Abstracts of Papers and Posters Presented at the 97th Annual Meeting of the AAVSO, Held in Nantucket, Massachusetts, October 16–19, 2008

The International Year of Astronomy and Citizen Science

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Abstract 2009 has been endorsed as the International Year of Astronomy by both the United Nations and the United States Congress. This talk will briefly outline the IYA cornerstone projects and then will go into more detail regarding the AAVSO's role as leading a citizen science project regarding the variable star epsilon Aurigae.

Variable Star Astronomy Education Outreach Initiative

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Abstract The American Association of Variable Star Observers (AAVSO) published a comprehensive variable star curriculum, *Hands-On Astrophysics, Variable Stars in Science, Math, and Computer Education* in 1997. The curriculum, funded by the National Science Foundation, was developed for a comprehensive audience—amateur astronomers, classroom educators, science fair projects, astronomy clubs, family learning, and anyone interested in learning about variable stars. Some of the activities from the *Hands-On Astrophysics* curriculum have been incorporated into the educational materials for the Chandra X-Ray Observatory's Educational and Public Outreach (EPO) Office. On two occasions, in 2000 and 2001, triggered by alerts from amateur astronomers, Chandra observed the outburst of the dwarf nova SS Cygni. The cooperation of amateur variable star astronomers and Chandra X-Ray scientists provided proof that the collaboration of amateur and professional astronomers is a powerful tool to study cosmic phenomena. Once again, the Chandra and AAVSO have teamed up—this time to promote variable star education. The *Hands-On Astrophysics* curriculum is being re-designed and updated from the original materials to a web-based format and is nearing completion. The new version, re-named Variable Star Astronomy, will provide formal and informal educators, and especially amateur astronomers, educational materials to help promote interest in and knowledge of variable stars.

Update on HST Campaign on Pulsating White Dwarfs in Cataclysmic Variables

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Abstract For the past six years, we have conducted programs on the Hubble Space Telescope, coordinated with ground support from the AAVSO network of observers. These programs have determined temperatures for nine of the dozen known pulsating white dwarfs that exist in cataclysmic variables. Unlike single, non-accreting, white dwarfs, which have a very narrow range of temperatures within their instability strip, the accreting pulsators range from 10,500K to 16,500K with most being near the hot end. In addition, the accreting pulsators are found to stop showing pulsations at times, a phenomenon not seen in the single white dwarfs. The superoutbursts of two of our systems in 2007 complicates the picture further but allows the chance to study the effect of temperature changes on a relatively short timescale.

Forty Years of Mystery: Unraveling BZ UMa

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Abstract The dwarf novae BZ UMa has perplexed astronomers for decades. Activity typical of both UGSU and intermediate polar (IP) dwarf novae have been detected while no expected UGSU type superoutbursts had been detected since the star was discovered in 1968. Finally, the diligence of variable star observers was once again rewarded with a superoutburst in April, 2007. We report on statistical analysis of the 2007 superoutburst and subsequent polarimetry measurements. We integrate all our findings into a proposed description and classification of the system.

120 Years of RZ Dor

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Abstract Archival data on RZ Dor is examined to update its type and period. Data ranging from pre-1900 Harvard plates through AAVSO visual estimates

made during the 1980s and 1990s, to 21st century CCD photometry, is used to confirm its type as Mira and determine an accurate period. The value of multiple independent accessible datasets is confirmed yet again.

The Evolution of R Coronae Borealis Stars

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Abstract Among the hydrogen-deficient post-asymptotic giant branch (post-AGB) stars are the R Coronae Borealis (RCB) stars, a small group of carbon-rich supergiants. About fifty RCB stars are known in the Galaxy and the Magellanic Clouds. Their defining characteristics are hydrogen deficiency and unusual variability—RCB stars undergo massive declines of up to 8 magnitudes due to the formation of carbon dust at irregular intervals. Apparently related to the RCB stars are the hydrogen-deficient carbon (HdC) stars. The five known HdC stars are similar to the RCB stars spectroscopically but do not show declines or IR excesses. The evidence for and against the two scenarios that have been proposed for the origin of RCB stars is discussed in the light of recent observational data. These scenarios are, the double degenerate and the final helium-shell flash models. The former involves the merger of a CO- and a He-white dwarf. In the latter, a star evolving into a planetary nebula central star is blown up to supergiant size by a final helium shell flash.

How Do Pulsating Giant Stars Make Dust?

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Abstract Mira variables of spectral types M (more oxygen than carbon), S (carbon ≈ oxygen), and C (more carbon than oxygen) all show signs of dusty winds. Radiative acceleration of the dust is thought to play a crucial role in driving the winds, once the atmosphere has been levitated by the pulsation. However, efforts to model the nucleation and growth of dust grains have encountered a host of difficulties. The process is complex, involving a very large number of reactions of particles (atoms, molecules, clusters, and grains) with each other. The coupling of the grains to the radiation field is also difficult to model with confidence, as it depends on the composition, the size, and the shape of the grains. Common approximations to make the problem tractable have lead to results that contradict observations; for example, they predict that S stars should produce no dust, but some S stars do. Some ideas for solving

this problem come from laboratory studies. There may also be ways to get the right result without so much work by taking advantage of natural feedback evident in the models.

