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AAVSO Newsletter



LISTEN UP!
RESTLESS UNIVERSE
THE NEW AAVSO PODCAST
FOR IYA.4

FROM THE DIRECTOR'S DESK

ARNE A. HENDEN

Another year has passed! I've been Director for 3 years and 10 months (but who is counting...), and have had a lot of fun. We've made great strides in updating the organization, from porting the AAVSO International Database into a relational database, VSP, VSX, new standardized formats, improved sequences, and enhanced publications like *eAAVSO* and the revamped *Newsletter*. Three overriding goals are at the heart of any change: improving the efficiency of headquarters staff; making it easier for observers to make their observations in a reliable, scientific manner; and providing better support to the professional researchers and educators using the submitted data.

The biggest change this past calendar year has been the improvement in the comparison star database. We've revised many of the measures so that the photometry is far more reliable and the sequences make more sense to the visual observer. At the same time, multi-wavelength photometric calibrations were added to support the CCD observer. We've continued our all-sky calibrations at Sonoita Research Observatory, especially of the Long Period Variable fields where the existing sequences were in pretty bad shape.

The robotic observatory network (AAVSONet) is expanding, with the Mt. John University Observatory telescope nearly ready to go on-line, and Paul Wright's telescope at Tom Krajci's New Mexico site now available. We'll be working on the headquarters telescope in the spring, so that the building will actually start looking like an astronomical facility with a fresh white dome on top! AAVSONet will really take shape in 2009, so keep tuned and think hard about projects that can be performed by these telescopes around the world.

Aaron, Matt, Mike Simonsen, and myself have been writing grant proposals. Hopefully some of these neat new projects will be awarded, and when that happens, I'll announce them on the discussion group. Many of the new projects will depend on volunteers, so I hope you all get involved!

The economic crunch has hit us all, including the AAVSO. So far, we are in acceptable financial shape and all losses are "virtual" as we use our cash reserves, but either the situation will show signs of turning around soon, or we will

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THE INTERNATIONAL YEAR OF ASTRONOMY...

The United Nations officially declared 2009 to be the International Year of Astronomy. The AAVSO is proud to be taking part by leading a capstone project: the monitoring rare and mysterious 2009-2010 eclipse of Epsilon Aurigae. In the summer of IYA 2009, third-magnitude Eps Aur will experience its next eclipse, which occurs every 27.1 years and lasts 714 days, nearly two years! Projects are being developed to include three audiences: amateurs, the general public, and educators, in this exciting observing campaign. For more info on the IYA check out www.astronomy2009.org.



PRESIDENT'S MESSAGE

DR. PAULA SZKODY

The start of a new year always brings out the promise of new ways of doing things. Change is in the air, starting with a new president and a different way of working with the world scene, as well as a change in our individual lives as we deal with the economy and our retirement accounts. The future can't be predicted, but the AAVSO Council spent time at its meeting in Nantucket thinking about how best to position the AAVSO for whatever it is the future holds. This involved both safeguarding our endowment and continuing to move forward to remain at the forefront of variable star observing.

One change that we are attempting is to move the current loose committee structure into sections that can provide more direction to observers. These sections will have a chair, one or more science advisors that are tied into the professional community, and one technical person that

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THE 97TH AAVSO FALL MEETING

Access the full archive and highlights of the AAVSO's 97th Annual Meeting now online at: <http://www.aavso.org/aavso/meetings/archivefall08.shtml>. You can check out photos, watch video of key talks, the data mining workshop, MMO sessions, and access the PDFs and PowerPoint presentations from the scientific paper session, and also read comments from MMO Director Vladimir Strel'nitski and AAVSO Councilor Kate Hutton.

FROM THE DIRECTOR'S DESK CONTINUED...

need to start implementing belt-tightening measures. Much of our funding depends on our endowment and on donations from our members and observers, so please keep us in mind as you make your gift-giving plans.

So what is coming in the next year? Kate Davis is revamping the web site; a fresher-looking appearance will be obvious, but the main goal is to make it easier to find things on the site. Doc will be working on the AAVSONet features, making it possible to obtain calibration photometry from our existing million-star photometric database and obtaining images of any area of the sky that we've covered. Kate Hutton and Mike Simonsen are working on the LPV section, a forerunner on our new section-oriented structure. Two great meetings (a joint one with SAS at Big Bear, CA in May, and the fall meeting in Boston) are on tap, and Rebecca is even starting work on the joint AAS and AAVSO meeting during our 2011 centennial year. We're doing 12 episodes for the 365 Days of Astronomy podcast, starring Mike Simonsen, Rebecca, and Travis. New observing tools will come on-line, courtesy of Aaron, Sara and Elizabeth. The epsilon Aurigae campaign will be underway. Kepler will be launched, and Hubble will be repaired. It sure sounds like another fun year to me! ★

PRESIDENT'S MESSAGE CONTINUED...

will handle web pages, wikis, and electronic communication between members. The seven sections will be: EBs/exoplanets, Short Pulsators, LPVs, CVs/transients, IT/database/surveys, Solar, and Education. The Council members plan to find chairs for these sections by the Spring meeting. The chairs will then pick the science advisors and tech people and determine how they want to handle their section. The hope is that by the end of 2009, each section will have a list of the most important objects to observe and the science that can be best served.

Another change on the horizon is increased ability for robotic observing, both in the northern and southern hemispheres. In the near future, there will be time available on four telescopes that will comprise AAVSONet to be used by AAVSO members.

Lastly, another important change that has happened recently and will continue into the future is the vastly expanding data coming from surveys. The workshop at Nantucket began to touch on these issues; how to access the existing databases and what is coming in the future. David Hogg inspired everyone with his enthusiasm for the possibilities. The difficulties of good internet conditions on the island prevented a real workshop with all participants on laptops or desktops trying out access, although Aaron Price managed to cover a lot of ground nonetheless (see his presentation on the AAVSO website [here](#)). However, this topic generated so much interest that we will repeat and expand this into an interactive workshop at the spring meeting in Big Bear, California. More details will come later, but come prepared to hook in by wireless and get into the databases. Arne has created an excellent summary on amateur science in the era of surveys, what needs to change and what will remain of the same importance.

Speaking of the workshop, the Nantucket venue was a lot of fun (notwithstanding the difficulties of flying in high winds on a small plane or having ferries cancelled due to the same!). Celebrating the 100th anniversary of MMO and hearing about its history and having a tour of the town and

observing sites was a real treat, thanks to Vladimir Strel'nitski and Toni McKerrow from MMO. Robert Naeye provided interesting details on both exoplanets and being a science editor. Plus, we managed to totally surprise Vladimir and Lee Anne Willson with their awards.

Happy 2009, may we all have record clear skies this year. ★

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS

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NEWSLETTER EDITOR	Travis J. Searle
EYEPIECE VIEWS EDITOR	Gamze Menali
DEVELOPMENT	Michael A. Simonsen

The *AAVSO Newsletter* is published in January, April, July, and October. Items of general interest to be considered for the *Newsletter* should be sent to travis@aavso.org. Additional photos in this issue courtesy of Gamze and Haldun Menali, Michael Saladyga, and the AAVSO Archives.

Membership in the AAVSO is open to anyone who is interested in variable stars and in contributing to the support of valuable research. Members include professional astronomers, amateur astronomers, researchers, educators, students, and those who love variable star astronomy.

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AWARDS and RECOGNITION

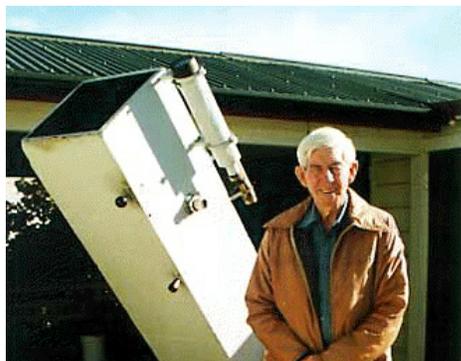
PRESENTED AT THE 97TH FALL MEETING - NANTUCKET, MASSACHUSETTS

THE AAVSO MERIT AWARD

The AAVSO Merit Award is presented to members who are deemed to have made an outstanding contribution as an observer, or as a long-standing benefactor. Both the 40th and 41st Merit Awards were presented this fall. The first to **Lee Anne Willson**, for her service and leadership as AAVSO president and councilor, and her devotion to astronomy education, collaboration, and research. The second award went to **Albert Jones**, for his dedicated contributions to variable star astronomy for over 60 years, including over 500,000 visual observations of Southern Hemisphere stars.



Recipient of the 40th AAVSO Merit Award, Lee Anne Willson, accepts her certificate from Director Arne Henden in Nantucket, October 2008.



41st Merit Award honoree and long-time member and observer Albert Jones poses next to his telescope at home in Nelson, New Zealand, in 2004.

THE WILLIAM TYLER OLCOTT DISTINGUISHED SERVICE AWARD

Initiated in 2000, this award is presented to a member of the AAVSO for outstanding contributions in mentoring and promoting variable star astronomy. The recipient of the 2008 Olcott Award was Dr. Vladimir Strel'nitski, for his vigorous and ongoing promotion of astronomy to the public and his devoted mentorship of future astronomers through the Maria Mitchell Observatory REU Program.



AAVSO Director Arne Henden (L) presents the 2008 Olcott Award to Maria Mitchell's Vladimir Strel'nitski.

