AAVSO Estimates and the Nature of Type C Semiregulars: Progenitors of Type II Supernovae *(Abstract)*

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Abstract The nature of the variability in the M supergiant type C semiregular (SRC) variables is examined using new and archival spectroscopic and spectrophotometric observations of the stars phased according to AAVSO magnitude estimates. SRC variables appear to be more regular than sometimes suggested, although the nature of their pulsation remains unclear in some cases. Some SRCs appear to undergo irregular fading episodes that may result from dust ejection. But recent light curves of the stars display large scatter that hinders reliable determination of their cycle lengths, a problem that needs to be addressed to improve the usefulness of AAVSO data for learning more about massive stars as they approach the terminal stage of their evolution as Type II supernovae.

Preliminary Analysis of MOST Observations of the Trapezium *(Abstract)*

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Abstract We present our first assessment of light curves of the Trapezium stars obtained by the MOST satellite in early 2011. The data sets consist of four stars of the θ^1 Ori system (A, B, C, and D), along with 34 GSC stars in the field nominally used for guiding. The photometry of the brightest stars is sufficient to detect variability at a level well below one mmag, while photometry of the fainter guide stars has not yet been assessed. An early look at the data indicates intrinsic signals are clearly present; non-trivial systematics also related to the spacecraft and sampling are also present, and we discuss potential means for dealing with these issues. We will also discuss our plans for analyzing the data and deriving physical information on these stars.

High School Students Watching Stars Evolve *(Abstract)*

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Abstract Some stars pulsate (vibrate). Their pulsation period depends primarily on their radius. The pulsation period changes if the radius changes, due to evolution, for instance. Even though the evolution is slow, the period change is measurable because it is cumulative. The observed time of maximum brightness (O) minus the calculated time (C), assuming that the period is constant, is plotted against time to produce an (O–C) diagram. If there is a uniform period change, this diagram will be a parabola, whose curvature—positive or negative—is proportional to the rate of period change. In this project, we study the period changes of RR Lyrae stars, old sun-like stars which are in the yellow giant phase, generating energy by thermonuclear fusion of helium into carbon.

We chose 59 well-studied stars in the GEOS database, which consists of times of maximum measured by AAVSO and other observers. We included about a dozen RRc (first overtone pulsator) stars, since these have not been as well studied as the RRab (fundamental mode) stars because the maxima in their light curves are not as sharp. We will describe our results: about 2/3 of

the stars showed parabolic (O–C) diagrams with period changes of up to 1.0 s/century, some with increasing periods and some with decreasing periods. The characteristic times for period changes (i.e. period divided by rate of change of period) were mostly 5–30 million years. These numbers are consistent with evolutionary models. Some stars showed too much scatter for analysis; we will discuss why. A few stars showed unusual (O–C) diagrams which cannot be explained simply by evolution.

This project was carried out by coauthors MacNeil, Meema-Coleman, and Morenz, who were participants in the prestigious University of Toronto Mentorship Program, which enables outstanding senior high school students to participate in research at the university. We thank the AAVSO and other observers who made the measurements which were used in our project.

Eclipsing Binaries That Don't Eclipse Anymore: the Strange Case of the Once (and Future?) Eclipsing Binary QX Cassiopeiae *(Abstract)*

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Abstract We report on the cessation of eclipses of the former 6.005-day eclipsing binary QX Cas. This 10th-magnitude star is a member of the young open cluster NGC 7790; in 1954 QX Cas (B1 IV–V + B3 V) was discovered by Erleksova (1954: *Astr. Circ.* 155) to be an eclipsing binary. Subsequently Sandage (1958: *ApJ*,128,150) and Sandage and Tammann (1969: *ApJ*, 157, 683) obtained accurate photometry of QX Cas that confirmed its eclipsing nature and provided accurate measures of UBV magnitudes and colors. The early light curves display two narrow eclipses with depths of ~ 0.32 magnitude and ~0.28 magnitude, respectively. Moreover the Min II occurs at 0.37 P—indicating an moderately eccentric orbit. To secure modern light curves, we have carried out UBVRI photometry using the 0.8-m Four College Automatic Photoelectric Telescope (FCAPT). Photometry was conducted on >110 nights and the observations now cover all the orbital phasespace of the binary. However, this photometry (and overviews of all recent photometry) show no evidence of eclipses. Thus QX Cas is no longer an eclipsing binary! QX Cas joins another former eclipsing binary—SS Lac—that over twenty years ago also ceased eclipsing.

