The Spectrogram

Newsletter for the Society of Telescopy, Astronomy, and Radio

March 2003

Inside this Issue

S*T*A*R
P.O. Box 863
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On the web at:

http://www.starastronomy.org

March's Meeting

The next meeting of S*T*A*R will be Thursday, March 6th.   The meeting will begin promptly at 8:00 PM at the King of Kings Lutheran Church, 250 Harmony Street, Middletown.

Our featured speaker will be Dr. Dale Gary, Director of NJIT's Owen Valley Solar Array and Associate Director of the Big Bear Solar Observatory. Dr. Gary's talk is entitled "Tuning in to the Sun: New Developments in Solar Radio Science".

Dr. Gary explains, "The Sun is a strong source of radio emission, which can affect your shortwave radio and even your cell phone. This talk will begin with a discussion of how radio emission from solar flares can affect us on Earth.

Following that, we will discuss how New Jersey Institute of Technology (NJIT) is leading a coalition of universities and industry in a new effort to build the ultimate radio telescope for observing the Sun. Called the Frequency Agile Solar Radiotelescope (FASR, pronounced FAY-ZER), it will be the world's premiere solar radio facility for at least 20 years after completion. The latter part of the talk will focus on the current state-of-the-art in imaging the Sun in radio waves, and will present a vision for the new science that will be done with FASR."

Calendar

September 5, 2002
Ernie Rossi

October 3, 2002
David Segelstein & Gordon Waite

November 7, 2002
Dr. Haimin Wang

December 5, 2002
Canceled due to poor weather

January 2, 2003
Dr. Eddie Guerra

February 6, 2003
Bob Sal

March 6, 2003
Dr. Dale Gary

April 3, 2003
Open

May 1, 2003
Freeman Dyson

June 5, 2003
Annual Business Meeting

Thank you to this month's contributors! The Spectrogram is your newsletter, and it needs your support. If you have astronomy related articles, announcements, or other material, please forward it to Greg Cantrell at cantrell@optonline.net.

President's Corner

By Greg Cantrell

Our March meeting will feature Dr. Dale Gary, Professor of Physics in the New Jersey Institute of Technology's Center for Solar Research. Dr. Gary's website lists his research interests as "Solar physics and phenomena of the atmosphere of the Sun and solar-like stars, including solar/stellar flares, sunspots, active regions, filaments and prominences, quiet Sun network." His talk with focus on "New Developments in Solar Radio Science", and should prove very interesting.

Following Dr. Gary's talk, there will be a discussion and vote on updating the club bylaws. Electronic and written copies have been widely distributed to club members, allowing ample time for consideration of these amendments. If you have any comments or concerns, please forward these to me prior to the meeting at cantrell@optonline.net.

Hope to see everyone at the March meeting! Clear Skies!

February Meeting Minutes

The meeting was called to order by President Greg Cantrell, who offered a moment of silence in remembrance of the crew of Space Shuttle Columbia. Following this, STAR member Ernie Rossi gave a short presentation on the history of manned space flight. Ernie's presentation was followed by an open conversation by club members of the Columbia disaster.

Announcements:

Greg discussed registration for the field trip to the Hayden Planetarium on Saturday March 22nd. Ticket prices for the trip are $45.00 per adult, $30.00 per child ages 2 -12.

Mike Lindner discussed his recent astronomy presentation to his son's classmates, and encouraged others to actively seek out opportunities to share astronomy with children.

Larry Campbell announced that the February 5th Star Party at Union Hill School in Holmdel was a great success, with at least 300 students and their families in attendance. Larry passed out 'thank you' pictures drawn by several of the children.

Dave Britz announced that a star party was planned for April 11th at the Neptune Middle School, and promised to provide additional information on the club's BBS, as well as an announcement for the club newsletter.

Greg announced that an anonymous donor had given STAR an orange tube Celestron C8, under the condition that the scope be donated to a child or to a group that would use it for observing with children. Further, the scope cannot be sold, but will remain the property of STAR and must be returned in the event that the person or organization no longer uses the scope in the manner intended. Mike Lindner has tentatively identified a group that meets these qualifications. However, Greg is interested in hearing from other club members that might know of similar persons or groups.

Presentation:

Bob Sal of the Astronomical Society of the Toms River Area (ASTRA) gave a gret presentation entitled "Binoculars and Binocular Astronomy"

He discussed various types of binoculars and binocular mounts. Bob also discussed several objects that offer great views through binoculars. Bob's conversational style and humorous observations made this one of the best presentations of the year.

Star Party Announcement

Neptune Middle School Star Party to be held April 11th from 7am to 9.30pm not including setup time (rain date May 9th). We have about 200 kids and even more parents in 5th and 6th grade and this is the schools first year of participation in the Astronova astronomy program **-** most of the kids have never looked through a telescope before to say little of the monster scopes some of our members have, so this will be the kids "first light" experience. I have chosen nights with the first quarter Moon, Jupiter and Saturn prominent in the sky which should leave lasting memories **-** we have focused on the Solar System in this program. The schools PTA is arranging for activities and refreshments so it should be a memorable night.