SOLAR/SID AWARDS

The solar observer awards are presented to solar observers who have reached milestones sunspot observations. For a cumulative contribution since 1999 of 1500 sunspot observations in support of the American Relative Sunspot Number program and service to the AAVSO Solar observing program, certificates were awarded at the 97th Annual Meeting to:

Mike Boschat
Mieczyslaw Szulc
The IPS Observatory

For a cumulative contribution of SID data reports for at least 40 months in support of the National Geophysical Data Center SID Database and service to the AAVSO Solar observing program, certificates were awarded to:

Michael King
Paul Mortfield

DEVELOPMENT UPDATE

MICHAEL A. SIMONSEN

The Top Ten Reasons People to Contribute to the AAVSO:

10. I've reached a point in my life where I can afford to give to my favorite non-profit organizations, and AAVSO is on top of the list.

9. I want to leave an important legacy when I'm gone. My financial advisor says it isn't that hard to do.

8. I use AAVSO data in my research and this is a good way to thank the organization for this important resource.

7. Janet Mattei.

6. I buy a lot of stuff from Amazon.com. Every time I do I use the link from the AAVSO home page so the AAVSO gets a percentage of my total purchase amount. I get stuff, and AAVSO gets a contribution.

5. I use the AAVSO website, the light curve generator, the Variable Star Plotter, Quick Look data, and VSX all the time. It costs money to keep all that running, right?

4. It was easy and convenient to add my contribution to my annual dues renewal, so I did.

3. My donations are tax deductible. I'd rather give my money to the AAVSO than the IRS.

2. I want to help pay for the new headquarters building. It's awesome!

And the **NUMBER ONE** reason to contribute to the AAVSO is:

"I believe in the goals and mission of the AAVSO, and know that my support insures the future of this grand organization."

The reason you should make a donation today:
All of the above. ★

THE AAVSO AND 365 DAYS OF ASTRONOMY



We're pleased to announce that the AAVSO has agreed to write and produce twelve [podcasts](#) for the IYA 2009 project, 365 Days of Astronomy.

The [365 Days of Astronomy Podcast](#) will publish one podcast per day, for all 365 days of the International Year of Astronomy, 2009. The podcast episodes are written, recorded, and produced by people from around the world. Our show is called **Restless Universe** and features Travis Searle, Rebecca Turner, and Mike Simonsen. We'll be talking about variable stars and related topics. The first episode will air **January 7th, 2009**. Restless Universe will air on the 7th of each month throughout 2009. If you miss the original airing, you can find us in the [archives](#) for the [rest of the year](#).

You can subscribe to both the 365 Days of Astronomy podcast and blog using the [available RSS feed](#) or via Apple's iTunes. 365 Days of Astronomy, that's what IYA 2009 is all about. We hope you'll tune in! ★

THE 2009 AAVSO CALENDAR

Now available: The official 13 month 8.5" by 11" wall calendar featuring images contributed by AAVSO members and observers. Julian dates are listed for each day of the year.



The calendars are shipped sealed in plastic. Limited supplies are available so [order now!](#) \$11.99 plus postage.

THE AAVSO'S CENTENNIAL HISTORY

AAVSO member and past-president Thomas R. Williams, and AAVSO staff member Michael Saladyga are working together as co-authors of what promises to be a substantial and well-documented history of the American Association of Variable Star Observers.

The book, titled *Advancing Variable Star Astronomy: The Centennial History of the American Association of Variable Star Observers*, will be published by the Cambridge University Press. The book's release is expected to coincide with the AAVSO's 100th anniversary celebration in 2011.

Williams and Saladyga spent much of 2007 in preparing an outline and proposal of the book, and in seeking-out prospective publishers. The actual research and writing of the book is now well underway.

This will be a full-length history, a book of about 500 pages, with thorough documentation of sources. It will include a bibliography and index,



AAVSO Centennial History co-authors Thomas R. Williams (L) and Michael Saladyga (R).

and will be well-illustrated. An additional feature will be a number of sidebars covering the people of the AAVSO and the scientific ideas of variable star astronomy; these will be written by volunteer contributors from the professional and amateur communities.

Over the last 100 years, the AAVSO developed from a modest beginning as an organization of amateur astronomers into the most highly-regarded example of "citizen science," in which both amateur and professional astronomers advance the cause of science and science education.

This book-length centennial history will make available for the first time an accurate and thorough institutional history for scholars while celebrating the achievement for AAVSO members. ★

SPRING 2009: BIG BEAR, CALIFORNIA

The 98th Spring Meeting of the AAVSO

Join the AAVSO May 19-21, 2009, for a joint meeting with the 28th Symposium on Telescope Science of the Society for Astronomical Sciences (SAS). Amateurs and professional astronomers will discuss the use of CCD cameras, software, hardware, and the latest CCD, photometric, and spectroscopic techniques.

Location and Preliminary Details:

The meeting will take place at the Northwoods Resort, Big Bear Lake, California. You can visit the Northwoods website at: <http://www.northwoodsresort.com/>. Fees: **preliminary** \$30 member registration, \$99 guest rooms, \$35 banquet fee. The program will include paper sessions, talks, workshops, and a banquet on the evening of the 21st. Audio from the meeting will be broadcast live!

A detailed schedule and registration web site will available in January 2009. More information will be posted as it is available on the AAVSO website and at the SAS website: <http://www.socastrosci.org/>. ★



NUCLEOSYNTHESIS AND THE MOON CARRIER

BY ALAN PLUMMER (PAW) LINDEN OBSERVATORY, NSW, AUSTRALIA

Recently, an important anniversary in the history of science passed almost unnoticed. 2007 marked the 50th anniversary of the publication of the work describing where you, I, and almost all the stuff we see, comes from. The work was done by Margaret and Geoffrey Burbidge, William Fowler, and Fred Hoyle, and the paper was titled 'The Synthesis of the Elements in Stars' (in *Rev. Mod. Phys.* 29, 547 - 650 (1957), also called B²FH). This publication was but one of the steps in what is a monumental achievement; understanding the creation of the elements.

This is not just an abstract story. Any amateur astronomer with a small telescope can see, to some degree at least, the synthesis of the stuff of life and where it lives. Though to see clearer through the eyepiece we need to 'stand on the shoulders' of not only the Burbidges, Fowler, and Hoyle, but also those of Einstein, Eddington, Bethe, and more. And Moon Carrier; his work underpins a big part of this story. (I'm not the first to use this nickname in this way. Some readers will know already who Moon Carrier is; others will have to read on.)

Current understanding holds that the Big Bang made the lightest elements only: hydrogen, helium, and traces of lithium. The former is central to life's chemistry, and the later two not so. Elements heavier than these have been, and still are, synthesized from this starting point. We're going to need five nuclear reactions for this discussion: the p-p chain, the CNO cycle, the triple- α process, and both the s- and r-processes. There is a brief description of these in the APPENDIX, which can be skipped, but I urge the reader to have a go.

Now we're prepared to look at what makes life and where it lives. We're standing on mostly oxygen, silicon, aluminum, iron and so forth; a lot of it in the form of silicates like beach sand and so on. The atmosphere is largely nitrogen and oxygen, and smiling back at you in the mirror is mostly carbon, hydrogen, oxygen, and nitrogen.

Carbon, and more...

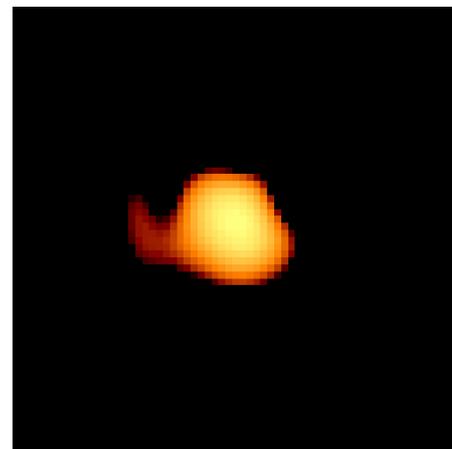
Most of the carbon in the universe comes from carbon stars. These particular stars are slightly more massive, and much more evolved than the Sun. They are a sub-class of red giant stars. Here, hydrogen (H) in the core has already been fused, or burnt, into helium (He) through the CNO cycle, and the helium then burns, via the triple- α process, into carbon and oxygen.

The carbon star's envelope becomes enriched with elements made by the s-process: zirconium, strontium, and some of all the elements up to iron. Some of the triple- α products from deeper in the star find their way into the envelope, too, including the all-important carbon, plus some nitrogen, oxygen, magnesium, and more. These are brought to the surface through convection, similar to that seen in a pot of boiling water.

These stars have cooler envelopes than do Sun-like stars because they are 'puffed out' to a size comparable to our inner solar system. The lower envelope temperatures allow complex molecules to form and be ejected over time into interstellar space during the final evolution of the star. They become cloaked in dusty carbon 'soot' and molecules that are important for life. In fact, the presence of carbon in molecules *defines* organic chemistry.

One of the brightest carbon stars in the sky is R Leporis. Lying just to the south of Orion and plotted in most atlases; it looks like a red hot coal in the eyepiece. So too are U and Y Hydrae easily found on most charts. Compare these to the less evolved star Sirius, which appears as a brilliant white diamond in the eyepiece.

Hans Bethe (1906-2005) did a lot of the work in determining the nature of the p-p chain and CNO cycle. These reactions were not easy to find; they are extremely unlikely to occur and are only possible *at all* in complex 'chains' and 'cycles'. Bethe was looking for the way in which



Mira (Omicron Ceti). Photo Credit: Adam Block/NOAO/AURA/NSF.

the Sun could fuse hydrogen into helium and so release energy. He worked out the CNO cycle first, although it turned out that this needs a higher temperature than is found in the Sun, like that in the more massive carbon stars. The Sun at present is powered by the p-p chain, which Bethe worked out soon after the CNO cycle.