We present the analysis of previous light curves and the analysis of recent spectroscopy and HST observations of QX Cas to determine its orbital and physical properties. We discuss the reasons that could cause QX Cas to stop eclipsing. These include binary system disruption or an impulsive orbital change from a close encounter with another cluster star or (most likely) from orbital perturbations from a putative bound tertiary companion.

QX Cas and other related eclipsing binaries that stopped eclipsing or show changes in their eclipse depths could be interesting targets for AAVSO members to monitor using CCD or photoelectic photometry. In addition, the changing orbital inclination of QX Cas and other similar, previous eclipsing binaries can be studied with spectroscopic radial velocity observations which are dependent on the star's orbital inclination. This research is supported by NSF/RUI Grants AST05-07536 as well as NASA Grant HST-GO 10116 which we gratefully acknowledge.

High Speed UBV Photometry of ε Aurigae's 2009–2011 Eclipse *(Poster abstract)*

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Abstract We present rapid cadence U, B, and V photometry of ε Aurigae during its 2009–2011 eclipse. Data are analyzed to look for both periodic and random variation. Observations are presented from two observers. The first is from Rockyford, Alberta, Canada, and used a ST-7 and ST-8XME with 50mm and 135mm lenses, respectively. This observer recorded continuous filtered time series up to 11 hours long. The second is in Hereford, Arizona, and used a ST-10XME with a 0.36-m SCT.

δ Scorpii 2011 Periastron: Visual and Digital Photometric Campaign *(Poster abstract)*

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Abstract Approximately a hundred observations of δ Scorpii, from April to September 2011, made for the AAVSO visually and digitally with a commercial CMOS camera, have been plotted. The three most luminous pixels either of the target star and the two reference stars are used to evaluate the magnitude through differential photometry. The main sources of errors are outlined. The system of δ Sco, a spectroscopic double star, experienced a close periastron in July 2011 within the outer atmospheres of the two giant components. The whole luminosity of δ Sco increased from about Mv = 1.8 to 1.65, peaking around 5 to 15 July 2011, but there are significant rapid fluctuations of 0.2–0.3 magnitude occuring over 20 days that seem to be real, rather than a consequence of systematic errors due to the changes of reference stars and observing conditions. This method is promising for being applied to other bright variable stars like Betelgeuse and Antares.

Bright New Type-Ia Supernova in the Pinwheel Galaxy (M101): Physical Properties of SN 2011fe From Photometry and Spectroscopy *(Poster abstract)*

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Abstract We report on the preliminary multi-wavelength photometry and spectroscopy of SN 2011fe, a bright, new Type-Ia supernova (SN Ia) that

occurred in the spiral galaxy M101 (Pinwheel Galaxy). One of the closest and brightest SN Ia in the last forty years, the supernova was discovered on August 24, 2011, by the Palomar Transient Factory during the star's initial rapid rise (Nugent *et al.* 2011). SN Iae occur in binary systems in which a degenerate white dwarf component accretes mass from its companion star (or undergoes a merger with another white dwarf), overcomes the Chandrasekhar limit, and deflagrates in a spectacular explosion. The peak brightnesses of most SN Iae are remarkably similar. This allows SN Iae to be used as accurate cosmic distance indicators and thus they are crucial to understanding cosmology, dark energy, and inflation. SN 2011fe is being extensively observed over a wide range of wavelengths by both amateur and professional astronomers (including several AAVSO members). The UBVRI photometric observations discussed here are being carried out with the 1.3-meter Robotically Controlled Telescope (RCT) located at Kitt Peak National Observatory. The RCT data show a peak apparent magnitude of mV (max) ~ +10.0 mag, in agreement with other measures. Using the M 101 distance modulus of (mV – MV)0 = 29.04 (~21 million LY) as determined by Shappee and Stanek (2011), and assuming interstellar reddening of AV = 0.03 (from E(B-V) = 0.008) toward the objects in SN 2011fe's neighborhood, we estimate the absolute magnitude in the V band of SN 2011fe to be MV = –19.07 mag, which appears to be slightly under-luminous than the SN Iae average of <MV> = –19.30 (Hillebrandt and Niemeyer 2000). Visual and IR spectroscopic data gathered from Buil and Theirry (2011) show strong absorption features, especially those of Co II ~ 3995 Å, Si II ~ 6150 Å, Fe II/Mg II blends ~ 4500 Å, and the Ca II near-IR triplet ~ 8250 Å. Crucially, the spectrum shows no hydrogen and helium lines, which, coupled with the strong Si lines, means that SN 2011fe is a Type-Ia SN. Constraints on the progenitor system (for a single degenerate model) by Li *et al.* (2011) rule out bright red-giant mass donors, but do not rule out faint secondaries. SN 2011fe is important because of its relatively high brightness and early detection in a nearby, well-studied, face-on galaxy with a good distance determination and little ISM extinction. The prodigious amount of data that continues to be gathered will lead to exciting opportunities in the future that include further study of the spectral time series evolution, Δm15(B) relation, and Hubble Constant calibration. In this poster, we discuss the up-to-date physical and photometric properties of this SN and compare them to those of other Type-Ia supernovae.