Coming from the south on Route 35, Heck Avenue is the first left turn going north on Route 35 after the intersection with route 33/Corlies Avenue, go along Heck through the intersection with Neptune Blvd. The school will be the second building on you left after the intersection. Parking in front of the sports oval off Heck.

Coming from the north on Route 35 Heck Avenue is the 11th right turn going south on Route 35 after the intersection with Route 66 and circle below the Seaview Mall. If you hit Route 33 you have gone too far. Go along Heck through the intersection with Neptune Blvd. The school will be the second building along Heck on you left after the intersection. Parking in front of the sports oval off Heck.

For more details please contact David Britz 732 530 7439 after 6.30pm or on briswold@aol.com Look forward to seeing you there and my sincere thanks for your support.

What's Mike Been Up To?

By Michael Lindner

ATM has taken a back burner once again. I have done some polishing, but have nothing significant to report. However, a number of folks have expressed curiosity about the Foucault test, so I thought I'd go into Foucault theory in detail.

I'm not going to describe the actual test here, I did that last year in the December issue of *The Spectrogram*, which may be found at http://www.starastronomy.org/Library/Spectrogram/2001-2/spectrogram-12-2001.pdf. What I'm going to describe is the process of analyzing the data from a Foucault test to determine the shape of the mirror.

As some of you know, I am the maintainer/author of "TEX", a Foucault data reduction program available for free at http://home.att.net/~mikel. I am not the original author of TEX, however. When I first got into mirror making, I was looking for a Foucault program I could run under Linux, and there wasn't one. TEX was one that ran under DOS, and happened to have freely available source, so I ported it for my own use, and offered the changes back to the authors.

The one author I was able to contact told me that I had not only ported it but also fixed some bugs and made some significant changes, so I could "own" it now.

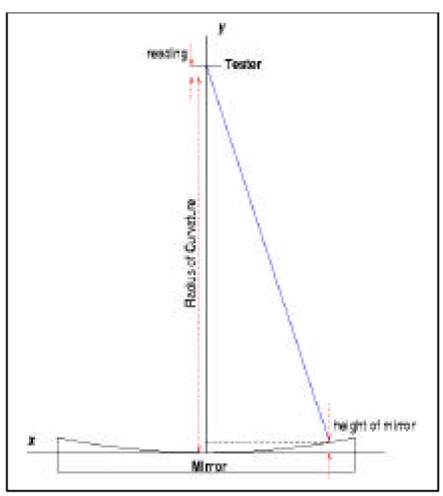
TEX gets its name because it uses the nomenclature and formulae described in Jean Texereau's classic book *How to Make a Telescope*. If you don't already own this book, and have any interest in grinding glass, this is definitely the book to get.

Texereau describes the equations for determining a mirror's shape from Foucault data, explains them, and goes on to work out an example. In theory, I could just copy what he says for this article, but that would be cheating (and plagiary as well)! He uses terms which accurately describe the process, but do not make clear the marvelous things that are going on mathematically.

Basically it all boils down to this. For a mirror, the angle of reflection equals the angle of incidence. That is, if I reflect light off a mirror, the angle it makes approaching the mirror is the same as the angle it makes leaving the mirror. If you know that (and who didn't have that drummed into them in 6th grade science class) you can derive the Foucault test analysis (provided you can solve differential equations).

So, to make the math easier, let's consider a "moving source" Foucault tester (one where the knife edge and light source move together). They are close enough together that for analysis purposes we can consider them as being in the same place.

That means that when light leaves the tester, strikes the mirror, and comes to focus at the knife-edge, the source and knife-edge must be perpendicular to the mirror's surface at that point. Consider this diagram. I've drawn the mirror



facing up, with the tester at the top, and superimposed a coordinate system, with the center of the mirror's surface at (0,0). Note the blue light beam leaving the tester and returning along the same path. If you remember 7th grade geometry you know that the slope of a straight line is the difference in the *y* value of any two points on the line divided by the difference in *x* value of the same two points, or Ä*y*/Ä*x*.

The value of Ä*x* is the distance from the center of the mirror to the point in question. The value of Ä*y* is a little trickier. It's the radius of curvature (which we measured at the start of the test) plus the distance the tester moved from that spot (which is the reading we have taken) minus the height of the mirror at that point (which is what we're trying to solve).

So we know the slope of the light beam. Big deal. Well, that's the key, because we also know that the light beam is perpendicular to the mirror, and the slope of a perpendicular line is the negative reciprocal of the slope of the original line, so the slope of the mirror at that point is –Ä*x*/Ä*y*.

Now, if you've had some calculus, you'll realize that if we know the slope of a curve, we can find the curve by taking its integral. Yay! Unfortunately, the equation for the slope of the mirror's surface depends on the mirror's surface itself. Boo. However, if you've taken one more year of calculus (yay?), you've encountered the dreaded, much maligned "diff-eq", or differential equations, and recognize this as a first order differential equation, namely $y' = -x/(R+f-y)$ where R is the radius of curvature and f is a function which fits the readings we have taken.

