News from the Society for Astronomical Sciences

Vol. 9 No. 2 (April, 2011)

Triennial Election of SAS Committee

The SAS is a non-profit public benefit corporation incorporated in California, which is managed by a Board of Directors. The Directors are elected for 3-year terms by the membership. The current Directors' terms of office will end on June 1, 2011. Accordingly, the 2011 Symposium will include a brief business meeting to elect 7 Directors to hold office for the next three years.

The following candidates will be presented to the Membership for approval as Directors, to serve from June 2, 2011 through June 1, 2014:

LeRoy Snyder
Robert Stephens
Robert Gill
Brian Warner
Jerry Foote
Dale Mais
Robert Buchheim

Under the Bylaws of the SAS, members may nominate alternate candidates at the meeting, in which case a written ballot must be taken to select the 7 Directors. If no alternate candidates are nominated, then those listed above may be approved by voice vote.

Workshops at 2011 SAS Symposium

The SAS 2011 Symposium will be preceded by two half-day educational workshops (to be held on Tuesday, May 24, 2011). These will be:

"Hands-on Analysis of Eclipsing Binary Light Curves", presented by Dirk Terrell.

You've gotten great photometry of an eclipsing binary. Now what? This workshop will show you the basics of analyzing light curves using the PHOEBE program which is based on the powerful Wilson-Devinney (WD) program used by most professionals in the field. PHOEBE is a cross-platform (Linux/Unix, Windows, OS X) graphical program that greatly simplifies the use of WD.

The workshop will consist of a mix of lecture-style background information and hands-on analysis of real data.

Dirk Terrell is an astrophysicist at the Southwest Research Institute's Department of Space Studies in Boulder, Colorado. His research work focuses mainly on theoretical and observational aspects of close binary stars. He has contributed to the development of both WD and PHOEBE.

"Developing and Using Your Remote Observatory", presented by Tom Krajci and Tom Smith. This workshop will cover practical aspects of automating your observatory so that you can run your telescope and instruments from the warmth of your home, be it 100 feet or 10,000 miles away. Our two presenters have a wealth of experience in this subject.

The schedule and price for these workshops is available on the REGISTRATION page of the SAS website (www.SocAstroSci.org)

Reminder: Deadline for Papers

If your paper has been accepted for presentation at the Symposium, the deadline for the final text (to be published in the Proceedings) is April 16, 2011. Please send the final version to the Program Committee at program@SocAstroSci.org.

If you are preparing a Poster Paper, you are invited to provide either (a) a one-page summary, (b) a single PDF of the entire poster, or (c) a paper that follows the general style of regular papers. These should be sent to the Program Committee (prior to the April 16 deadline), to be included in the published Proceedings.

SAS 2011 Symposium: Registration Information

2011 marks the 30th Anniversary of the Society for Astronomical Sciences! This year's Symposium is shaping up to offer a diverse array of talks, workshops, and networking opportunities, so you do not want to miss out. The schedule of papers is on page 4.

Registration information is available on the REGISTRATION page of the SAS website (www.SocAstroSci.org). Pricing prior to May 1 is:

Workshops: $ 50 (each)

Symposium: $ 30 (SAS members)

$ 50 (non-Members)

Banquet: $33 (per person)

SAS Membership: $ 25/yr

Prices go up after May 1. The deadline for registrations (for the Symposium and the Workshops) is May 16.

The banquet will be a prix-fixe dinner in the banquet hall of the Northwoods Resort. In addition to good food, good cheer, and good wine (cash bar), the banquet will include the inevitable raffle – some items that you will covet, and others that you will wonder about.

Your Symposium Registration fee includes the keynote lecture after the banquet. Our speaker is Dr. Petrus Jenniskens, who will describe ""The impact and recovery of 2008 TC3". This is quite a story, which combines science, exotic travel, and adventure, and will be of interest both to scientists and their non-scientist guests.

The SAS Symposium is held at the Northwoods Inn, in Big Bear, California. Big Bear is located in the San Bernardino Mountains, about a 2 hour drive east of Los Angeles. If you plan on staying at the Northwoods Inn, remember that hotel is not included in the Symposium registration. Do ask the Northwoods for the special conference rate on your rooms.

The Big Bear Solar Observatory is a striking feature on Big Bear Lake. Unfortunately, because of ongoing installation work for the NST (in the large dome), no public tours are scheduled for the summer of 2011.

Asteroid Lightcurve Data Archive at the Minor Planet Center

Our last Newsletter reported on Brian Warner's presentation of the Asteroid Light Curve Data Exchange Format (ALCDEF) at the AAS Division of Planetary Sciences meeting (Pasadena, September 2010).

It is hoped that ALCDEF will become the standard format for archiving and retrieving asteroid lightcurve observational data. This is important because ALCDEF enables researchers to retrieve, manipulate, and analyze the actual observational data – brightness vs. time – which is the unambiguous phenomenon. Most published papers contain only the results of analyses (such as inferred rotation periods), which might be superseded by additional or later data.

A huge step was taken when the Minor Planet Center agreed to host the archive of asteroid time-series photometry in ALCDEF format. This puts the archive under the custody of a well-recognized, well-managed, funded, and long-lived organization. All of your asteroid lightcurve data can thus be made available to researchers around the world, just as your astrometry data are available when you submit them to the MPC. Attribution information for data is included in an ALCDEF file so that you can get proper credit.

The data archive began with a goodly population of observations, and it is growing nicely as more small-telescope researchers put their current and past observations into the MPC archive. It currently contains over 800,000 data points, on 1475 asteroids

Don't hide your data: After you've completed analyzing your data on a particular asteroid, and your conclusions have been published (e.g. in the *SAS Proceedings*, or the *Minor Planet Bulletin*), your time-series photometry is still valuable for a variety of additional uses (e.g. shape modeling). You did a lot of work to collect all that light from the asteroid, so please consider submitting it into the ALCDEF archive. You will be doing a good deed. As the Man said, "Let your light shine before men, so that they may see your good works".

Those of you who use MPO Canopus for your asteroid lightcurve projects can do this easily. The recent version (V10.3.0.0 and later) of Canopus will generate ALCDEF files, ready for submission to the Minor Planet Center's ALCDEF page.

http://minorplanetcenter.net/light_curve

The most recent version of the Canopus Users Guide includes tutorials on generating an ALCDEF-compliant file. If you recently upgraded it will be in the \MPO\DOCS directory. Or you can get it from

http://www.bdwpublishing.com/Manuals/UsersGuide_V10.pdf

If you have questions regarding ALCDEF or how to generate files in Canopus, first check the ALCDEF page on MinorPlanet.info

http://www.minorplanet.info/alcdef.html

There you'll find a link to download the standards document.

If your data are not in Canopus and you want to participate, contact Brian Warner and he'll help you get your data out of the dusty filing cabinet.

By the Way: If you are an infrequent user of the Minor Planet Center's data or services, you may need to update your link. The new address is:

http://minorplanetcenter.net/

Symposium Sponsors

We are grateful to our loyal Sponsors, whose support is critical to making the annual Symposium on Telescope Science possible.

Their fine products have facilitated many small-telescope research endeavors.

Please remember them when you are adding to your observing equipment.

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SCHEDULE FOR SAS 2011 Technical Sessions (subject to change without notice)

Wednesday 5/25

		Time	
Coffee/Registration		***08:00***	***08:45***
Welcome		08:45	09:00
Robert Naeye	In Search of Other Worlds	09:00	09:30
R. Jay GaBany	Good Science With Modest Instruments	09:30	10:00
Debra Ceravolo	Spectral Mapping: A Scientific Approach to "Pretty Picture" Imaging	10:00	10:30
Coffee Break		***10:30***	***10:45***
Brian Warner	ALCDEF: Save the Lightcurves!	10:45	11:00
Lance Benner	Radar Observations of Asteroids	11:00	11:45
SAS Board	SAS Elections	11:45	12:00
Lunch		***12:00***	***13:30***
Russ Genet	Telescopes from Afar	13:30	14:00
Peter Ceravolo	The Wide-field Cassegrain: Exploring Solution Space	14:00	14:30
Eric Craine, Brian Craine, Erin Craine	The Sky Brightness Data Archive (SBDA)	14:30	15:00
Coffee		***15:00***	***15:15***
Olivier Thizy	Pro/Am Spectroscopy Collaborations	15:15	15:45
Robert Gill	Hi-Res Littrow Spectrograph	15:45	16:15
Kodiak Darling (Doug Walker students)	Visual Binary Observations	16:15	16:45
Sponsor Infomercials		16:45	17:15

Thursday 5/26

Coffee		***08:00***	***08:30***
John Hoot	Point and Shoot Astronomy	08:30	09:00
Robert A. Koff	Finding Targets of Opportunity	09:00	09:30
Richard Berry	High-precision Astrometry using a Differential Measurement Technique	09:30	10:00
Gary Vander Haagen	The Silicon Photomultiplier for High-speed Photometric Studies	10:00	10:30
Coffee		***10:30***	***10:45***
Jerry Horne	Kepler Variables in the Field of EV Lyr	10:45	11:15
Gary Cole	Polarimetry of Epsilon Aurigae from Mid-eclipse to Third Contact	11:15	11:45
Group Photo		***11:45***	***12:00***
Lunch		***12:00***	***13:30***
Robert Buchheim	A Modern Incarnation of Tycho's Parallax Method	13:30	14:00
Rodney Howe, Stirkis Iakovos	Imaging M15 with a Small-aperture Telescope by Treating the Core as a Single Star	14:00	14:30
Thomas Smith, Arne Henden, Donn Starkey	Flat Field Calibrations for the AAVSO Photometric All Sky Survey (APASS)	14:30	15:00
Coffee		***15:00***	***15:15***
David Boyd	An Alternative Method of Deriving Transform Constants	15:15	15:45
Richard Kowalski	Catalina Sky Survey: A Summary of Current and Planned Operations	15:45	16:15
Closing Remarks		16:15	16:30
Dinner		***17:30***	
Keynote Speaker			
Peter Jenniskens	**2008 TC3**	**19:00**	**20:00**

Technical Note

Computing a Continuum and Equivalent Width for a Stellar Spectrum

by Stan Gorodenski

Equivalent Width (EW) is an important statistic for studying spectral line evolution. A good estimate of EW requires a good estimate of the continuum. Some methods assume a straight line or a visual fit of a curvilinear line as the continuum. The primary purpose of this article is to describe an alternative method for computing a continuum and EW. My method is based on least squares models and takes more time than these simpler methods, but once the computer program is written the procedure goes fairly quickly for subsequent observations of the same star, or new stars.