This research is supported, in part, by NSF/RUI grant AST1009903 and NSF/RUI grant AST0507542. We also gratefully thank both the RCT Consortium and AAVSO members for the photometric data.

References

Buil, C., and Thierry, P. 2011, ARAS (http://astrosurf.com/aras/surveys/supernovae/sn2011fe/obs.html)

Hillebrandt, W., and Niemeyer, J. C. 2000, *Ann. Rev. Astron. Astrophys.*, **38**, 191.
Li, W. *et al.* 2011, arXiv:1109.1593v1. (http://arxiv.org/abs/1109.1593v1)
Nugent, P. *et al.* 2011, *Astron. Telegrams*, No. 3581, 1.
Shappee, B. J., and Stanek, K. Z. 2011, *Astrophys. J.*, **733**, 124.

The World's Strangest Supernova May Not Be a Supernova At All *(Abstract)*

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Abstract SN 2008ha is the least luminous supernova ever to be observed. It is unclear what caused this obscurity to occur. For the last three years I have been doing independent follow-up research on SN 2008ha.

SN 2008ha is believed to be 100 times brighter than a nova, but 1,000 times dimmer then a supernova. The spectrum to some degree was classic Type Ia supernova because of the lack of hydrogen and abundance of silicon, but there are many other factors to be considered. SN 2008ha had a short rise time of only 10 days (typical Type Ia is 19.5 days). It has low expansion velocities of only 2,000km compared to the typical Ia with very small kinetic energy per unit mass of ejecta. Although some elements of the spectrum are consistent with those of a Type Ia, narrow lines were observed. This is just one of several characteristics that SN 2008ha shares with the "SN 2002cx-like class" of supernovae. SN 2008ha is believed to be the most extreme of this sub-class of supernovae with the smallest amount of space between lines, 5 days shorter rise time, being significantly fainter, and having lower velocities. With all these things considered, it does make classification as a Type Ia questionable. In fact it is even questionable if this is a supernova at all, and not just an "imposter." This may have just been a "star burp" which means that the supernova may have failed, resulting in some parts of the star being left, maybe even enough remains to explode again as seen in the case of SN 2006jc. This may have occurred because the explosion was not deep enough in the core of the star, and only eliminating some or all of the hydrogen envelope and leaving behind the carbon and oxygen inner layers, instead resulting in a Type Ic supernova. It would be interesting to see what, if anything is left of the star; this could make it a possible Hubble candidate. The idea that it may "burp" again makes it especially important.

An Amateur-Professional International Observing Campaign for the EPOXI Mission: New Insights Into Comets *(Abstract)*