There are many ways to solve this. The method Texereau uses is specific to fitting the data to a parabola *only*, and thus takes many many shortcuts, simplifications and approximations. The effect is to solve the above equation, but the math looks nothing like you would expect. There's nothing wrong with the method or the results, and it is simple enough to do by hand.

Briefly, it works like this. Some constant is subtracted from each reading, to make the average of the readings close to 0. Next we subtract the expected reading from each reading. For a parabola, this is $x^2/2R$. Next we divide by the expected difference in readings (for a parabola, $x/4R$). To find the slope of the curve, we divide by –R/2. We now have the slope of the mirror at the center of each zone. If we draw lines of that slope and connect them, we approximate the curve. The closest fitting parabola to the data is found, and the difference between that parabola and the "curve" we computed is the error in the mirror's surface.

Rather cryptic, and it's hard to see how the computations solve the equation above. In addition, the approximation is made that each zone under test is flat, which can lead to a pessimistic estimate of the mirror's true error. That may be a good thing, if you want to produce a high quality mirror, but some would consider it inelegant.

Fortunately, since Texereau wrote down this method, computers have become ubiquitous. With a computer, we don't have to use our brains to come up with shortcuts, because the equations can be solved numerically by brute force, and beautifully smooth curves can be plotted in milliseconds.

On "Seeing in the Dark"

An amateur astronomer's perspective
by John Heidema

You can find several, generally very positive reviews of this book in print and/or on the Web. Most all of them are by reviewers who didn't know what "M31" or "Dobsonian" meant before opening it. This book is the most recent of several by author Timothy Ferris (Simon & Schuster, 2002). Based on the reviews, two different relatives gave me gift copies over the recent holidays. I thought our members might like a review of the book from a perspective more like their own.

Ferris is a serious amateur astronomer, and this book gives pleasant glimpses of his evolving interest since his early teenage years (with much less light pollution) near Miami, Florida. The book gives an organized look at amateur astronomy beginning with the basics, also exploring and expanding on the contributions of dedicated amateurs to professional astronomy and then progressively examining the common and uncommon observing targets in the remaining chapters, beginning with the Sun and Moon and ending with quasars and the most distantly observable galaxies. Along the way, the author gives good intro explanations for many of the modern issues in astronomy and astrophysics.

Most of the 18 chapters also have a short, related attachment describing the author's interaction or interviews with many well-known (O'Meara, Levy, Moore) and not so well known accomplished amateurs and a few interesting scopes. The book also has several appendixes describing basic amateur observing methods, favorite amateur observing targets, and some sources for more detailed information.

The book will tell many stories familiar to the more experienced and informed amateur, but you may find a few that are new to you. I especially liked some of the short chapter attachments describing interactions with very accomplished but more obscure amateurs, as well as the author's one-nighters with some impressive telescopes.

This book probably works best for the interested layperson or the not-yet-very-experienced amateur. It is certainly well written, and it will leave such readers better informed and probably more enthusiastic about amateur astronomy and its concerns (e.g., light pollution).

In short, I would give this book a luke-warm recommendation for informed and experienced amateur astronomers -- you will find only a limited amount of new stories or information here. But it is probably an excellent gift book for your interested adult friends or older youngsters new to amateur astronomy.

A group of S*T*A*R members preparing for a night to remember at the 1999 Black Forest Star Party, held at Cherry Springs, PA

An Amateur Astronomers Experiment With Video Capture of Leonid Meteor Spectra

By David Britz

The predicted Leonid meteor storm of 2001 provided the motivation for the author and a colleague Russ Drum to try to image and record the Leonid meteors and if possible also record the spectra of the brighter meteor's passage through the atmosphere. The author had previously collected various components that he thought would be required to record the meteor events. At the heart of this assembly was a Russian Rostov Cyclop 11B2 2nd generation image intensifier that would be used to intensify the fainter meteors and their spectra. A low cost black and white video security camera was also available to capture the intensified meteor images as well as a mini 8mm portable VCR to record the resulting video. The image intensifier and video camera required the use of a relay lens to transfer the image of the night scopes output cathode to the CCD of the video camera. The author constructed and assembled these components. To create a continuous recording, the camera's video output was routed to a video amplifier/splitter and then finally to the VCR and monitor. An external streaming video digitizer called Dazzle was also connected to one of the splitter's outputs and then on to a computer for digital video clip storage. The digitizer was used to directly record longer duration events like smoke trails and was then later used to create MPV video clips of selected video taped meteor events. See below Figure.1

