheric entry, and his subsequent expeditions to search for and recover samples of the asteroid from the strewn field in northern Sudan. This was a wonderful story that began in outer space, continued on the ground in an exotic locale, and is still ongoing in laboratories around the world to tease out the chemistry, petrology, and history of this remarkable object.

A Bright Future

Astronomy is special in many ways. One of the special features of our science is that making new discoveries and valuable observations is not solely the province of professional astronomers. As the presenters and audience at SAS demonstrated, "backyard scientists" with modest telescopes and diligent efforts are making important contributions to our understanding of the universe.

Videos of many of the presentations from the Symposium will be available on the SAS website (www.SocAstroSci.org) within a few weeks, along with links to the Proceedings.

The next SAS Symposium will be held at Big Bear, CA, on May 22-23-24, 2012.