The High Desert Observer

May 2020

The Astronomical Society of Las Cruces (ASLC) is dedicated to expanding public awareness and understanding of the wonders of the universe. ASLC holds frequent observing sessions and star parties and provides opportunities to work on Society and public educational projects. Members receive electronic delivery of *The High Desert Observer,* our monthly newsletter, plus, membership in the Astronomical League, including their quarterly publication, *Reflector,* in either paper or digital format. ASLC members are also entitled to a $5 (per year) discount on *Sky and Telescope* magazine.

Annual Individual Dues are $30
Annual Family Dues are $36
Annual Student (Full Time) Dues are $24

Annual Dues are payable in January. Prorated Dues are available for new members. Dues are payable to ASLC with an application form or note to: Treasurer ASLC, P.O. Box 921, Las Cruces, NM 88004. Contact our Treasurer, Patricia Conley (treasurer@aslc-nm.org) for further information.

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Table of Content

2 From the President's Desk— Tracy Stuart
3-7 Uranograph Ursa— Bert Stevens
8-16 Member Article- Spectroscopy— David Doctor
16-23 Member Article, – One Small Patch Of Sky— Alex Woronow
24-26 Member Astrophotography
27 New Probe To Use X-Ray Scanner In Search Of Extraterrestrial Life

Member Info Changes

All members need to keep the Society informed of changes to their basic information, such as name, address, phone number, or email address. Please contact Treasurer@aslc-nm.org with any updates .

April Meeting

Our next meeting TBD later, as circumstances permit. The ASLC will not be holding meetings, gatherings or public outreach events until it is deemed safe to do so. Wash your hands!

Events

ASLC hosts deep-sky viewing and imaging at our dark sky location in Upham. We also have public in-town observing sessions at the Pan Am Plaza (on University Ave.) and at Tombaugh Observatory (on the NMSU campus) All sessions begin at dusk.
At our Leasburg Dam State Park Observatory, we hold monthly star parties. Located just 20 miles North of Las Cruces, our 16" telescope at this site is used to observe under rather dark skies.

Masthead Image: Moon rising over the Organ Mtns. Las Cruces, in Penumbral Eclipse, February 10, 2017.

From the Desk of the ASLC President

Tracy Stewart

How was our moon formed?

We all know the answer to that question. About 4.5 billion years ago the early Earth was hit by a Mars-size planet named Theia after the mother of Selene, goddess of the Moon.

Well maybe not. Carbon emissions from the moon are causing astronomers to question this theory of the formation of our moon. An ion mass spectrometer aboard the Japanese spacecraft Haguya detected carbon emissions over the entire lunar surface with the amounts varying with respect to the lunar geography. The amount of carbon detected cannot be explained by micrometers or accumulation of carbon after the formation. The carbon must have been embedded in the Moon at its formation. However carbon is very volatile and would have been vaporized by the heat generated by the colossal impact event.

Something to think about!

We are still under lock-down at least until May 15th. The way things are going who knows if that will change and even the lock-down is lifted we still have the wishes of Good Samaritan to consider. In other word we don't know if there will be a May meeting. If we do have one, I could sure use a speaker. Any ideas. STAY HEALTHY!

THE ANSWER IS 42.

Some Useful Links

https://www.youtube.com/watch?v=ZEMSVgGb38I

https://www.youtube.com/watch?v=wZTGh35kioQ

https://www.youtube.com/watch?v=ZBInhPFFVog

https://www.youtube.com/watch?v=LL8ccdst1fs

The Uranograph

By Bert Stevens

Constellation of the Month: Ursa Major, The Great Bear

Ursa-Major-illustration.jpg

Ursa Major, the Big Bear, is the third largest constellation in the sky, occupying 1,280 square degrees. The most prominent part of the constellation is the Big Dipper, which comprises its northeastern quarter. The two start at the west end of the Dipper, called the Pointers, point toward the north pole star, Polaris. Following the arc of the Bear's tale (which is also the handle of the Dipper), two first magnitude stars come into view. The first is Arcturus in Boötes and then Spica in Virgo. A convenient memory device is "arc to Arcturus, then speed on to Spica".