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Abstract Comets are leftovers from the early solar system and may have played a role in delivering water and organics to the prebiotic Earth. Because comets may preserve a record of the early solar system conditions, they are the focus of small body missions. The EPOXI (Extrasolar Planet Observation and Characterization (EPOCh) + Deep Impact Extended Investigation (DIXI) = EPOXI) flyby of the nucleus of comet 103P/Hartley 2 provided us with physical properties of the nucleus and clear evidence of chemical heterogeneity with CO_2-driven jets as a dominant volatile loss mechanism at perihelion compared to subsurface water-ice sublimation. An international Earth-based observation campaign played a complementary role to the in-situ data, providing recovery images of the comet at large distances, physical information about the nucleus size, and from a coordinated multiwavelength program nearly continuous coverage from August 2010 through encounter on 4 November 2010. From the Earth-based campaign it was clear that comet Hartley 2 had a small nucleus (0.57 km radius), with a rotation period near 16.4 hours prior to the onset of activity. As the activity developed the periodicity was found to change significantly over a period of months. The highly active nucleus had long- and short-term gas production variability with peak activity shortly after perihelion. The comet's activity has been photometrically monitored (as scattered light from the dust coma) from the time of recovery to the present, and the nearly continuous coverage of the comet from August 2010 into 2011 would not have been possible without the amateur contributions. Using these brightness data, we have developed an ice sublimation model to estimate the amount of dust emitted from the comet (and hence the total scattered light) as a function of heliocentric distance as it is driven by a gas flow. The model includes nucleus ices: H_2O, CO_2, CO, and H_2O sublimating from the large chunks seen both from the EPOXI spacecraft and the Arecibo radar observations (Harmon *et al.* 2011). The model indicates that like other comets, water-ice sublimation began to create an observable dust coma/tail near 4–4.4 AU as the comet approached the sun, but that near perihelion, strong CO_2 outgassing in the form of jets (as seen by the spacecraft) was responsible for lifting large ice/dust grains from the surface. CO_2 is likely a strong contributor to activity on the outbound leg of the orbit. The models show that the fractional active nucleus area is small for water production (typical of other comets) and that at perihelion most of the water production is likely from the ice grain halo. Sublimation from deeper CO_2 reservoirs is

likely an important driver of activity for this comet, including out to and beyond aphelion, and this may be a characteristic of unusually active comets—relating to differences in chemistry from either formation or subsequent evolution. This paper will present mission highlights, and emphasize the important role that the amateur observations has in understanding the behavior of this comet.

Light Curve of Minor Planet 1026 Ingrid *(Poster abstract)*

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Abstract We have imaged minor planet 1026 Ingrid over the time period of July 29, 2011, to late September 2011, using the Wheaton College 0.25m telescope at Grove Creek Observatory in Australia via internet access. This telescope is equipped with a Santa Barbara Instrument Group STL-1001E CCD Camera, used with a clear filter. Over 1,000 30-second images were obtained and imported into the MPO Canopus software package for light curve analysis. Our preliminary estimate of the rotation period of 1026 Ingrid is 5.390 ± 0.001 hours, which is consistent with the previous estimate of 5.3 ± 0.3 hours (Székely, P., *et al.* 2005, *Planet. Space Sci.*, **53**, 925).

Membership of the Planetary Nebula Abell 8 in the Open Cluster Bica 6 and Implications for the PN Distance Scale *(Poster abstract)*

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Abstract The potential link between the newly discovered open cluster Bica 6 and the planetary nebula (PN) Abell 8 (PN G167.0-00.9) proposed by Bonatto *et al.* (2008) is confirmed on the basis of new UBVRI CCD photometry for the cluster and spectroscopic observations of its brightest stars, in conjunction with an analysis of 2MASS data for the cluster. The reddening, estimated distance, and radial velocity (+58 ± 6 km/s) of Abell 8 are a close match to the parameters derived for Bica 6: E(B–V)(B0) ≈ 0.40, d = 1.6 kpc, Vr = +57 ±4 km/s (11 stars). The radial velocity match is particularly interesting given that the velocities are more than 50 km/s larger than expected for Galactic orbital motion at l = 167°. The cluster age of 1 billion years implies a mass of –2.5–3 $M_{\odot}$ for the planetary nebula progenitor star, although the picture is complicated by a few blue stragglers as likely cluster members. The central star of the PN is an optical double in the 2MASS survey, with the companion indicated to be a cluster M dwarf. Abell 8 is a highly evolved PN containing a low luminosity central star (Mv ≈ +8), with a distance implied by cluster membership favoring the short PN distance scale.

What Mass Loss Modeling Tells Us About Planetary Nebulae *(Abstract)*

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Abstract Planetary nebulae are the result of mass loss from an AGB star (specifically, a Mira variable or post-Mira infrared source) that is swept up by a later fast wind and/or ionized when the central star becomes hot. The central stars of planetary nebulae are the naked cores of the former AGB star. Not all AGB stars form PNe, however, and the ones that do may be mostly binary

star systems. Using both a large grid of detailed mass loss models and some simple analytical mass loss formulae we can relate observations of PNe and their nuclei to the character of the late AGB (Mira stage) mass loss.