Although existing Windows-based spectrum processing programs can be very easy and quick to use, some have a number of disadvantages, at least from my perspective. For one, they are largely a black box, although with some study and inquiry one can deduce what is happening. Another disadvantage is that the continuum and EW computational methods are limited to what are in the programs, obviously. Also, some of the methods, as already mentioned, consist of visually fitting a line, or assuming a straight horizontal line, as the continuum to real data without statistical significance considerations. The final limitation, and to me an important one, is that the point and click menu driven methods in some of these packages make it difficult to get a record of what was done so that the results can be reproduced. The method I will describe gets around all these limitations. Also, because I did it myself I know and understand what I did, and I have the personal satisfaction of having 'built' it myself, so to speak.

A secondary purpose of this article is to show that the processing and statistical analyses of a spectrum are not mysterious and complex but simple concepts and procedures that can be performed by oneself. Although existing spectrum software packages make processing a spectrum quick and easy (I use VSPEC, IRIS, and AUDACE) they can be supplemented, as described here, when the need arises.

<u>Methods Description</u>

The spectrum has to be minimally processed to the point where it can be submitted to the scientific community for study by other researchers. Beyond this minimal processing, telluric lines have to be removed. A heliocentric correction has to be applied for line center estimation, but it is not required for continuum or EW estimation. The spectrum does not have to be normalized for the method described in this article, although the protocol is to normalize it for the scientific community.

The procedure to be described relies on two software packages. VSPEC is used to display the profile (i.e., the graph of intensity vs. wavelength), and to write it out as a .txt file for input into an SPSS (Statistical Package for the Social Sciences) computer program. SPSS models the continuum and computes EW's (as well as setting confidence limits), and is also used to produce graphs. I am biased toward SPSS because I used it as a statistical and programming package for over 20 years before I retired and so I am very knowledgeable of its programming syntax and capabilities. I was able to purchase my own stand alone copy at a reasonable price for my home PC, but other statistical packages with programming capabilities can be used, including EXCEL.

Getting a good continuum estimate for computing EW is a challenge. As already mentioned, some methods assume the continuum is a straight horizontal line. One problem with this method is that even if it is a horizontal straight line, it becomes somewhat subjective where the line should be placed vertically on the spectrum. Another problem is that not all continuums will be horizontal straight lines. I read one professional paper that proposed what appeared to be arbitrarily constructing a straight line between the beginning and end points of a spectral line. Some of the examples in the paper deviated significantly from being horizontal. The advantage of the method I will describe is that the continuum and its placement is not arbitrary but is based on least squares statistical estimates.

The method of computing the continuum in this article is an alternative to the one that uses EXCEL instead of SPSS that I described in

http://users.commspeed.net/stanlep/EquivalentWidth.doc

I developed this method and presented it at a spectrophotometry meeting held in my home in September, 2008. In that presentation I discussed what a continuum and EW are. Rather than repeating this here, the reader can read the first six pages of the referenced document document. This presentation was also reviewed by some very knowledgeable members of a discussion group called Spectro-L. Except for minor typographical errors, none of the concepts or techniques used were criticized. In a sense, it passed a peer review.

The method described in EquivalentWidth.doc for deriving a continuum is better than assuming a straight line, but it is based on visually constructing a smoothed line with point and click and a sliding bar. This curvilinear line becomes the continuum. Because it relies on a point and click and sliding bar, it is difficult to reproduce and keep a record of how it was developed. Also, because there were no statistical significance considerations in its construction, one cannot be certain this visually fit line does not introduce an error making the EW too large or too small. The method described here has the advantage of being based on a least squares fit to what is considered to be random noise.

The steps for determining the continuum and computing EW's and confidence limits are:

1. Identify the parts of the spectrum that are emission or absorption lines.
2. Remove the emission and absorption lines, i.e., setting their intensity values to system missing.
3. Develop a polynomial model to estimate the continuum from the remaining intensity values. These are considered to be noise.
4. Compute EW's and confidence limits.

The December 7, 2010 Sodium D lines spectrum of Epsilon Aurigae will be used as the demonstration spectrum. It was taken with a Meade 16" LX200R telescope, an LHIRES III spectrometer, and an ST-8XME camera at my observatory in Dewey, Arizona. Figure 1 is an SPSS plot of the profile from a .txt file written out by VSPEC. As mentioned, the usual protocol is to normalize a spectrum, i.e., dividing each intensity value by a continuum value. Figure 1 is not normalized, to demonstrate that normalization is not required to calculate an EW.

VSPEC is convenient to use to identify the beginning and end of absorption and emission lines. The beginning and end of the lines were entered into an SPSS computer program to remove them. Figure 2 is an SPSS plot of the spectrum with the lines removed. The remaining is considered to be noise.

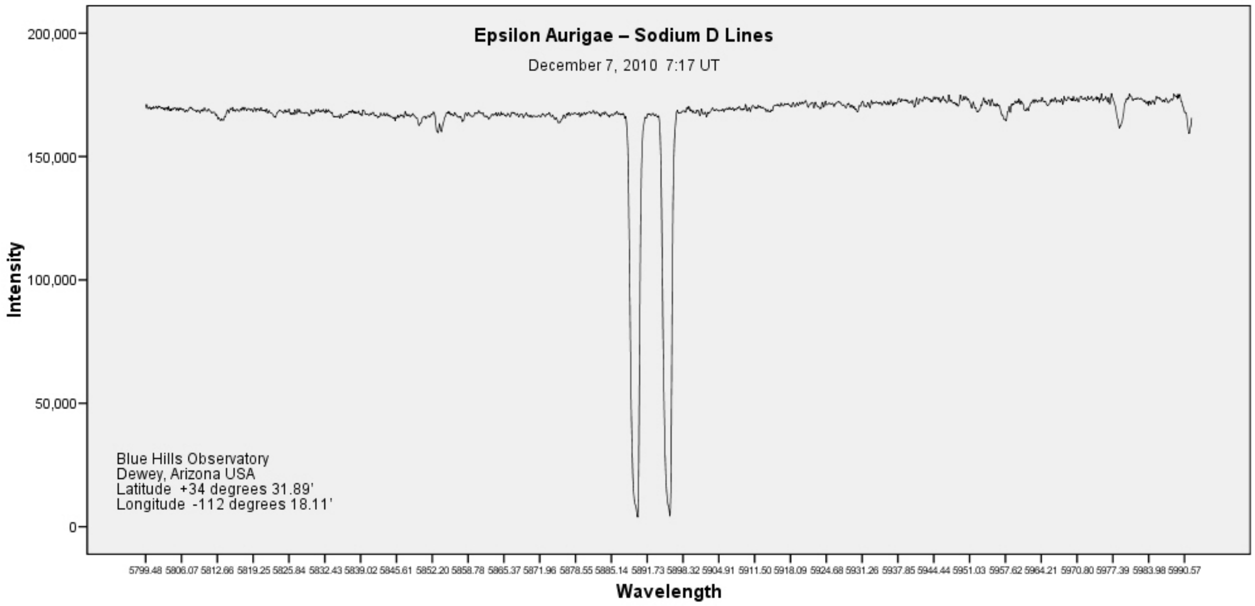

Figure 1

For this article I am fitting a continuum to the entire spectrum even though I am only interested in the Sodium D lines. From my experience, it is not always possible to use the entire spectrum and get a good continuum for a specific line. Nor do I think it is good, from a modeling perspective, to use the entire spectrum if different regions of the spectrum are not comparable. For example, if one is developing a model of Arizona's (Arizona is where I live) economy to predict some measure of economic growth, it would not make sense to include data going back to the start of the 20th century because the economy and demographics were entirely different then. One would probably have to add variables not relevant to today's economy. Likewise with a spectrum. It can be seen in Figure 1 that the spectrum is not entirely homogeneous. Instead of using the entire spectrum, as I am doing for this illustrative example, it may be more appropriate to use the left 2/3 for the Sodium D lines continuum estimate (although for this spectrum and lines it has virtually no impact). The right 1/3 has a cluster of lines and some dips the left 2/3 doesn't have. Consequently, it may be more appropriate to limit a continuum model for, say, the 5957A and 5978A lines to this region. Also, if the series is heteroscedastic (this one is not), by using the entire spectrum one would inflate or deflate the estimates of the upper and lower confidence limits of a line's EW depending on where the line is in the spectrum. If the line was in a region of low error, the confidence limits would be inflated. If it was in a region of high error, they would be deflated. Heteroscedasticity is another reason for dividing the spectrum into regions.