Ursa Major, the Great Bear, is the third largest constellation in the sky. During the month of May, it prowls high in our northern sky. Not only did the ancients in Greece and Rome think of this grouping as a great bear, but a number of North American tribes (Algonquin, Iroquois, Illinois, and Narragansett, among others) did likewise. This constellation contains the famous asterism known as the Big Dipper, though in England it is also known as the Plough. The French and Irish both consider the asterism to be a chariot.

The mythology behind the Great Bear begins with King Lycaon of Arcadia. His daughter, Callisto, was chosen to become one of the beautiful nymphs who followed the goddess Artemis, sister of Apollo. Artemis was the patroness of childbirth and the protector of babies. The one thing she prized above all was chastity. She went so far as to ask Zeus for eternal virginity, which Zeus granted.

Zeus, however, was not above taking advantage of the nymphs even though they had taken a vow of chastity. One night, Zeus came to Callisto in the guise of Apollo. He overcame her scruples and took advantage of her. Eventually, Callisto delivered a son, named Arcas (from the Greek arktos or "bear"). Zeus knew that Artemis would be angry with Callisto for breaking her vow, and even worse, if his wife, Hera, found out, Callisto's life would be in jeopardy. To protect her, Zeus turned Callisto into a great bear. She retained her human mind, so she was unable to make friends with other animals, yet at the same time, as a bear, she might be hunted down by the local population. It was a lonely existence.

One day, Callisto's son Arcas spied her in the woods and aimed his arrow at her. Seeing this, Zeus turned Arcas into a bear and he immediately recognized his mother. Zeus grabbed both of them by the tail, and swung them around and around, stretching their tails far longer than those of earthly bears. Zeus let go of them, flinging them up into the sky, where they became Ursa Major and Ursa Minor.

As always, Hera eventually did find out about Zeus's dalliance with Callisto and the honored place he gave her and her son in the sky. This outraged Hera and she went down to Earth to visit her friend Oceanus, god of the ocean. She complained to him that the two bears had displaced her from her place in the sky. She pleaded with Oceanus to keep the bears penned up. Oceanus promised her that the two would never be allowed to travel far and would never be allowed to enter Greek waters.

Since Greece was surrounded by water on the east, south, and west, Oceanus' stricture keeps the two bears from setting in the west or rising in the east. They could only circle the North Pole in Ursa Minor's tail. All the stars in our sky turn daily around the north pole, keeping the two bears above the northern horizon as seen from Athens or Rome. From our latitude, all the stars of the Big Dipper asterism do go below the horizon, except for Dubhe, the northwest star of the Big Dipper. This star (and all the stars in Ursa Minor) are called circumpolar, because they circle the pole but never set.

The seven stars of the Big Dipper are each moving in a slightly different direction. Indeed, the Dipper has only appeared as such for the last 50,000 years, and in a similar time it will become so distorted as to be unrecognizable. This quick motion is a result of their all being within one hundred light-years of our Sun.

Mizar, the star in the middle of the Big Dipper's handle forms an interesting pairing with the nearby fainter star, Alcor. These two stars are only a fifth of a degree apart, but Alcor is over six times fainter than Mizar. This made the pair a test for keenness of vision among Native Americans. These two stars are moving through space together, but are around a light-year apart, being at slightly different distances in addition to their separation in the sky. At this distance, they are probably not gravitationally bound together into a double star system.

Alcor and Mizar, along with most of the other bright stars in Ursa Major are moving roughly with the same motion as part of the Ursa Major Moving Group. Only the bright stars Dubhe (Alpha Ursa Majoris) and Alkaid (Eta Ursa Majoris) are not part of this moving group, but fifty-six other stars in Ursa Major and other constellations are part of this moving group that was once an open cluster which formed five hundred million years ago.

Mizar itself is a quadruple star system with Mizar A and Mizar B being only 14.4 seconds-of-arc apart. Mizar B has a periastron (closest point to Mizar A) of 380 astronomical units (AU-the average distance between the Earth and our Sun). Their orbital period is in the thousands of years. These two stars are a visual binary, a multiple-star system where the stars are close together in space and bound together by their mutual gravity.