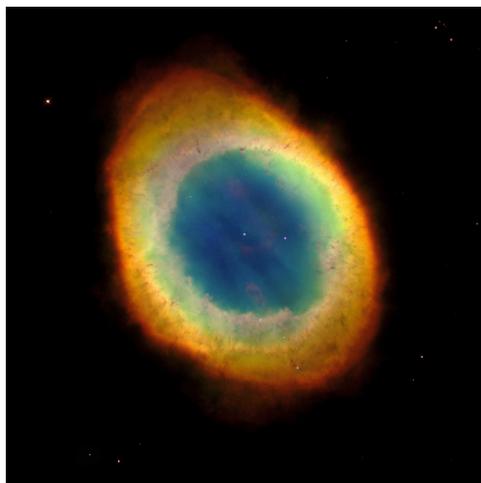
Nitrogen, and more...

Most of the nitrogen in your body and in the air, and a portion of the silicates under your feet, comes from oxygen-rich red giant stars losing their envelopes to interstellar space. There are still the carbon 'soot' and s-process elements present; however, these giants are characterized more by the presence of molecules such as titanium oxide (sunscreen!). As a by-product of the CNO cycle, the envelope is also rich in nitrogen.

There are many O-rich red giants easily found; R Doradus is possibly the closest to us, and will be marked on most atlases a bit northeast of the Large Magellanic Cloud. Not as red as R Lep, it looks like an amber jewel in the eyepiece. Other O-rich giants easily found are R Centauri and the famous Mira in Cetus, pictured in the photo at the top of this page.

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PLUMMER: NUCLEOSYNTHESIS AND THE MOON CARRIER



The Ring Nebula. Photo Credit: The Hubble Heritage Team (AURA/STScI/NASA)

During a later evolutionary stage these stars are visible as fuzzy planetary nebulae (PNe). The star sheds its nitrogen rich envelope which can then be lit up by the newly exposed and *very* hot core, which is now called a white dwarf. Remember the triple- α process; the white dwarf will be carbon and oxygen ‘ash’, and sometimes, if the ‘burning’ has continued further, oxygen, neon, and magnesium.

Any atlas will show a plethora of PNe. The northern Ring Nebula looks like a smoky bicycle wheel hung in space, with a dark sky and 15-20cm or more telescope aperture. And the southern NGC 3918 is a smaller and bright blue patch viewed with a similar aperture.

It is for the s-process (and r-process below) that the B²FH paper was so important. Margaret Burbidge was an astronomer, who tempted her physicist husband Geoffrey into astrophysics to join in the work. It was Fred Hoyle (1915-2001), though, who was the driving force behind the paper, but with politics in science as everywhere, it was only Fowler (1911-1995) who received the Nobel Prize. Hoyle had too many crackpot ideas, like the building blocks of life coming to earth from space, (an idea now considered extremely plausible; and he was a sci-fi writer to boot!) for

the Committees’ taste. Fowler, on the other hand, was a mathematician of excellent reputation, and much more ‘sound’.

Oxygen, and more...

The most significant sources of oxygen in the universe are core-collapse supernovae (SNe). The most massive of stars, of 8-10 up to 100 times the mass of the sun, lose vast amounts of mass into space (quickly!), before exploding as supernovae. Here, the hydrogen core has burnt first into helium, then to carbon, oxygen, neon, magnesium, and so on right up to iron; and the s-process continues synthesizing other elements in the envelope.

The most famous core-collapse supernova, SN 1987A, is estimated to have ejected a staggering 1.6 times the mass of the Sun of oxygen alone, plus all the other elements in the envelope. And here we meet Moon Carrier.

Moon Carrier (1910-1995) was born in India and his real name in Sanskrit means ‘He Who Carries the Moon’. Although educated at Madras University, he still had to largely educate himself in quantum mechanics by reading the original papers. On his boat trip westward to England at the age of 19, he came to the conclusion that a white dwarf star could only exist *up to* a mass of around $1.4M_{\odot}$ (M_{\odot} means a mass equal to one Sun) and after that, matter must take on a new and heretofore unheard of state, now called ‘degenerate’. It turns out that this change in nature of the stellar core is what drives the supernova explosion. His work goes to the heart of this story; the nature of matter and how it behaves in the cores of massive stars. And no one believed him. Or rather, no one *admitted* that they believed him.

In England, Arthur Eddington (1882-1944) was the pre-eminent physicist of the time, and what he thought was Obviously Correct. While contributing to the unraveling of these five nuclear processes in a big way, he did Moon Carrier no favors. He not only wrongly refuted his theory, but publicly humiliated him. Eddington organized

an extra long time slot for Moon Carrier to present his work to the Royal Astronomical Society, and had secretly booked the following time to pull his work to pieces. Moon Carrier didn’t stand a chance, and the Powers That Were denied his right of reply. He was young, had dark skin, and was from the colonies. He published with difficulty, and let the work stand or fall. It stood, but got recognition only after Eddington died in 1944.

It took until 1983, nearly 50 years after the Society’s meeting, for Moon Carrier to be awarded the Nobel Prize for that work. Actually, he shared that year’s prize with Fowler for the B²FH paper. More recently, an orbital observatory was named after Moon Carrier.

To return to our story; core-collapse SNe don’t release much iron. Once the massive star’s core is processed into *all* iron, it catastrophically collapses into the new-born neutron star, whose existence was deduced by Moon Carrier. Nor are huge amounts of the r-process elements made, these are synthesized in greater quantity in thermonuclear supernovae.

Iron, and more...

The primary sources of iron and heavier elements in the universe are thermonuclear supernovae, also called type 1a SNe. These are very different objects to the core-collapse type; thought to be close binary systems in which a white dwarf can gain mass from the partner and so reach a critical mass of $\sim 1.4M_{\odot}$ and *completely* explode. This thermonuclear explosion makes in one fell swoop all the r-process elements up to iron and beyond, including silver, gold, uranium and such.

A single typical thermonuclear supernova will produce so much iron that it alone would weigh half as much as the Sun, plus a significant amount of sulfur and argon. Type 1a SN explosions are probably where the individual Fe atoms in your body and under your feet have been made.

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PLUMMER: NUCLEOSYNTHESIS AND THE MOON CARRIER



Supernova 2005df in NGC 1559, discovered by Bob Evans. Photo Credit: ESO PR Photo 26/05.

If you want to observe a supernova with a telescope, you have to be keen, or lucky! The best way is to keep an eye out on www.rochesterastronomy.org/snimages/ for a new discovery that is visible with your sized telescope. The type 1a SN 2005df pictured above was observed by me for a few days with only a 20cm scope, from 30 million light years away.

Some likely core-collapse SNe candidates on your atlas are Betelgeuse, Gamma-2 Velorum, and Eta Carinae. (Of course, if any explodes tonight you'll not need the map!) For likely thermonuclear SNe progenitor systems try watching U Scorpii or V445 Puppis, with charts available from the AAVSO's [VSP](#). You'll need 30cm and more telescope aperture for these, though.

CONCLUSION

This project was (and still is; there is much not yet pinned down) a decades long team effort. Eddington was one of Einstein's greatest advocates. It was Eddington's book on general relativity that Moon Carrier had on his boat trip to England, and despite the above mentioned behavior, the two men apparently always maintained a friendship.

Fowler was Moon Carrier's academic supervisor in England, and wrote that Bethe's publication in 1939 of the CNO cycle changed his life. Bethe joined the Manhattan Project with Einstein, but Moon Carrier, although invited, did not. Hoyle,

while not invited, apparently guessed what was going on in the top secret project, because he was keenly interested in all things concerning nuclear physics. It was with the atom bomb that the power of the r-process was first seen; in the tests elements up to and beyond uranium were seen to be synthesized. It's also worth noting that later in Moon Carrier's career, when editor of the *Astrophysical Journal*, he took a chance (rightly) on publishing work that 'everyone knew' was likely wrong.

Moon Carrier is Subrahmanyan Chandrasekhar, of course. The mass of $1.4M_{\odot}$ is called the 'Chandrasekhar limit', and the space telescope is the Chandra X-Ray Observatory. It is certain that people not mentioned here were every bit as important as those who were, and contributed as much, so I recommend the titles mentioned below, and there will be many more in your local library.

So get an atlas and a telescope and find a carbon star if you can, a red giant or two, and some planetary nebulae. While you wait for a supernova, try for the Crab Nebula, which is a supernova remnant. I've been told that another SN remnant, the Veil Nebula in Cygnus, is visible with a 30cm telescope. And while you're doing this, think of where the carbon, nitrogen, oxygen, iron, and sulfur atoms in your body have been, even *before* they were floating around in space, later to become you. Think also of the hundreds of thousands of hour's work that have been done in order to piece this all together. And when next you get a crowd of onlookers around your telescope, tell them a story.

Help by Nick Lomb is gratefully acknowledged.

General references and further reading:

Extreme Stars: At the Edge of Creation, J. B. Kaler Cambridge University Press 2001.

Stardust, J. Gribbin, Penguin, 2000.

'*He Who Carried the Moon*', D. McLaughlin, in *Analog F&SF* July/Aug 2001. ★

APPENDIX

The proton-proton (or p-p) chain; a star of up to $4M_{\odot}$ (M_{\odot} = a mass of one Sun) will begin fusion through this process, by which four hydrogen (H) nuclei, also called protons, meld into one particle of helium (4He), also called an α particle. Fusion is the joining of two or more particles into one. There are big obstacles to overcome, but if accomplished, energy is released. Here, the by-products are two positrons, two neutrinos, and some gamma rays. Tiny traces of other elements are also synthesized.