The Chandra Variable Guide Star Catalog

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Abstract The Chandra X-ray Observatory has observed about 37,000 stars in the wavelength range 4000-9000 Å as guide stars for maintaining pointing control of the satellite. While these guide stars were intended to be non-variable in order to maximize the pointing accuracy, we have found that 673 are variable, generally at the 0.05 magnitude level. The catalog of these variable guide stars includes many types of variable stars, including pulsating stars, detached eclipsing binaries, contact binaries, etc., with spectral types generally in the range A through K. Light curves of these variables are the same length as the X-ray observation performed by Chandra, varying from 1 ksec to 170 ksec. *The Chandra Guide Star Catalog* includes about 300 stars that appear to be newly discovered variables. A description of the instrumentation is included and interesting examples from the catalog are shown and discussed. We introduce a new collaboration between the Chandra Variable Guide Star Team and members of the AAVSO, who will enhance this catalog with expertise in variable star characteristics. For future investigation, we intend to reprocess all available photometry in order to look for long-term variability and lower amplitude fluctuations that may not be apparent in the visual inspection of the existing time series. This work was supported by NASA contract NAS8-37073.

A Microprocessor-based Starfield Simulator

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Abstract We present a microprocessor-based system for reproducing the realtime behavior of stellar time-series, including the effects of selectable degrees scintillation noise. At present, the system has sixty-four white LEDs which are individually programmable. The simulator may be used to investigate measurement and analysis biases since all properties of star (constant and variable) are under the control of the programmer. A live demonstration of the unit will be provided.

Automated Calibration and an Open-source Sky Survey

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Abstract I describe a system that can take any astronomical image (professional, historical, or amateur) and, based on the content of the pixels alone, determine the pointing, rotation, and scale of that image, plus other calibration information (such as date, bandpass, point-spread function, and sensitivity). We are using this system to start an "open-source sky survey" in which we build up time-resolved imaging of the sky, and a physical model of the sources therein, from heterogeneous data from all available sources. This is a great opportunity to start a rich communication channel between professional and amateur astronomers, with data and ideas flowing both ways.

Overview of the DASCH Photometry Pipeline (poster)

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Abstract DASCH is "Digital Access to a Sky Century at Harvard," the effort

to digitize approximately 520,000 astronomical plates in the Harvard College Observatory collection. This paper is an overview of the photometry pipeline which has generated over 400 million magnitude measurements from over 3,400 scanned plates.

First Steps Towards a Solar Flare Detector Using the AAVSO Design (poster)

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Abstract Solar flares—ephemeral events often lasting only twenty minutes or so—can be detected indirectly using "sudden ionospheric disturbances," or SIDs. SIDs increase the efficiency of very low-frequency radio waves being reflected by the Earth's ionosphere. During a solar flare, a terrestrial radio station that is normally received as a weak signal can suddenly become much stronger. This characteristic rise in signal strength has been recognized for its correlation with observed solar flares. The AAVSO SID Program offers instructions on its website for construction, tuning, and use of a very low frequency radio receiver appropriate for monitoring solar flares. We have begun building and testing a SID detector, and we look forward to participating in the AAVSO SID Program as solar activity increases in the current new Cycle 24. Our experience may suggest improvements that will make building future SID detectors easier. Besides contributing to the AAVSO database, we are interested to detect solar flares in a timely way for visual observation using a hydrogen-alpha filter. We are also interested in the inevitable, eventual recurrence of "monster" solar flares—for example, the white-light event of 1859 observed by Richard Carrington and the consequent world-wide, violent geomagnetic storm.

Reclaiming the Astronomical and Historical Legacy of Antonia Maury

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Abstract Antonia Maury is perhaps best known in astronomical history circles as a student of Maria Mitchell's at Vassar and a pioneer in spectral classification at the Harvard College Observatory. Among her other astronomical interests were eclipsing and spectroscopic binaries, especially beta Aurigae (which she discovered) and beta Lyrae, whose peculiar behavior occupied her interest in the later years of her career. This paper will highlight Maury's often

overlooked contributions to variable star and binary star astronomy, and strive to put a human face on this brilliant yet enigmatic woman astronomer through personal stories told to the author by Dorrit Hoffleit.

Henrietta Swan Leavitt

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Abstract Henrietta Swan Leavitt, born in 1868, was a great woman astronomer. Though she is not widely known for her work, she studied Cepheid variable stars and devised a law which states that a star's brightness is directly linked to the length of its period. This launched the quest to discover how to measure the universe.

Abstract of Poster Presented at the 94th Spring Meeting of the AAVSO, Held in Las Cruces, New Mexico, March 25–26, 2005

Outreach at Cornell University's Fuertes Observatory (poster)

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Abstract Fuertes Observatory on Cornell University's North Campus in Ithaca, New York, has been rendered useless to research by age and increasing light pollution from a built-up North Campus. However, the Cornell Astronomical Society has adopted the Observatory and has used it to create a growing astronomical outreach program. By creating a popular lecture series and carefully choosing particular astronomical objects to show visitors to the Observatory, the Society is assisting in enhancing popular astronomical education in Ithaca. This poster gives details as to the groups that come to the Observatory, the lecture topics that have been given, and the best astronomical objects that have been shown in light polluted skies.

Abstracts of Papers and Posters Presented at the Joint Meeting of the Society for Astronomical Sciences and the American Association of Variable Star Observers, Held in Big Bear Lake, California, May 19–21, 2009

The AAVSO Wide-Field Photometric Survey

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Abstract The Robert Martin Ayers Sciences Fund has provided funding for a photometric survey of the entire sky. This survey will be conducted in five photometric bands (Johnson *B*, *V*, and Sloan *g′*, *r′*, *i′*) using a pair of ASA N8 astrographs and Apogee U16m 4k × 4k CCD cameras. The survey begins with installation at Dark Ridge Observatory near Weed, NM, to cover the northern declinations. In early 2010, the system will be moved to Chile, where it will survey the southern skies. We estimate the limiting magnitudes of the survey to be between 10th and 17th magnitude, and approximately 100M stars will be in the final catalogue. All intermediate products will be available from the AAVSO web site starting in summer 2009. This paper will present early results from the survey, and discuss the ancillary science that will be performed on non-photometric nights. *[Ed. note: survey formally named the AAVSO Photometric All-Sky Survey (APASS)]*