This points to one potential pitfall of this method. Determining the beginning and ending of a line, what is a line, and the adjacent parts of the spectrum that may be affected by a line are subjective to a degree. The result may be that confidence limit estimates may be too small. On the other hand, relying on an automated method may result in estimates being too large.

The spectrum in Figure 1 is composed of 1461 pixels. Of these 710 were set to system missing values for intensity because the intensities were deemed to be absorption or emission lines, or influenced by lines. This left 751 intensity values as data points to develop a polynomial model of the continuum. A stepwise regression performed on the data resulted in the following model:

$$Y = A_1 + A_2X^2 + A_3X^3 + A_4X^4$$

where

Y = Intensity

X = Pixel location

A_1 = Constant term

A_2 to A_4 = Coefficients

It is easy to over fit a continuum model, i.e., keep adding higher order terms, X to the n^{th} power that, although statistically significant, only minimally reduce the residual error. In SPSS one can quickly fit regression models with higher order terms and then plot the standard error of a model against the order of the model. For the continuum being estimated, the plot in Figure 3 shows that terms of higher order than the fourth do not substantially reduce the residual error of the model. Hence, a fourth order model was accepted.

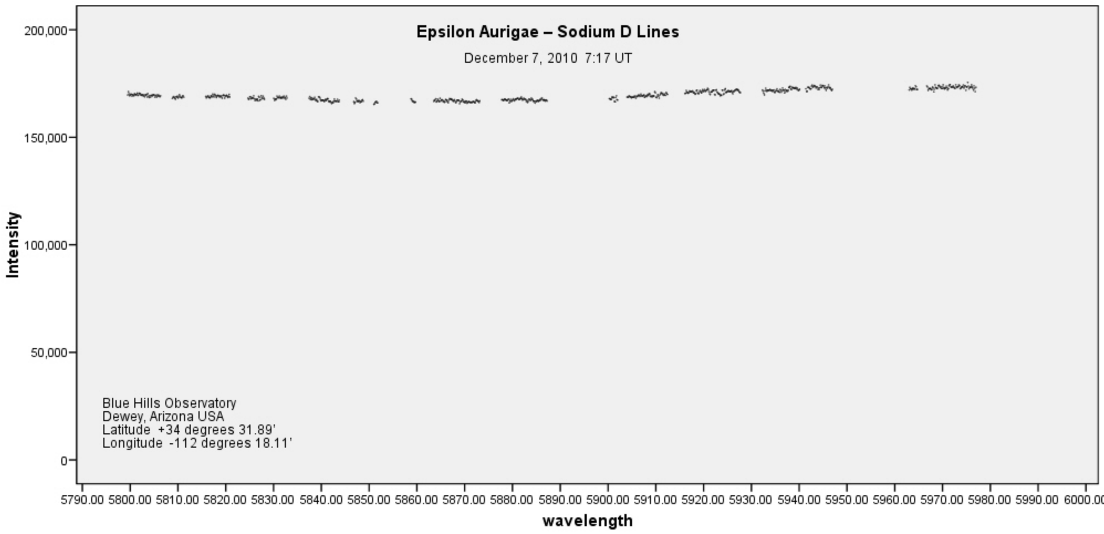

Figure 2

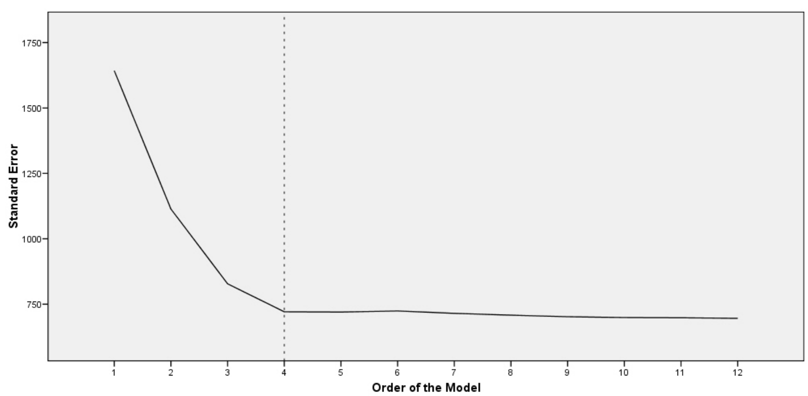

Figure 3

Figure 4 is a graph of the fitted line to the data. The sinusoidal shape of the curve is exaggerated by the scale of the graph. Figure 5 is a graph of the fitted line which is now called the continuum. As can be seen, the model very nicely fits the data and very well predicts the continuum values in the regions where the intensity values of the absorption and emission lines were set to system missing.

Figure 6 is the graph of the Sodium D1 and D2 lines with the continuum overlaid. For this spectrum the estimated continuum is essentially a straight horizontal line. Although there is a slight detectable slant to the continuum (it can be seen better in an enlarged graph), for all practical purposes this small deviation from a horizontal line would probably be insignificant for estimating an EW. One would than ask, Why go through all this trouble and not just assume a straight horizontal line? Three reasons. First, the continuum may not always be so close to being a horizontal line. Page 14 of

http://users.commspeed.net/stanlep/EquivalentWidth.doc

is one example where it is obviously not a straight line for H-α. Second, one still has the problem of where to place the continuum along the y axis. The least squares fit statistically places the line where it should be, and this can be better defended than an eyeball placement using point, click, sliding bar, and drag. Finally, one has a record of what was done that is reproducible.

The next step in the process is to determine the beginning and ending pixel locations for the two Sodium D lines from Figure 5. The D1 line starts at 671 and ends at 698. For the D2 line the respective values are 717 and 742.

The algorithm for computing EW is on pages 4 to 6 of the EquivalentWidth.doc document located at

http://users.commspeed.net/stanlep/EquivalentWidth.doc

Essentially, it is the sum of the difference between the continuum, Ci, and intensity, Ii, divided by the continuum, and then multiplied by the width of a pixel in angstrom units, Δλ. The equation is:

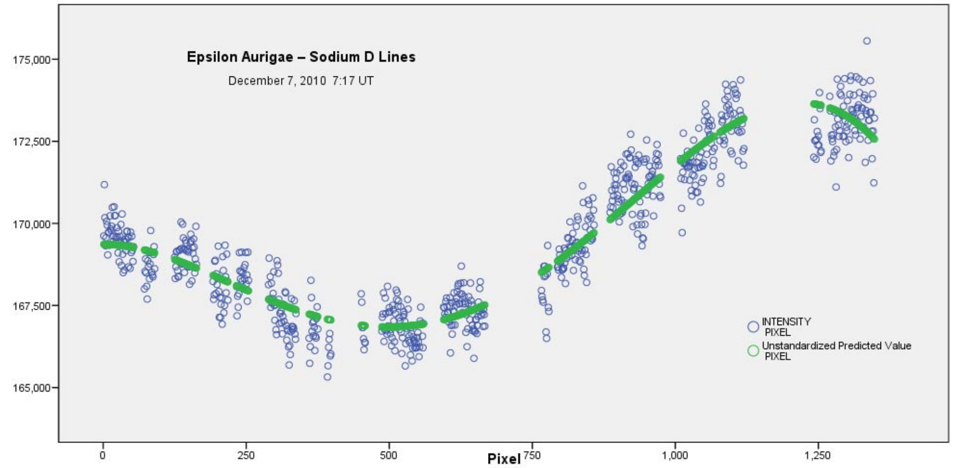

Figure 4

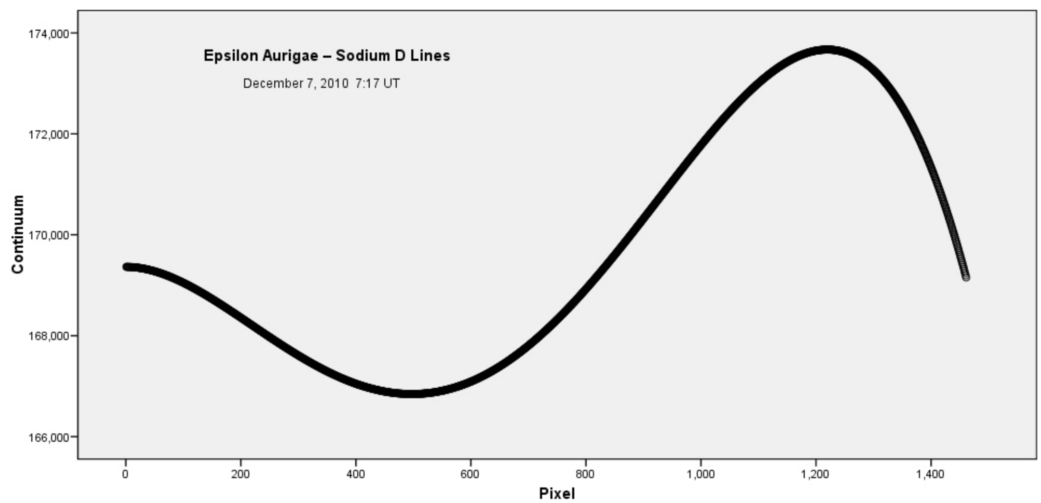

Figure 5

$$EW = \sum \frac{(C_i - I_i)}{C_i} \Delta\lambda$$

Δλ equals 0.132 A/pixel and was obtained by subtracting the angstrom value at the previous pixel location from the value at the current pixel location. Programming the EW equation and this lagged procedure for computing Δλ in an SPSS program, and entering the beginning and ending pixel locations for the two Na D lines, gives EW estimates for the D1 and D2 lines of 1.77Å and 1.66 Å, respectively.