Stars, Planets, and the Weather: If You Don't Like It Wait Five Billion Years *(Abstract)*

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Abstract Over the last decade realization has grown that high-energy phenomena such as X-ray and EUV radiation, winds, and coronal mass ejections exhibited by stars like our own Sun have an importance far beyond local "stellar weather." From the stormy magnetic extremes of stellar youth to the gentle breeze of stellar middle age and beyond, I describe how stellar weather is now central to problems as diverse as the evolution of supernova Type Ia progenitor candidates, planet formation, and the development and survival of life in planetary systems.

The Hunt for the Quark-Nova: a Call for Observers *(Abstract)*

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Abstract A Quark Nova is the explosive transition from a neutron star to a quark star that is theorized to take place days or weeks after a small fraction of "normal" Type II supernova events. The Quark Nova signature is the delayed brightening of the new object by about five magnitudes. The proposed close

long-term monitoring of Type II supernova events should reveal the presence or absence of the signature double-hump of a Quark Nova and allow us to estimate the frequency or upper limit to the rate of such events. Normal supernova search techniques and follow-up activities may miss the subsequent brightening that takes place during the Quark Nova event. We seek CCD-equipped observers with modest-sized telescopes to join a collaborative effort to search for these events. Your job would begin after Type II supernovae are discovered by others. You, with a team of other observers, would follow all new Type II discoveries for about one to two months looking for the signature "double-bump." As there are not many known Type II supernovae active at any given time, the observational commitment is not expected to exceed about one hour per night. We have set up an on-line database to manage the process and record the observations and a communications forum to provide support to the observers and structure to the project (see http://quarknova.ucalgary.ca). The confirmation that these objects exist will be a significant event in supernova research.

Collaborative Research Efforts for Citizen Scientists *(Poster abstract)*

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Abstract The AAVSO's Citizen Sky project encourages participants not just to collect and categorize data, but to critically analyze and publish research findings. Our participants form teams of different yet complementary skills that work together towards a common goal. Each team has a leader and a professional astronomer assigned to act as an advisor. In this work we explore the formation of teams, by what means they find research topics, and how they

manage their collaborations. We acknowledge support from the NSF Informal Science Education Division under grant DRL-0840188 to the AAVSO and the University of Denver.

Exploring the Breadth and Sources of Variable Star Astronomers' Astronomy Knowledge: First Steps *(Abstract)*

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Presented at the 100th Annual Meeting of the AAVSO, October 8, 2011

Abstract There is considerable interest related to the astronomy content knowledge of various groups, whether that group consists of 3rd graders who have just learned the phases of the moon, or astronomy graduate students who are working on original research. Similarly, the Center for Astronomy and Physics Education Research (CAPER) Team and the American Association of Variable Star Observers (AAVSO) are interested in the general astronomy content knowledge of the AAVSO members. To increase our understanding of the knowledge base of today's variable star astronomers, we asked a subset of members to respond to an online general astronomy content knowledge survey called the Test Of Astronomy Standards (TOAST). The TOAST is a twenty-nine-item, multiple-choice format assessment instrument which addresses the full range of topics commonly taught in an introductory astronomy survey course, and is criterion referenced aligned to the consensus learning goals stated by the AAS Chair's Conference on ASTRO 101, the AAAS Project 2061 Benchmarks, and the NRC National Science Education Standards. This paper presents preliminary results on this work to the AAVSO membership in the hope that the findings will begin a conversation about the kinds of experiences and education that are transformative for this important group of astronomy researchers.

Rasch Analysis of Scientific Literacy in an Astronomical Citizen Science Project *(Poster abstract)*

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Abstract We investigate change in attitudes towards science and belief in the nature of science by participants in a citizen science project about astronomy.

A pre-test was given to 1,385 participants and a post-test was given six months later to 165 participants. Nine participants were interviewed. Responses were analyzed using the Rasch Rating Scale Model to place Likert data on an interval scale allowing for more sensitive parametric analysis. Results show that overall attitudes did not change, $p = .225$. However, there was significant change towards attitudes relating to science news (positive) and scientific self efficacy (negative), $p = .001$ and $p = .035$, respectively. This change was related to social activity in the project. Beliefs in the nature of science exhibited a small but significant increase, $p = .04$. Relative positioning of scores on the belief items suggests the increase is mostly due to reinforcement of current beliefs.