AAVSO Long Period Variable Section Update

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Abstract The first of the new AAVSO "sections" is the Long Period Variable (LPV) section. This section has decided to "own" Semiregular (SR), irregular (L), and RV Tauri (RV) stars, as well as Miras. There is an LPV Section Wiki, and there has been much discussion on the AAVSO discussion e-mail list regarding the type and number of stars that should be included in the AAVSO LPV Programs. One of our first major tasks is to produce a list of stars to recommend to observers, stars for which the observers can feel that their work will be of value in the present and future age of automated surveys. The core of the list is the AAVSO "legacy stars." The legacy stars will include those stars that have a long and rich history with the AAVSO (more than 15,000

AAVSO observations in fifty-plus years) and those that have been the subject of many scientific publications. The remaining LPV program stars will include those with at least 5,000 observations in the AAVSO International Database, those too bright for most surveys, those that are in fields too crowded for the surveys, plus any that are specifically requested by researchers. The AAVSO Binocular Program will include stars with minima brighter than about 10th magnitude, visible in binoculars for the majority of their cycles.

BL Eri: A Contact Binary System

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Abstract BL Eri is a W-type W UMa system with a mass ratio of 0.546 and a contact parameter $f = 0.2$ for the primary star, indicating over-contact, and $f = -0.0008$ for the secondary, indicating near-contact. The system stars have low surface temperature and a short period of 0.42 day. New CCD photometric light curves in *V* and *R* bands and computed parameters solutions using a light curve synthesis program are presented. Prior visual, photographic, and photoelectric observations from February 1978 through October 2004 are analyzed along with this paper data obtained in October 2008. O–C data have been analyzed using a linear ephemeris but were better described by a quadratic ephemeris. The first time radial velocity curves of BL Eri were obtained in 1988 and used to compute the mass ratio of the system along with prior observational data used to compute the physical quantities of the system. The spectral type, orbital period, and angular momentum changes are discussed.

The Addictive Properties of Occultations

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Abstract Observing asteroid occultations is challenging and rewarding—and is addictive! Techniques are evolving rapidly, with almost monthly contributions to the field. While the predictions of occultations are frequently accurate to a few seconds and a few tens of miles, there are still many challenges of location, weather, equipment, and data analysis that make every observation effort unique. In this paper, we discuss why occultations are useful to observe and how one finds out when/where occultations will occur. We consider the theory of the observation and the pros and cons of the different methods of observing. We also consider other applications of the observing methods used in occultation work.

High Resolution Asteroid Profile by Multi-Chord Occultation Observations

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Abstract For millennia, man has observed celestial objects occulting other bodies and distant stars. We have used these celestial synchronicities to measure the properties of objects. On January 1, 1801, Italian astronomer Giusappe Piazzi discovered the first asteroid that would soon be named Ceres. To date 190,000 of these objects have been catalogued, but only a fraction of these have accurate measurements of their true size and shape. The International Occultation Timing Association (IOTA) currently facilitates the prediction and reduction of asteroidal occultations. By measuring the shadow cast on the earth by an asteroid during a stellar occultation one can directly measure the physical size, shape, and position in space of this body to accuracies orders of magnitudes better than the best ground-based adaptive optics telescope, and can provide verification to 3D inverted reflective light curve prediction models. Recent novel methods developed by IOTA, involving an individual making multiple observations through unattended remote observing stations, have made way for numerous chords of occultation measurement through a single body, yielding high resolution profiles of asteroid bodies. Methodology of how observing stations are deployed will be demonstrated, and results of some of these observations are presented as comparisons to their inverted light curve are shown.

Lightweight Mirror Developments

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Abstract One goal of the Alt-Az Initiative is the development of transportable 1.5-meter class research telescopes. To this end, several Initiative members are developing lightweight, low cost, primary mirrors. Both multiple and single mirror telescope configurations are being considered. Thin meniscus mirrors are being slumped, and approaches for actively correcting these thin mirrors are being investigated. Sandwich mirrors with glass spacers and others with Foamglas cores are under development. Nanocomposite, polyurethane, and glass replica mirrors, which do not require optical grinding or figuring during production, are being evaluated. Finally, spin-cast polymer mirrors are being explored. Although several of these mirror developments are still

very experimental, and some may only be useful in optically undemanding applications such as on-axis aperture near IR photometry or low resolution spectroscopy, it is our hope that these efforts will enable the development of transportable, low cost, lightweight, 1.5-meter class telescopes.

Optimizing Opto-mechanical Performance Using Simple Tools and Techniques

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Abstract You just purchased a modest setup for your observatory—perhaps a mass produced Schmidt-Cassegrain on a German equatorial mount. However, optically and mechanically it's not performing as well as you would like. What can you do? Some simple assessments and repairs may make all the difference. Assessments can be as easy as visual inspection of various mount components, such as the tripod, where gaps between components reduce stiffness or allow unexpected shifts when loads change. Some assessments are only slightly more involved. Main mirror flop can be evaluated by aligning the main telescope and finder on a bright star and then slewing to various parts of the sky. Pointing differences between the two will be readily apparent if this problem exists. Most mid-level mounts use worm drives, but often excessive spacing between worm and worm gear produces large, and unnecessary, amounts of backlash. Visual inspection of your dovetail mounting system may leave doubts in your mind as to adequate stiffness. Imaging through the entire night may show you that your aluminum tube telescope causes excessive focus shift as temperature drops. Over time, your Schmidt-Cassegrain corrector plate may no longer be securely held by its retaining ring, and the same may apply to the secondary mirror cell. Repairs for these problems are often not difficult if you're mechanically inclined. Gaps in mount components can be eliminated with shims. Combating mirror flop may be the most difficult task. This can involve re-gluing the main mirror and bolting the main mirror cell in a fixed position. Corrector plate and secondary mirror cells can be improved with set screws and shims—implementing sound kinematic principles. Worm gear spacing can often be adjusted with simple tools. This brief paper can't possibly cover all problems and solutions, but it can give you the proper mindset to looking at your system with a critical eye and implementing simple, inexpensive fixes. You may be pleasantly surprised by the improvements.