Mizar was the first telescopic binary to be discovered, first seen in 1617 by Benedetto Castelli who asked Galileo Galilei to observe it. Galileo produced a detail record of his observations. The binary nature of this star is hard to miss even in early telescopes, with Mizar A at magnitude +2.2 and Mizar B at magnitude +3.9, separated by the radius of Jupiter in the sky.

There are many instances where a pair of stars will appear close together in the telescope, but they are not gravitationally bound together because they are at vastly different distances and only appear to be close together because they coincidently line up in the sky. These are called optical doubles.

A third class of double star is the spectroscopic double. These stars are so close together that they cannot be separated in a telescope. A spectrogram of a spectroscopic double with two different spectral classes would show the characteristic spectral lines of each star's spectral type. When the two stars have the same spectral type, they would have the same spectral lines and the star's binary nature would be harder to discover.

If the orbital plane of the binary stars is not perpendicular to our line of sight, then the spectral lines of each star will show a different doppler shift as the stars orbit each other. When the line connecting the two stars is perpendicular to us, one star will be moving toward us, blue-shifting its lines, while the other star will be moving away from us, red-shifting its lines. The result is that the combined lines will become wider, or if the stars are moving fast enough, splitting them into two separate lines.

When the line connecting the two stars points toward us, the two stars will be moving left and right and not toward or away from us. This gives them the same doppler shift of zero, causing the spectral lines to be narrower. By taking frequent spectrograms of the star, the changes to the line width would allow this star to be identified as a spectroscopic double.

Mizar A (Zeta^1 Ursae Majoris) and Mizar B (Zeta^2 Ursae Majoris) are each a spectroscopic double star. Mizar A is composed of two spectral class A2 stars that are almost identical, with slightly different masses. This variation causes the doppler shifts of the two stars to be slightly different due to the slightly different resultant motions. The patterns in the spectral lines repeats every 20.6 days, which is the orbital period for this pair of stars. With Mizar A being close and bright, it was the first spectroscopic binary to be discovered, during Antonia Maury's spectral classification work

