News from the Society for Astronomical Sciences

Vol. 10 No. 1 (January, 2012)

31st Annual "Symposium on Telescope Science"

The 2012 Symposium on Telescope Science will be held at Big Bear, CA on May 22-23-24. This will be a joint meeting of the SAS and the AAVSO. Everyone who is interested in small-telescope astronomical science is invited to attend. The enthusiastic participation by both amateur and professional astronomers in recent years bears witness to the important roles that the Symposium plays:

- An opportunity for non-professional researchers to present their projects and results, and learn from other backyard scientists.
- The privilege of receiving research advice from professional astronomers.
- Continuing education on methods, results, and opportunities for pro-am collaboration in small-telescope astronomical research.
- Venue for informal networking among the astronomical research community, both amateur and professional.

This joint meeting of SAS and AAVSO promises to be a useful and memorable Symposium. The agenda will feature two half-day Workshops, two days of technical papers, an AAVSO business meeting, evening banquet and keynote lecture.

Registration for the symposium, the workshops, and the banquet will open on January 31, on the SAS website (www.SocAstroSci.org). We expect the Symposium to be fully subscribed, so register early. We look forward to seeing you there!

Call for Papers

Papers are now being accepted for the SAS 2012 Symposium on Telescope Science. Topics on the full range of small-telescope science are welcomed: amateur and small-telescope research results, pro-am collaborations, science education, evaluation of recent professional results on relevant targets (e.g. small solar system bodies, planets, variable stars), innovations in astronomical instrumentation, and special uses of astronomical data.

Please send the abstract of your proposed presentation/paper to the Program Committee at

Program@SocAstroSci.org.

Deadlines are:

Abstract submission: March 16, 2012

Final Papers due: April 13, 2012

Abstracts may be submitted in plain text or MS Word format. The formatting requirements for final papers –

Small telescopes at GMARS were used this fall to test the filters used on the DAWN spacecraft mission, in anticipation of its arrival at Ceres in 2015. Duplicate Dawn spacecraft filters were sent to principals of the Center for Solar System Studies (CS3) and used to obtain phase curves of Ceres. Images through the 7 narrow band filters of Dawn's Framing Camera were needed so that the Dawn imaging team would know how to sequence the exposures as the spacecraft approaches Ceres. Images were obtained through this 110 mm refractor and a 12-inch RCX to create seven H-G Phase curves of Ceres. © Bob Stephens including an MS Word template – are provided on the SAS website (www.SocAstroSci.org). All accepted papers will be published in the SAS Proceedings, and indexed in the NASA ADS.

Poster papers are also welcomed. The due-date for Poster abstracts is the same as for presentation papers (March 16). If you provide either a one-page summary or a full paper of your Poster by the deadline for final papers, then it will be included in the Proceedings volume and indexed in NASA ADS.

SAS-2012 Photometry and Spectroscopy Workshops

The SAS-2012 Symposium will feature two half-day workshops, to help participants learn new skills and become familiar with the tools and procedures of astronomical Spectroscopy and Photometry. The workshops will be held on Tuesday, May 22, 2012. Dr. Martin's Spectroscopy workshop will be held in the morning, and Dr. Price's Photometry workshop will be held in the afternoon. Check the SAS website Registration page for details on how to register for these workshops.

"Spectroscopy with Small Telescopes" workshop will be presented by Dr. John C. Martin.

The field of spectroscopy is a new frontier now available for amateur astronomers to explore. In the right context, it is no more complex than the long practiced methods of photometry. There are also a wide variety of projects better suited for small telescopes over large telescopes. In this workshop, Dr. Martin will be sharing his expertise with spectroscopy and small telescopes to give the participants a basic working knowledge (independent of any particular hardware or software setup) of how spectrographs work, how to optimize their efficiency on a small telescope, and how to reduce and analyze the data that they produce. He will also discus projects for those who have the equipment as well as databases of spectroscopic data that are publicly available for data mining.

Dr. Martin is an Assistant Professor of Astronomy-Physics at the University of Illinois Springfield where he is also the director of a community supported research observatory. He earned his PhD from Case Western Reserve University and has research interests in spectroscopy, the evolution of massive and hot stars, and small telescopes. His most recently published work has used the Hubble Space Telescope and Gemini South Telescope to observe the massive star Eta Carinae. He is also the recipient of a National Science Foundation grant to study the variability of massive stars and supernova imposters in the local group of galaxies.

"Using the Photometry Analysis Package VPHOT" workshop will be presented by Dr. Aaron Price.

VPHOT is AAVSO's on-line photometry analysis software, which is freely available to all AAVSO members. It has an intuitive interface on the surface, yet behind the scenes it has a powerful photometry algorithm designed by Dr. Arne Henden. It performs aperture photometry, searches for new variable stars across the full field, gives a wide variety of diagnostic plots, and writes standard output files ready for direct submission to the AAVSO. It will work on your own images, or images taken through AAVSOnet, the AAVSO network of robotic telescopes. It can be used for any variable object, including minor planets.

This demonstration will walk the audience through the most common uses of the software and will come with a printed tutorial handout. VPhot is available for free to AAVSO members ($60/year) and was originally written by Geir Klingenberg.

Dr. Price is the Assistant Director of the AAVSO. He has a BS in astronomy and a Ph.D. in STEM Education from Tufts University. He is active in the astronomy outreach community as a U.S. committee member for the International Year of Astronomy and creator of the Slacker Astronomy podcast.

Videos of Workshops from SAS-2011 are available

The 2011 SAS Symposium featured workshops on "Remote/Robotic Observatories", and "Eclipsing Binary Stars". Video recordings of these workshops are now available.

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).

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. Noting that many interesting systems are within the range of backyard scientists, Dr. Terrell concluded with a clear message: "You will be doing a service to science by taking the data, making the lightcurve, doing the analysis, and publishing your results."

If you would like a copy of the recording of these workshops, contact Bob Buchheim at rbuchheim@earthlink.net. If you attended the workshop (or paid the registration fee and for some reason did not attend), then the DVD price is $3. If you were not a registered attendee, then the DVD costs $53 (for each workshop). Make checks payable to "SAS".

Probing the Winds of Wolf-Rayet Stars: A Pro-Am Campaign for Summer 2013

reported by Thomas Eversberg

We would welcome the participation of SAS members in a planned joint amateur and professional spectroscopic+photometric campaign to observe two important Wolf-Rayet stars in the summer of 2013. The stars are WR 134 and WR 135, located in the constellation Cygnus.

The purpose of this project is to understand the connection between the stars' hidden invisible surface and their strong radiatively driven winds. A four-month-long international campaign, providing nearly continuous observation "round the clock" will enable us to test for periodicities and stochastic clumping in the winds.

We plan to run the campaign from May 17 to September 17 of 2013. We invite amateurs and professionals to join our team with their spectroscopic and photometric instrumentation.

The target stars are relatively bright (about 8 mag), high in the sky during our campaign and data requirements can be matched with small size telescopes and standard equipment. The necessary preparation all over the world and the importance of defining and harmonizing different instrumental setups forced us to start with the campaign planning relatively early – 1.5 years in advance. This provides amateurs time to prepare themselves by doing test observations, (which may indeed turn out to be useful for the campaign).

Dr. Tony Moffat has prepared the "science case" to define our goal and to have a basis for making telescope proposals. The science case and instrumental necessities can be found at

www.stsci.de/wr134/index.htm.