The CNO cycle; this is a circular reaction using carbon, nitrogen, and oxygen atoms as catalysts to process four H atoms into 4He , and energy. Stars with H cores a bit more massive (and so hotter) than that of the Sun, and the Sun itself later in its evolution, will shine through this process.

The triple- α fusion process; in stars of sufficient mass, the 4He in the core can burn. This process needs a density 100,000 times that of lead, and a temperature of 100 million K. Three 4He atoms, or α particles, can fuse into a carbon (^{12}C) atom, and another α particle can join to make oxygen (^{16}O), and then also magnesium, aluminum, silicon, neon and so on. Unstable ^{13}C is produced along the way, and this is an important neutron source for the process of slow neutron capture, or the 's-process'.

The s-process; It is possible under extreme conditions for a neutron to be captured into the nucleus of another atom, thus synthesizing a new element. It is called 'slow' neutron capture not because the neutrons are slow, but because these captures are very unlikely to happen, and so the new elements are made slowly. The s-process makes strontium, zirconium, barium, and some of all the elements up to iron.

The r-process; Under even more extreme conditions, such as those found inside a supernova, or atomic bomb explosion, so many neutrons can hit so many nuclei that new elements can be synthesized rapidly. R-process elements include copper, uranium, silver, mercury, lead, and gold. In fact, the r-process is the only source of these elements, in the quantity they exist.

LEAVITT'S LAW GIVEN BIRTH AT 100TH ANNIVERSARY SYMPOSIUM

BY DOC KINNE (KQR)



Henrietta Swan Leavitt (1868-1921).

The story of Henrietta Leavitt and her discovery of the Period-Luminosity Relationship of Cepheid variables is well known to most members of the AAVSO.

Ms. Leavitt had been hired by Edward Pickering, the AAVSO's scientific advisor, as a "computer" in 1893. Computers in those days were people, usually women, who were hired to do repetitive calculations, the same sort of work which we use electronic computers to do today. Leavitt worked as such a computer at the Harvard College Observatory, just down the road from the current AAVSO HQ. Her job, along with several other women, was to do basic photometry on the photographic plates taken for the observatory. While doing this work Leavitt noticed that some types of stars seemed to have a relationship between their apparent brightness and the frequency of their pulsing variation – brighter stars pulsed more slowly. If this relationship could somehow be calibrated it would provide a useful "yardstick" to begin to measure the universe. Indeed, this is what happened, and this year we celebrate the 100th anniversary of the discovery of the Period-Luminosity Relationship of Cepheid variables.

Something discovered 100 years ago you might not think would still be a useful research tool today, but a celebratory symposium held at Harvard College Observatory this past November

would indicate otherwise. On the afternoon of November 6, 2008, Phillips Hall at Harvard College Observatory hosted a full house of attendees eager to hear ongoing research that was still using Leavitt's discovery. The AAVSO was very well represented at this gathering. Staff members Drs. Arne Henden and Matt Templeton, as well as Doc Kinne, were in attendance, but it didn't stop there. AAVSO Treasurer David Hurdis, member Anna Hillier, and research friends Drs. Margarita Karovska and Vladimir Strelitski, among others, were in the audience as well.

The program started, appropriately enough, with an overview of Ms. Leavitt's life as told by George Johnson of the New York Times, author of *Miss Leavitt's Stars: The Untold Story of the Woman Who Discovered How to Measure the Universe*, one of the largest biographical works available about this pioneering American astronomer. Johnson was able to present several fascinating tidbits about Leavitt, the person. Several places where she lived in Cambridge still stand, for example, and Johnson was able to show some photographs of those homes. He was also able to show a page of Leavitt's last will. The entire value of her estate upon her death was \$314.91. About \$200 of this was in Liberty Bonds.

Wendy Freedman of Carnegie Observatory continued, providing an interesting bridge between Leavitt's history and current research by taking a look at the past, present, and future of the Period-Luminosity relationship itself. This ranged from noting when Leavitt had started noticing the relationship on plates dated 1904, to 1912, when the relationship was noticed, but enough evidence was not thought to be there to make a claim on, then to 1925 when 24 Cepheids could be counted in the Small Magellanic Cloud. Current and future research was represented with Freedman recounting the work being done to constrain the Hubble Constant, H_0 , using data from extra-galactic Cepheid variables in M100, NGC1365, and 4414, observed with the Hubble Space Telescope. Such projects in the early part of the decade constrained H_0 to 10%. Current projects of this type hope to constrain it to 3%!

Other papers and presentations given at the symposium can be found at <http://www.cfa.harvard.edu/events/2008/leavitt/>.

One interesting conclusion was agreed upon during the symposium. It was noted that Edwin Hubble has both a physical constant and a space telescope named after him. Shapley has a galactic supercluster named for him. The discoveries of both men were made possible with the Cepheid Period-Luminosity Relationship that Henrietta Leavitt discovered. It was agreed by the symposium attendees, spurred on by Wendy Freedman, especially in light of the 100th Anniversary, that the Cepheid Period-Luminosity Relationship be henceforth referred to as 'Leavitt's Law'. Indeed, presenters in the latter half of the symposium began doing just that.

Perhaps after a century this astronomer who gave us one of the first methods of measuring the distances to the stars may finally get her proper due. ★

NOTEWORTHY

AAVSO VISUAL MANUAL NOW IN ITALIAN

A special thank you to Dr. Giuseppe Bianco for his hard work in translating the *AAVSO Visual Observing Manual* into Italian. The Italian translation is [now available online](#), along with versions in French, Spanish, Turkish, Japanese, Chinese, and Polish.

HELP!: THE MENTOR PROGRAM

Since the earliest days of the AAVSO, experienced observers have helped new observers by corresponding, answering questions, and even providing personal guidance at the telescope. Want to "talk shop" with an experienced variable star observer? Just [contact the AAVSO](#) and we will put you in touch with our mentor program coordinator. If you would like to put your equipment and skills to use contributing to science, and having fun, let us teach you how!

JULIAN DATE / MOON PHASE CALENDARS

2,450,000 plus the value given for each date

JANUARY 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1 	2 	3
4 	5 	6 	7 	8 	9 	10
11 	12 	13 	14 	15 	16 	17
18 	19 	20 	21 	22 	23 	24
25 	26 	27 	28 	29 	30 	31

SKY EVENTS: January 3-4 - Quadrantids Meteor Shower peaks.
January 26 - Annular Solar Eclipse (Africa, Southeast Asia, Australia).

FEBRUARY 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1 	2 	3 	4 	5 	6 	7
8 	9 	10 	11 	12 	13 	14
15 	16 	17 	18 	19 	20 	21
22 	23 	24 	25 	26 	27 	28

SKY EVENTS: February 9 - Penumbral Lunar Eclipse, visible throughout most of eastern Europe, Asia, Australia, the Pacific Ocean, and western North America.

MARCH 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1 	2 	3 	4 	5 	6 	7
8 	9 	10 	11 	12 	13 	14
15 	16 	17 	18 	19 	20 	21
22 	23 	24 	25 	26 	27 	28
29 	30 	31 				

SKY EVENTS: March 8 - Saturn at Opposition. March 20 Vernal Equinox (Northern Hemisphere) 11:44UT / First day of Spring.

OBSERVING CAMPAIGNS UPDATE

MATTHEW TEMPLETON

There were many observing campaigns organized and run by the AAVSO during 2008, and 2009 looks to be just as busy. As of the writing of this article, we have nine observing campaigns currently underway, including both data collection campaigns, and campaigns to support observations with the Very Large Array radio telescope, the Spitzer Space Telescope, and the VERITAS gamma ray telescope.

By far, the most extensive campaign of the past year was to assist AAVSO President Dr. Paula Szkody with HST observations of [six dwarf novae](#) known to have pulsating white dwarf primaries. Dr. Szkody required AAVSO assistance to monitor these CVs around the scheduled time of HST observations, in order to provide a safety check that the objects were not in outburst which might overload the instruments on board Hubble. A number of AAVSO observers assisted with

observations of these very faint ($V = 17$ to 19.5) objects, including observations made with the leased-access GRAS telescopes. All HST observations were successfully made, and we look forward to seeing the results!

Observers also helped telescopes a little closer to home, including a campaign to monitor [BZ UMa](#) in support of polarimetry with the University of Hawaii 2.2-meter, a campaign to observe the transiting exoplanet system GJ 436, and a campaign to observe high-mass X-ray binaries in support of spectroscopy at the Dominion Astronomical Observatory.

In 2009, we're continuing the AAVSO-based long-term campaigns on [QX Pup](#) and [ASAS182612](#), along with the long-term monitoring project on [U Sco](#). We recently began several new projects as well, including high-precision photometry of [P Cygni](#), and a new monitoring campaign on [YZ](#)

[Cnc, Z Cam, and EM Cyg](#) -- again in support of radio observations with the VLA. I'm sure there are more campaigns to come in the New Year!

Thanks to all of the observers around the world who responded to the many requests for observations during 2008. AAVSO campaigns show the astronomical community at its best - working together to do great science. Here's to clear skies in 2009! ★

GET THE LATEST CAMPAIGN NEWS...

Subscribe online to receive AAVSO *Alert Notices* and *Special Notices* directly to your email's inbox. Stay on top of stellar activity and get detailed information on current and upcoming observing campaigns by visiting <http://www.aavso.org/publications/email> to subscribe today!



EYEPIECE VIEWS

GAMZE MENALI (MGQ), EDITOR

WELCOME TO 2009!

Greetings All,

It is amazing that we are marking the beginning of another year. Time flies!