The only thing left now is computing the upper and lower confidence intervals. How to do this is not described in books I have. I searched the internet but without success. I could have asked a professional or someone more knowledgeable but this would take the fun out of it. Read instructions? Heck no! After thinking about this for awhile it came to me. As already mentioned, the EW of a line is just the individual the contribution of each pixel, summed over all pixels. For one pixel, the contribution to the EW is

$$EW_{pixel} = \frac{(C_i - I_i)}{C_i} \Delta\lambda$$

where C_i and Δλ have already been defined, the latter being equal to 0.132Å.

where σ is the standard deviation equal to 720.77, and t =1.96 for 750 degrees of freedom (recall there are 1461 pixels, 711 intensity values were set to system missing, and one degree of freedom is lost from the mean of the residu-

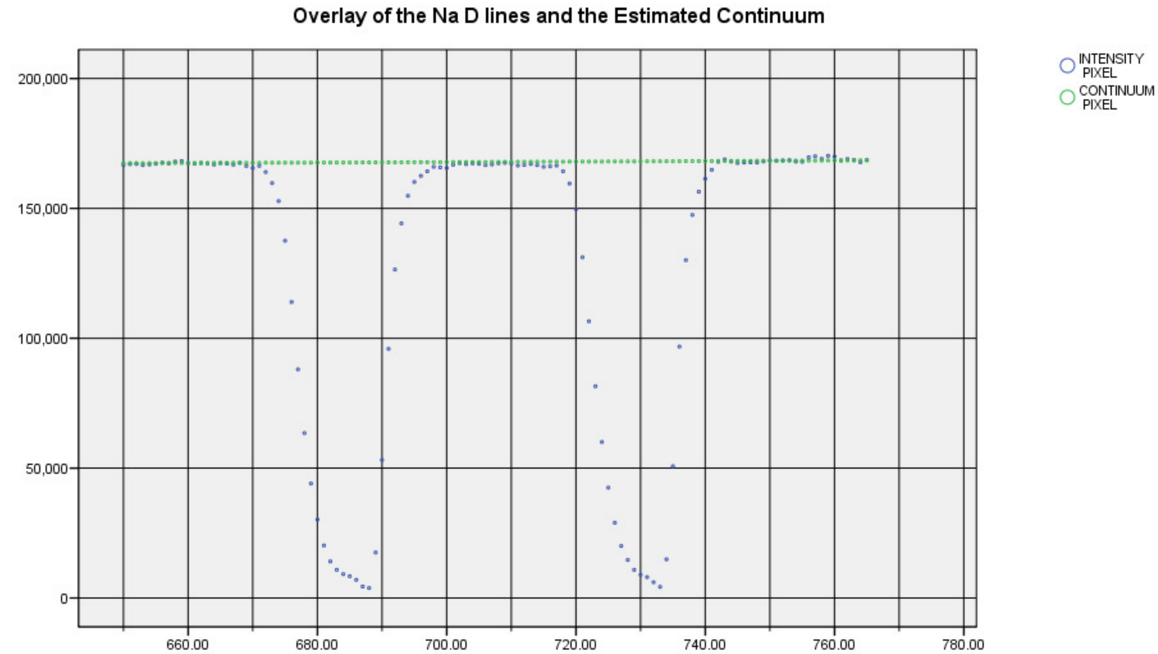

Figure 6

Each I_i is a random variable, i.e., it is the intensity of the spectrum at the i^{th} pixel location, that deviates around the estimated continuum at the i^{th} pixel location. Hence, to get a confidence limit estimate what is needed is an estimate of the standard deviation of the residuals of the regression model around the continuum. It is available in the SPSS regression output as the standard deviation of the residuals . In our example, itis equal to 720.77. It can be computed independently from the residuals, which is what I did.

From a corollary of a theorem in statistics, the variance of the sum of n independent variables is the sum of the variances of the n variables. In this case, the n variables are the n pixel values of the line intensities. If each I_i is treated as an independent variable, then the upper and lower confidence limits for each I_i are (I_i + σt) and (I_i - σt), respectively. Hence, computationally, the upper 95% confidence limit on EW s

$$UCL_{EW} = \sum \frac{[C_i - (I_i + \sigma t)]}{C_i} \Delta\lambda$$

The lower 95% confidence limit is

$$LCL_{EW} = \sum \frac{[C_i - (I_i - \sigma t)]}{C_i} \Delta\lambda$$

These algorithms were programmed into the SPSS program to get the following 95% confidence limit estimates.

	EW	Upper 95% C.L.	Lower 95% C.L.
D1 Line	1.77	1.80	1.74
D2 Line	1.66	1.69	1.63

Conclusion

This article demonstrated that some of the concepts and processing in spectroscopy are simple and not mysterious, and can easily be performed without having to rely on existing point and click software. It also provided an alternative method for determining the continuum, which is a crucial part of computing a good estimate of the EW. I have shown this can be done in statistical packages like SPSS, even EXCEL, and this allows one to keep a record of what was done so results can be reproduced. This is in contrast to some of the point and click and sliding bar methods of other, and admittedly easier to use, software. Finally, this article demonstrated that one can conduct, i.e., supplement, processing and analyses that might not be available in existing spectroscopic processing software.

I hope that this article has also demonstrated to the reader that there is an advantage to the least squares method over the visual fit methods. For example, one application of the latter is to visually fit a smoothed curvilinear line to a spectrum and then divide the spectrum by the smoothed line. This produces a spectrum that follows a nice horizontal line, straight as an arrow. However, there were no statistical significance considerations involved. Hence, as previously mentioned, one cannot be certain that this visually-fit line does not introduce an error, making the EW too large or too small. These methods are quicker than the least squares method I described, but not that much quicker, in my opinion, to justify discarding it. Once the computer program is written, it is quick and easy to run and update. Some may argue my spectrometer does not have the precision to justify the extra trouble and time to get a least squares estimate. However, I prefer a method based on statistical principles instead of guessing a line. I might abandon this for another method as I learn more about spectroscopy, but for now it works well for me.

For those interested, the SPSS syntax will be provided on request.

Editor's Note: Not only is this a powerful way to deal with the non-constant continuum, but it is also a rare example of how you can fit the term "heteroscedastic" into your conversation. Both your statistics professor and your English teacher would be proud!

Small-Telescope Astronomical Science in the News

December 2010 – March 2011

compiled by Bob Buchheim

I began this column to satisfy my own curiosity – just how many papers based on small-telescope observations show up in the literature? There is quite a high volume of such papers, it turns out. I have been surprised by the diversity of topics covered, beyond the expected variable-star and asteroid studies. I also infer that there is an ongoing need for more small telescopes – and their owners – to spend some time and effort in the service of science.

Since the response to this column has been positive, I'll continue it until either (a) a motion to cease is sent to the Newsletter editor, or (b) other obligations divert my attention. If you have comments on any of the research projects noted below, or other suggestion, please do let me know (rbuchheim@earthlink.net).

The GJ1214 Super-Earth System: Stellar Variability, New Transits, and a Search for Additional Planets
by Zachory K. Berta, et al
http://arxiv.org/PS_cache/arxiv/pdf/1012/1012.0518v1.pdf

This paper covers several different sets of data relating to the host star GJ1214 and its transiting exo-planet. The small-telescope portion comprises a long photometric study made with the MEarth telescope. MEarth is a set of 8 telescopes. Each telescope is 40 cm (16 inch) aperture, fitted with a CCD imager with 0.757 arc-sec pixels, and a 715 nm long-pass spectral filter (i.e. deep red and infrared). It turns out that it is of great value to accurately characterize the host star's photometry, so that large-telescope spectroscopic and planet-transit lightcurves can be properly interpreted. In particular, if the star's brightness varies, that variability can be transformed into random "noise" in spectra and transit-timing calculations. In order to characterize this star, the authors conducted a long-term (3 years) monitoring of the star's out-of-eclipse brightness. They found compelling evidence of a pseudo-periodic 52.7-day modulation, of amplitude ± 0.0035 mag (comparable to the transit depth) which is identified as the rotation period of the star (the modulation being caused by star-spots).

The authors also discuss several tricky features that they had to account for in order to be confident in their photometry at the $\sigma \approx 0.003$ mag level. These included the following effects, which small-telescope scientists should be aware of. (1) The MEarth's thinned-chip CCD's can exhibit a phenomenon called "persistence", in which a brightly-illuminated pixel on one light-frame will tend to have increased dark-current on subsequent exposures, which can give rise to spurious offsets and ramps in the resulting lightcurve. This is mitigated by purposely moving the FOV (by more than several pixels) between each image. (2) Night-to-night changes in system characteristics (of unknown origin) cause slight offsets. In order to minimize the effect of this phenomenon, each night's data (which might be anywhere from a few images to a few dozen images) is combined into a single data point, and these nightly-averages are used to search for the rotation-period signal. In addition, the array of nightly-averages is used to estimate the night-to-night photometric "jitter", and this "jitter" is treated as a random noise variable. (3) The target star is a very red star (an M-dwarf), whereas most available comp stars have more "normal" colors. This color difference between target and comp is modulated by night-to-night variations in atmospheric absorption in the water-bands that dominate the absorption in the spectral region being used; hence causing a sort of "second-order extinction" effect that can be comparable to the stellar-rotation lightcurve amplitude. In order to mitigate this effect, the team takes advantage of the MEarth observing sequence, in which the telescope cycles among several stars sequentially through the night. The ensemble of these observations is used to establish a nightly zero-point.