Enhancements to the Sentinel Fireball Network Video Software

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Abstract The Sentinel Fireball Network that supports meteor imaging of bright meteors (fireballs) has been in existence for over ten years. Nearly five years ago it moved from gathering meteor data with a camera and VCR video tape to a fisheye lens attached to a hardware device, the Sentinel box, which allowed meteor data to be recorded on a PC operating under real-time Linux. In 2006, that software, SENTUSER, was made available on APPLE, LINUX, and WINDOW operating systems using the PYTHON computer language. It provides basic video and management functionality and a small amount of analytic software capability. This paper describes the new and attractive future features of the software, and, additionally, it reviews some of the research and networks from the past and present using video equipment to collect and analyze fireball data that have applicability to SENTUSER.

Photometry and Light Curves in the Solar System

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Abstract In a coordination between Williams College and MIT, we have been observing Pluto and Charon as they occult stars, the resulting light curves revealing changes in Pluto's atmosphere and the sizes, shapes, densities, and other aspects of these bodies in the outer solar system. We have seven of our POETS (Portable Occultation, Eclipse, and Transit System) sets of apparatus, mostly for travel to large telescopes in the path of the occultations but two on long-term status in New Mexico at a 2.5-m telescope and in Hawaii on a 3-m telescope, respectively. Each system includes an Andor Technology DV-887 frame-transfer CCD (often used at 10 Hz readout), a GPS for accurate time, and associated computer. During my sabbatical at Caltech, I am associated with Mike Brown's group, and we are observing mutual occultations of Haumea (the second dwarf planet past Eris, which he also discovered) and its moon Namaka, which should establish the size, gravitational fields, and many other aspects of each. We even have an excellent, absolutely calibrated, set of light curves from the ACRIMsat of the light curves showing the total solar irradiance of the sun during transits of Venus and Mercury. Reference: Souza, Steven P., *et al.* 2006, *Publ. Astron. Soc. Pacific*, **118**, 1550.

Sloan-r' Photometry of Comet 17P/Holmes Beyond 3.8 AU: An Observing Methodology for Short-period Comets Far From Perihelion

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Abstract A photometric method is described for accurately quantifying the brightness of short-period comets far from perihelion. The method utilizes the *Sloan Digital Sky Survey Catalog* (Data Release 7) as a homogeneous source of reference star magnitudes. Results are based on SDSS-r' filtered images taken using 2.0-m aperture telescopes for which the exposure time was adjusted to achieve a constant motion-blur of 2.0 pixels (0.56 arcsec) on the CCD chip. Aperture photometry using circular and tilted elliptical apertures was performed on images, which were stacked to increase signal to noise. Magnitude dependence on "seeing" was determined, and this calibration was used to normalize photometry to constant seeing thereby maximizing photometric accuracy. From observations of Comet 17P/Holmes between 2008 October and 2009 March, a very significant outburst of 17P was found to have occurred on 2009 Jan 4.7 (± 0.5 day). Night-to-night measurements of the brightness of the inner coma (3,000-km radius) exhibited a scatter of only 0.015–0.019 magnitude. No short time-scale (< 36 hr) periodicity was found in the fading light curve. From literature data, it was estimated that reflected light from the nucleus contributed 7–11% of the signal within the inner coma, and it is concluded that either the nucleus of 17P must be relatively spherical (projected axial ratio of < 1.25), or, if its shape is more typical of other comet nuclei, it has a rotational period in excess of 10 days (assuming the observations were not made with the nucleus "pole-on" to the Earth). Evidence from intermittent activity displayed by the nucleus is indicative of a possible 44-day rotation period.

Spectrashift Exoplanet Transit Search Project: 40,000 Light Curves and Counting

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Abstract Spectrashift has recently branched out from its radial velocity work detecting exoplanets, and has now fully implemented an exoplanet transit search

program. Junk Bond Observatory's 0.8-meter fully automated RC telescope has been engaged in this effort full-time since October of 2008. To date the search has examined more than 40,000 light curves. The Spectrashift strategy is to look at fewer but fainter stars, putting this search into the magnitude range the majority of professional searches cannot penetrate. Custom software was developed for the reduction pipeline to handle the volume of data. The software implements artificial intelligence algorithms to sort out the most likely candidates for human inspection at the end of the pipeline. To date the project has come up with several "triple hits" where a transit-like event has happened on three occasions. The Spectrashift team's ultimate goal is to include a network of non-professional telescopes around the world for 24-hour coverage of star fields. It is believed this is the first serious non-professional transit search effort.

ILOX—A Small Visible Imager on the Lunar Surface

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Abstract The International Lunar Observatory Association has been invited to provide a piggyback science instrument to fly onboard Odyssey Moon's attempt at the Google Lunar X-Prize. It is likely that the science instrument (ILOX) will be a 10-cm aperture visible imager (300 nm to 700 nm), 1,024 square pixels, with a 2.5 degree field of view. ILOX will have eight filter positions (two polarizers, six color filters) which will allow a variety of measurements to be performed. Total exposure time for ILOX will be < 1 Lunar Day (14 Earth days) from the lunar equator. Limiting magnitude is expected to be 12. We hope to measure the Earth's short wave albedo, characterize the Earth's polarization signature relative to solar phase angle, and possibly map ocean chlorophyll-a with 14 km resolution. We expect to investigate the lunar dust-lofting event associated with the lunar terminator as the terminator approaches ILOX. We will attempt to image a blazar jet in the visible and derive a power spectrum.