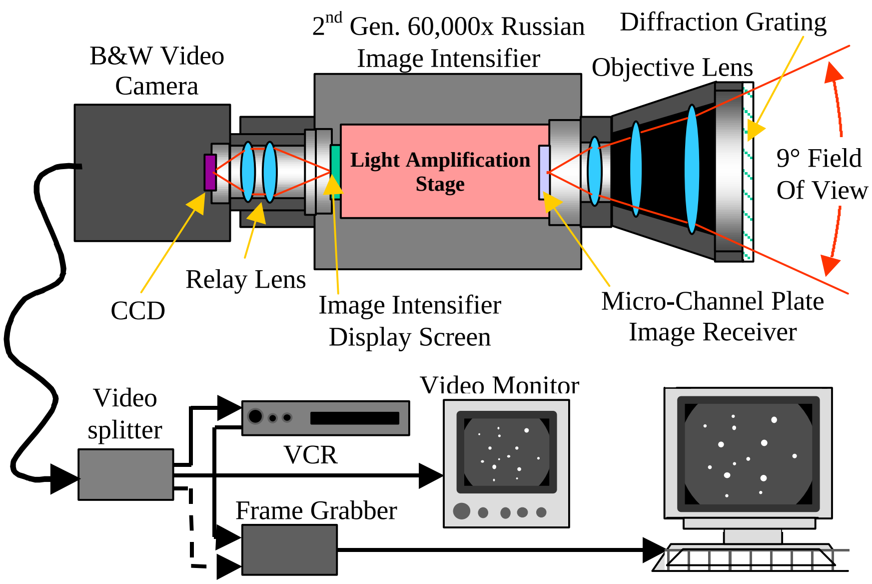


Figure 1. Setup capture and recording

Figure 2 Multi-frame stacked image and combined video of a Leonid meteor and off set spectra

The author didn't have the time to search for nor was he in the position to buy a scientific grade transmission grating. To be able to create the meteor spectra under collimated conditions and to minimize dispersion distortion, the author had to find a grating large enough to cover the Russian image intensifier's 3-inch aperture lens. The solution came in the form of a photographic diffraction filter used for special photography effects. The Cokin Diffractor B40 filter is a diffraction grating used to produce artistic spectral images within the camera's field of view from bright light sources, including the sun and the moon. The filter is available for around $40 USD and available from Minolta Corp.

The Grating Filter

The Cokin filter has 240 lines/mm, a 0 Order efficiency of 85%, a 1st order efficiency of 5.3% and 2nd order efficiency of 2.22%. Though not an ideal grating for the application, the author was more interested in seeing if this jerry-rigged assembly would even work. The grating details were kindly provided by Ed Majden. Figure 2 shows an assembly of four "stacked" video frames that includes the meteor nucleus, plasma tail, and a 1st order spectral emission located at the frames bottom right-hand corner, showing a well defined magnesium line at 520nm. The sets of dots are multiple images of field stars imaged and offset with sequential video frames being centered on the meteor's nucleus. The offsets show the motion of the meteor relative to the frame/camera.

The Results

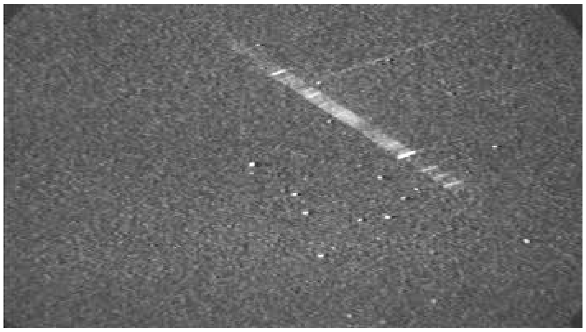


Figure 3 Single video frame from a Leonid meteor spectra transit

The author was able to capture five meteor/spectra transits over a period of two and a half hours and many other faint meteors without associated spectra. Only one spectra transit was bright enough and ideally located in the video frame to show the entire transit event unobstructed. Figure 3 is one frame from a set of eight captured from this event. The spectra transit shows distinct emission spectra in the visible and infrared spectra (out to 875nm), as well as the neutral oxygen line trail. Each of the spectra video frames was 35.2 milliseconds long for a total spectral emission time of 246.3 milliseconds. See Figure 5. The meteor transit and neutral oxygen line tail lasted well over a second. Coma Berenices is the background star field; the field of view is approximately 9 degrees wide.

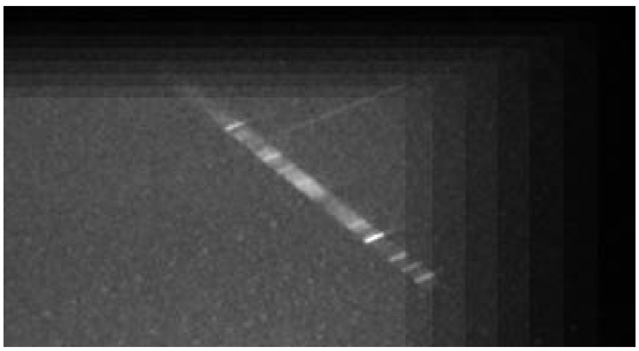


Figure 4 Multi-frame stacked image of the Leonid meteor spectra transit shown above

Figure 4 shows a stacked integration of eight video frames including the frame shown in Figure 3. The set of stacked frames is reminiscent of the meteor spectra images that could be recorded with film-based time exposures. The stacking and averaging of the frames significantly reduces background noise and increases the images dynamic range, sharpness and resolution of the spectra. Emission lines that are barley visible in the single video frame are quite distinct in the stacked image. Careful examination of both Figures 3 and 4 revealed that the imaged spectral emission lines occupy a width of approximately two pixels; this pixel sampling is close to the optimal nyquist sampling criteria. The resulting two-pixel spectral line width indicates that the combined gratings dispersion, image intensifier resolution, and camera's pixel size were fortuitously close to optimal for this system's jerry rigged setup.