The key conclusions from this portion of the study are that GJ1214 is a spotted star with a now-known rotation period of 52.7 d, implying weak magnetic activity; that the level of star-spot photometric variability will not impede currently-feasible spectroscopic studies intended to learn about the planet's atmosphere (including HST and anticipated Spitzer observations); but that as higher-sensitivity spectrographs become available (e.g. the James Webb telescope), it will be necessary to simultaneously monitor the star's photometry to mitigate spurious effects in the spectra.

Qatar-1b: A Hot Jupiter Orbiting a Metal-Rich K Dwarf Star
by K. A. Alsubai, et al
http://arxiv.org/PS_cache/arxiv/pdf/1012/1012.3027v1.pdf

Small-telescope systems (such as HATnet, WASP, XO) have an enviable record of discovering exo-planets, but they do not have the discovery space "locked up" – there appears to be plenty of room for additional, similar systems to make discoveries. Here is a report on the first exo-planet discovery from the Qatar Foundation's "Alsubai Project". The planet Qatar-1b is in a 1.42-day orbit around a 12.8 mag star (fainter than most other small-telescope, WFOV planet searches can reach), located at declination +65º (farther north than SuperWASP's coverage), and its transit depth is pretty deep – a bit over 0.02 mag. Radial-velocity spectroscopy shows it to be a bit more massive than Jupiter.

The Qatar Foundation's exo-planet search system. Image credit: John Smith (Hidden Loft Observatory)

A note from John Smith: *One of the co-authors of the paper on Qatar-1b is John Smith (Hidden Loft Observatory, Tucson), which made me wonder, "how did a guy from Tucson hook up with researchers in Qatar?" Here is his answer:*

"I am the author of CCDAutoPilot, an observatory automation program used by many amateur imagers for aesthetic imaging as well as some science. Initially I was approached by the Principal Investigator, Dr. Khalid Alsubai, to automate an exoplanet search facility in Australia. That plan was terminated and I was tasked with building a suitable system to be located at New Mexico Skies as well as automating the process. The prototype system, consisting of a two-camera system, was put together initially in my back yard as a proof-of-concept. We recovered WASP-2B, establishing functionality. The system was moved to New Mexico Skies in June 2009. In October 2009, I upgraded the system to 5 camera-lens combinations. There are 4 x 400mm/F2.8 and 1 x 200 mm F/2 Canon lenses. Attached to each is a FLI PL16801 4k x 4k camera. The system is designed for fully autonomous operation year round with automatic target selection, data acquisition over a 40° x 40° FOV and suitable calibration frames. Control and synchronization is provided by a modified version of CCDAutoPilot using 5 PC's and one Mac Pro. Approximately 35 GB of data are taken nightly. Initial assessment is done in the observatory then loaded on a 2 TB external drive which, when full, is sent to St. Andrews, Scotland for processing.

As of the end of September 2010, 1.8 billion photometric points were obtained, 950 thousand stars were measured and 10 class A candidates were identified. Qatar-1b is the first published discovery.

I gave a presentation on this system at the Advanced Imaging Conference 2010 in Santa Clara, CA."

WASP-34b: A Near-Grazing Transiting Sub-Jupiter-Mass Exoplanet in a Hierarchical Triple System
by B. Smalley, et al

WASP-41b: A Transiting Hot Jupiter Planet Orbiting a Magnetically-Active G8V Star
by P.F.L. Maxted, et al
http://arxiv.org/PS_cache/arxiv/pdf/1012/1012.2977v1.pdf

The topic of exo-planets may conjure up visions of huge telescopes and ultra-sophisticated equipment. These certainly have there place, but the Super-WASP system is a fairly modest array of 8 CCD imagers, each fed by an 11.1-cm (4.4-in) camera lens, conducting highly accurate photometry of relatively bright stars. The system has been a prolific discoverer of exo-planets. These papers present two recent discovery announcements.

WASP-34b is in a 4.3-day orbit around a 10.4-mag solar-type star in the southern constellation of Crater.

WASP-41b is a Jupiter-mass planet in a 3-day orbit around an 11.6-mag star. One of the complications of observing this system is that the star displays chromospheric activity, whose photometric manifestation (~ 1%) is large compared to the transit depth of the planet (~0.02 mag). By following the long-term stellar variability, the authors were able to infer that the star's rotation period is 18.3 days.

Rapid Oscillations in Cataclysmic Variables. XVII. 1RXS J070407+262501
by Joseph Patterson, John R. Thorstensen, Holly A. Sheets, Jonathan Kemp, Laura Vican, Helena Uthas, David Boyd, Michael Potter, Tom Krajci, Tut Campbell, George Roberts, Donn Starkey, and Bill Goff
http://arxiv.org/PS_cache/arxiv/pdf/1012/1012.3408v1.pdf

The lead author is Dr. Joe Patterson, founder of the CBA. I've listed all of the co-authors of this paper because many of them will be familiar to our readers, as participants in the Center for Backyard Astrophysics (CBA) and good friends of the SAS. Their modest 20-cm to 35-cm (8-in to 14-in) telescopes provided much of the photometry used in this report. The wide longitude coverage provided by the worldwide network of CBA observers was a valuable complement to the higher-SNR and faster-cadence observations made with the 1.3-m at the MDM Observatory.

This paper reports on a long-duration observing campaign on the x-ray and visual cataclysmic variable star 1RXS J070407+262501, which is found to be an "intermediate polar" (aka "DQ Her") type star – a magnetically active system consisting of a white dwarf that is accreting material from a close companion, and whose magnetic activity largely disrupts the (usually-expected) accretion disk, so that material falls directly onto the white dwarf. The system is about 16th magnitude, but still presents a fascinating array of variabilities to dedicated small-telescope photometrists. A strong (nearly 0.3 mag) double-peak brightness oscillation at P= 480 s marks the spin period of the white dwarf. Precise timings of this oscillation show that its period is decreasing by about 0.1 ms/yr. There is also a 4.38-h period, representing the orbital period of the companion star, a 6.3-h period of unknown origin, and beat frequencies of these periods.

The source of the 6.3-h signal is an unresolved mystery. It might be a manifestation of the "super-hump" phenomenon, but the standard explanation of that requires a precessing accretion disk, which doesn't exist in DQ Her type stars. Or it might be a spurious signal related to the hand-off of observations between observatories. The paper concludes that the reality of this signal can be determined "...by a much longer observing campaign, or by the star's decision to flash a signal of greater amplitude." Stay tuned, or – better – add your telescope to the CBA's network.

Rotation Periods of Binary Asteroids with Large Separations – Confronting the Escaping Ejecta Binaries Model with Observations
by D. Polishook, et al.
http://arxiv.org/ftp/arxiv/papers/1012/1012.4810.pdf

In the January, 2011 edition of this column, I noted the research by P. Pravec on the observational evidence for rotational fission of "rubble pile" asteroids. In the rotational fission model, YORP-induced spin-up creates centrifugal forces that tear the asteroid into an unbound pair. Lightcurve studies offered good evidence for the predictions of this model.

There is, of course, an alternative scenario for the formation of binary asteroids: an impact or collision should splash out debris. Two pieces of ejecta/debris might fall into a gravitational embrace as they fly away from their parent body, thereby creating a wide-separation (loosely-bound) asteroid pair. The key implication of this scenario is that the daughter asteroids would be expected to have slow rotations, with period comparable to their mutual orbital period.

The present paper examines the rotational lightcurves (and mutual-event lightcurves when observable) of five asteroid pairs which were previously-suspected of having formed in this way. Data was taken with 1-m (40-in) and 0.46-m (18-in) telescopes at the Wise Observatory. The authors find that four of these asteroids have relatively rapid rotation (2-h to 8-h period), which argues for the "fission" scenario instead of the "escaping ejecta binary" scenario.

This doesn't say that the escaping-ejecta scenario doesn't happen. Indeed, one of the asteroids studied here is almost certainly explained by the escaping-ejecta scenario (it is too large to be effectively spun-up by YORP). But it looks like the fission model just got another vote of confidence.

Although the authors don't say so, there appears to be reason for adding two of these objects to your observing list. First, (17246) 2000 GL74 doesn't have a well-justified rotational period (it's small and faint, and this study didn't reach a conclusion about its lightcurve period). Second, some researchers have suspected that (1509) Esclangona might display color changes as it rotates. An observational campaign to validate this suspicion would be interesting.

Photometric and Spectroscopic Investigation of TW Draconis
M. Zejda, et al
http://arxiv.org/PS_cache/arxiv/pdf/1012/1012.5679v1.pdf

This paper reports on an extensive photometric and spectroscopic (including radial velocity) study of the Algol-type eclipsing binary star TW Draconis. The photometry consists of a very large set of CCD and PEP observations (taken at private and university observatories, mostly in the Czech Republic) made with telescopes ranging from 15-mm (0.6-in) to 620-mm (24-in) aperture, in U, B, V, R, and I bands. The total photometric data set spans nearly 6 years and 50,000 measurements. The data is high quality, showing several curious features in the lightcurve. First, one of the stars is apparently a pulsating variable (P≈ 1.25 h, and amplitude ≈0.01 mag). Second, there are definite "deformations" in the lightcurve near the secondary eclipse: a slight "bump" in brightness just before ingress, and a slight "dip" just after egress (possible star-spots). And, of course, the secondary eclipse depth is a strong function of band, due to the different spectral types of the stars involved, being barely detectable in B-band (ΔB = .07 mag), but quite respectable in I-band (ΔI= 0.2 mag). All of this is complicated by the fact that TW Dra is the A-component of a visual (and possibly physical) binary pair, with the B-component only 3.3 arc-sec distant.