Thinking Out Loud: An Optical SETI Campaign Suitable for Amateur Astronomers?

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Abstract To date, there has yet been no confirmed detection of signals transmitted by an extraterrestrial (ET) entity/civilization. Reconsideration

of this problem from the vantage point of amateur astronomy has suggested a logical and reasonable alternative to current professional radio and optical searches. The experiment is suited to the capabilities and strengths unique to the serious amateur having his own well equipped observatory.

The Early History of Photometric Observations of Asteroids Made At Table Mountain Observatory

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Abstract An Ascop S-20 photomultiplier tube mounted in a Mt. Wilson-designed dry-ice cold-box assembly was used with a pulse-counting system to measure the colors, magnitudes, rotational rates, and phase coefficients of over 300 different asteroids between 1978 and 1993. During this time period, nearly one third of all known asteroid rotational rates (~150) were obtained from this effective system. All observations were made with manual telescopic pointing, with data written out long-hand utilizing the 0.6-meter telescope at JPL's Table Mountain Facility. Nearly forty refereed journal (mostly *Icarus*) papers were published containing these results, with yet a few more to come.

What's Next in Asteroid Photometry?

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Abstract Our knowledge of an asteroid starts with determination of its position over time using astrometry, calculation of orbital parameters, and collection of time-series photometry data to reveal its light curve, rotational period, and amplitude. Selectively, radar studies are performed by Arecibo and Goldstone to obtain orbital, size, shape, and surface data. Further insight into asteroid populations, general taxonomic class, albedos, estimated diameters, and shape require knowledge of their absolute magnitude (H) and phase slope parameter (G) values. The H-G values are determined through reduced photometric data as the asteroid passes through its opposition or 00 phase angle. Collection of these data is ideally suited to smaller observatories since the time required is considerable and therefore costly for larger facilities. The H-G parameters were determined for 901 Brunsia and 946 Poesia, thereby yielding new insight into their absolute magnitudes, albedos, diameter, and general taxonomic classification.

Slow Rotating Asteroids: A Long Day's Journey Into Night

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Abstract While there is no formal definition of a "slow rotator" among asteroids, anything with a period of at least 24 hours can be considered to be at least at the fast end of the group. These objects are of particular interest to those studying the evolution and dynamics of the asteroids within the solar system for several reasons. Most important among them is to generalize theories regarding the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect, which is the thermal re-radiation of sunlight that can not only affect the orientation of an asteroid's spin axis but its rate of rotation as well. In those cases where the spin rate is decreased, an asteroid can eventually be sent into a state of "tumbling" (NPAR—non-principal axis rotation) that can last for millions of years. However, not all slow rotating asteroids appear to be tumbling. This is not expected and so careful studies of these objects are needed to determine if this is really the case or if the tumbling has reached a condition where the secondary frequency—the precession of the spin axis—has been reduced to near zero. Furthermore, there appears to be an excess of slow rotators among the Near-Earth asteroids (NEA) and inner main-belt populations. Determining whether or not this is true among the broader population of asteroids is also vital to understanding the forces at work among the asteroids.

Extending a Spectroscopic Survey of Main Belt Asteroids With Micro Telescopes: A Proof of Concept Project

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Abstract In 2002, Schelte J. Bus and Richard P. Binzel proposed a new taxonomy for main belt asteroids based on slope values over segments of the spectral curve; this new classification system has started to gain general acceptance. Their analysis was based on spectrographic data gathered in the late 1980s and early 1990s at Kitt Peak Observatory on research instruments of 2.4 and 1.3 meters in aperture. Most of the original 1,447 asteroids were each observed on a single night. A few, which were observed on multiple

nights, exhibited unexplained variations. Spectra and photometric color studies have been done of some asteroids since then, mostly as studies of dynamical families. The authors have undertaken a "proof of concept" project to explore and resolve the technical challenges associated with re-observing some of these asteroids and extending the survey beyond the original targets using small telescopes. Employing a commercially-made 0.36-meter catadioptric telescope and camera/ spectroscope combination, the authors have attempted to reproduce some of the curves from asteroids included in the Bus and Binzel papers. Their work has focused on demonstrating the fidelity and repeatability of a data capture and analysis process on targets of at least 13th magnitude. The authors profile the hardware and software used to conduct the proof of concept project, techniques for data collection and analysis, and review the results of their work to date.

Filling Your Astronomy Program

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Abstract Every astronomy club has the random month without a speaker and the random blank space in their newsletter that needs just a couple of inches of content. In this talk we present ways to fill your program with content freely provided by the AAVSO via their speakers bureau and writers bureau. These two programs provide libraries of content that can be used to provide presentations or to fill any astronomy not-for-profit publication, respectively. Also, learn how you can help enhance these repositories with your own content.

Spectroscopic Binaries Studies

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Abstract We will introduce some historical background on spectroscopic binaries, amateur high resolution spectroscopy observation, procedure, and processing steps. We will show actual results on three binaries (Mizar, beta Aurigae, and AW UMa) taken with Lhires III Littrow spectrographs and an eShel echelle spectrograph. We will discuss further developments in this field.

Revisiting the O'Connell Effect in Eclipsing Binary Systems

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Abstract Many eclipsing binary light curves exhibit a feature known as the O'Connell effect, where the two out-of-eclipse maxima are unequally high. The effect is entirely unexpected, because the two side-by-side configurations of the components should appear equally bright from our line of sight. Several theories have been proposed to explain the effect, including asymmetrically distributed starspots, clouds of circumstellar dust and gas, or a hot spot caused by the impact of a mass-transferring gas stream. Currently, most published models of systems with asymmetric maxima incorporate starspots to rectify their models to fit the observational data. However, the limitations of starspot solutions, as well as other possible explanations for the asymmetry, are rarely discussed. In order to revitalize the study of the O'Connell effect, the astronomy program at Truman State University in Kirksville, Missouri, has initiated a project to construct complete *BVRI* light curves of poorly studied eclipsing binary systems exhibiting the O'Connell effect, including V573 Lyr and UV Mon. We are also exploring methods of applying Fourier analysis to large, all-sky databases to extract correlations that may help to evaluate competing theories for explaining the effect.