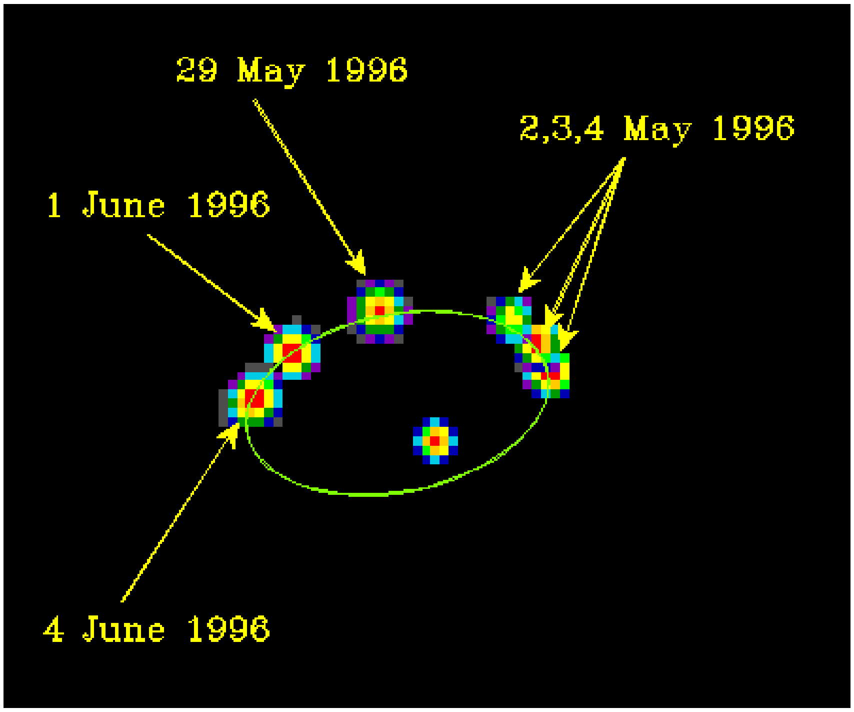
Uranograph cont…

Maury was a member of the Harvard Computors, classifying stellar spectra in the 1890s. She noted that sometimes Mizar had single spectral lines and sometimes they doubled up. She used the observations to compute the first spectroscopic binary orbit, published in 1897 under her own name. This was the first time a woman's name appeared on the title. One hundred and seven years later, the Navy Prototype Optical Interferometer (NPOI) on the Anderson Mesa station of Lowell Observatory in northern Arizona was able to image the two components of Mizar in extreme resolution in 1996. NPOI is an optical interferometer that creates the highest resolution images in the world.

The other star, Zeta^2 Ursae Majoris, is also composed of two A-type stars. These two are starting to evolve off the main sequence into the subgiant classification. These stars appear to be rich in metals (remember that in astronomy, elements heavier than helium are considered to be metals). The spectral lines do not provide a conclusive classification beyond being an A-type star.

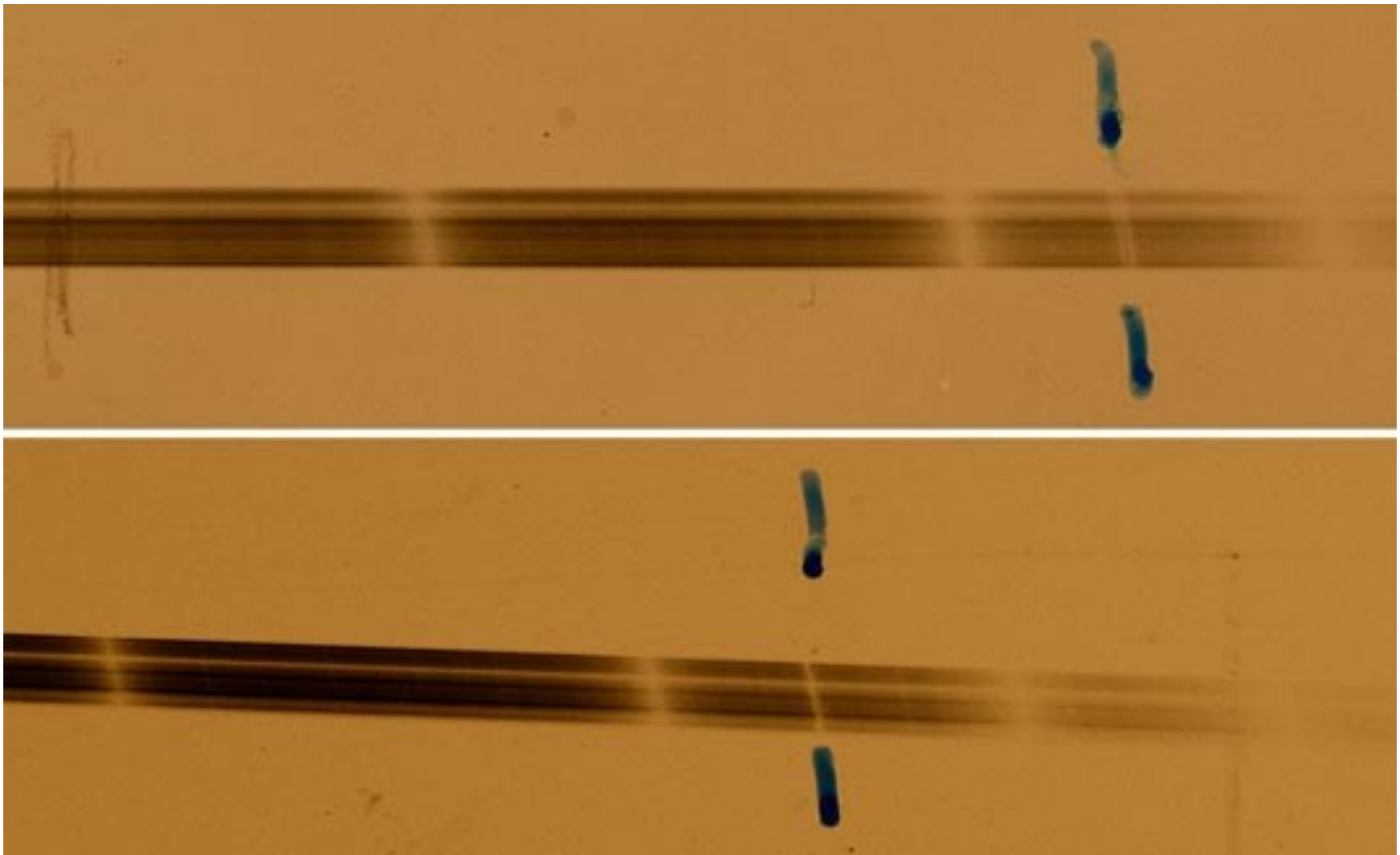
Speaking of multiple stars, the first double star system to have its orbit computed is Alula Australis (Xi Ursae Majoris) located at one of the bear's feet. The two stars that make up this double are magnitude 4.3 and 4.4, but they are only 1.8 seconds-of-arc apart, making them easy in most telescopes. The computation of their orbit in 1828 by French Mathematician Felix Savary marked the first time an orbit was computed for objects outside our Solar System. More recent observations have shown that there are actually four or five stars that are part of this system and that it is twenty-nine light-year away.