The authors combine all of the photometric, spectroscopic, and radial velocity data into the PHOEBE model, to conclude that the mass ratio is q= 0.4. Their spectroscopic data also shows that there is almost certainly an accretion disk in the system.

Stellar Winds in Interaction
Proceedings of the International ProAm Workshop on Stellar Winds
Convento da Arr´abida, Portugal 2010 May 29 - June 2
Editors: Thomas Eversberg & Johan H. Knapen
Complete proceedings available at:
http://www.stsci.de/pdf/arrabida

By now, an article by Eversberg titled "Stellar Winds above Atlantic Clouds - A collaboration between amateurs and professionals" may have appeared in Sky & Tel, reporting on the successful Pro-Am conference and collaboration held in Portugal following an observing campaign on WR 140 (= HD193793), a WR+O binary with a highly eccentric orbit and a period of about 8 years. The complete proceedings of this conference are available for free download at the web link above, and they include three "motivational" papers (by Robin Leadbeater, Jose Ribeiro, and Thomas Eversberg). All three are enthusiastic about the capabilities for photometry and spectroscopy that are now in the hands of amateur astronomers, and amateur's ability to make important contributions to the study of certain objects and phenomena. As has been noted elsewhere, some of these projects – while important – are usually "off limits" to professional astronomers because they require very long observing runs and a major commitment of telescope time (both of which are extraordinarily rare commodities in the realm of professionals, but which are easy to justify if you own the observatory and have full-time use of it).

Two specific items in the Proceedings caused me to exclaim “wowee!”:

- Eversberg shows an image of the Hubble Deep Field, taken with a C-14, that shows most of the “Hubble” objects (18-h exposure by Jörg Zborowska). After you’ve made the lightcurve of M31-V1 (one of Arne Henden’s challenges from SAS-2010), you may want to try to replicate this!
- Ribeiro notes that an amateur spectroscopist (using instruments like Shelyak’s LHires-III) with a 28-cm (11-inch) telescope has measured stellar radial velocity oscillations caused by an exo-planet (orbiting a mag 7.7 star), with an accuracy of 75 m/s – which is quite sufficient accuracy to map the radial-velocity signature of the exo-planet!

The success of this campaign and the conference is hoped to result in an ongoing forum for more pro-am collaborations. The group’s website (including an initiation to join them) is at http://www.stsci.de/contento/).

Here is an observing reminder from Everberg: The Be star δ-Scorpii will reach periastron in July 2011, and continuous monitoring of its spectrum is underway by a pro-am group. I suspect that they would welcome additional help from SAS spectroscopists.

2009 Superoutburst of Dwarf Nova 1RXS J053234.9 +624755
by A. Rutkowski, et al
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.0940v1.pdf

Here is another project that takes advantage of the complementary capabilities of small telescopes (long duration of coverage from multiple sites) and large telescopes (shorter exposure time, rapid cadence, and better SNR) to study the lightcurve of an outbursting dwarf nova (aka cataclysmic variable) star. The “small telescopes” ranged from 25-cm (10-in) to 60-cm (24-in) aperture and accounted for over half of the observing runs in this campaign, part of the “Curious Variable Experiment (“CURVE”).

The authors make particular note of their observations of a “precursor” to the outburst, in which the brightness of the star rises, then fades slightly, before rising again with the onset of superhumps. The authors regret the lack of multi-band (color) information on the precursor – which perhaps should influence future observing plans for the early stages of CV outbursts.

Stellar rotation in the Hyades and Praesepe: gyrochronology and braking timescale
by P. Delorme, et al
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.1222v1.pdf

The SuperWASP system (of camera lenses feeding CCD sensors, to give very accurate high-cadence photometry of selected star fields) was designed to search for exo-planet transits, but when you stare at an open star cluster with such a system, you can learn all sorts of interesting things. This report is based on data taken by SuperWASP on fields that contain the Hyades and Praesepe star clusters. The authors applied the SuperWASP processing pipeline to search for stars that were both (a) cluster members, and (b) showed quasi-periodic brightness fluctuation that could be interpreted as stellar rotation.

This is useful because one of the predictions of stellar evolution theory is that isolated main-sequence stars’ rotation periods should converge to a well-defined band, determined by the age and mass of the star. Indeed, this study finds that both the Hyades and Praesepe have quite nice linear relations of rotation period vs. J-K color. Their stellar rotation period data (interpreted with a “spin down” law) also suggests that the Hyades is slightly older than Praesepe.

Short period eclipsing binary candidates identified using SuperWASP
by A.J. Norto, et al
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.1223v1.pdf

In addition to searching for stellar rotation periods (see above article), the SuperWASP’s huge archive of stellar photometry is also a fruitful hunting ground to search for eclipsing binary stars, which is what the present paper reports. There appears to be a short-period cut-off that prohibits low-mass binaries from having periods shorter than about 0.2 d. The current record-holder is GSC 2314–0530 with a period of 0.1926 d. The present authors were specifically searching for very-short-period systems, in order to increase the available sample of such stars for further study.

They identified 53 short-period systems in the SuperWASP archive, of which a few were previously known systems. (They also found a batch of pulsating variable stars, but those are being saved for a later report). In particular, 23 of their systems are at the short-period cut-off. These certainly need further detailed study. The author’s plea is: “We urge others to carry out multi-colour photometry and radial velocity spectroscopic follow-up of these systems.” Most of them are at the northern declinations, and half of them are brighter than 14th magnitude, so they are probably within reach of many SAS photometrists.

Deep, Wide-Field CCD Photometry for the Open Cluster NGC 3532
James L. Clem, Arlo U. Landolt, D. W. Hoard, and Stefanie Wachter
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.3268v1.pdf

This photometric study of an open cluster used multi-band CCD imaging on a 0.9-m (35-in) telescope. While that may be a larger ‘scope than most of us have access to, this is an instructive paper describing procedures (and pitfalls) that will be valuable to smaller-telescope projects related to determining color-magnitude diagrams for galactic clusters.

The authors used multiple exposures in each color, to gather calibrated photometric data from about V≈ 8 to V≈ 21, and imaged a matrix of 25 fields to get complete spatial coverage of a 1-degree square field. Each star was located in RA, Dec, and its brightness determined in B, V, R, I bands – a total of over 280,000 stars. Yowee! Then, a series of tests was done to distinguish cluster members from field stars: proper motion (for the ~17,000 stars with UCAC3 data), infrared colors (for the ~26,000 stars with J-H-K data from 2MASS), and a culling process based on the probability of membership in a self-consistent region of color-magnitude space.

The resulting color-magnitude diagram is impressive, both visually and technically. At the bright end, isochrone fitting of the "turnover" indicates a cluster age of 300 Myr. At the faint blue end, the white dwarfs also indicate a cluster age of 300 ± 100 Myr. They are also able to derive the cluster's distance, stellar luminosity function, percentage of binary stars, and total stellar mass from this data.

Binary microlensing event OGLE-2009-BLG-020 gives a verifiable mass, distance and orbit predictions.
J. Skowron
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.3312v1.pdf

When circumstances are just right, two stars (following their own independent paths around the Milky Way) will happen to line up nearly perfectly when viewed from Earth's location. The nearer star's gravity can form a "gravitational lens", creating a transient brightening of the more distant star's light. If the lens is created by an isolated star, then the brightening has a characteristic profile. If the nearer star is accompanied by one or more companions (stars or planets), then the characteristic gravitational microlensing profile shows a complex pattern of secondary peaks that is significantly different from the simple/single lens solution, and if the event is well-monitored, then the nature of the companions can be inferred. Remarkably, the microlensing event can be well-followed by small telescopes. Thus, a network of small-telescope scientists can gather the data necessary to characterize a planet orbiting a distant star. Among the 100+ authors of this paper are backyard scientists whose names you might recognize, including L.A.G. Monard, J. McCormick, W. Allen, A. Maury, and J. Drummond.

The whole microlensing event lasted over 50 days, presenting a 5-magnitude rise and fall of brightness. The most critical 4-day period at the mid-time of the event accounted for a 2.5 magnitude rise and fall, portions of which were captured at McCormick's Farm Cove Observatory and Monard's Bronberg Observatory

The combination of small-telescope observations and high-power theoretical analysis showed that the lensing object was a binary star, whose physical and orbital parameters are determined by the lensing solution. Of great importance is that the lensing system is bright enough (mag 15.5) that radial velocity measurements are feasible, to provide an independent check on the microlensing-derived properties, and by extension an independent validation of the whole scheme of microlensing calculations. The lead authors strongly encourage a radial velocity study for this purpose.

HAT-P-27b: A Hot Jupiter Transiting a G Star on a 3 Day Orbit
by B. B´eky, et al
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.3511v1.pdf

Here is the 27th exo-planet discovery report from the HAT project's search using 200-mm f/1.8 camera lenses feeding CCD imagers. The planet is a Jupiter-size body in a 3-day orbit around the 12th mag star GSC 333-0351. The transit is nearly 1.5% deep, and lasts about 1.5 hours, so this may be an attractive candidate for follow-up by SAS observers – it is located between Bootes and Virgo.