Our main exchange platform will be the VdS discussion forum (see link "Campaign forum" to the "ConVento" thread). All professional participants are already registered. Please check this out and think about your participation. Then use the link "How to join us", download the Word file, fill it out and return it as indicated. Then register in the forum and enjoy the progress of the campaign.

As soon as you register as a participant, we will consider you as a team member and rely on your contribution. (Please inform us if you must subsequently drop out, so that we do not run into trouble. Information exchange is everything!)

We want to support astronomical ProAm enthusiasm as we did in 2008/2009 when a group of amateurs and professionals investigated the WR + O binary WR 140 in a joint campaign at different ground and space based observatories. The project was highly successful and resulted in a number of refereed publications plus a contribution to a PhD thesis. Information about this most recent campaign can be found in the respective webpage about WR 140.

Editor's Note: This sounds like a great opportunity to do three things: (1) purchase that spectrograph that you've been lusting after, (2) gain practice and proficiency with it, and (3) contribute to an exciting research campaign. An 11- to 14-inch (28- to 36-cm) telescope and a spectrograph with resolution of about 1Å appears to be well-matched to this project.


Members of the ProAm ConVento Group during the WR 140 campaign workshop 2009 in Portugal

Submit your asteroid lightcurve data to ALCDEF!

You have probably been told more than once – "if your data lies unpublished in a dusty file cabinet, then it surely will perish", and be of no use to the progress of science. The Asteroid LIghtcurve Data Exchange Format and associated database is a convenient means of putting your asteroid photometry data into an archive that can be accessed by other researchers who can take advantage of it. Since your data is tagged with your name, when a researcher publishes a paper that used your data, you will receive credit.

Is ALCDEF data actually used by researchers? Two papers presented at the recent joint meeting of the European Planetary Science Congress and AAS Division of Planetary Sciences drew data from ALCDEF. The titles were "New physical models of asteroids derived from sparse and dense photometry" (by J. Durech, et al) and "Spin-vector distribution of asteroids – the role of the YORP thermal effect" (by J. Hanus, et al). The list of co-authors on these two papers includes a long roster of backyard scientists whom you will probably recognize: B. D. Warner, D. Higgins, J. Oey, F. Pilcher, R.D. Stephens, R.K. Buchheim, R.A. Koff, D. Polishook, V. Benishek, J.W. Brinsfield, R.I. Durkee, R. Goncalves.

The moral of the story is clear -- putting your data into ALCDEF is a service to science, and may allow you to add a publication to your resume.

Three Anniversaries

The participants in the 2011 SAS Symposium will recall that it marked the 30th anniversary of the Society for Astronomical Sciences.

Two more anniversaries that are relevant to small-telescope science were also noteworthy celebrations in 2011:

The American Association of Variable Star Observers (AAVSO) celebrated its centennial, marking 100 years since its founding in 1911.

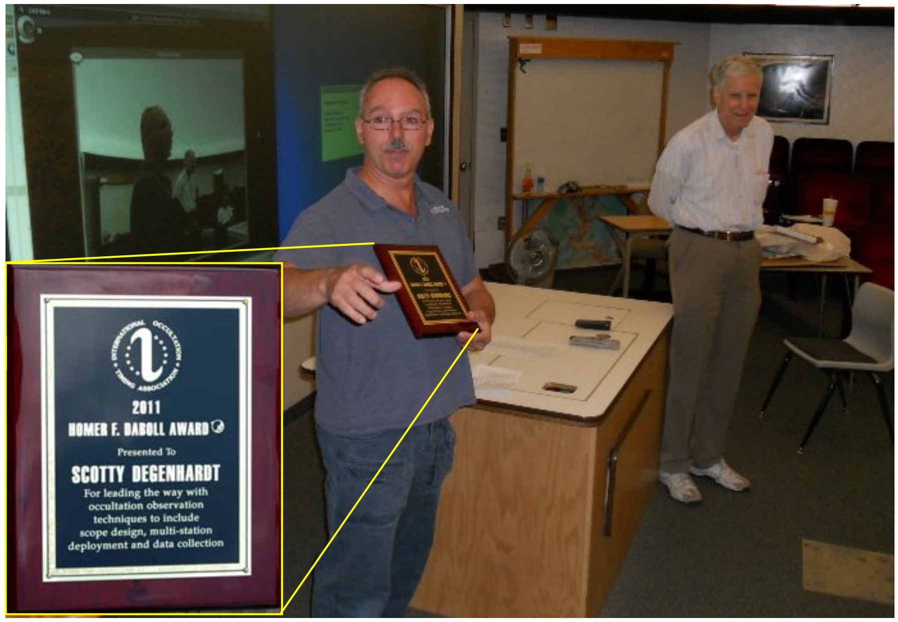
The Information Bulletin on Variable Stars (IBVS) marked its 50th anniversary in October 2011. The first issue – IBVS No 1 – was published by Konkoly Observatory for the IAU Commission 27 (Variable Stars) in 1961. A "Jubilee" edition (IBVS 6000) is available at http://www.konkoly.hu/IBVS/ibvs6000/proc.html

Scotty Degenhardt is 2011 DaBoll Awardee

Every year, the International Occultation Timing Association (IOTA) recognizes a person who has made a noteworthy contribution to occultation science by awarding the "Homer DaBoll Award" at their annual meeting.

The 2011 award was presented to Scotty Degenhardt, for leading the way with occultation observation techniques including telescope design, multi-station deployment, and data collection.

Those of you who were at the 2009 SAS Symposium will probably remember his overnight expedition to deploy a dozen "mighty mini" systems across the path of an asteroid occultation. This sort of dense coverage of asteroid occultations has made possible a dramatic increase in the accuracy of asteroid size and shape profiles.



Scotty Degenhardt receives the 2011 Homer DaBoll award, at the annual meeting of the IOTA. Dr. David Dunham, IOTA President, is in the background.
Photo credit: Tony George

Kepler Finds a Planet in an Eclipsing Binary

by Dr. Dirk Terrell
Southwest Research Institute
SAS Advisor

About ten years ago I happened to strike up a hallway conversation at work one day with one of my colleagues who specializes in planetary atmospheres. The topic of habitability in extrasolar planetary systems came up and I asked him if anyone had looked at the habitability possibilities in binary star systems. He couldn't think of any work done in that area, which really surprised me. So, we hatched the idea of combining my background in binary star astrophysics with his background in planetary atmosphere modeling to write a proposal to NASA's Exobiology program to model the evolution of planets orbiting close binary stars. We knew that planets had been discovered orbiting one star of a wide binary, but we were proposing to model planets like Tatooine in the Star Wars movies, where the planet orbited both stars.

After months of preliminary research merging various modeling codes and writing the proposal, we submitted it to NASA. A few months later we got the reply: "no thanks". The reviewers said the idea was "intriguing" but that "the vast majority of potentially habitable planets are in wider binaries." You see, it can be difficult to convince your colleagues to fund research into new areas, especially when the conceptually easier problems (planets in single star systems or wide binaries) still have low-hanging fruit to be picked. So, we tried again in the next proposal round, with an improved proposal that dealt with some of the questions posed by the previous reviewers. The result? "An imaginative, interesting and ambitious proposal" but "the prospects for observations of planets in these systems is unclear." The proposal was again rejected. At that point, we gave up. (I should say that I am at what is known as a "soft-money" institution where we have to get grants to cover our salaries, so if the grant isn't awarded, the research doesn't get done.)