The Citizen Sky Planetarium Trailer *(Poster abstract)*

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Abstract Citizen Sky is a multi-year, citizen science project focusing on the bright variable star ε Aurigae. We have developed a six-minute video presentation describing eclipsing binary stars, light curves, and the Citizen Sky project. Designed like a short movie trailer, the video can be shown at planetariums before their regular, feature shows or integrated into a longer presentation. The trailer is available in a wide range of formats for viewing on laptops all the way up to state-of-the-art planetariums. The show is narrated by Timothy Ferris and was produced by the Morrison Planetarium and Visualization Studio at the California Academy of Sciences. This project has been made possible by the National Science Foundation.

The World Science Festival *(Abstract)*

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Presented at the 100th Spring Meeting of the AAVSO, May 22, 2011

Abstract New York City in the late 20th century rose to be a planetary capital

for the sciences, not just astronomy. This growth was mainly in the academic sector but a parallel growth occurred in the public and home field. With the millennium crossing, scientists in New York agitated for a celebration of the City as a place for a thriving science culture. In 2008 they began World Science Festival. 2011 is the fourth running, on June 1–5, following the AAVSO/AAS meetings. World Science Festival was founded by Dr. Brian Greene, Columbia University, and is operated through the World Science Foundation. The Festival is "saturation science" all over Manhattan in a series of lectures, shows, exhibits, performances. It is staged in "science" venues like colleges and musea, but also in off-science spaces like theaters and galleries. It is a blend from hard science, with lectures like those by us astronomers, to science-themed works of art, dance, music. Events are fitted for the public, either for free or a modest fee. While almost all events are on Manhattan, effort has been made to geographically disperse them, even to the outer boroughs. The grand finale of World Science Festival is a street fair in Washington Square. Science centers in booths, tents, and pavilions highlight their work. In past years this fair drew 100,000 to 150,000 visitors. The entire Festival attracts about a quarter-million attendees. NYSkies is a proud participant at the Washington Square fair. It interprets the "Earth to the Universe" display, debuting during IYA-2009. Attendance at "Earth..." on just the day of the fair plausibly is half of all visitors in America. The presentation shows the scale and scope of World Science Festival, its relation to the City, and how our astronomers work with it.

New Life for Old Data: Digitization of Data Published in the *Harvard Annals (Abstract)*

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Abstract We describe the volunteer-driven project to digitize published

visual observations found in the *Annals of the Harvard College Observatory*, the publication of record for Harvard's variable star data archives prior to the founding of the AAVSO. The addition of published data from the 19th and early 20th centuries to the AAVSO International Database has the potential to enable significant new science by extending long term light curves farther back in time with high-quality visual and photographic data. AAVSO volunteers working on this project have together digitized over well over 10,000 observations from the *Harvard Annals*, adding decades to the light curves of some stars. We highlight the work done so far, and show the potential to expand the project by both AAVSO Headquarters and by the volunteers themselves.

Data Release 3 of the AAVSO All-Sky Photometric Survey (APASS) *(Poster abstract)*

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Abstract APASS is an all-sky survey in five filters (B,V,g',r',i') covering the magnitude range 10–17. It is currently underway at two sites: Dark Ridge Observatory in New Mexico, and CTIO in Chile. The survey will take approximately two years to complete, and will provide a precision of 0.02 magnitude for well-sampled stars. This paper presents the current status of the project and provides the access methods to the catalog.

Data Evolution in VSX: Making a Good Thing Better *(Abstract)*

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Abstract A review of the current status of the AAVSO International Variable Star Index (VSX) is presented. Starting with an heterogeneous set of catalogs automatically imported, the data included in VSX have been constantly evolving and the role of observers contributing their new discoveries or revising known variable stars is growing more important each day. Examples are given of the improvements made in several aspects of star data such as identification, classification, elimination of duplicate entries, and updates.

VSX: the Next Generation *(Abstract)*

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Abstract The AAVSO International Variable Star Index (VSX), the most comprehensive and up-to-date assemblage of publicly-maintained variable star data on the planet, will be undergoing a major overhaul in the coming year to greatly improve the database design, as well as the Web-based user interface. Five years after its official launch, VSX has evolved into an essential component of the AAVSO enterprise information architecture, tightly integrated with many of the technical organization's other mission-critical processes. However, its unique configuration and functionality are largely based on decades-old data formats and outmoded Web methodologies which will generally not scale well under the anticipated deluge of data from large-scale synoptic surveys. Here, we present the justifications and vision for VSX 2.0, the next generation of this indispensable research tool, including overviews of the creation of a brand new, fully-normalized, database schema, and the ground-up redesign of the front-end Web interface.