WASP-40b: independent Discovery of the 0.6-MJup transiting exoplanet HAT-P-27b
D.R. Anderson
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.4643v1.pdf

Luckily, the competing exo-planet teams seem to be a congenial society. Here, the WASP team notes that they independently discovered HAT-P-27b (see the article immediately above), but that the HAT team got the word out more promptly. Happily, both WASP and HAT find essentially identical observational properties (photometric and spectroscopic), and similarly congruent astrophysical inferences. This is valuable because it lends confidence in the observations and analyses of both teams.

The AMANOGAWA-2SB Galactic Plane Survey I: Data on the Galactic Equator
by Takahiro Yoda, et al
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.3547v1.pdf

When we talk about "small telescope astronomical science", we usually think in terms of optical telescopes. But it turns out that there is a role for small *radio* telescopes, also. This paper reports on a radio survey of the galactic equator, using a 60-cm (24-inch) radio telescope in the 200 GHz band. They developed a waveguide-type sideband-separating receiver and conducted a survey of the CO transition (J= 2-1) along most of the galactic plane, examining both the carbon-13 and carbon-12 isotope signals. By discovering a non-linear correlation between the ^{12}CO and ^{13}CO intensities, they are able to estimate the characteristic temperature (19 K) and density (100 H_2/cm^3) of molecular clouds.

GSC 2576–02071 and GSC 2576–01248: Two Algol-Type Eclipsing Binaries Studied Using CCD Observations and Historical Photographic Data
by K. V. Sokolovsky, et al
Peremennye Zvezdy (Variable Stars) 31, No. 1, 2011
pre-print at:
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.3741v1.pdf

If you've ever done an asteroid lightcurve and discovered that one of your comp stars was a variable, you'll know that it is a "good news – bad news" story, and you may empathize with the authors of this paper. They set out to study one eclipsing binary star, and found that there was a second one in the same FOV, only 3 arc-min away.

CCD photometry of the field was done with a 50-cm (20-in) Maksutov telescope. Both stars show nice Algol-type lightcurves, with both primary and secondary eclipses clearly visible. And each star has its own "personality".

GSC 2576–1248 is a short-period system (P ≈ 0.52 d) that displays the "O'Connell effect": its two maxima are of unequal brightness. This is usually explained as the manifestation of a bright- or dark-spot on one of the stars. In the case of this system, the nature of the O'Connell effect changes slowly over time (lightcurves taken a year apart are quite definitely different), which the authors hypothesize is indicative of a spot that moves slowly relative to the orbital reference frame, and hence probably indicates non-synchronous rotation of one of the stars.

GSC 2576–2071 (serendipitously discovered in the same FOV) is a long-period system (P ≈ 8.3 d). Its eclipses are partial, and the secondary eclipse is at φ≈0.52, indicating an eccentric orbit.. The authors note that this system "is a promising apsidal-motion candidate." At V≈13.3 (out of eclipse) it is well within the reach of small-telescope CCD photometrists. Occasional timings of both the primary and secondary minima will be needed to search for apsidal motion of the eccentric orbit, so do consider adding this to your observing list.

The Diversity of Light Curve Variations of Blazhko Stars
by A. S´odor
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.5099v1.pdf

Some pulsating variable stars have lightcurves that change – cyclically and repetitively – over time. The point of peak brightness moves up and down, and may move a bit in phase, also; as does the brightness minimum. The lightcurve changes of these "Blazhko" stars are, indeed, diverse, ranging from quite subtle to quite pronounced. One way to describe them is to plot the "loop" that the maximum/minimum follows in magnitude/phase space. In most (but no all) of these stars, the locus of maximum light follows a counter-clockwise loop; and in all cases, the locus of minimum light moves opposite to that of max light. There is probably a message in this diversity, which may some day be explained by improved models of stellar pulsation. Meanwhile, it appears that there is an ongoing need for small-telescope CCD photometrists to monitor and characterize these stars.

V456 Ophiuchi And V490 Cygni: Systems with the Shortest Apsidal-Motion Periods
P. Zasche and M. Wolf
submitted to Astronomy & Astrophysics
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.5269v1.pdf

Here are two eclipsing binary systems with eccentric orbits, each of which is a "record setter" of sorts. V456 Oph has the shortest orbital period known for an eccentric system (P ≈24 h), and V490 Cyg (with P≈27 hr) has the shortest-known apsidal period (18.8 yr). These results are based primarily on a compilation of historic times of minima and a few lightcurves from recent survey systems.

The authors note that both of these stars are in need of more careful study – neither has a complete (multi-color) lightcurve, nor reliable spectroscopic data (both stellar type/temperature and radial velocity study is needed). V456 Oph is Vmag 10, which may make it a good target for some SAS spectroscopists. Is anyone ready to take the challenge? V490 Cyg will be a tougher spectroscopic target, at Vmag 13.

A Hot Spot and Mass Transfer in the Algol-type Binary System WZ Crv
by Natalia A. Virnina, et al
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.5801v1.pdf

Here is a nice photometric study of WZ Crv, which was done using one of the southern-hemisphere telescopes of the Tzec Maun Foundation – a 150-mm (6-in) refractor. The authors prepare a complete lightcurve in V- and R-bands, showing both the primary and secondary eclipses. The primary eclipse has a "flat bottom" (indicating a total eclipse); the color index at this point is then used to determine the spectral type and temperature of the eclipsing star. The color index changes noticeably out of eclipse (and in the secondary eclipse). This is used to infer the spectral type and temperature of the second star. The asymmetric lightcurve suggests the presence of a hot- or cold-spot on one of the stars, but a follow-up study will be needed to determine of the spot location is stable.

Times of minimum light are derived from the literature, from the ASAS data archive, and from the author's observations, to create an Observed-minus-Calculated curve. The O-C plot suggests a gradually-changing orbital period (presumably due to mass transfer).

First Results from the RAO Variable Star Search Program. I. Background, Procedure, and Results from RAO Field 11
by Michael D. Williams & E. F. Milone
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.5650v1.pdf

Some of you may remember those wonderful Baker-Nunn satellite-tracking cameras that were critical instrumentation early in the space age. Here is a report on an interesting idea: turn one of those extremely-fast optics – in this case, it is 50 cm = 20 in aperture, and f/0.96 (!) – into an astronomical-survey instrument, and monitor a small region of the sky (4-degree-square in this case) to search for variable stars.

What they found, after just over a month of observations, was 35 variable stars, of which 25 are new discoveries. Follow-up multicolor photometry and spectroscopy is needed for virtually every one of these systems.

Transit Timing Variations in the HAT-P-13 Planetary System
Andr´as P´al
http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.0525v1.pdf

This paper is right on the edge of my criterion for "small telescope" science, since it is based on CCD photometry taken with a 100-cm (40-in) telescope. But it might be replicable by SAS's careful exo-planet transit observers with smaller instruments. The authors monitored several transits of the HAT-P-13 exo-planet (transit depth ≈ 0.01 mag), and applied a standard model of transit shape and stellar limb-darkening to calculate accurate times of transit.

What they found was that their three observed transits were self-consistent, but that they fell significantly far from the recognized ephemeris for this planet (O-C ≈ 0.015 d). This could be a hint that something odd is going on in the exo-solar-system. Additional observations are certainly needed.

Multicolor Photoelectric WBVR Observations of the Close Binary System HZ Her = Her X-1 In 1986–1988. I. Method And Observations 2010
by A.N. Sazonov
http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.0379v1.pdf

The target of this photometric study is a binary system consisting of the x-ray source (and presumed neutron star) Her-X-1, and the optical star HZ Her. The authors used 600-mm (24-in) and 480-mm (19-in) telescopes and a single-channel photometer to monitor the system in WBVR bands over a three-year period. (The "W" filter is similar to U-band).

The system displays several fundamental periods: the 1.24-sec rotation of the neutron star (observed in x-rays), the ≈1.7-day orbital period (which creates both x-ray eclipses and 2-3 mag fluctuations in the optical brightness), and a ≈35-day period that represents precession of the accretion disk around the neutron star. When photometric data is wrapped to the 35-day period, it becomes apparent that each cycle shows unique features; that the color changes noticeably throughout the cycle, and that the shape of the lightcurve changes noticeably from year-to-year. The author finds evidence of occasional stellar flares, and something [blobs of hot material (?)] transiently appearing in the accretion disk.

A Photometric Variability Survey Of Field K And M Dwarf Stars With HATnet
by J. D. Hartman, et al
http://arxiv.org/PS_cache/arxiv/pdf/0907/0907.2924v2.pdf

Two byproducts of the HATnet's program of searching for exoplanet transits with small-aperture CCD systems are (1) an enormous archive of time-series photometry for the stars in it field of view, and (2) expertise in searching that archive for periodic signals. This report describes an effort to run a portion of the photometric archive through a sieve that searches for signals that are distinct from exoplanet transits – flares, eclipsing binaries, pulsating variables, and multi-periodic behavior.

The authors used other catalogs to pre-select stars that were most likely to be K and M dwarfs, before running them through the searching sieve. They found over 27,000 K and M dwarfs in the HATnet database, identified over 2,000 probable-variables, but then had to invoke visual examination of lightcurves as the final test.

The catalog from this variability survey may be a fruitful source of stars needing additional study. It will be posted at the HATnet website.