Our sky is littered with double stars. Some very close together and others far apart. This indicates that star formation is seldom an isolated incident, but frequently happens in multiples. Ursa major is an example of multiple star formation, not just from Solar-System-sized clouds forming single stars, but vast clouds forming a hundred stars at a time, including many binary stars.



The motion of the spectroscopic binary Mizar A is depicted in images from the Navy Precision Optical Interferometer (NPOI). While the two stars actually orbit their center-of-mass (called a barrycenter), this image has one of the two stars used as a reference point. NPOI is a special type of telescope that allows extremely high-resolution images by locating up to six small telescopes up to 833 feet away from the central facility where the beams are combined to form the images.

Uranograph cont…



Above:

Spectra of Mizar A taken at Harvard College Observatory show the splitting of the K-line of ionized calcium. The top plate was taken on Mar 29, 1887, while the bottom plate was taken seven days later. The K-line was Doppler-shift split into a double line as the two components of Mizar A were moving toward us (blue shift) and away from us (red shift). The bottom plate has the components moving right and left, so the Doppler shift is near zero and the line is single. Antonia Maury realized that this was the signature of a binary star.

Left:

Portrait of Antonia Maury, discoverer of the first spectroscopic binary, Mizar A.

Spectroscopy

By: Dave Doctor

Brief Intro to High Resolution Spectroscopy

Most of what we know about the universe and how it works is the result of astronomical discoveries made by spectroscopy. Spectroscopy is the analysis of light we receive from an object.The dispersion of the light from the object into its component wavelengths enables astronomers to infer many physical properties of that object, including temperature, velocity, composition and distance to name just a few.

What I believe those of us who participate in this branch of amateur astronomy find so compelling is the fact that even today, you and I can contribute to meaningful astrophysical research and discovery, with very modest backyard equipment!

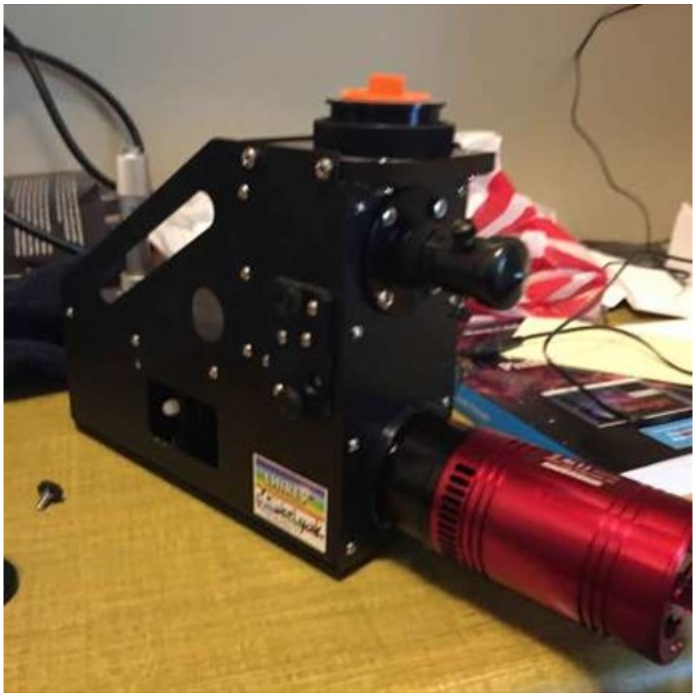
The purpose of this article is to provide a brief practical introduction to acquiring a spectrum with a "high resolution" set up. We are not going to delve into the physics behind the observations or the optical architecture behind the spectrographs. If after reading this you can say to yourself: "Gee, that doesn't seem so difficult. I think I can do this", then this was a success.