Looking back, 2008 offered much for us to be grateful. The AAVSO has continued to grow by leaps and bounds, especially in regards to our international observers and members. We continued to upgrade to new technology and resources as they became available.

For 2009, quite a bit is in store for us. As you know the United Nations has officially declared 2009 to be the International Year of Astronomy.

The United States IYA Program Committee has created a Research Experiences for Students, Teachers and Citizen Science working group to design IYA activities around citizen science and pro-am collaboration. The AAVSO is the hosting organization for the working group.

For more information on this please visit the URL: <http://www.aavso.org/aavso/iya.shtml>

Also please continue visiting us on the web (and visit often!) for more exciting and fun projects, campaigns, etc. We look forward to a very fruitful 2009 and beyond!

It feels wonderful to be part of this great group of people from around the world. We would

like to suggest that when things get you down, just look up at the majesty of the stars and revel in their beauty. And when you are finished and ready to come back down to Earth, think about how all the variable star organizations in the world cooperate together.

May the harmony in the skies and fellowship among variable star observers of all nations bring peace and love into our lives and in our world.

May 2009 offer more clear skies than the year before!

Best wishes for a wonderful New Year!

Thanks and good observing! ★

VISUAL TARGETS OF INTEREST FOR WINTER 2009

MICHAEL A. SIMONSEN (SXN)
IMLAY CITY, MICHIGAN

There has been a lot of discussion lately about what visual observers can do to make an honest contribution to science. What variable stars are really interesting to astronomers, and what observations are likely to lead to new understanding of the properties of these and other stars?

It's no secret that with CCDs being capable of higher precision and numerous surveys covering the sky, with more coming online in the future, visual observers will have to be more selective about what they observe if they want to make a meaningful contribution to science. But, there is still a lot the visual observer can do.

No survey exists at the moment that covers the entire sky every night in any bandpass or to any limiting magnitude. ASAS-3, for example, has a cadence of about once every three nights or so. It has a useful range of magnitude coverage from around 8 to 13.5V, and it only covers the sky from

the South celestial pole to around +28 degrees in declination.

Pretty much anything north of ASAS-3 sky coverage is still a viable target for visual observers, in spite of the fact that ASAS is running a similar survey in the northern sky right now. There is no guarantee that data will ever become public. There are a number of other surveys going, but the data is not publicly available, and until it is, these surveys do not impact the visual observers usefulness at all.

There are also plenty of targets for visual observers to monitor that require higher cadence of observations, or that a three day delay in notification of activity, like a rare outburst of a cataclysmic variable, a precipitous fade of an R CrB type star, or some other unusual rapid behavior, would cause valuable science to be lost.

Most surveys do not spend much time observing stars approaching conjunction with the Sun, nor do they adequately observe stars in the morning sky that are just coming out from behind the Sun. So observing stars that are setting soon after

sunset or rising in the pre-dawn hours can also be fruitful territory for visual observers.

No surveys cover stars brighter than 8th magnitude, and individual CCD observers tend to avoid stars this bright also. Stars that get as bright as this, or are always brighter than this will remain good visual targets for a long time. Naked eye and binocular variables remain the domain of visual observers for now.

Similarly, visual observers with larger telescopes, able to observe stars fainter than 13th magnitude can still support science by covering the gap between the faint end of ASAS coverage and the bright limit of many of the new surveys coming online.

So with that in mind, here are some suggestions for visual targets for winter 2009.

Cataclysmic Variables

There are a number of CVs that rarely go into outburst. Catching one of these on the rise is not only useful, it can be a lot of fun.

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SIMONSEN: VISUAL TARGETS

First there are three recurrent novae. One visible in the southern sky early in the evening, T Pyx, is overdue for a dramatic outburst. Two more that are worth getting up early in the morning for as winter progresses are U Sco and T CrB. An outburst of any of these stars will be big news and very interesting.

Andromeda, Cassiopeia, and Perseus in the north hold several treasures in the rare, if ever seen category; LL And, PQ And, V630 Cas, UW Per, V336 Per. If you've never heard of these CVs before, it's because no one has seen them in a while. Normally, I would have included UW Tri in this short list, but it just had a rare outburst in late October 2008. AL Com, IR Com, and UZ Boo would be happy discoveries on a cold night.

Some circumpolar stars, easily observed on winter nights include DV UMa, an eclipsing UGSU, and KV Dra.

The ecliptic is well stocked with rarely outbursting cataclysmics. EI Psc, XY Psc, V701 Tau, EG Cnc, a UGWZ that exhibits post outburst re-brightenings as it fades, NSV 18241 in Leo, RZ Leo, and HV Vir. A little further south you can monitor WX Cet, CG CMa, and EX Hya.

R Coronae Borealis stars

There are some northern RCBs that observers can and should monitor very clear night for evidence of sudden fading episodes from maximum, or the unpredictable way they brighten to maximum from a deep fade. These are DY Per, Z UMi, R CrB, and SU Tau. LT Dra is listed as RCB in VSX. That is one I didn't know about. In the south RY Sgr is above the ASAS limit at maximum and V CrA is at or near the limit, hovering around 8.3 or so at maximum. Many RCBs get fainter than the ASAS limit, so following the deep fades of some of these when they occur may also be something worth pursuing, if you have the aperture and dark skies to do it.

Miras and SRs

Any Miras north of +28 degrees declination are still great candidates for the visual observer. You might also consider tracking down stars that are

going into conjunction. In the winter these might include stars in Aql, Aqr, PsA, Sge, Vul, Lyr, and Del. If you're an early riser, stars emerging from conjunction in Cen, Lup, Sco, Sgr, Sct, Oph, Her and CrB provide an opportunity for you to cover stars not likely well observed by the surveys.

There are dozens of bright SR stars to observe that are generally not covered by any survey. For the winter months these include: RS And, TZ And, AQ And, V Ari, UU Aur, X Cnc, RS Cnc, RT Cnc, TU Gem, TV Gem, NQ Gem, Y Lyn, SV Lyn, CE Lyn, RV Mon, SX Mon, W Ori, BQ Ori, CK Ori, SU Per, AD Per, Y Tau, and TT Tau.

There are also plenty northern circumpolar SRs you can observe year-round. U Cam, RY Cam, ST Cam, UV Cam, WZ Cas, V393 Cas, V465 Cas, Rho Cas, W Cep, RU Cep, RW Cep, SS Cep, AR Cep, FZ Cep, Mu Cep, RY Dra, TX Dra, UX Dra, AH Dra, Z UMa and RY UMa.

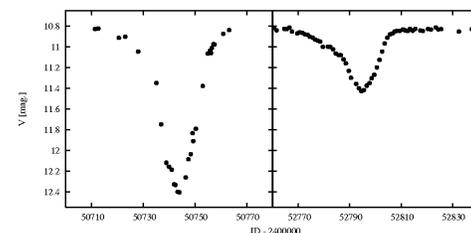
Eclipsing variables

Since making and sky checking the IYA training charts for Algol, I've found myself looking up and doing a quick estimate every time I go outside on a clear night. I even managed to catch an eclipse of Algol from Nantucket during the 2008 fall meeting. That Friday night was the only time the sky was clear during the whole trip, and it happily coincided with the planned observatory tours and star party, as well as an eclipse of Algol.

A very interesting eclipse will take place this winter. EE Cep is a poorly understood eclipsing binary, similar to Epsilon Aur, in that the secondary is probably an object surrounded by a disk of dust. Eclipses only happen once every 5.6 years, it is well placed for observation and the range of magnitudes is from 10-12th magnitude. Mid-eclipse should occur on or near January 14, 2009. The longest eclipse lasted 60 days, so observations from early December through the end of February are potentially useful. The most interesting action will take place between January 2 and 27.

As you can see, there are plenty of opportunities as a visual observer in the next few months to support science. Don't let anyone tell you the age

of visual observations is dead. You can chuckle to yourself when you are the one to catch the next outburst of T CrB while some of your friends were observing superhumps of yet another UGSU with their CCD only a few degrees away all night.



EE Cep light curves in V passband of two last minima: left - 1997 eclipse (Mikolajewski and Graczyk 1999, + Cook's CCD data (Halbach 1999)), right - 2003 eclipse (Mikolajewski et al., 2005a).

AN OVERVIEW OF MY PROGRAM STARS

GERRY DYCK (DGP)
ASSONET, MASSACHUSETTS

Perhaps I am similar to other visual observers in that I think of my program stars in various loosely overlapping categories according to their behavior and my attitude towards them.

I might call these categories: my "Regulars" (for whom I might wait until the end of the month to report an outburst), my "Long Shots" (for whom I might jog to the telephone to report an outburst), my "Not-Yets" (for whom I would wish to have a cell phone handy if I actually saw an outburst), and my "Specials" (for whom I have extra affection because of some unique history between us). Here are a few examples of stars in each group:

1. "Regulars" RX And, SS Cyg, AB Dra, AH Her, KT Per, SU UMa, EM Cyg, CN Ori, SS Aur, and others. These are the stars whose outbursts I record on a fairly regular basis. When an outburst comes I am pleased, but not surprised. These are

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DYCK: MY PROGRAM STARS

the stars, one of which I can rely on to show at a star party as an example of a cataclysmic variable and explain to the viewers that “last night that star was not visible in this telescope.” I know that a dozen or more other AAVSO observers have probably seen this outburst before I did, so I am not in a hurry to report it – it can just appear in my end-of-the-month report. (I don’t yet use WebObs.)