A few years passed ... and this September an interesting announcement was made by the Kepler team: Kepler-16 was an eclipsing binary with a planet (Kepler-16b) orbiting around it! The binary consists of a K-type star of about 70% the mass of the Sun and an M-type star of about 20% the mass of the Sun. These two stars orbit one another in a slightly eccentric orbit about every 41 days with a semi-major axis of about 0.22 astronomical units, which is considerably closer than Mercury is to the Sun (0.38 AU), so this is indeed a close binary. The planet, with a mass about 1/3 that of Jupiter, orbits this pair of stars in an almost circular orbit every 229 days at a distance of 0.7 AU, about the same distance that Venus is from the Sun. Since the stars are of lower mass than the Sun, they are noticeably cooler and it turns out that the planet is far enough away from them that liquid water would not exist on its surface, which is estimated to have a temperature of 170 K to 200 K (-100 F to -150 F). So, at first glance, it appears that this planet is not a strong candidate for supporting life as we understand it.

Those of you who participated in the workshop on eclipsing binaries at the 2011 SAS Symposium know that eclipsing binaries enable us to measure accurate properties of the two stars, such as their sizes. With Kepler-16b, the situation gets even better because the dynamical interaction of the planet with the two stars (and the observable change in the eclipse timing) and the information from the transits of the planet across the stars, allow us to measure the properties of the two stars to remarkable accuracies.

The paper published in the September 16th issue of the journal *Science* lists the mass of the K star as 0.6897 solar masses with an error of about 0.0035 solar masses, or about 0.5%. The radius is 0.6489 solar radii with an error of about 0.0013 solar radii, or about 0.2%. Systems like Kepler-16 will thus allow for some very stringent tests on our models of stellar structure and evolution.

The light curve in Figure 1 shows just how remarkable Kepler's instrumentation is. When the secondary star eclipses the primary (i.e., the primary eclipse), the light level drops by about 13%, an eclipse easily measured from the ground. When the primary eclipses the secondary (the secondary eclipse), the drop is smaller, about 1.6%, because the surface brightness of the cooler secondary is so much smaller than that of the primary. But even that is not too difficult to measure from the ground with modest instrumentation. When the planet transits the primary star, the brightness drop is similar to the secondary eclipse, about 1.7%, so Kepler-16b could have been discovered by ground-based telescopes. Where Kepler shines, though, is in the photometric precision of the observations. Kepler is so good that it also unambiguously detected the transit of the planet across the disk of the secondary star, which results in a brightness drop of only 0.1%. You have to plot the flux in tenths of millimags to see the scatter in the Kepler data!

Kepler-16b is the first of what I believe will ultimately be many discoveries of planets around close binary star systems. Observations show that most stars are in binary or multiple systems, so if we are to truly understand how common planetary systems are, as well as how common habitable planets are, we need to understand how they might exist in binary star systems.

With the discovery of Kepler-16b, maybe NASA will take a greater interest in that proposal of ours. We plan to resubmit it next year. If we get it, I might have some interesting things to show at the 2013 Symposium.

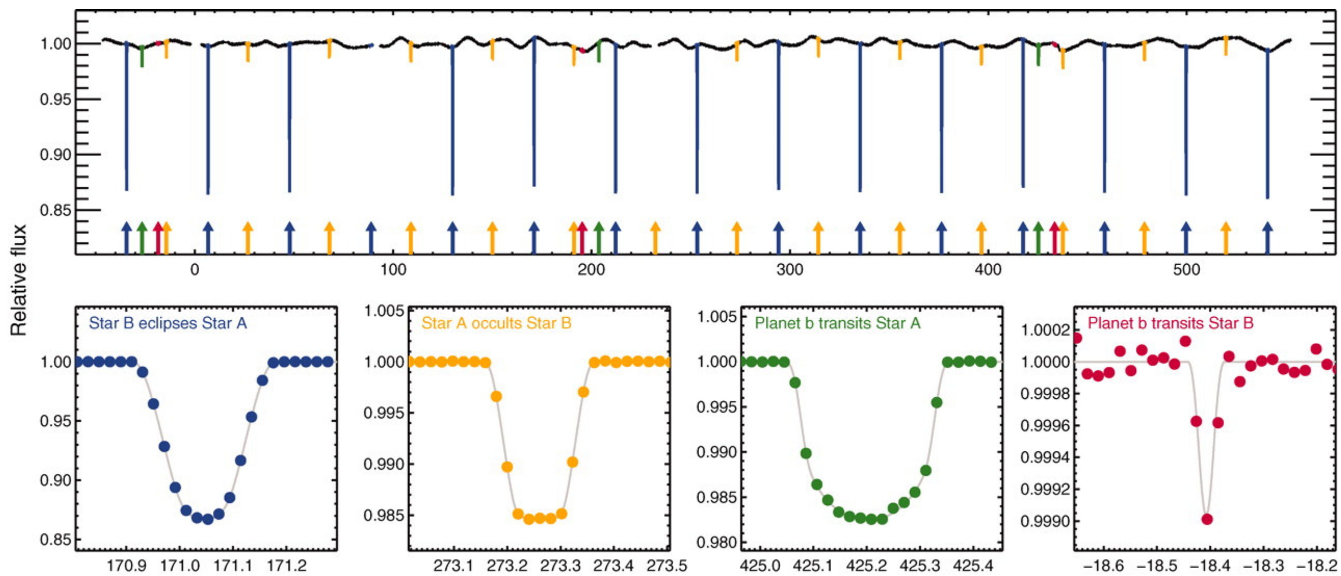


Figure 1: The light curve of Kepler 16 showing the stellar eclipses (blue and yellow) as well as the transits of the planet across the stellar disks (green and red).Note that there is variability outside the eclipses, presumably due to the migration of starspots across the primary star's surface.

Small-Telescope Astronomical Science in the News
October - December 2011

compiled by Bob Buchheim

In the December issue of Reflections (the newsletter of the Mount Wilson Observatory Institute), director Hal McAlister noted that 21st century astronomers consider the 100-inch Hooker telescope to be a "small telescope". Our instruments – whose capabilities for research are the focus of this series of articles – might be labeled "tiny" or "diminutive" on this scale, I suppose. But by steadfastly insisting that we backyard scientists are still members of the "small telescope" community, we maintain that enviable cache, and proudly distinguish ourselves from our amateur-astronomer brethren who are not so photometrically or spectroscopically inclined as we are.

Keep gathering – and analyzing – those photons!

The research papers highlighted below are proof that there are worlds – and stars – remaining to be conquered by small telescopes of the sort that can be found in colleges and backyards.

Orbital-Period Variations and Photometric Analysis for the Neglected Contact Binary EH Cancri

by Yang, Y.-G. et al

Pub. Astro. Soc Pacific, v. 123 p. 8995 (2011 August)

Many of you attended Dr. Terrell's workshop on eclipsing binaries at the SAS-2011 Symposium, in which he described the value of photometric studies of eclipsing-binary stars, and the wealth of information that can be inferred about these stars by small-telescope photometry. Here is a report on EH Cnc that is a good illustration of what can be done. These (Chinese) researchers gathered V- and R-band lightcurves of this star using an 85-cm (33-in) telescope and CCD imager; but given its brightness – 12th magnitude – it would have been readily accessible to a smaller telescope. They then fit the lightcurves with the Wilson-Devinney code to estimate its mass ratio (photometric mass ratio, q) and then create a very clean fit showing it to be a W-type contact binary system.

They then evaluated their own time-of-minimum observations with all published data, to show that the system's period is gradually decreasing ($dP/dt \approx 1 \times 10^{-7}$ d/yr); and that there appears to be an additional cyclic change in period (which might be due to the light-time effect of a third body in the system).