Using a Web Cam CCD to Do *V*-Band Photometry

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Abstract With the plethora of cheap web cam-based CCD cameras in the market today, it seemed expedient to find out if they can be used to do photometry. An experiment was planned to determine if it was possible to perform this kind of exacting measurement. Arne Henden (AAVSO) believed it would be possible to do *V*-band photometry to 0.05 magnitude accuracy with a web cam CCD. Using a 6-inch refractor, the heart of M42 was repeatedly imaged. θ^2 Ori and SAO 132322 were the comparison stars and V361 Ori was the target variable. Since the 1/4 HAD CCD chip only allows for a field of 10 × 7 arc minutes using the 6-inch refractor, the number of targets was limited. The RGB on the chip itself provides the filters needed for photometry. The *G* bandpass on the chip ranges from 425 to 650 nm with a peak band pass at 540, *and V* bandpass is 475–645 with a peak at 525. The results indicate that a web cam CCD can be used for *V*-band photometry. With a 10-second calibrated exposure without the Peltier cooling being engaged, the results for the two target stars were ± 0.18

magnitude. θ^2 Ori was 0.18 brighter in *V* than the actual measurement from the Tycho catalog. SAO 132322 was 0.012 magnitude dimmer than the listed Tycho measurement. Then, using SAO 132322 and θ^2 Ori as comparison stars, V361 Ori was estimated at magnitude 7.786. This is in line with visual estimates received before and after this date. With more estimates of known magnitude comparison stars, a correction factor should be estimated and applied to the variable work that will make it more accurate. This correction factor should bring it close to Arne Henden's estimate of 0.05 mag accuracy.

Intrinsic Variability of β Lyrae Observed With a Digital SLR Camera

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Abstract We show that a digital SLR (DSLR) camera (Canon XTi) follows a linear response to light exposure when images are saved in raw format. We also demonstrate its usefulness for photometry of bright variable stars such as beta Lyrae (4.2m–3.2m) and other bright variable stars. Mounted on a stationary tripod and fitted with a standard zoom lens set at 55 mm FL at *f*/5.6, this camera obtains reasonably precise photometry (± 0.02m) for bright stars. Imaging bright stars with a telescope and CCD imaging detector is hampered by rapid saturation and the lack of suitable bright comparison stars in the field of view. Subtracting the average brightness for beta Lyrae, we can easily detect the intrinsic variability of beta Lyrae (15%) with a period about 280 days. More such observations are requested to learn more about the period and phase of the intrinsic variability of beta Lyrae.

An Intensive CCD Photometry Campaign to Observe DW Ursae Majoris

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Abstract We report on a coordinated observing campaign in April and May 2008 to study the eclipsing dwarf nova DW Ursae Majoris. This belongs to the group of SW Sex stars, nova-like variables containing accretion disks which exhibit superhumps in their light curves suggesting that their accretion

disks are elliptical and precessing on time scales of a few days due to tidal interactions with the companion star. It has been suggested that the changing geometry will cause the depth of eclipses to be modulated on the accretion disk precession period. The aim of this campaign was to provide for the first time sufficient continuous photometric coverage of an eclipsing superhumper to test this hypothesis. Twenty-six experienced amateur CCD photometrists in seven countries participated in the project and altogether made almost 55,000 magnitude measurements over a four-week period, keeping DW UMa under observation for more than 50% of the time. The results provide direct measurements of the orbital, superhump, and disk precession periods, confirming unambiguously that the superhump signal is a beat between the orbital and precession periods. They also reveal modulation not only of the eclipse depth but also of the eclipse time of minimum and width on the accretion disk precession period. The project is a good example of cooperation between the amateur and professional communities to address an open research issue.

New Observations of Three Lyra Variables

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Abstract New *V*-, *B*-, I_c-, and *R*-band photometry is obtained for V480 Lyr, V575 Lyr, and GSC 2118-0402. These new observations, when combined with other published observational data, allowed the determination of multiple period values for each star. From its multi-period behavior and from an examination of other intrinsic parameters, V480 Lyr was determined to be that of an RV Tauri type star, which differs from earlier classifications of the star. The new observational data on the δ Sct variable V575 Lyr confirmed two earlier observed periods of this variable star and identified an additional third period of pulsation. Additionally the precession of the primary period was identified, and new *B–V*, *V–I*, and *V–R* color indices were obtained. New observations of the V575 Lyr field star, GSC 2118-0402, are also examined and analyzed. These observations identified the range of magnitude variation and pulsation periods, which allowed the star to be tentatively classified as a δ Scuti variable.

ε Aurigae, 2009: The Eclipse Begins—Observing Campaign Status

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Abstract The eclipse of 3rd-magnitude epsilon Aurigae is forecast to begin during August 2009, reaching totality by year's end, based on all six prior eclipse events studied—1982, 1955, 1930, 1902, 1874, and 1847. We have organized a campaign during the past several years in order to raise awareness about this rare opportunity, and to promote reporting of observations of all kinds. We have forty registered participants, seventy-six people signed up for alert notices, plus numerous informal expressions of interest. Categories of observations being reported in *Campaign Newsletters* (eleven since 2006) which include Photometry, Spectroscopy, Polarimetry, Interferometry, and Citizen Science (website: www.hposoft.com/Campaign09.html). In this presentation, we provide a brief update on the optical and near-IR photometry obtained to date. The nature of the short term light variations will be discussed in the context of mapping the eclipse behavior. Spectroscopy benefits from small telescope capabilities now widely available, along with traditional large telescope, higher dispersion work. Examples of each will be presented, along with the research objectives. Polarimetry provided key insights during the last eclipse, and we continue to promote the need for new data using this method. Finally, interferometry has come of age since the last eclipse, and a status report on this powerful method to directly detect the passing dark disk will be provided. Along with these traditional measurements, we will briefly discuss efforts to promote Citizen Science opportunities among the public, in coordination with AAVSO and as part of the International Year of Astronomy, IYA 2009.