Temporal Imaging

One significant advantage of video recording is the possibility of capturing the evolving and decaying of spectral lines due to the meteors ablation and heating of new material as the meteor passes through the atmosphere. Figure 5 shows general brightening and fading of spectral emission lines from the beginning to the end of the meteor spectra transit event. Closer inspection will also reveal several spectra lines emerging and or disappearing independently from the rest of the more consistent and enduring emission lines. The author can only surmise new material is being exposed and heated to provide these fleeting effects. Seven of eight sequential recorded raw frames are displayed in this trimmed and assembled montage, and the event progresses in time from right to left with the spectral emission phase lasting approximately one quarter of a second.

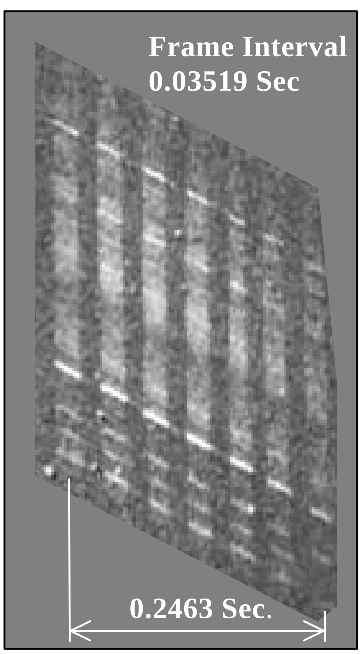
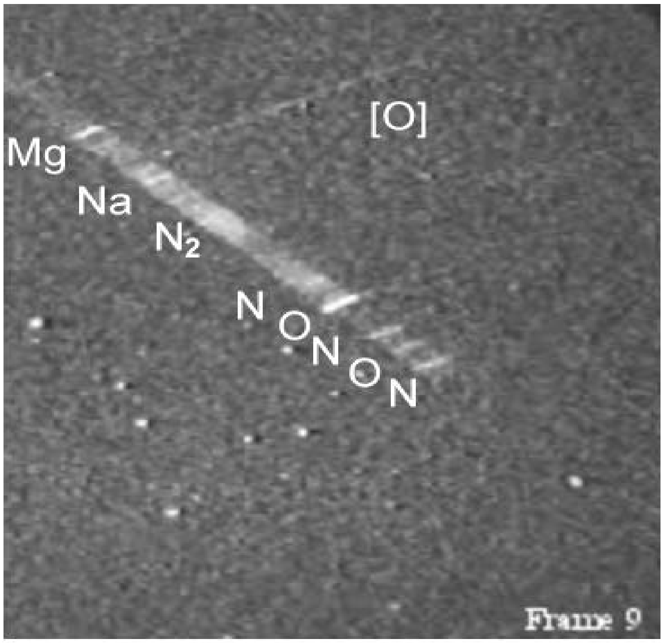
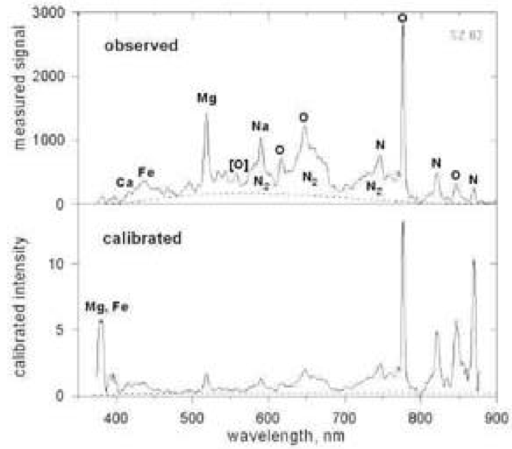


Figure 5 Leonid Spectra Montage





Spectral Plot was supplied by Dr. Jiri Borovicka of the Ondrejov Observatory as derived from his paper Published in the Meteoritics and Planetary Sciences publication 1999

Figure 6 includes a Leonid spectra picture produce by the author. Dr. Jiri Borovicka of the Ondrejov Observatory was kind enough to identify the emission lines captured in this picture. Dr. Jiri Borovicka has also generously allowed the inclusion of his high resolution Leonid spectral plot generated from his earlier investigative research and paper on Leonid spectra titled “First results from video spectroscopy of 1998 Leonid meteors” by J. Borovicka, R. Stork, and J. Bocek, Meteoritics & Planet. Sci. 34, 987 (1999).