The authors note that understanding of this system would greatly benefit from a spectroscopic study to confirm the spectral type and effective temperature, and a radial velocity study to establish the physical parameters of the system.

Rough Times in the Galactic Countryside
by Curtis Struck
Nature, vol 477 p 286 (15 September 2011)

Over the past decade, cosmologists have recognized the importance of galactic interactions, and particularly the effects of "cannibalization", where a large galaxy disrupts and incorporates a smaller one. Recent modeling has suggested that the morphology of our own Milky Way has been dramatically affected by such galaxy mergers. This review article is not "small telescope" research, but it seems appropriate to note that it is dramatically illustrated by R. Jay Gabany's image of the "death spiral" of a small galaxy being gobbled by NGC 5907.

A Pluto-like radius and a high albedo for the dwarf planet Eris from an occultation
by B. Sicardy, et al
Nature, v.478. 27 October 2011, p.493

The title almost says it all. A great many observers attempted to record the predicted occultation of a 16th magnitude star by trans-Neptunian object Eris – the paper has 72 authors – but only two obtained "positive" results. The "negative" results were nevertheless important, because they provided upper bounds on the derived size of the object. Two items struck me particularly about this report. First, the "successful" occultation lightcurves came from 40- and 50-cm telescopes (16- and 20-inch), while a 2-meter (85-in) instrument contributed the closest "negative" result. So, in this race, the small telescopes won. Second, the lightcurve from the 40-cm (16-in) scope showed the faint glow of Eris itself during the occultation. It's pretty impressive (to me, anyway) that a modest telescope and CCD exposures of just 15 s can detect a 19th magnitude object.

With two occultation chords, the authors provide a quite accurate estimate of Eris' diameter. Coupling this with its measured brightness provides an accurate albedo – a shockingly high $\rho_V \approx 0.96$, which suggests that Eris has a very clean icy surface. The very sharp edge of the occultation lightcurve indicates that Eris has virtually no atmosphere (surface pressure less than 2.9 nano-bars).

That such wide-ranging conclusions can be drawn from an occultation that lasted less than a minute and a half, is testimony to the great value of small-telescope occultation observations.

2MASS J01074282+4845188: A new nova-like cataclysmic star with a deep eclipse
by Dinko P. Dimitrov and Diana P. Kjurkchieva
New Astronomy, v17 (2012) 34–37

We've all heard the message that the ever-increasing data from large surveys will create a flood of opportunities for detailed follow-up studies by small telescopes. Here is an interesting star, and also an interesting example of the sort of detective work that the small-telescope follow-up may entail.

First the star: The author's photometry in V-, R-, and I-bands, using a 60-cm (24-in) telescope and CCD showed a lightcurve that had most of the hallmarks of a cataclysmic variable. These included non-symmetrical eclipse profile with a pre-eclipse "hump" and a post-eclipse "standstill"; no obvious secondary eclipse, but a shallow brightness dip at about $\varphi \approx 0.65$ and a modest color change near phase $\varphi \approx 0.5$ (bluer out-of-eclipse, and redder in primary eclipse). Detailed analysis of the out-of-eclipse light showed compelling evidence of "flickering". All of this is consistent with the picture of a CV, in which the primary eclipse is caused by the accretion disk. The eclipse itself is quite deep – over 2.5 magnitudes in V, so this is a potentially important addition to the small number of recognized nova-like CV's with deep eclipses.

The authors also used a 2m (79-in) telescope with a 300 l/mm grism to generate a low-resolution spectrum, showing pronounced Hα emission line. The shape of the line changes quite rapidly. The spectral study is thus also consistent with the picture of an eclipsing CV.

The detective work that such follow-up entails is also an interesting aspect of this paper. The star was found in a catalog of short-period eclipsing binaries, which identified it as a 14th magnitude star. It had been observed by TrES and SWASP, both of which provided nicely-phased (albeit noisy) lightcurves with eclipse depth of at most a few tenths of a magnitude. However, these surveys have poor angular resolution and are mostly based on automated data reduction pipelines. It turned out that the coordinates and star identification were in error – the actual variable is a 15th magnitude star which had been blended in with the (non-variable) identified star.

So, here is an example where the synergy between the wide-ranging survey (to identify an interesting object) and the dedicated small-telescope follow-up (to characterize the object) worked out very nicely.

A Thousand Hours of GW Librae: The Eruption and Aftermath
by Laura VIcan, Joseph Patterson, William Allen, Bill Goff, Thomas Krajci, Jennie McCormick, Berto Monard, Robert Rea, Peter Nelson, Greg Bolt, Robert Koff, George Roberts, Matt Wood, and Jonathan Kemp
Pub. Astro. Soc. Pacific v123 p1156 (2011 October)

Cataclysmic variable stars are complex systems consisting of a white dwarf, an accretion disk that feeds it, and an evolved companion star that provides a stream of mass to the accretion disk. They display a variety of phenomena visible to small-telescope photometry, some of which are fairly well-understood, others of which are complete mysteries. This paper describes the observations and conclusions drawn from a multi-year campaign on GW Lib, following its 2007 outburst. I've listed the names of all of the authors, because many of you will recognize most of them. The data in this paper came almost exclusively from the small telescopes of the participants in Dr. Patterson's Center for backyard Astrophysics. Most telescopes were about 30 cm (12 in) ±20%.

This study demonstrates the remarkable power of small telescopes when wielded by dedicated observers, beginning with the discovery that kicked off this study. The outburst of GW Lib in august 2007 was detected – visually – by Rod Stubbings in Australia. His dedication and diligence enabled the photometrists to begin gathering data while the outburst was still rising, so the photometric record begins less than a couple of days after the initial explosion.

There are so many interacting phenomena going on in a CV during and after outburst that very long data sets, with as few gaps as possible, are essential to characterizing the star's brightness changes. A globe-girdling network of telescopes is necessary for such a campaign, as is the flexibility that private researchers have to immediately turn to, and stay on, the target of opportunity. Unfiltered CCD differential photometry can record both the huge brightness change of the outburst (8-9 magnitudes from quiescence to peak outburst) and the subtle oscillations and flickers (peak amplitudes ≈ a few hundredths of a magnitude) that occur throughout the outburst and its aftermath.

GW Lib displayed a characteristic CV outburst profile: explosive rise (quiescence to max brightness in just a couple of days), gradual fading to a plateau (over about 25 days), then a rapid drop of 3-4 magnitudes, followed by a gradual fade toward quiescence. Overlaid on this envelope, the observers were able to reliably characterize the amplitudes, periods, and amplitude/phase modulation of several smaller signals, including the orbit of the two stars, the superhump frequency (related to interaction between the orbit and the accretion disk), plus a "20-minute" period signal which might be related to either instability in the accretion disk or a non-radial pulsation of the white dwarf star, and a "2-hour" period signal whose source is a complete mystery,

If you have any interest in starting to contribute to CV photometry, it is worthwhile to read this paper for its good explanation of the observing techniques, data reduction, and the many types of data that are extracted from the time-series photometry.

AC Piscium, A Short-Period Cool Dwarf Algol Binary
by R.G. Samec, et al
Pub. Astro. Soc. Pacific v123, p1169 (2011 October)

Dr. Terrell, during his workshop on Eclipsing Binary stars (SAS-2011 Symposium), made the determination and modeling of EBs seem pretty straightforward. Of course, his objective was to get us educated and motivated. Here is a report on a project for photometric characterization and modeling of an EB that turned out to be a bit more involved.