ε Aurigae Hydrogen-α Emission Line Variation: The Horn Dance

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Abstract The Hopkins Phoenix Observatory has been doing high resolution spectroscopy on the 3rd magnitude long period (27.1 year) eclipsing binary star system epsilon Aurigae since August 2008 using a Lhires III spectrograph with a 2,400 line/mm grating mounted on a 12-inch Meade LX200 GPS telescope. Observations have been in both the sodium D-line region of the spectrum and with near continuous observations of the hydrogen alpha region. The out-of-eclipse hydrogen alpha spectrum shows significant night-to-night variation.

While many star systems exhibit a strong hydrogen alpha absorption line, like Be stars, epsilon Aurigae also shows strong blue and red shifted emission components sometimes called wings or horns bracketing the absorption line. Unlike the Be stars, in which the blue and red horns remain relatively constant, the hydrogen alpha horns of epsilon Aurigae seem to be in a wild dance with continuous motion up and down. This paper will discuss techniques and results of recent out-of-eclipse high-resolution spectroscopy of epsilon Aurigae.

The 2009 Eclipse of EE Cephei: An Educational and Collaborative Journey

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Abstract In December 2008, Jeff Hopkins of the Hopkins Phoenix Observatory (HPO) put out a request for assistance in extracting data from images taken by the AAVSO SRO (Sonoita Research Observatory) of EE Cephei, an 11th magnitude (V) long period (5.6 years) eclipsing binary star system that was due to eclipse in January of 2009. The Hopkins Phoenix Observatory originally planned to do *BVRI* CCD photometry of EE Cep for the 2009 eclipse, but equipment and logistical changes at HPO meant the EE Cep project would not be possible. However, in the fall of 2008 Arne Henden of the AAVSO announced the availability of a remote robotic 16-inch telescope (the Sonoita Research Observatory) in southern Arizona for use by members of the AAVSO. Jeff Hopkins contacted Arne Henden and arrangements were made to have the EE Cep star system imaged with *BVRI* filters beginning in November 2008 and running through February 2009. Image files were archived on the AAVSO web site. Soon after his initial request went out, Jeff Hopkins was contacted by John Pye from Maui Community College, who agreed to help with the project by having one of his students, Lauren Elder, examine the image files and extract EE Cep and three comparison stars flux (ADU) counts for each band. The resulting data were then sent to the Hopkins Phoenix Observatory for data reduction and analysis. The project was a successful joint collaboration with forty nights of observations for over 300 *BVRI* data points from 20 November 2008 to 17 February 2009. Light curves for each band as

well as color indices were plotted and eclipse contact points were determined. The data were also contributed to the EE Cep Campaign organized by Cezary Galan at the Centre for Astronomy at Nicolaus Copernicus University in Torun (Poland). Our results are plotted along with those of several dozen other observers from around the world.

The Light Curve of UZ Sagittae

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Abstract A complete light curve of the eclipsing binary UZ Sge has been determined in *V* and *R* bands. Four new times of minimum are reported (two for primary eclipse and two for secondary eclipse), which verify other recent O–C observations. The color index changes significantly during both primary eclipse and secondary eclipse, providing some constraints on the stars' temperatures. BINARYMAKER3 software has been used to compare the observed *V* and *R* light curves with two models of this system (with quite different mass ratios of q = 0.14 and q = 0.68, respectively) that have been suggested in the literature.

An Estimate of the Integrated Magnitude of the LCROSS Impact Ejecta Dust Curtain for Exposure Calibration Practice

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Abstract The LCROSS-EDUS (Lunar CRater Observation ans Sensing Satellite-Earth departure upper stage) lunar impact will generate a dust ejecta curtain about 10 km × 5 km high according to the NASA-LCROSS Team current best estimate impact model (CBEIM). The dust ejecta curtain could reach 20 km × 20 km. The LCROSS Team has not issued a curtain magnitude estimate for use by amateur imagers. For the limited purpose of pre-event exposure calibration practice, a rough first-order estimate of the LCROSS impact dust ejecta curtain is between 0.3 to 3.5 integrated magnitudes or 5.5 to 6.4 mpsas. This apparent brightness provides a favorable contract index against typical Earthshine (dark limb) irradiance between 12 to 17 mpsas for the dark limb (mean value 15.44 mpsas) but not against Moonshine (bright limb) at 4 to 6 mpsas.

Data Mining Techniques Applied to the GNAT Library Archive (poster)

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Abstract The Global Network of Astronomical Telescopes (GNAT) is in the process of developing a large library of data for its newly discovered variable stars. This revised archive has been recently opened to the public, is largely unexamined, and provides a valuable resource for data mining. The GNAT archive is constantly growing as survey imaging continues; in 2009 the survey imagery is estimated to contain in excess of 150,000 new variable star entries selected from more than about nine million observed stars. The algorithm used for identifying variable stars in these images yields examples of nearly all known classes of such stars. One of the key goals of developing data mining techniques is to be able to narrow down this large volume of data to specific stars of interest. We discuss the nature and content of the GNAT variable star archive, including a discussion of limitations and boundary conditions that affect the data. We present some basic ideas of data mining, examine specific approaches to the GNAT archive, and provide examples of how to extract information related to these variable stars.