2. “**Long Shots**” SW UMa, EY Cyg, DO Dra, UV Per, DX And, and others. These are the stars whose outbursts will send me to the telephone to report an outburst. In my earlier days I considered it cool to report such an outburst before Danny Overbeek or Glenn Chaple did. Such friendly, competitive games interest me much less now, but I still make the effort to phone in a rare outburst

of one of these stars. I recall with satisfaction that such a rare outburst of DO Dra was seen during a full moon when I almost did not motivate myself to go out to the observatory.

3. “**Not-Yets**” KX Aql, HN Cyg, V404 Cyg, V344 Ori, RZ Leo, SS UMi, and others. These are the stars for which I accept the word of others that they are indeed variables, as I have seen so far nothing but their absence with my 17.5-inch telescope. And yet, I keep checking them out during each session - just in case. I think I have reported more than one thousand “fainter-thans” for KX Aql. Expectation is the thing, you see. I remember telling Janet Mattei that “if KX ever pops I would like to be there.” She responded, “You probably will be.” Her words were an inspiration and a great motivator.

A BACKYARD PHOTOELECTRIC AND SPECTROGRAPHIC OBSERVING PROGRAM

BRIAN MCCANDLESS (MBE)
GRAND VIEW OBSERVATORY, ELKTON, MARYLAND

Introduction

AAVSO Newsletter 38 reported a decline in observations from members using single-channel photoelectric photometry (PEP). Whether this is a result of fewer actual PEP measurements being made or fewer submissions to the AAVSO database, a strong case can still be made for carrying out a dedicated PEP program, based on abundant targets, established methodology, and equipment simplicity. My observational program combines photoelectric photometry and CCD spectroscopy, and I offer this short article to share my experiences and hopefully inspire others to consider a PEP-based observing program.

The satisfaction gained from observational stellar astronomy, whether as an amateur pursuit or professional career choice, lies in the quantification of changes occurring in the stellar show. If you are reading this, then you are already convinced that systematical study of starlight

variability is a valuable pursuit which contributes to the understanding of stellar, planetary and galactic evolution. Gratification comes not only from short-term discovery of new objects but also in the steady pursuit of subtle changes over time, contributing to high quality archival data whose immediate value may not be apparent. Therefore, all systematic observational programs are valuable, and the astronomical community most benefits from those observations in which the limits of sensitivity, statistical significance, and sources of error are well understood and documented, regardless of the specific method used.

Numerous emails and discussion threads reveal that many observers struggle to develop a program, any program, as a way to transition

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EYEPIECE VIEWS

4. “**Specials**” U Gem – the prototype of the CVs which I observe and first such star which I observed in outburst, giving me the stimulus and excitement to begin my thirty-year adventure in outburst detection. To date I have reported 6,600 outbursts of U Gem-type stars.

YZ Cnc – which I remember for having alerted the IUE satellite controllers of its outburst in 1982 (with help from Janet Mattei). This event was one of immense satisfaction to me as I pondered how the AAVSO had allowed me to create a link between my low-tech backyard observatory and a high-tech NASA observatory in space.

UZ Ser – which is special to me because I was the first to document the Z Cam-like standstills in the summers from 1985 to 1988. It was the first time that I felt I had discovered something new in the sky and I was doubly pleased when Dr. John Percy agreed with me.

BC UMa – which I associate with a rare outburst detected under unusual circumstances described in an earlier issue of Eyepiece Views. The outburst was detected on the first night after I had raised my merry-go-round observatory a few feet to get a better horizon. BC was just above the tree line and would have been undetectable except for my extra labor that day.

IP Peg – which I associate with Janet Wood of Cambridge University, who was observing at MacDonald Observatory and eager for news of any CV outbursts. Helga and I were observing with a portable telescope and were able to inform her that IP was in outburst that very night. During a visit to Cambridge she gave us the deluxe tour of the University, including a memorable Evensong at St. John’s Chapel, where we were able to sit in the choir with the singers.

FO Aql & AY Lyr – which have nothing special in common except that both were in outburst on the same night when we were observing with Clyde Tombaugh in Las Cruces. When either of these two (or rarely, both) is in outburst I fondly recall how I was able to meet my childhood hero, a fellow farm boy from Kansas. ★

MCCANDLESS: BACKYARD PHOTOELECTRIC AND SPECTROGRAPHIC OBSERVING PROGRAM

from casual observations of astronomical wonders to more systematic study. With the millions of binoculars and telescopes that have been sold over the past few decades, it seems natural that a dedicated fraction of amateurs would seek to maximize the scientific impact of their observational data. However, guidelines for how to establish an observing program and then meeting the equipment requirements for that program is wanting, and real-time human guidance, i.e., mentoring, is improving but still lags behind equipment availability. Contrast this state of affairs with that of the mid-20th century, the reverse problem, when there were seemingly more mentors than mirrors.

My own entry to variable star observing came in the mid-1970's while earning my B.S. in astronomy at the University of Maryland, where I performed *BV* photoelectric measurements of eclipsing binary star systems with a 1P21-based photoelectric photometer as part of course-work. A decade later I purchased an Optec SSP-3 solid-state photometer with filters for *BVRI* measurements, but it took another decade for me to settle into a routine observing program. Over the years my interest has shifted towards intrinsic variable stars, especially those red stars with small amplitude light variation, the SARV's, whose changing light curves derive from stochastic processes in the stellar atmospheres. By combining multi-color photometry with spectroscopy, the challenge is to separate thermal and radial variations from variations in absorption and emission phenomena. For my program I selected a few bright and poorly studied SARV targets to monitor over time. It would be exciting to follow fainter objects and those with changes on shorter time-scales, but the atmospheric conditions in the mid-Atlantic, where I am based, are typically quite poor, and it is virtually impossible to schedule an observing program. I also participate in the Epsilon Aurigae project (primary eclipse coming in 2009), follow a few favorite long-period variables such as mu Cephei and R Leporis and respond to AAVSO calls for observations such as nova V459 Vulpeculae (late 2007) and CH Cygni (fall 2008).

Channel Photoelectric Photometry

Single-channel PEP is well-suited for analysis of SARV stars, with changes occurring over weeks to months and visual brightness varying by 1 magnitude or less. Under typical conditions at my site, and with care, differential PEP yields precision ~5 milli-mags. With the available photometer systems, wavelengths from the ultraviolet to the near infrared can be explored - sufficient spectral coverage to support a variety of observing programs. For differential photometry, a comparison star with suitable color index can usually be found within a degree of the variable. PEP can also be exploited for routine monitoring of flare stars, long-period Mira variables, and the decay curves of bright novae. It is well-suited for all-sky photometry of asteroids and comets. PEP allows real-time events to become readily apparent, such as periods of scintillation and the approach of clouds or aurorae since the observer interacts directly with the telescope, detector and star. As with visual observing, the observer is an integral part of the process. While the up-side of this is obvious, the downside is that the number of data possible in a given observing run is less than afforded by array methods. PEP is more sensitive to small amplitude variations than are visual estimates and it affords access to a wide magnitude range, so the dynamic range is good and there are plenty of interesting objects to monitor; a natural progression from visual telescopic observation by the mere addition of a filter-based detection system.

Using different filter sets and detectors allows a wide wavelength range to be covered at a modest cost. No computer is required for PEP data acquisition, and there are no files of dark frames or flats to manage, so an evening's set-up takes only a few minutes, has low power requirements, and can be readily deployed at remote sites from a car.

For AAVSO members and affiliates, PEP observers may send raw data to HQ and need never carry out the mathematical reduction, thereby completely eliminating the need for a computer. However today, the widespread use of computers at home

allows the observer to perform complete analysis of their data – for me, this is usually accomplished on the numerous cloudy nights available! I think that a lot of people may never consider the possibility of PEP since the cost of a basic CCD system is similar but adds justifiable value, with potential for discoveries of new objects, creation of area archival information, and providing aesthetically-pleasing images.

PEP Hardware

Three critical elements comprise an astronomical photometric system: telescope, mount, and detector. The telescope focuses light onto a photosensitive element, the detector, which permits quantification of the received light. The telescope mount keeps light focused on the detector during the required interval. Finally, the detector reproducibility should equal or exceed variations in seeing during a run interval. All three components, the telescope, mount, and detector, must function in harmony and in accordance with the demands of the project.

For visual variable star observing, mount stability and tracking are not critical and a good observer can work around defective hardware by interactive tracking and repeating observations. For PEP observing, the mounting requirements are more stringent if there is no active tracking. The star must be held in the center of the diaphragm or detector for the duration of each integration cycle. I have experimented with several off-the-shelf telescope mounts and find that the mid-priced models available today can support 8 to 10 inch optical tubes of the Cassegrain type operating at *f*/10-*f*/11 and hold the star on the detector (a coverage of 50-80 arcsec in SSP photometers) for over a minute, the primary limitation being the polar alignment. The systems I use for PEP photometry and CCD-based spectroscopy are shown in Figures 1 and 2. The photometers are located at the Cassegrain focus; the resulting large image scale in the photometer eyepiece requires excellent alignment between finder-scope and primary telescope with photometer. For

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MCCANDLESS: BACKYARD PHOTOELECTRIC AND SPECTROGRAPHIC OBSERVING PROGRAM



Figure 1. Optec SSP-3 and SSP-4 photometers on Grand View Observatory, Vixen (left) and Celestron (right) telescopes. Note the generous finderscopes - invaluable for time-efficient target acquisition.



Figure 2. Grand View Observatory telescopes configured for simultaneous photometric and spectrographic observing runs. The wider aperture of the Celestron 14-inch permits 9th magnitude star spectra to be acquired in the same time that the Vixen 10-inch can acquire a set of BV, VR, or RI photometric data, about 20 minutes.

many targets, I have found that it helps if the finder-scope has sufficient aperture to cover the magnitude range of field stars of the variable and sufficient field of view to permit locating the variable, comparison and check stars. The finder should be comfortable at all positions and be optically oriented similarly to the photometer eyepiece. I have installed right-angle finders with 80 mm diameter and field of view (FOV ~ 1 deg) corresponding to the AAVSO B-scale charts, FOV ~ 2 degrees.