The authors used an 81-cm (32-in) telescope to conduct B-V-R-I CCD photometry of this14th magnitude eclipsing binary. The phased lightcurve shows a deep primary eclipse, a huge asymmetry in the out-of-eclipse brightness (the post-eclipse peak is nearly 0.2 mag fainter than the pre-eclipse peak brightness), which creates a very asymmetric secondary eclipse, and clear evidence that the lightcurve changes a bit from orbit to orbit. This suggests that at least one of the stars is heavily-spotted. This system is a possible visible counterpart of a bright x-ray source, which is consistent with the assumption of magnetically-driven star spots. There is not a long-enough history of time-of-minimum data to draw reliable conclusions about period changes (which might be expected in a magnetically-active system).

These complicated features made it unclear whether the system was detached or semi-detached, or even whether it was a non-synchronous rotator. The authors ran a large matrix of possible solutions with Binary Maker and Wilson-Devinney, to find a model that was a good fit to all of their data. The star appears to be a semi-detached system, with the secondary star filling its Roche lob (and hence significantly distorted shape), mass ratio $q \approx 0.5$, with a huge dark spot on the primary star. Although the solution fits the data nicely, it is hard to explain how the system got into this configuration.

The authors end with a call for spectroscopic study (for radial velocity) to provide absolute size and orbit data; and for ongoing eclipse timings to that the orbit evolution can be studied.

Combining asteroid models derived by lightcurve inversion with asteroidal occultation silhouettes
by Josef Durech, et al
Icarus v214 p652–670 (2011)

The "et al" in the author list has several names that will be familiar to many of you who are doing asteroid occultations and lightcurve photometry: Mikko Kaasalainen, David Herald, David Dunham, Brad Timerson, Josef Hanuš, Eric Frappa, John Talbot, Tsutomu Hayamizu, Brian D. Warner, Frederick Pilcher, and Adrián Galád.

Asteroid occultation timing can provide absolute size and instantaneous profile information, while lightcurve photometry can provide rotation state and 3-D shape model of the asteroid. The authors here show how these two complementary data sets can be combined. Lightcurve-derived shape models have an (unknown) arbitrary scale, but the occultation data permits them to be placed on an absolute size scale. Lightcurve-derived shape models are usually convex-only "wrapping paper" models, which do not reflect concavities (craters and valleys) in the asteroid; but occultation profiles can clearly display concavities in the profile, thereby adding important new information. And lightcurve-derived spin-state solutions often have a "180-degree ambiguity" that may be resolved by comparing the two implied profiles to the observed occultation profile.

Indeed, for several asteroids, the authors show that one of the two alternative lightcurve shape models is inconsistent with the occultation profile, thereby nicely resolving the ambiguity in the spin state.

The paper concludes with "We thank all the observers for their efforts and for providing their observations." Keep up those occultation and lightcurve observations!

First Modern Photometric Investigation of the Puzzling W UMa Type Close Binary System of TZ Bootis
by P.-E. Christopoulou, A. Parageorgiou, and I. Chrysopoulos
Astronomical Journal v142 p99, 2011 October

TZ Boo is an overcontact eclipsing binary. The history of studies of TZ Boo contains a variety of curious and sometimes discordant conclusions. The secondary eclipse depth varies, so that sometimes it is deeper than the primary eclipse. The O-C curve of eclipse timings shows a secular decrease in period, overlaid on several "jumps" in which the period suddenly changes (the exact number and timing of these jumps seems to depend a bit on which data are included and how it is interpreted). Times of minimum also suggest a sinusoidal period change (light-time effect) by a third body in a P≈ 30-yr orbit, but spectroscopic studies suggest a third body in a P≈9-yr orbit. Photometric and spectroscopic mass ratio estimates range from q≈ 0.13 to 0.21, and orbit inclination estimates range from φ≈ 67 to 80 deg. So, a modern re-examination seemed to be due.

The authors used a 35.5-cm (14-in) telescope to create B-V-R-I CCD lightcurves. Their lightcurve and modeling indicates that the secondary eclipse is flat (but with a slight slope), and shallower than the primary eclipse, and an over-contact parameter of f≈ 0.52. Their new times-of-minimum light and retrospective analysis of published Tmins seems to provide compelling evidence for a third body in a P_3=31.4 yr orbit of high eccentricity, but evaluation of its probable mass and magnitude lead them to the conclusion that the "third body" is actually a close non-eclipsing pair of small stars. The third-light contribution is about L_3≈22%, consistent with this being a triple-star system.

Despite this nicely-done photometric study, the authors note that there is a need for (a) high-resolution spectroscopy and (b) follow-up lightcurves to understand the radial velocity, spectral features, and variations in the lightcurves' shape. I'm not sure about the spectroscopic requirements, but the photometric effort was well within the capability of many SAS members.

UBVR$_C$I$_C$ Analysis Of The Recently Discovered Totally Eclipsing Extreme Mass Ratio Binary V1853 Orionis, And A Statistical Look At 25 Other Extreme Mass Ratio Solar-Type Contact Binaries
by R. G. Samec, et al
Astronomical Journal, v142 p117, 2011 October

One postulated end-game for very close, high-mass-ratio overcontact binary stars (W-UMa's) is continued in-spiral and eventual merger of the two stars into a single "re-born" stellar object. The authors of this paper have been following a research program of finding and characterizing systems that may be heading in this direction.

They used a 31-in (78-cm) telescope to create dense and accurate CCD multi-color lightcurves (UBVRI), and model them using BinaryMaker and WIlson-Devinney codes. The model shows V1853 Ori to not only be an over-contact system (the two stars overlap noticeably), but the pair is filling a sizable fraction of the outer Roche lobe; and there is noticeable spot activity. So, it is most likely heading in the direction of an eventual merger. However, their study of the eclipse timings does not display any evidence of period change.

Granted that the history of eclipse timings extends over less than 5 years, it isn't surprising that no conclusions can be drawn yet. The authors recommend continued efforts to time the eclipses. This is, of course, a project well-matched to small telescope CCD observations.

Spectral Evolution of the Unusual Slow Nova V5558 Sagittarii
by Jumpei Tanaka, et al
P*ubl. Astron. Soc. Japan* v63, p911, 2011 August 25

Here is an interesting example of what can be accomplished with quite modest spectroscopic equipment. The authors used a 28-cm (11-in) telescope and a low-resolution spectrograph (λ/Δλ≈ 600, roughly comparable to the SBIG SGS or Shelyak LISA spectrographs) to monitor the nova's spectrum, from before its initial maximum to well into its terminal decline. Their data provide an interesting counterpart to the B-V-R-I photometric lightcurve.

This turned out to be an unusual nova in several respects, including a very slow rise (almost 2 months from discovery to first maximum brightness), and multiple brightness peaks after the first maximum, as the lightcurve moved up and down with a characteristic timescale of about 15-25 days, for nearly 4 months before settling into a smooth decline.

The spectrograms show significant spectral changes that seem to (roughly) correlate with the photometric evolution. Pre-maximum spectra are dominated by strong Balmer and He-I emission lines, which are sharp (rather than more typical flat-topped nova spectra). Near the first maximum brightness, the He-I lines fade, and some Fe-II lines appear. Throughout the re-brightening stage, the spectrum changes in a variety of ways, with lines coming and going and the shape of the continuum also changing. The blue-shift of the absorption component of the "P Cyg" absorption profiles gradually increases for the entire duration of the observations (which spanned just over a year).