High vs Low Resolution

When people see the words "high resolution" they are probably apprehensive right off the bat about going further. This terminology has little to no correlation with the degree of difficulty of spectrum acquisition. Resolving power of a spectrograph is defined by $R = \lambda / \Delta \lambda$ where the "$\Delta \lambda$" is the smallest detail you can detect in the spectrum. Typically low resolution includes anything up to R= 1000. Medium resolution covers everything up to about 5,000 or so and high resolution for amateur equipment can go up to around 20,000. For example, if you are observing the H alpha line with an R= 20,000 you will be able to see changes in the spectral profile down to about 0.3 angstroms. Resolution is determined predominantly by the number of etched lines in the dispersion element you are using, known as the grating. So for example a typical high resolution grating may have 2400 lines/mm whereas a low resolution grating may have 300. Whether you choose high resolution or low resolution depends on what it is you want to observe and not on the relative ease of equipment operation. If you are going with high resolution using a typical high resolution spectrograph you are looking at small regions of the spectrum at one time, perhaps 100 angstroms at most. Because of this you are going to be focusing on single stars or stellar systems e.g binaries where very small changes in the spectral profile of a single line such as H alpha can be accurately measured. These types of observations can be very useful to astronomers for resolving physical parameters of the stellar system such as the orbital period , detection of previously unknown companions, extrasolar planets, sudden cataclysmic events etc. Lower resolution set-ups will facilitate observing the entire spectrum at one time and can be useful for spectral classification, observing extended objects such as planetary nebulae, galaxies, supernovae, and measuring large radial velocities e.g. quasars etc.

What do I need?

As we are focusing on high resolution for now, you will need of course a high resolution spectrograph. The standard for amateurs is the Lhires ("Littrow high resolution") which refers to the mechanical design. These have been manufactured by Shelyak Instruments for many years and the spectrograph comes ready to use with everything you will need except a power supply. I use an AC adaptor which plugs right into the spectrograph from a standard outlet. Visit Shelyak.com for more details.



Yes it is certainly quirky looking but lightweight and has a threaded collar for a standard SCT which you can see at the top of the left side image. There are 2 ports, one for the camera which you see at the bottom and a guide port. The schematic on the right illustrates the light path through the spectrograph. Notice the main camera shown at the bottom left is not seeing anything but the small amount of light going through the slit which reflects off of the mirror at the bottom, travels through a doublet lens to arrive at the reflection grating and then back through the doublet to the main camera. Your "guide camera" is therefore the only way to see your target and surrounding stars and does that by means of light reflecting off of the slit and back through the guide port via another small doublet lens.

You will need 2 cameras. Many folks are using Atik cameras as their main camera because their sensors have a high QE in the red region where you are going to spend the majority of your time doing high resolution observing. The guide camera can be anything but it is recommended to use one that has a wide field and high sensitivity. This will enable you to see both the target and suitable guide stars in the surrounding field. ASI ZWO cameras are a very good option.