The only present-day supplier of PEP equipment is Optec, Inc., through the SSP line of products.

The SSP-3 utilizes a silicon detector and covers the wavelength range from 400 nm to 1100 nm. The SSP-3 used at our observatory was purchased in 1986 and is still cranking out reliable counts in seven filter bands: Johnson-Cousins *BVR* and Wing *WA*, *WB*, and *WC*. The SSP-4 utilizes an indium gallium arsenide detector and allows detection in the *J* and *H* near-infrared bands, at 1.2 and 1.65 μm . The central wavelength and band pass width of all the filters I use are listed in Table I on page 15. For the SARV observing project, the Wing *WB* and *WC* bands and the NIR *J* and *H* bands allow measurement of the blackbody continuum, while filters with shorter wavelengths provide information primarily on atmospheric changes in the stellar atmosphere. For example, the Wing *WA* filter is used to detect absorption from molecular TiO. Spectra of 3 different class variable stars in wavelength region of Wing *WA* and *WB* bands are shown in Figure 3. The spectra were taken with the SBIG SGS spectrograph using ST7-XME CCD camera on the 14-inch telescope shown in Figure 2. The three stars are lambda Andromedae (RS CVn, G8 III-IV), NO Aurigae (SRc, M3 III), and mu Cephei (SRb, M2e Ia). The spectra are offset for clarity and clearly show TiO bands in NO Aurigae and mu Cephei at $\lambda > 715$ nm and relatively featureless region centered on the *WB* band at $\lambda \sim 750$ nm.

Not mentioned above is the U band, centered at ~ 350 nm, which contains information on the Balmer discontinuity and continuum suppression, or blanketing, by atmospheric species such as carbon. Unfortunately *U* band photometry is not practical for my project since both types of Cassegrain telescopes I use employ a corrective lens that absorbs UV light; on the Vixen, it is mounted internally, while on the Celestron it is mounted at the entrance aperture. This fundamentally precludes use of *U*-sensitive photomultiplier tubes with small telescopes and red stars.

Observation and Reduction

The observing season, with photometric quality skies on day per week, runs from late October through early May. An observing run begins

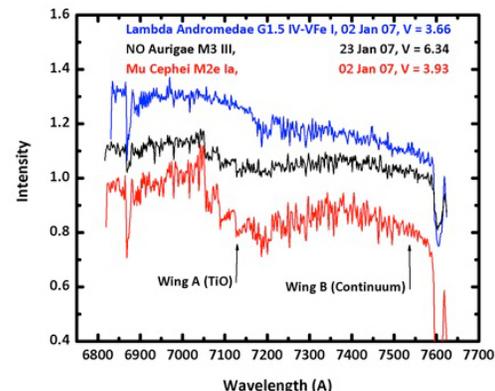


Figure 3. Spectra of 3 different class variable stars in wavelength region of Wing *WA* and *WB* bands taken with SBIG SGS spectrograph using ST7-XME CCD camera: lambda Andromedae (RS CVn, G8 III-IV); NO Aurigae (SRc, M3 III); and mu Cephei (SRb, M2e Ia). The TiO absorption bands are readily apparent in the M-type stars.

by setting up equipment at dusk - if the night promises to be humid, then an objective lens heater and dew-cap are installed. Both SSP-3 and SSP-4 units require time, about an hour, to stabilize. Although the SSP-4 detector is thermoelectrically cooled, the electronics run at ambient temperature, which results in a large variation in the baseline, affecting both sky and star data. As an example, Figure 4 shows SSP-4 counts for dark detector and for the near-zenith sky of lambda Aurigae in *J* band, plotted versus

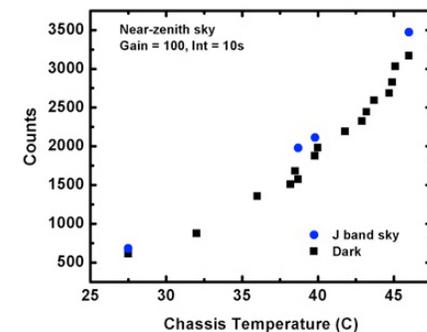


Figure 4. SSP-4 dark (squares) and J band sky (circles) counts versus chassis temperature: $T = -40^\circ\text{F}$, Integration time = 10 sec; Gain = 100.

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the photometer chassis temperature at the time of the measurement. The data was culled from the past year of SSP-4 use to observe epsilon Aurigae. In each case the detector temperature was set to 40°F below ambient temperature, the integration time = 10 sec and the gain = 100. The data sets fit both a 2nd order polynomial and an Arrhenius relationship (log of counts versus 1/T in Kelvin) with R-square > 0.95 and are probably related to the amplification circuit. The high readings obtained on warm days, coupled with the dewing that can occur on the detector in humid weather define my infrared observing season. The SSP-3 photometer does not exhibit this sensitivity to chassis or ambient temperature.

After setting up the equipment, a priority list is formulated, and obviously, targets setting in the west rise high on the list. To organize an observing run, all the target and comparison star positions are listed by right ascension on a master sheet attached to a clipboard. Data is taken in a stenographer's pad supported on an old milk crate on top of a stool. A red LED lamp provides the necessary light for taking data. At the top of each page are written the calendar date, Julian day, temperature, relative humidity, seeing conditions, moon aspect, and dark current of whichever photometer is being used. Several trial data are taken on sky and target to optimize the photometer gain for that object in the relevant bands.

The 14-inch telescope on a CGE mount is the principal light bucket, and for all but the brightest objects, 10 second integration times are employed. I also use smaller, more portable telescopes for remote observing. Table II lists the angular scale of the SSP-3 detector aperture and raw *V* band count rate (star minus sky) near the meridian for lambda Aurigae ($V = 4.71$) using the three optical tube assemblies. With the smallest, 8-inch f/9

Table I. Central wavelength and band pass width of filters for SSP-3 and SSP-4.

Filter	Central λ (nm)	Band Pass (nm)	Use
<i>B</i>	440	100	SSP-3, Blue and H γ
<i>V</i>	540	95	SSP-3, Visual
<i>R</i>	640	180	SSP-3, Red and H α
<i>WA</i>	712	11	SSP-3, TiO
<i>WB</i>	754	11	SSP-3, NIR Continuum
<i>I</i>	880	280	SSP-3, Near-IR
<i>WC</i>	1025	42	SSP-3, NIR Continuum
<i>J</i>	1250	200	SSP-4, NIR J-band
<i>H</i>	1650	300	SSP-4, NIR H-band

Table II. SSP-3 aperture scale and *V* band count rate near meridian for comparison star lambda Aurigae ($V = 4.71$) using three optical tube assemblies. Aperture area is corrected for secondary mirror obstruction.

Telescope	Diameter (inch)	Area (inch ²)	f/#	SSP-3 Aperture (arc sec)	SSP-3 Star-Sky (Counts/sec)
Vixen VC200L	8.0	45	9.0	113	94
Vixen VMC260L	10.2	74	11.0	72	116
Celestron 1400	14.0	138	10.0	58	448

Table III. Multi-band photometry of NO Aurigae near relative maximum, minimum and mid-brightness in 2007-2008. Julian date is 245000+ indicated value. The data is shown to ± 0.01 magnitude; the actual observational errors for JD254538 were $B \pm 0.02$, $V \pm 0.004$, $R \pm 0.003$, $WA \pm 0.01$, $WB \pm 0.01$, $I \pm 0.01$, $WC \pm 0.005$, $J \pm 0.007$, $H \pm 0.005$.

JD	<i>B</i>	<i>V</i>	<i>R</i>	<i>WA</i>	<i>WB</i>	<i>I</i>	<i>WC</i>	<i>J</i>	<i>H</i>
4538.60	8.39	6.31	4.89	3.52	3.01	3.33	2.90	2.07	1.23
4435.63	8.41	6.35	4.94	3.55	3.01	3.37	2.85	2.07	1.20
4491.51	8.46	6.44	5.03	3.72	3.16	3.43	3.10	2.09	1.22

telescope, the wider field of view makes it difficult to isolate some stars from nearby field stars, for example, the beautiful triple system of the check star (67 = AUID 000-BBL-467, chart 1071 amm) for the SRb variable and carbon star UU Aurigae.

At the telescope, one line of data in the steno pad contains the local time, object name, gain setting, three or four 10-second star readings and three or four 10-second sky readings. An observing run consists of sandwiching variable and check star readings between comparison star readings, so nightly extinction can be determined for each target variable dataset. As mentioned, three to four readings of 10 seconds apiece are taken for variable, comparison, and check star. In addition, three to four sky readings are taken between each star measurement, and my procedure is to always use the same sky region for each star – this is noted on my charts and is memorized. The position must be close to the star but far enough

away to prevent internally reflected light or atmospherically scattered light from reaching the detector. Although this seems excessive attention to the sky, it is necessary since my data quality is nearly always limited by the seeing conditions, not by the equipment. On a given night I form a mental 'model' of the changing atmosphere by continually monitoring the sky and comparison star values. Large random variations or sudden decreases in either value alert me to end the run, casting doubt on the value of the previous data. On dew-prone nights, I inspect the objective lens between each target observation run. As a rule I throw away data taken during a period in which dew has formed on the corrector plate.