AAVSOnet: the Robotic Telescope Network *(Poster abstract)*

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Abstract AAVSOnet is the growing network of robotic telescopes owned and operated by the American Association of Variable Star Observers. With telescopes ranging from 60-mm to 0.61-m in aperture located around the globe, the network fulfills a multitude of science goals. The largest telescopes will be fitted with instruments capable of doing both spectroscopy and photometry. We have pairs of 20-cm telescopes in Chile and New Mexico conducting an all-sky photometric survey (APASS) from 10th to 17th magnitude. These pairs of telescopes monitor the sky in two filters simultaneously in Johnson B and V, as well as Sloan g, r, i, and z. There are telescopes in the 25–35-cm range available to conduct automated programs of stars selected by AAVSO members, and five small telescopes monitoring poorly studied stars brighter than 10th magnitude in both the southern and northern hemispheres. All the data for every star on every image are archived at AAVSO headquarters for future data-mining; images are uploaded to member accounts where they can be analyzed by a powerful suite of photometric tools and observations submitted to the AAVSO International Database.

Hα Emission Extraction Using Narrowband Photometric Filters *(Abstract)*

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Abstract Maria Mitchell Observatory (MMO) has explored using Narrowband Photometric (<100Å) filters to substitute for spectroscopic observations. The method is thought to have significant signal-to-noise advantages over spectroscopic observations for small telescopes. These small telescopes offer advantages for projects requiring intensive monitoring where telescope time is limited on larger telescopes. RR Tau, a suspected UXOR, was intensively observed by the MMO 0.6-m Ritchey-Chrétien telescope in Nantucket, Massachusetts, and the 0.29-m W28 AAVSOnet telescope from Cloudcroft, New Mexico, during the 2010 Winter and Spring seasons. Observations were

made in Hα with 45Å and 100Å narrowband filters as well as the continuum at 6450Å with 50Å and 100Å filters. Hα emission was extracted with an error of 8% and compared to the change in the continuum. RR Tau exhibited a 30% change in emission while the continuum changed by over a factor of 5.

Automation of Eastern Kentucky University Observatory and Preliminary Data *(Poster abstract)*

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Presented at the 100th Annual Meeting of the AAVSO, October 8, 2011

Abstract Eastern Kentucky University is a regional comprehensive institution located in Richmond, Kentucky. Its service area includes much of the eastern part of Kentucky, commonly referred to as Appalachia. As such, Eastern has truly been a "school of opportunities" for the region. We offer three astronomy courses and one of them, AST 135, has an outdoor lab component, in which the students observe the moon and the brightest planets using 6-inch SCT. To expand our offerings by adding advanced classes in observational astronomy, and with support from the University and a small grant from the AAS (Small Research Grants), we constructed a small observatory for that purpose.

We have a 14-inch telescope (C14 from Celestron), with a research grade mount (Paramount ME), housed permanently in a two-room facility. The telescope room has a retractable roof and the control room is insulated against the elements. The telescope is conveniently located near campus, in a location away from city lights and vehicular traffic, with access via a secure gate. The observatory is on a concrete pad poured directly onto the ground, to minimize vibrations. The instrument package consists of a SBIG STL-6303E CCD camera with filter wheel and full complement of photographic, narrow-band, and photometric filters (Hα and UBVRI). Courtesy of the AAS grant, we also have a temperature-compensated focuser (TCF-S3i), off-axis guider, and SBIG AO-L adaptive optics accessory.

Our first step has been the measurement of our CCD transformation parameters, to assess the capabilities of our telescope-camera combination. We imaged a standard photometric field from Landolt (1992) (R.A. $09^h\ 21^m\ 32^s$, Dec. +02° 47' 00" (J2000, Plate 38 of Landolt). Data were obtained with a time integration of 90 seconds, binned 2 × 2 (~1 arcsec/pixel) at air mass X = 1.31. We determined the CCD transformation parameter as described by the AAVSO

document "Computing and Using CCD transformation coefficients" (Cohen 2003). We obtained the following:

$$T_{bv} = 1.329;\ T_{vr} = 1.000;\ T_{ri} = 0.912;\ T_{v} = -0.065;\ T_{r} = -0.042$$

We estimate a 5% uncertainty in our measurements. This past summer, with student support, we were able to perform our first measurements of light curves, particularly of the AAVSO Short Period Pulsator Program—suggested δ Scuti star DY Her and the RR Lyrae stars UU Boo and XX Cyg. Our light curves (we have two complete BVRI sets for DY her) were not corrected using our transformation parameters, but just compared with the reference stars provided by AAVSO. We will present the data obtained and our current efforts in automation of the observatory operations. We have the necessary hardware to monitor the environment via video and remotely operate the roof and the telescope.