The Solar Neighborhood XXIV. Parallax Results from the CTIOPI 0.9-m Program: Stars with μ ≥ 1.″0/yr (MOTION Sample) and Subdwarfs
Wei-Chun Jao
http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.0994v1.pdf

Determination of trigonometric parallaxes may sound sort of "19th century", but it is still a much-needed activity (for example, to fill out the census of stars that are our closest neighbors in space). This report describes procedures and results from an ongoing project using the 0.9-m (35-in) telescope on Cerro Tololo to make CCD astrometric measurements of parallax and proper motion of nearby stars (identified by their relatively high proper motion). Both the equipment (modest aperture, and CCD imager with plate scale of 0.4 arcsec/pixel) and the procedure (demanding high SNR, multiple images very close to culmination, high-order plate constant model, and stability of equipment) seem to be – barely – within the range of careful amateur astrometrists.

"Tsessevich" Project: An Attempt to Find the System YY Dra. I
by Natalia A.Virnina
http://arxiv.org/ftp/arxiv/papers/1102/1102.1271.pdf

I knew that there were a few "lost" asteroids out there, and that some visual double stars were mislocated, but I hadn't thought about the possibility that some variable stars had also "gone missing". This paper describes the search for one lost variable – YY Dra. The story begins (as so many mysteries do) with error and tragedy. The coordinates that Dr. Tsessevich recorded for an eclipsing binary star that he discovered in 1934 almost certainly contained a clerical error. The tragedy is that the relevant plates (of the Moscow collection) are missing, presumably destroyed amid the carnage that World War II inflicted on the Russians.

The author used a 106-mm (4-in) refractor at the Tzec Maun Observatory in New Mexico to survey the 10º X 10º region around Z Dra (which Dr. Tsessevich was sure was on the same plate as his discovery star). The procedure is to repetitively make images covering the search region, and examine each image for variable stars. The expectation is that quite a few new variables will be found, and hopefully one of them will match the characteristics of Dr. Tsessevich's star.

So far, five new variables have been found, but none of them is confidently identified as the "lost" star. The search continues.

Differential Photometry Of 2MASS J09440940-56171171
by K. M. G. SILVA, et al
http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.2809v1.pdf

Cataclysmic variable stars have been the subject of quite a few small-telescope research projects, including the extensive observational data gathered by participants in the Center for Backyard Astrophysics. A majority of these reports provide rapid-cadence photometry (usually unfiltered) during outbursts, when the targets can be quite bright. The present report takes a different tack: the authors report on R-band photometry of a suspected cataclysmic variable in its quiescent state. The star is faint – R ≈ 16 (out-of-eclipse) to R ≈ 18 (at maximum eclipse) – but 2-minute CCD exposures with a 0.6-m telescope provide quite nice lightcurves. From several nights of data, the authors are able to determine the orbital period (P= 0.1879 d = 4.51 hr), the eclipse width (Δφ = 0.112 cycle), and to show compelling hints that the lightcurve coming out of eclipse changes slightly from eclipse to eclipse. All of this suggests (to me) that small telescopes can make useful lightcurve observations of CVs in their quiescent states, to complement outburst-centered photometry.

The Evolution of Cataclysmic Variables as Revealed by their Donor Stars
by Christian Knigge, Isabelle Baraffe, Joseph Patterson
http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.2440v1.pdf

This isn't a "small telescope" research report, but those of you who are aficionados of cataclysmic variable stars might enjoy this detailed review of the theory of CVs, one of whose authors is Dr. Joe Patterson – leader of the Center for Backyard Astrophysics and good friend of the SAS.

Development and Performance of the PHOT (Portable High-Speed Occultation Telescope) Systems
by E.F. Young, et al
http://arxiv.org/ftp/arxiv/papers/1102/1102.2911.pdf

This paper describes the design, performance, and operation of a portable system for recording occultations by solar system objects. PHOT (Portable High-Speed Occultation Telescope) is sort of a professional-astronomer's scaled-up version of Scotty Degenhardt's "Mighty Mini" system. (I was a tad disappointed that Scotty's path-breaking development wasn't referenced in this report.) The heart of PHOT is a back-illuminated frame-transfer CCD, chosen for its very short read-out "dead time", and >20Hz frame rate (for good time resolution of the occultation lightcurve), and a custom-made GPS-based timing and triggering device to provide very accurate absolute time for each image (± 500 µsec). The authors normally mate this imaging system to 14-in (36-cm) telescopes for transportable operation. (Since the total weight of the system, including telescope and mount, is over 300 lb, it isn't exactly "portable"). The large aperture provides good SNR on stars as faint as 14-15 mag, and also good resolution.

Intranight variability of 3C 454.3 during its 2010 November outburst
by R. Bachev, et al.
http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.3307v1.pdf

Many variable radiative processes show a color-vs.-time evolution (recall the coil on that hot plate in your college dorm room – gradually changing from brown to cherry red as it heated up). Many active galactic nuclei show sizable more-or-less-random brightness fluctuations. So the idea of this project was to monitor the blazar 3C-454.3 in BVRI bands, to search for time-lags between brightness fluctuations in the different colors. The authors used 50-cm (20-in) telescopes and CCD imagers to take "quasi-simultaneous" images in the four bands, at roughly 2-minute exposures, to achieve differential photometric accuracy of about 0.01 mag.

This project was narrowly saved from being a "null result". Of the six nights that are reported, only one night showed a (barely) statistically-significant "time lag" signature. On that one night, the plots of brightness vs. time seem to show a systematic time lag, in which the brightening happens first in I-band, and then appears sequentially in R, V, and B, with a lag (from I to V) of 19 minutes.

This seems like the sort of project that could be usefully replicated by SAS photometrists, who could devote many more nights to search for patterns in the color evolution of brightness fluctuations, and examine not just the very-rapid (intra-night) fluctuations but also longer time-scales.

A 116 Year Record Of Mass Transfer In R Arae
by Reed, Phillip A
IBVS No 5975 (14 February 2011)
http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.3230v1.pdf

R Arae is an interacting Algol-type system with a ≈4.4 day orbital period. The author examined the full historical record of times of minimum light (including AAVSO archives and his own recent observations) to prepare the first reported O-C curve for this system. The data nicely fits a parabolic O-C curve (indicating a continuously-changing orbital period). Assuming that the period change is caused by mass transfer, the inferred mass transfer rate is 0.3 solar masses per million years.

Period Changes in SX Phoenicis Stars. III. XX Cygni
by George J. Conidis, et al
Publ. Astro. Soc. Pacific, v. 123, p. 26 (2011 Jan)

XX Cyg is a high-amplitude delta-Scuti star with low metallicity, considered to be one of the "SX Phe" type variable stars. The authors used a 0.6-m (24-in) telescope and CCD to make I-band lightcurves (with photometric accuracy of $\sigma \approx 0.002$) and times-of-maximum (t_{max}) measurements of this star. There has been some controversy over the nature of period evolution in this star – did its period undergo an abrupt change (in around 1942), or has it been changing continuously? By examining both their recent (2001-2009) dense set of t_{max} and the 100-year history of t_{max} data, the authors find that the "continuously changing" oscillation period is a better match to the data.

However, as they acknowledge, there is a huge scatter in the data points around the best-fit "changing period" hypothesis (i.e. a parabolic fit to the Observed-minus-Calculated plot) – far larger than can be explained by measurement errors. Something else is clearly going on with this star (and others like it that are part of the author's long-term program of monitoring SX Phe stars). More data is needed! Monitoring of these stars is well within the range of many SAS photometrists.

The Light and Period Variations of the Eclipsing Binary AA Ursae Majoris
by Jae Woo-Lee, et al
Publ. Astro. Soc. Pacific, v. 123, p. 34 (2011 Jan)

Here's a photometric study of an eclipsing contact binary, done with a 61-cm (24-in) telescope and CCD imager with B, V, and R-band filters. A Wilson-Devinnery model to fit the lightcurve data shows the need to incorporate a star-spot into the model, although lightcurve analysis alone cannot distinguish between a hot-spot, or a complementary cool-spot.

The authors investigated the history of times-of-minimum eclipse (t_{min}), and found compelling evidence for a parabolic "O-C" curve, indicating a continuously-changing orbit period. The modern CCD-based t_{min} data lie very close to the parabolic trend line, with the residuals showing a very apparent "sinusoidal" pattern. The authors interpret this sinusoidal variation in as the light-time effect of a third body in the system. The calculated third-body would be an M-dwarf, almost certainly too faint to detect photometrically or spectroscopically. An alternative explanation would be a stellar-activity cycle, but the authors argue that this hypothesis is not consistent with data.

WASP-33: the first δ Scuti exoplanet host star
E. Herrero, et al
Astron. & Astrophys. 526, L10 (2011)

We've known for a while that careful photometry with small telescopes and CCD imagers can detect the transit signature of exoplanets, even though the eclipse depth presents only about a 1% light drop (10 mmag). Some of you have done that. This article presents another valuable use of the capability for precision differential photometry – searching for low-amplitude variation in the star's brightness. The authors report on differential CCD photometry, using 30-cm (12-in) and 60-cm 24-in) telescopes to study both the transits of WASP-33 and the host star's brightness fluctuations. The 30-cm telescope belongs to Spanish amateur R. Naves, who provided more than half of the data reported here.

The photometry used R-band filters, and defocused the imager to reduce the effect of pixel-to-pixel sensitivity variations; thereby achieving 2-3 mmag accuracy. At this level of sensitivity, WASp-33's transit – a 1.5% (=15 mmag) drop – is cleanly measurable. Both the "in transit" and out of transit" lightcurves show a periodic signal (P≈ 68 min, A≈1 mmag) that is presumably a delta-Scuti-type pulsation, which appears to be synchronized with the planet's orbit, at 26 pulsation periods per 1 planet orbit. How the planet-star interaction might cause such a synchronous signal is a mystery.

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