Image Processing

The BMP pictures included in this article are derived from MPV video clips selected from the author’s recorded Leonid 2001 collection. The BMP frames were produced from the MPV video clips by a “freeware” software package called VirtualDub. Figure 3 is a raw BMP frame taken directly from a Leonid 2001 video clip with no image processing or alterations. Figures 2 and 4 were “stacked” and averaged using MaxImDL image processing software but otherwise unaltered. Figure 5 is an assembly of seven raw frames without image processing but using Photoshop to trim and assemble the separate frames into a single montage.

Conclusion

The successful capture of Leonid spectra demonstrated by the author’s experimental set up is further enhanced by the realization that expensive high-grade scientific grating were not used to obtain the above results. Amateur astronomers will likely become increasingly involved with meteor spectroscopic imaging as reasonable priced 2nd and 3rd generation image intensifiers like the “I-cubed”, wide-angle lenses, low cost video cameras and digital recording and image processing become increasingly available. The availability of these off-the-shelf components also opens up the possibility of creating whole-sky coverage meteor spectra surveys, using clustered arrays of the above described system that could be afforded by amateur and professional groups alike. With low cost digital video recording products also becoming available, high quality digital video recordings of whole-sky meteor storms events will soon be possible and affordable to interested groups.

My sincere thanks to Ed Majden and Dr. Jiri Borovicka for their encouragement and review of this paper and my wife Jeanne for her editorial review and support.

CCD – An Alternative to a Larger Scope

By John Ambrose

Who hasn't looked through the eyepiece at one time or another and said to himself, I need a bigger scope, everything is just too dim. I have had my bouts with aperture fever also but one event got me thinking about the whole matter and forced me to do a little research.

I was up at Mt Laguna, California, visiting my old astronomy club while out on business in San Diego. I took my 5 inch Celestron (C5+) along for the occasion. I was looking at M1 and beside me was a fellow with a 10-inch LX200 looking there also. As I looked through his scope I expected to see an image 4 times brighter since the ratio of imaging area is 4:1. What I saw was an image just as faint but twice as large. Hey, I thought, this does me no good at all - twice a faint smudge is still a faint smudge. What is wrong with this picture?

Well the problem as most here have already guessed is that both systems were f/10's and anyone familiar with photography knows that the f/stop of you camera is directly proportional to image brightness. In order to increase brightness you need to step down an f/stop or two. The same holds true in astronomy except that we don't open an iris we increase the ratio of the aperture to the focal length – we get a faster scope (or add a focal reducer if you can). If I wanted a brighter image with the 10-inch aperture an f/6.3 scope would have done a better job and an f/4 better still assuming we use the same eyepiece for comparisons. It is true that a 10" f/10 shows stars brighter and you see more of them because you have that large primary focusing more light onto the point source star images. But for distributed objects such as nebula and galaxies and the like the objects have the same surface brightness as in my 5-inch because they are stretched twice as large.

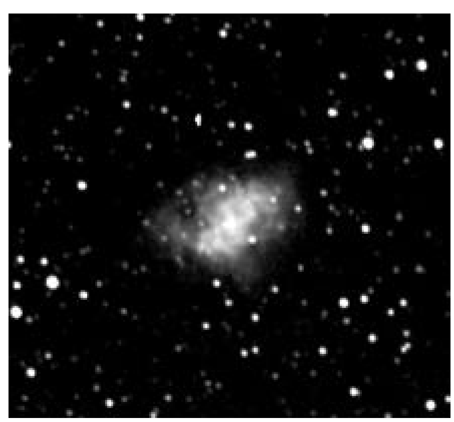
In order to make the image look four times brighter the 10-inch scope would have to have the same focal length as my 5. Then the images would be the same size in each scope and the 4:1 advantage would be seen directly in the 10 inch. So for this to happen the 10-inch scope would need a focal length of 50 inches making it an f/5. Now if you pop another eyepiece in the 10 doubling its power you lose your 4:1 advantage and are back to your f/10 image brightness.

An interesting rule can be derived from this and that is that as you double magnification you reduce image brightness by a factor of 4. So if you start at 50 power and double to 100 and double again to 200 your image brightness is reduced by 16 over what you had when you started. Ouch, that is a big price to pay for twice doubling power. We always knew the image got dimmer but maybe not exactly by how much. As in a famine it is good to start out fat, likewise when ramping up power it is good to start out with a fat primary in a fast system. However, ramping up power to 100 or 150x on a bright distributed object like the "Blue Snowball" (NGC7662) can actually improve your seeing. But not because the rule is invalid it is just that the decrease is object brightness is not as noticeable as the decrease in background brightness, so the net gain is an increase in contrast and a better view.

Image brightness aside a larger primary has the additional advantage of greater resolving power. The Dawes limit goes from .9 arcsec with a 5-inch scope to .5 arcsec with a 10 because of the smaller diffraction pattern of the 10. So in a 10-inch scope you have twice the star splitting power with doubles and you will be able to see much more detail on planets.