References

Landolt, A. J. 1992, *Astron. J.*, **104**, 340.

Cohen, L. 2003, "Computing and using CCD Transformation Coefficients," AAVSO internal document (http://mira.aavso.org/sites/default/files/ccdcoeff.pdf).

Status of the USNO Infrared Astrometry Program *(Poster abstract)*

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Abstract The USNO Infrared astrometry program has been in a suspended state since a June 2006 cryogenic accident with our imaging camera. We describe the current status of bringing the program back to full operation. We expect to re-start an expanded astrometric program in the near future and present our initial list of targets. This will also provide an opportunity for the community to suggest potential cool, low-mass targets which are in need of high quality parallaxes and proper motions. We earlier published preliminary astrometric results for 40 L and T dwarf fields based on the first two years of observations (Vrba *et al.*, Astron. J., 127, 2948 (2004)). Those initial objects plus an additional nineteen fields added later comprise a total of one M dwarf, twenty-eight L dwarfs, and thirty-nine T dwarfs, including objects in binary systems. Final parallaxes and proper motions for these objects will be published later this year. The additional approximately four years of observations for the original forty objects improve the mean parallax errors orginially reported from 4.31 mas to 1.73 mas, with the best at 0.64 mas, and the mean proper motion errors from 6.56 mas/yr to 1.09 mas/yr.

Variable Star Observing With the Bradford Robotic Telescope *(Abstract)*

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Abstract The Bradford Robotic Telescope (BRT) is a collection of telescopes and other instruments located on Mount Teide, Tenerife, Canary Islands; this resource is available to all for use at no cost (http://www.telescope.org/info/BRT_information). With the recent addition of Johnson *BVRI* filters on the BRT's 24 square arc minute camera, this telescope has become a resource to be considered when monitoring certain stars such as LPVs. This presentation will examine the mechanics of observing with the BRT and show examples of work that has been done by the author and how those data have been reduced using VPhot.

Solar Cycle 24—Will It Be Unusually Quiet? *(Abstract)*

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Abstract For the last forty years or so all the AAVSO (American Association of Variable Star Observers) Very Low Frequency (VLF) Sudden Ionospheric Disturbance (SID) data have been sent to NGDC (National Geophysical Data Center). In this paper these data are put into a database and graphed in hopes of understanding these VLF SID submissions. The graphics show the NGDC accumulated Importance Rating (an index of the duration of solar flares) for all the AAVSO VLF SID submissions over the past forty years. And, if we compare these VLF SID data with the last three solar cycles of sunspot number counts compiled by the Solen group (Jan Alvestad: http://www.solen.info/solar/cyclcomp.html), it seems that the AAVSO VLF SID submissions to NGDC show our accumulated Importance Rating signals lag by 18 to 24 months after the start of each of the last three solar cycles! That puts our VLF radio's SID IR index measure at a point where it takes at least 100 sunspot counts per month before the VLF SID accumulated IR index even shows a signal through the noise floor of our ionosphere. The VLF observer's importance rating index is just monitoring the tip of these solar cycles with our VLF radios when compared to the sunspot number count indexes. And if the Solen sunspot predictions are right for Cycle 24, the solar sunspot peak won't even reach the 70 mark for this next cycle. So, our VLF SID IR index signal submissions may not even be detectable in Cycle 24!

A Generalized Linear Mixed Model for Enumerated Sunspots *(Abstract)*

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Abstract Monthly sunspot counts data from consistently submitting AAVSO observers were provided to determine monthly average sunspot numbers and the individual observer parameters that correct each observer's counts to the monthly average. The data span a fourteen-month period from May 2010 through June 2011. The parameters are determined from a mixed-effects, loglinear model constructed specifically from the fourteen months of Poisson-distributed sunspot numbers. This model differs in the treatment of the data distribution assumptions of the existing linear regression model developed by Shapley (1949). The loglinear model methodology exceeds the correction coefficient performance criteria set by Shapley, and provides a method for determining the relative sunspot number reported monthly by the American Association of Variable Star Observers Solar Section. Model improvements are discussed.