Phase Dependent Spectroscopic Monitoring of Cepheid Variable Stars (poster)

Bandon Decker
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Abstract Cepheid variables are pulsating yellow giant stars, with a surface temperature somewhat greater than that of the Sun. While Cepheids have been studied photometrically in great detail for many decades, the data on how the spectra of Cepheid variables change over time is relatively scarce. Of special interest is the O I triplet at 7774 Angstroms, because its variation over one cycle is related to the motion of unionized oxygen in the atmosphere of the star as it pulsates. Three classical Cepheid variables, FF Aquilae, T Vulpeculae, and SU Cygni were observed spectroscopically on fifteen nights at the Truman State University Observatory using a SBIG Self-Guiding Spectrograph and a 35-cm Meade LX200GPS telescope. Low resolution (5 Angstroms/pixel) were obtained from 3800 to 9500 Angstroms, as well as higher resolution spectra (1 Angstrom/pixel) from 7400 to 8150 Angstroms. For all three stars,

the spectra clearly revealed the change in surface temperature as a function of phase. Further analysis of the spectroscopic data enabled us to create plots of the equivalent width of the O I triplet as a function of phase for FF Aql.

Searching for Chaos in the Mira Variable Star U Cygni (poster)

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Abstract Mira variable stars are pulsating red giant stars whose light curves often exhibit seemingly random variations in amplitude and period from cycle to cycle. One possibility is that the long-term variations in Mira variable light curves are due to a simple linear combination of two or more pulsation modes. For some pulsating red giant stars, however, a multi-periodic solution has been shown to be insufficient, and a nonlinear analysis is required for complete description of the light curve behavior. The application of chaos theory to the light curves of pulsating variable stars remains relatively unexplored, however. In this project we investigated U Cygni, a pulsating Mira-type variable star with a period of approximately 463 days. Over 100 years of U Cyg visual photometric data were obtained from the American Association of Variable Star Observers. A Fourier analysis was conducted on the data and an O–C diagram was created to explore the limitations of standard linear time series analysis. Next, a nonlinear analysis using the TISEAN software package was conducted to search for chaotic behavior in the light curve of U Cyg. From the nonlinear analysis, we obtained phase space projections, determined the maximum Lyapunov exponent, and created a synthetic light curve to represent the U Cyg data. The results provide evidence for the presence of chaotic behavior in the light curve of U Cyg.

Time Delay Integration: A Wide-Field Survey Technique (poster)

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E. Hill
L. Leimer
K. McMillian
A. Miller
A. Prindle

Orange Lutheran High School, AP Physics C—Research Project, 2222 North Santiago Boulevard, Orange, CA 92867

Abstract The Advanced Placement Physics class of Orange Lutheran High School has conducted a survey-imaging project using a Time Delay Integration (TDI) technique. TDI enables very wide-field images to be collected in the form of long strips of the sky. A series of five consecutive nights were captured, calibrated, and compared to reveal possible transient phenomena such as supernovae, asteroids, and other events that have a noticeable change over 24-hour intervals.

Quantifying "Irregularity" in Pulsating Red Giants (poster)

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Alfred Lin
Christopher Menezes
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Abstract Hundreds of red giant variables are classified as type L, which the *General Catalogue of Variable Stars* defines as "slow irregular variables of late spectral type...which show no evidence of periodicity, or any periodicity present is very poorly defined." Self-correlation is a simple form of time-series analysis which determines the cycle-to-cycle behavior of the star, averaged over all the data; even for stars with no periodicity, it provides a "profile" of the variability, including the average "characteristic time scale" (Percy and Mohammed 2004, *J. Amer. Assoc. Var. Star Obs.*, **32**, 9, and references therein). We have applied this method to AAVSO visual observations of several dozen L-type variables, and found a range of behavior: despite their irregularity, most have at least one pulsation period; some also have "long secondary periods" whose cause is unknown. For all of them, we have determined a period, or an equivalent "characteristic time scale." There seems to be a continuous spectrum of behavior in pulsating red giants, from periodic to irregular. Co-authors SE, AL, CM, and SW were participants in the University of Toronto Mentorship Program which enables outstanding senior high school students to work on research projects at the university. This program will be described briefly. *[Ed. note: this paper appears in full in this issue of the* Journal*, beginning on page 71.]*

Over-Contact Binary GR Tauri (poster)

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Abstract New times of minima and ephemerides are presented on the over-contact system GR Tauri. An observed minus calculated (O–C) time of minimum chart was constructed, and, based on statistical analysis, the orbital period of the system is found to be decreasing with a rate of $dP/dE = 3.33^{-4}$ seconds/year^{-1} since 1931. Both components are filling their respective critical Roche lobes with fillouts f = 0.11 and 0.95. The light curve displays the O'Connell effect, which is discussed on the assumption mass is going from the primary to the secondary creating a hot spot. The thermal relaxation oscillations (TRO, Lucy and Wilson 1979), theory is discussed as an explanation.

Photometry of Variable Stars Using a Lensless Schmidt Camera (poster)

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Abstract This paper describes the design and use of a lensless Schmidt camera (LSC) as a more cost effective alternative to more expensive telescope types. The lensless Schmidt design uses a short focal length spherical primary mirror and an aperture stop placed at the radius of curvature of that mirror. This results in an optical system without coma or astigmatism and a wide field of view. However, the LSC does have residual spherical aberration which enlarges the size of the stars being imaged by a CCD. The amount of spherical aberration tolerable in measuring stellar magnitudes and the physical length of the camera determine the possible focal ratio and aperture combinations for LSC designs. An LSC was built by the author and used to obtain data on several variable stars. Photometric *V* data plots for V Boo, χ Cyg, and U Cyg are provided as examples of the data than can be captured with this type of instrument.