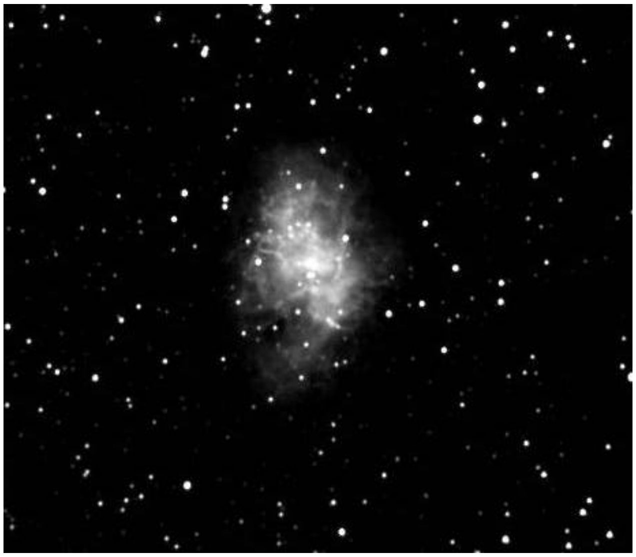
But for those who just want to brighten the fuzzies you might want to consider another alternative rather than going to a larger scope. I have found an excellent way to increase light gain is to plug in a CCD (Charged Coupled Device) camera. With a CCD image you not only get to see the object more defined and brighter you get to take it home with you and pin it up on the wall (which is much better than fond memories in my opinion). You also gain in image size since your view is not only brighter it is larger. The object is substantially larger than anything you will ever see through the eyepiece at that brightness. Also a CCD is able to very nicely cut through light pollution because of its large dynamic range and the ability through a contrast stretch to shift the viewing window above the light pollution floor to where it bounds only the object of interest. Various image processing techniques are also available to further enhance the image.

As an example of what can be had with a 5 inch scope and an entry level CCD see the shot of M1 below. This was one of my first shots with the SBIG ST-5C camera and my Celestron C5+ telescope. The shot was taken using an f/3.3 focal reducer and exposure of



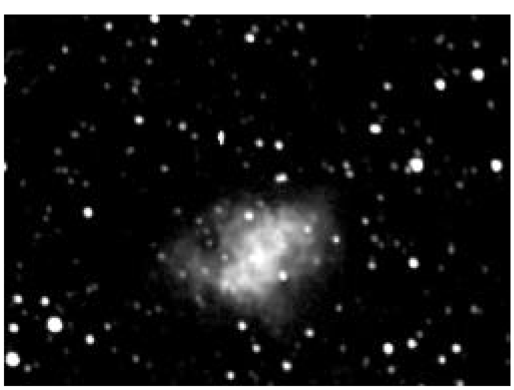
14 minutes (84 x 10 sec shots).

A more recent shot of M1 using upgraded equipment: telescope, LX200GPS 10 inch, and Starlight Express MX716 camera, is seen below. Exposure was 16 minutes (48 x 20 sec); also using an f/3.3 focal reducer.



The new camera has twice the field coverage of the old and the 10-inch scope twice the resolving power of the C5. Focus was achieved using a Hartman mask using triangle shaped rather than round holes. As you improve your equipment and technique your shots improve also.

But is a little unfair to my ST-5C to compare the images one to one in size since the MX716 contains four times the pixels and is double the dimensions of the ST-5C . A fairer comparison is to reduce the ST-5C image to show the same pixel density on the page like so…



Now the image doesn't look nearly so lacking. (Or at least not to me:)

Now as I look back on my first shots I can easily see the need for improvement though at the time they were my trophies. And possibly at some point in the future I may look at my current shots the same way. But the fun of CCD is that you will enjoy your shots no matter what stage you are in. They will be your trophies and you will be delighted in how much more you can now see of the objects you strained at the eyepiece just to detect.

CCD photography is the great equalizer for the small amateur telescope. Those comments in star atlases "needs at least a 10 inch", or "best seen in a 14 inch at 200 power", etc., will never apply again. All is within reach in CCD astronomy no matter the size of your scope. And you will be surprised at how many of your shots compare well to professional shots listed in Burnham that were taken prior to the 1977 publishing date. So if you are looking to invest in a system upgrade a bigger scope need not be the answer at all, you can stay with what you have and add a CCD camera. For a decent laptop computer and an entry level CCD you cost will be less than $2000. And you equipment will still work on a bigger scope if you got that route in the future. Enjoy!

The Age of the Universe

Most everyone has some familiarity with the measurements being taken of the microwave background, the relic afterglow of the big bang, also known as the CMB (Cosmic Microwave Background). These measurements are detailing the geometry of the universe to a high precision and the nature of the matter and energy that fill the Universe. Now the latest measurements of the CMB by NASA's Wilkinson Microwave Anisotropy Probe (WMAP) have nailed these measurements with an uncanny accuracy.