Last year, Dr. Arne Henden encouraged photometrists to maintain watch on novae for at least a year after maximum light (strange things have been observed ...), and it appears that the same message should be applied to spectroscopists. (Here's another reason to get that spectrograph that you've always wanted – you can practice on novae while you get ready for the Wolf-Rayet campaign).

Photometric Variability of Five Candidates for Proto-planetary Nebulae
by V. P. Arkhipova, et al
Astronomy Letters, v37, No. 9, p635 (2011)

I read an article recently by a stellar astronomer who bemoaned the diminishing emphasis on long-term monitoring projects. He noted that once upon a time, astronomers concentrated on measurement of time-varying parameters (e.g. astrometric motions of binary stars, lightcurves of variable stars); but today they gather deep and detailed information (e.g. galactic redshifts and gravitational lens morphology) that represents a "snapshot in time" – almost as if the universe were being viewed as a static and unchanging place. He held out hope that the amateur and small-telescope researchers might save stellar astronomy from its current neglect.

He clearly hadn't counted on the steadfast diligence of these Russian astronomers, who have maintained photometric monitoring of a handful of (suspected) proto-planetary nebulae for the last 15 years, and are still at it. This report presents their photometric results. Most of these stars display large-amplitude variability (a magnitude or more, peak-to-peak), and color changes (pretty much "in sync" with the brightness variation), with long characteristic periods (a couple of months or longer, and periodograms showing more than one significant peak). This makes a long and consistent observing program mandatory to understand their activity and evolution.

Mass Determination Studies of 104 Large Asteroids
by William Zielenbach
A*stronomical Journal*, v142, p120, 2011 October

This must have been a heart-wrenching paper to write: the idea was so clever, and the effort that went into the research so extensive, but in the end the conclusion that I drew was "it didn't quite work out."

This isn't exactly "small-telescope research", but since many SAS members provide asteroid position data to MPC, it is good to know that – even for asteroids with well-determined orbits – there is value in the ongoing asteroid astrometry.

Occasionally, an asteroid has a close encounter with a "test particle" – sometimes a spacecraft from Earth, sometimes a fortuitously close approach by another (smaller) asteroid. The gravitational force of the asteroid perturbs the path of the "test particle", and careful astrometry and analysis of the change in the test particle's state vector can provide an estimate of the mass of the perturber. This is a well-respected technique. The grand idea was to extend it into a statistical evaluation of the perturbations of many "test particles", whose individual state vectors might be subject to fairly large observational uncertainties, but which taken as an ensemble might beat down the uncertainties through sheer numbers, thereby enabling the researcher to determine a reliable mass for the perturbing body. So, he took the entire collection of observations from the Minor Planet Center, found 104 asteroids that were good candidates to be "perturbers" (i.e. they were reasonably expected to be heavier than the "test particles" – other, smaller asteroids – and were observed to have had close encounters with more than one "test particle"). And he ran the numbers, which must have been a prodigious expenditure of computer time.

Alas, for a variety of reasons, the results were not what had been hoped. Some asteroids were determined to have negative mass; others had masses that were discordant to spacecraft fly-by data by as much as a factor of 2 (in either direction), and others were so different from previous, well-founded studies, that – while plausible – they seemed (to the author) to be unreliable. What went wrong? He suggests a variety of pitfalls, including astrometric inaccuracy at the fraction-of-an-arc-sec level, suspected star catalog biases at the 0.3 arc-sec level, the vagaries of finite-difference optimization routines that can be pulled by "bad-actor" data points, and – possibly – the un-modeled effect of other asteroids. The model accounted for perturbations from the major planets, Earth's Moon, and the three largest asteroids, but at the level of precision demanded here the author suspects that "trying again" must include accounting for several hundred of the largest asteroids.

Sad as the result is, I found it refreshingly courageous for a "negative" result to be submitted and published. I have often thought that we learn more from setbacks than we do from easy victories.

Photometric Elements, Apsidal Motion, and the Third Body in the Eclipsing Binary V974 Cyg
by M. V. Kuznetsov, et al
Astronomy Reports, v55, No. 11, p989 (2011)

Here's a very useful report on CCD photometry of a binary star system that has almost everything: eclipses, an eccentric orbit, non-synchronous rotation, apsidal motion (faster than expected by general relativity), a third-body, and consequently light-time effects. All of which are detectable in the CCD lightcurve data and associated analysis. It is a well-separated system with fairly long period (P≈ 3.2 d) and nice deep eclipses (Δmag≈ 0.5 mag for both primary and secondary eclipses). The authors used a 50-cm (20-in) telescope and CCD to create a multi-color (BVRI) photometric lightcurve.

Part of the usefulness is that the authors provide the first complete lightcurve of the system – which is in itself a time-consuming project considering the long period. It is also useful for any of you who are interested in eccentric-orbit eclipsing binaries because it lays out in tutorial detail the relevant equations to disentangle period changes, apsidal motion, and light-time effect.

The net result of the author's analysis is that the system appears to be composed of two nearly-identical stars ($M_1 \approx M_2 \approx 2.2\ M_{Sun}$) in an eccentric orbit ($\varphi_{II} \approx 0.46$). The system also contains a third body, $M_3 > 0.6 M_{Sun}$ in a 26.5-yr orbit

This system probably deserves continued time-of-minimum study (both min_I and min_{II}, once or twice a year), to completely map the O-C curve and confirm the parameters of the third-body and the apsidal motion.

Color Variability of BL Lac in 2002–2008
by V. A. Hagen-Thorn, et al
Astronomy Reports, v55, No. 11, p1000 (2011)

One interesting group of cosmological targets that can be studied with small telescopes are active galactic nuclei. These authors report a multi-color CCD photometric study of the Blazar BL Lac, done with 70-cm (28-in) and 40-cm (16-in) telescopes. BL Lac displays pretty impressive brightness changes, some at month-long time scales and others in rapid outbursts. The authors combine a 6-year-long record of multi-color photometry in an interesting way: First, convert each band to flux (instead of magnitude); second, plot F_i vs. F_j for the entire data set. If the source's color (spectral energy distribution) stays constant during outbursts, then all of the data points in such a flux-flux diagram will fall on a straight line; and the slope of the line indicates the source's color.

It turns out that most of the data points do, indeed, fall on a straight line on flux-flux plots. So the color of the blazar source appears to be constant, regardless of its brightness fluctuation. At the brightest levels, the points deviate from the straight line defined by lower-brightness data points; but if the outburst data is treated in isolation, then it, too, falls on a straight line on the flux-flux plot. So, there may be two types of sources, or there may be something special happening during the brightest outbursts.

The authors note that their recognition that the outburst colors appear to be constant (for any given outburst) will require reconsideration of previous interpretations, which were based on a color-vs-brightness change.

The New RS CVn Binary V1034 Her Revisited and the orbital period - Activity relation of Short-period RS CVn binaries using photometric distortion amplitude
by LiYun. Zhang
Research in Astron. Astrophys. Vol. 9, 2011

The author used an 85-cm (33-in) telescope and CCD imager to create complete B-V-R-I lightcurves of this star, at two epochs separated by about 1 year. The target is an eclipsing binary, magnitude ≈ 12.9 out of eclipse, with primary eclipse depth of nearly 1 magnitude, and secondary eclipse depth of about 0.5 mag.