The photometers each use 2-position filter sliders, which allows data to be gathered in 'couplets' such as *B* and *V*, *R* and *I*, *J* and *H*. To maximize efficiency when measuring multiple colors, and to minimize exposing all filters to the elements, I complete an entire set of comparison, variable and check stars in two colors. Then, I remove that filter slider and move on to the next couplet, repeating the sequence.

The data are reduced in a self-written Excel spreadsheet that calculates Julian date and time, instrumental magnitudes, errors, and transformed magnitudes. One spreadsheet is used for one variable star using one filter couplet. The positions and magnitudes of comparison and check stars, as well as transformation coefficients are pre-loaded in to the top of each sheet by forming a template sheet for each star ahead of time. The reductions are carried out using the standard method of differential photometry described in the text by Henden and Kaitchuck (Willmann-Bell, Inc., 1990). Extinction corrections are calculated from comparison star readings at the beginning and end of each dataset. Color corrections

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are calculated using transformation coefficients determined separately, once per season using blue-red standard star pairs. Measurement errors are calculated by assessing the maximum and minimum readings for each star set, i.e., each row of data, and converting to a \pm magnitude about the mean magnitude. Only on the best nights, a few times per season, is the error governed by electronic noise in the photometer. In the mid-Atlantic, changing seeing conditions supersede extinction effects; for example, on a night with deteriorating upper atmospheric clarity, a rising star can become slightly fainter as it rises, and application of the usual extinction correction has no physical basis. In such a case the magnitude error is then estimated to be half the magnitude difference between comparison star readings, taken before and after variable and check star. This error always exceeds the statistical fluctuations obtained within three 10 second measurements. Once the magnitude and error reductions are complete, the results are transcribed into a hard-bound notebook and are subsequently entered into the AAVSO database. The data reduction takes about half the time of the observations.

Program Star Data

At present I am monitoring only 18 stars – and this is actually a daunting task for this working fellow. The conscious decision to restrict targets and go in-depth on a chosen few seems worthwhile. To give a sense of the data that can be generated from a backyard PEP and spectrographic observatory, I show data for a single SARV star. Nine-color photometric data for NO Aurigae (SRc, M3 III) taken with the SSP-3 and SSP-4 are listed in Table III, at three dates, representing times of relative maximum and minimum and mid-brightness. The comparison star for *BVRI* bands is GSC 2405-1906 (AUID 000-BBK-115, chart 1051cpf). This star was calibrated in other bands using iota Aurigae, pi2 Orionis, lambda Aurigae, and delta Aurigae using data from the Simbad database (*R* and *I*), Dr. Wing's published data (*WA*, *WB*, *WC*), and Dr. Henden's published data (*J* and *H*). The check star for B and V bands is GSC 2404-428 (no AUID number). The errors of the measurements

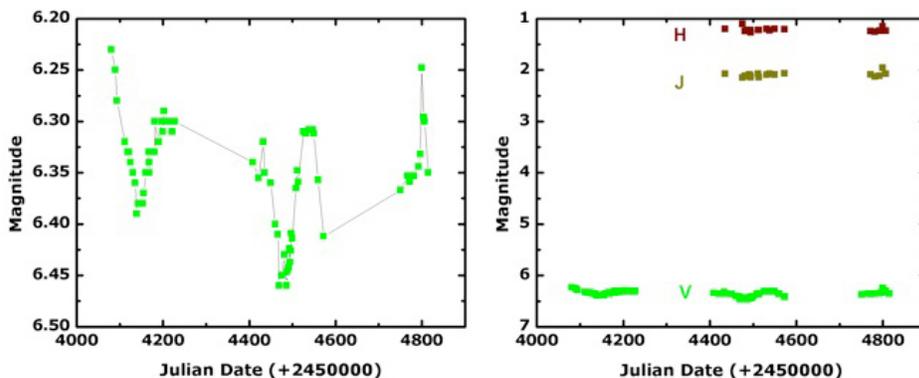


Figure 5. NO Aurigae light curves: V band (left), V, J, and H bands (right). Note the rapid event with maximum at JD 2454799.

are indicated in the table caption and are equal to better than 0.01 magnitude.

The *V* band light curve and combined *V, J, H* light curves for NO Aurigae are shown in Figure 5 and span two and a half observing seasons. Two *V* band minima are seen, one at $V = 6.39$ centered at JD2454141 and another at $V = 6.46$ centered near JD2454469, a separation of 328 days. Full nine-color data are incomplete, and the table shows a 0.13 *V* magnitude range but typically only ~ 0.02 variation in *J* and *H* bands; this suggests small variation in blackbody temperature and significant photospheric absorption changes. The *R*-band magnitudes in the table vary in-tune with *V* magnitudes, by 0.14 magnitude. The Wing *WA* band varies the most, by 0.2 magnitude, and together with the spectrum shown in Figure 3, suggests that the TiO absorption bands merit further study. Recently, a rising trend in *V* band was observed, and a sharp maximum occurred approximately on JD2454800. This feature was verified by repeated measurement, as weather allowed, and was also detected in the *J* and *H* bands (Figure 5, above). Spectra of NO Aurigae around $H\alpha$ (656 nm) taken at different dates in 2007-2008, shown in Figure 6, indicate small fluctuations in $H\alpha$ line absorption depth and perhaps a radial velocity shift correlated with *V* band magnitude, with blue-shift occurring during recent periods of maximum light. The appearance of an absorption line at 685 nm on JD2454531,

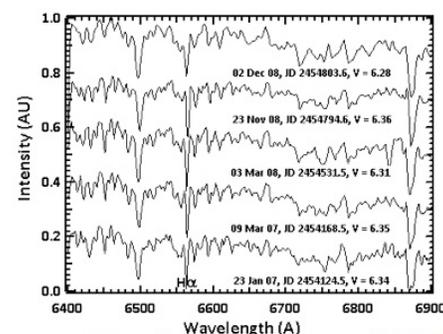


Figure 6. NO Aurigae spectra on five different dates in 2007-2008.

consistent with Ca absorption, indicates that chemical changes also need to be followed more closely. The changes in *WC* band magnitudes presented in Table III need follow-up, especially since the filter exhibits leakage above and below its fundamental band pass.

The small data set, for one small amplitude red variable star, shows how much change really occurs in a year or two and can be quantified by a modest backyard observatory. The *V* band light curve of this 6th magnitude star is easily monitored with an 8-inch telescope on a reasonable mount with an SSP photometer with no extraneous equipment. The PEP observation route seems to be a natural and simple progression

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for the visual observer interested in expanding the scientific value of their time at the telescope and allows access to wavelengths not covered by affordable CCD technology. In the future, I hope to see an AAVSO database for spectrographic data to augment photometric and visual data, to facilitate long-term monitoring of astrophysical properties of variable stars. I really look forward to the development of affordable infrared array detectors so that spectrographic measurements can be pushed into the infrared. Until then, I plan to continue my PEP visible-to-infrared program and its spectrographic complement.

Brian McCandless has been an astronomer since the 1960's. He earned his degree in astronomy from the University of Maryland at College Park in 1980 and is an Associate Scientist with the Institute of Energy Conversion, at the University of Delaware. He and his wife Julie operate their Grand View Observatory from sites in tidewater

Maryland and the Blue Ridge Mountains in Virginia. Brian submits data to the AAVSO database under observer code: MBE. He is preparing a manuscript summarizing photometric and spectrographic data and astrophysical calculations for 8 stars including 3 long period and 5 semi-regular variables – that will be submitted to JAAVSO in 2009.

The following books are recommended for further reading on the history and practice of photoelectric photometry and the properties of variable stars:

The Measurement of Starlight, J. B. Hearnshaw, Cambridge University Press, 1996; *Astronomical Photometry*, A. A. Henden and R. H. Kaitchuck, Willmann Bell, Inc. 1990; *Understanding Variable Stars*, J. R. Percy, Cambridge University Press, 2007; *Light Curves of Variable Stars*, C. Sterken and C. Jaschek, Cambridge University Press, 1996. ★

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IN MEMORIAM

MEMBERS, OBSERVERS, COLLEAGUES,
AND FRIENDS OF THE AAVSO

HUGH C. MADDOCKS (MDH) Gainesville, Virginia, USA

A professional indexer of books on topics ranging from engineering and physical science, to applied mathematics, Hugh first joined the AAVSO as a member and observer in 1989. His interest in astronomy began in the 1950's when he made his first variable star estimates. He also enjoyed observing meteor showers and northern lights for the IGY. Despite battling light pollution in northern Virginia, Hugh reported several hundred observations to the AAVSO over the years.

JAMES MOLNAR (MOL) Springfield, Virginia, USA

A long-time AAVSO member and avid observer, James submitted over 27,000 observations to the AAVSO International Database between 1966 and 2004. A chemist by trade, James got involved in the AAVSO in his early thirties, but had been fostering a love of astronomy and observing since the age of 13.

PAUL WRIGHT (WPF) Rosemount, Minnesota, USA

An instrumentation engineer, with a master's degree in Science History, Paul's interest in astronomy dated back to the 1950's. He did not begin observing until 1995, when he started looking mostly at Messier and Herschel Deep Sky objects. A devoted AAVSO member and observer since March of 2000, Paul indicated on his application that he hoped to "give back to astronomy by making variable star observations." Between 2000 and 2007 he contributed 752 observations to the International Database.

TATSUO YAMADA (YM) Inuyama, Aichi, Japan

A former high school principal, Tatsuo Yamada was also an avid and dedicated amateur astronomer. His connection to the AAVSO began in 1939, when he started observing at 15 years old. With some 6,398 observations to his credit, Tatsuo was not only an observer, but a loyal member and supporter of the AAVSO and its mission throughout his long life. ★