The first evidence of structure in the Cosmic Microwave Background (CMB) was found in 1991 by NASA's Cosmic Background Explorer (COBE) satellite, which mapped the entire sky with high sensitivity but coarse angular resolution. Then BOOMERANG, a balloon-mounted telescope that circum-navigated Antarctica mapped only about 2.5% of the sky but with an angular resolution 35 times that of COBE. BOOMERANG revealed hundreds of complex structures that are visible as tiny variations -- typically only 100 millionths of a degree (0.0001 C) -- in the temperature of the CMB. By observing the characteristic size of these hot and cold spots the geometry of space was determined to be very nearly flat. BOOMERANG data also provided an estimate of the matter and energy density of the universe, but only to an accuracy of about 10%.

On February 11, 2003 additional CMB data was released based on measurements by Wilkinson Microwave Anisotropy Probe (WMAP). WMAP measured the CMB to 1 millionths of a degree. Based on this data the portrait of the universe can now be described with an unprecedented accuracy on the order of 1%. The values of various cosmological parameters are summarized below.

1. The patterns in the big bang afterglow were frozen in place 0.38 billion (380 million) years after the big bang.

2. The first generation of stars to shine in the universe first ignited only 0.2 billions years (200 million years) after the big bang, much earlier than most scientist's expected.

3. The precise age of the universe is pegged at 13.7 billion years, plus or minus about 0.15 billion (150 million) years.

4. WMAP data confirms the both the big bang and Inflation theories continue to ring true.

5. The total matter content of the universe is 27%, with baryon (ordinary) matter content contributing on 4% and the dark matter content at 23%. The dark matter thus comprises 85% of the matter in the universe. It is unseen, unknown.

6. The mysterious dark energy content is 73%.

7. The universe will continue to expand forever, rather than collapse.

The WMAP probe orbits at the second Lagrange Point or "L2", about a million miles from earth. It will continue to observe the CMB for another three years, and it's data will reveal yet more insights into the theory of Inflation and the nature of the mysterious dark matter and dark energy which so dominates our universe.

The WMAP probe was named in honor of David Wilkinson who died in September 2002.

This article is based on an Internet email supplied by the Science.NASA.gov web site that was titled The Oldest Light in the Universe. Permission is granted to reprint this article in local (nonprofit) astronomy club newsletters. (c) 2003 by Ron Kunkel Used by permission.

Messier Objects - March

by Greg Cantrell

March reminds us that the cold, cloudy weather of winter will soon depart, to be replaced by warmer nights. This month's selections can be found primarily in two constellations, Leo and Ursa Major.

M 65 & 66 (NGC 3623 & 3627) – These round, bright galaxies in Leo share the field of view with edge-on galaxy NGC 3628, and make a wonderful view at low powers.

M 95, 96, & 105 (NGC 3351, 3368, & 3379) – This small cluster of galaxies is found in Leo. Look for NGC 3384 & 3389 in the field of view with M 105.

M 40 (Winnecke 4) – Two stars, magnitudes 9.0 and 9.3, found in Ursa Major.

M 81 & 82 (NGC 3031 & 3034) – M 81, a bright spiral galaxy, and M 82, seen nearly edge on, make up one of the finest views in the night sky. Find this wonderful pair in Ursa Major.

M 97 (NGC 3587) – Known as the Owl Nebula, this 11.0 magnitude planetary nebula in Ursa Major is a fine sight under dark skies.

M 101 (NGC 5457) – This large, magnitude 7.9 spiral galaxy in Ursa Major is seen face on, and can be a challenging object under anything but ideal sky conditions

M 108 (NGC 3556) – This magnitude 10.0 edge on galaxy appears as a thin streak that brightens somewhat toward its center. A difficult object to locate in Ursa Major under anything but ideal conditions.

M 109 (NGC 3992) – A magnitude 9.8 galaxy in Ursa Major, this spiral galaxy looks like a small oval patch of light.

Upcoming Events

Star parties and other astronomy-related events are an important part of the amateur astronomy experience. Listed below are several events offering dark skies and astronomical fellowship.

April 18 The **Astronomical Society of Greater Hartford** holds its annual **Starconn**. Visit http://www.asgh.org for more information.

April 27 – May 4 The 25th annual **Texas Star Party** will be hosted by the Southwestern Region of the Astronomical League. Visit http://www.texasstarparty.org/.

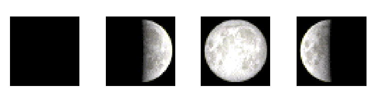
May 17 – 18 The **Northeast Astronomy Forum and Telescope Show**. More information at http://www.rocklandastronomy.com/neaf.htm

May 30 – June 1 The **Mason-Dixon Star Party** will be hosted by the York County (PA) Astronomical Society. Information can be found at http://www.masondixonstarparty.org

June 27 – 29 The **Jersey StarQuest** will be hosted by AAAP. More information at http://www.princetonastronomy.org

July 25 – August 3 The **Summer Star Party**, hosted by Rockland Astronomy Club, will be held in Savoy, MA. Visit http://www.rocklandastronomy.com for more information.

August 1 – 2 Stellafane. Visit http://www.stellafane.com for more information.



Mar 3 Mar 11 Mar 18 Mar 25