The RS CVn-type of this pair indicates significant starspot and magnetic activity, so it is a potentially-fruitful target for repeat photometric (and spectroscopic) studies. In particular, although it is a well-separated pair, the lightcurve is significantly asymmetric in the out-of-eclipse regions: it is almost 0.1 mag brighter at φ=0.75 than it is at φ=0.25. In addition, the author's lightcurves taken a year apart show significantly different shapes out-of-eclipse, especially in V- and R-band. He interprets this as evidence of changing star-spot configuration; and tentatively concludes that there are two “active” longitude regions that alternately appear spotted, with a variational time scale of a year or so.

There is only a 25-year history of times of minimum light on this system, so although there is a hint of O-C curve variation, continued timings are needed to property characterize the system. The suspected parabolic curve could be explained by magnetic activity, mass transfer, or third-body; and the current data is insufficient to argue strongly between these alternatives.

Spin vector and shape of (6070) Rheinland and their implications
by David Vokrouhlicky et al
preprint at arXiv:1111.2061v1

The authors report on a project to combine and interpret several years of lightcurves, most of which were gathered by CCD photometry on small telescopes in the 40-cm (16-in) to 80-cm range (32-in). The “et al” in the author list includes several names that may be familiar to many of you: Josef Durech, David Polishook, Petr Pravec,

6670 Rheinland is one of a pair of asteroids whose orbital elements are virtually identical, strongly suggesting that they have a common origin (e.g. by fission or spin-ejection of a surface element). Analysis of the orbital elements suggested a likelihood that Rhienland should be a retrograde rotator. Analysis of the asteroid by lightcurve inversion provided a very precise rotation period (P≈4.3 hr), and an impressive shape model. The pole solution is not well constrained, but does indicate a retrograde rotation as expected.

Additional lightcurves from future apparitions are needed in order to further constrain the rotational state, and confirm the shape model of this asteroid. The next good opportunity will be in late 2013.

Unfortunately, its orbital partner is too small, and hence too faint, to be a lightcurve target for small telescopes.

Estimating meteor rates using Bayesian inference
by Geert Barentsen, Rainer Arlt, Hans-Erich Fröhlich
WGN, the Journal of the IMO
preprint at
http://arxiv.org/PS_cache/arxiv/pdf/1112/1112.4372v1.pdf

Let’s say that you have undertaken a meteor count, and during one of your observing intervals of length T minutes, you counted N meteors. What is the average rate, over that interval? Hint: rate = N/T is not the correct answer, because the underlying “true” rate is a parameter of a random process, and your observed rate is merely a single realization of that process. As the authors note, it is sort of like estimating the odds of winning the lottery. Suppose that ten people each bought a lottery ticket, and none of them won. Is the underlying probability of winning really zero? Well, no; the true probability is a small (but non-zero) number, and “zero for ten” is merely one realization of a random process.

With pretty clear mathematics, the authors explain the rationale behind the standard calculation of the zenith hourly rate of a meteor shower, given a set of observations. They make a compelling argument for altering the standard equation for estimating the zenith hourly rate to read:

$$E(ZHR) = [n_{tot} + 0.5]/T$$

Airborne Observation of 2011 Draconids Meteor Outburst: The Italian Mission
by C. Sigismondi
Il Nuovo Cimento
preprint at:
http://arxiv.org/PS_cache/arxiv/pdf/1112/1112.4873v1.pdf

Here’s a “no telescope” observing project from an unusual venue. Dr. Sigismondi was flying from Italy to China on a commercial airline flight on the night of the predicted outburst of the Draconid meteor shower. Since his trajectory was entirely in darkness, over eastern Europe, Siberia, Mongolia and China, he selected a window seat on the side of the aircraft that would be facing North. He blocked the cabin lights by putting a blanket over his head and fixing it to the cabin, and directed the air conditioning vent into this little “tent” to prevent dew/fog on the window. He could see stars down to magnitude 5.5. For seven hours, he conducted a meteor count: he recorded meteors in 10-minute increments, noting their trajectory and (for the brighter meteors) their brightness. After correcting for his limited field of view and the trajectory of the aircraft, he was able to get a good estimate of the shower’s population index of n≈2.2±0.7 (compared to the published value of n=2.8); and make a nice plot of a double-peaked curve of zenith hourly rate, which stayed above ZHR>200 for virtually the entire flight.

He didn’t note any comments from other passengers (or air marshals). So, the next time you’re facing the dread prospect of a long night flight, you may want to check the meteor-shower calendar and follow Dr. Sigismondi’s example!

Do Disk Galaxies with Abnormally Low Mass-to-Light Ratios Exist?
by A. S. Saburova, et al
preprint at:
http://arxiv.org/PS_cache/arxiv/pdf/1112/1112.4058v1.pdf

Here is an interesting application of small-telescope astro-imaging of galaxies, to search for abnormal mass-to-light ratios. The authors used a 0.5-m (20-in) telescope to make photometrically-calibrated images of several galaxies in B- V- and R-bands; and used these images to determine the radial brightness profile and radial color profile of the galaxies. Their idea goes like this: The mass-to-light ratio of a galaxy can be predicted by making an assumption about the size-distribution of its stars (its “initial-mass-function”, IMF); and there seems to be pretty good evidence that most galaxies conform to a standard initial mass function. That same initial mass function (adjusted for stellar evolution since the formation of the galaxy) can be used to predict the color of the galaxy; and by separating the galaxy’s light into distinct components for the bulge, disk, and bar, the distinct colors of these components can be inferred.

For a given IMF (and corresponding brightness and color profile), you can calculate the largest-feasible rotation velocity $v_{max\ disk}$ – given a “normal” IMF. Then compare this to the observed “dynamic” rotation velocity curve of the gas disk (from spectroscopic study of the same galaxy, usually the Hα line). If the dynamic rotation velocity v_{rot} is significantly slower than the photometrically-derived disk rotation $v_{max\ disk}$, then that is an indication that the galaxy has an abnormally low mass-to-light ratio, which in turn probably points to an abnormal initial-mass-function (the authors suspect that the “abnormality” is that the galaxy’s IMF is deficient in low-mass stars).

Of the 9 galaxies that they examined (all of which had been previously suspected of abnormal mass-to-light ratio), they confirm that three (definitely) or five (probably) do have insufficient mass, given their luminosity. The authors note that there is great value in determining the radial-velocity profiles (v_{rot}) for their abnormal galaxies, and also in conducting surface photometry of more galaxies to compare the result with dynamic rotation data.

Marginally Low Mass Ratio Close Binary System V1191 Cyg
by B. Ulas, et al
New Astronomy v17 p46 (2012)

In a 2008 paper, Rucinski et al noted that this eclipsing binary system is unusual, and that it seems to be in a rapid-mass-transfer stage of its evolution. The present authors (who are affiliated with two Turkish Universities) have taken up the challenge. They used a 40-cm (16-in) telescope to develop a B- V- R-band CCD photometric lightcurve for the system, which they combine with Rucinski's radial-velocity curve to develop a complete solution to the system.

The system shows well-defined primary and secondary eclipses ($\Delta m \approx$ 0.3 mag), which are of different depth and shape, and displays unequal brightness maxima between eclipses (the O'Connell effect). The orbital period is about 7.5 hr. The author's compilation of new and historical times-of-minima clearly shows a changing period, which is consistent with the previously-published spectroscopic period-change (which is presumably due to mass transfer between the two stars). They also noted that the details of the shape and depth of the eclipses has changed measurably since an earlier lightcurve study (done in 1965).

The authors applied PHOEBE (yes, the same code that Dr. Terrell taught us at the SAS-2011 Symposium) to develop a simultaneous lightcurve and radial-velocity solution to the system. In order to replicate the O'Connell effect, they inserted a cool spot on the surface of the cooler star.

These low-mass-ratio binaries are important astrophysical laboratories. I think that there is an important message hidden in the connection between this paper and Rucinski's data: there are interesting systems, for which radial-velocity curves are available, that are in need of modern photometric study and simultaneous modeling ... and the necessary photometry can be done with quite modest telescopes ... and the modeling is within the capability of advanced amateur astronomers.

Absolute and Geometric Parameters of the W UMA-Type Contact Binary V404 Pegasi
by B. G¨urol, et al
Astron. Nachr. v332, No. 7, p690 (2011)

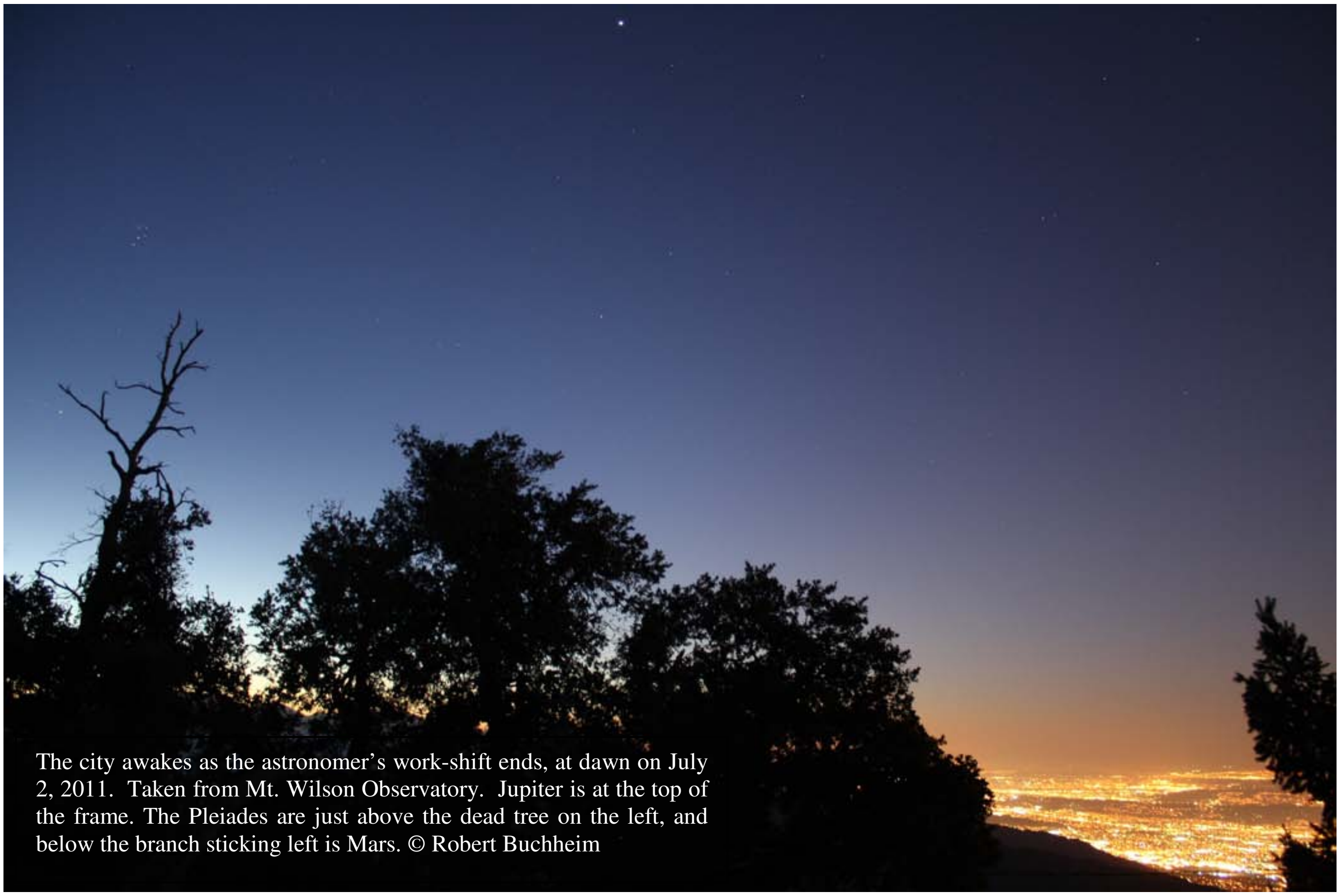
Here is a confirmation of the "message" that I inferred from the previous paper. A radial-velocity curve of this system was published in 2004, but a modern multi-band lightcurve study had never been done. The authors used a 40-cm (16-in) telescope to prepare a complete CCD lightcurve in B-, V-, R- and I-bands, and then combine the radial-velocity and photometric data into a complete solution to the system. Since there was no well-attested spectral-type available, and the distance is unknown so correction for interstellar reddening is problematic, they used 2MASS infrared color (J-K) to estimate the temperature of the hotter/brighter star, and based their solution on this. The complete solution then provides absolute measurements of all of the essential parameters of the system (masses, sizes, orbital radius, etc.).

Deep, Low Mass Ratio Overcontact Binary Systems. Xi. V1191 Cygni
by L. Y. Zhu, et al
Astronomical Journal, v142 p124, 2011 October

Remember the old saw that "a man with two watches never knows what time it is"? It applies to studies of eclipsing binaries, also.

The Turks (Ulas, et al, second paper above) weren't the only ones to do a photometric study of V1191 Cyg – the Chinese have been watching it, also (this paper). The main conclusions of the two groups are consistent. They determined the same values for the star's masses, radii, and separation (to within a fraction of a percent). However, they did see some things differently. They agree on the period-change; but the Chinese did a better job of searching out published times-of-minima, so their O-C curve spans a longer interval and is more complete than the Turk's. As a result, they see something that doesn't appear in the Turk's O-C analysis: in addition to the secular period-change (presumably due to mass-transfer), they find pretty good evidence for a cyclical, periodic variation in eclipse timing. This 26- to 32-yr period might be due to a third body, or might be a magnetic cycle. (The exact period isn't definite, because the period determination depends critically on assumptions that are made about the phase – primary or secondary minimum – in the early Tmin data points).

Curiously, the Chinese did not remark on the O'Connell effect – indeed, they describe their lightcurves as "symmetric" – and it is not apparent in their graphs. It is clearly visible in the Turk's lightcurves, and both data sets have excellent photometric accuracy. As a result, the Chinese model of the system does not include a cool spot. And it leaves a lingering uncertainty – did the shape of the lightcurve change (by ≈0.05 mag) in the year that separated the Turk's data set from the Chinese data? The Chinese note that the system worth continuous monitoring in the future, because the lightcurve of such a short-period, low-mass ratio system is expected to change fairly rapidly as it evolves.



The city awakes as the astronomer's work-shift ends, at dawn on July 2, 2011. Taken from Mt. Wilson Observatory. Jupiter is at the top of the frame. The Pleiades are just above the dead tree on the left, and below the branch sticking left is Mars. © Robert Buchheim

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SAS Contact Information

8300 Utica Avenue, Suite 105
Rancho Cucamonga, CA 91730

Lee Snyder: lsnyder@socastrosci.com
Robert Stephens:
rstephens@socastrosci.com

Newsletter Editors:
Dale Mais: dmais@socastrosci.com
Bob Buchheim:
rbuchheim@earthlink.net