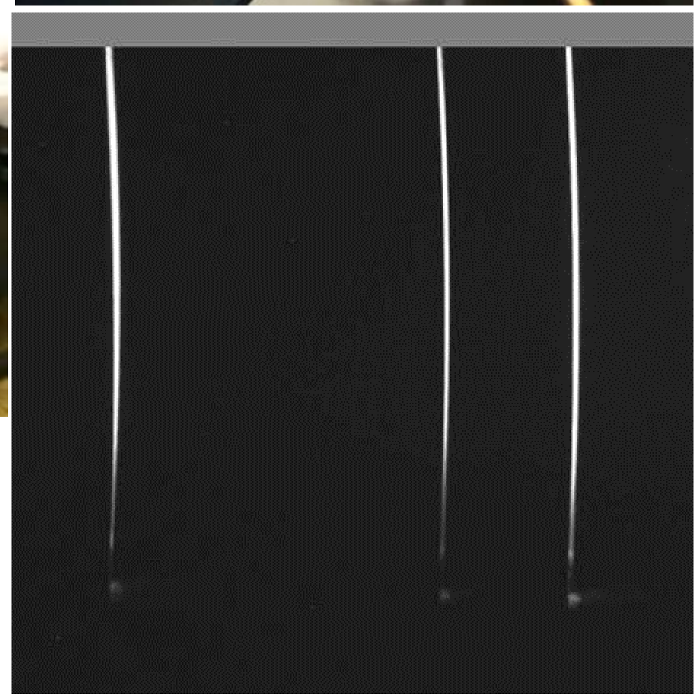
Lhires is optimized for an F/10-12 optical system. This is why many are using SCTs but anything that is within this range of focal lengths will work well.

Set-up and use

Most of the setup is done during the day. I highly recommend when you first get your instrument, put an eyepiece in the main camera port and look at the Sun which is totally safe to do! Follow the directions in the Shelyak manual. The small amount of light going through the 25 micron slit is not nearly enough to do anything harmful. It is very cool to do this because as you scroll through the Sun's spectrum you will see all the colors and the huge number of absorption lines! Familiarize yourself with the micrometer which is that tall silver thing sticking out with the numbers on it.

As you turn the micrometer knob and "scroll" to the red region of the spectrum observe what happens to the numbers on the micrometer. They should be increasing in value. When you get to H alpha you will have no doubt you are there because the absorption line is super dense. Write down the micrometer numbers at that point

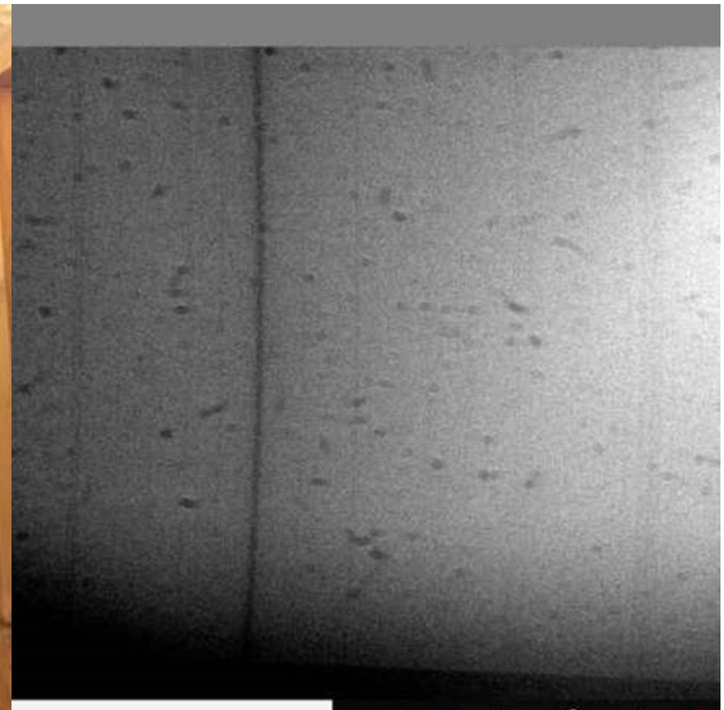
The next step is to go to a dark room and turn on the calibration lamp on the spectrograph, labeled "Calib". This is a neon lamp you will use to calibrate your spectrum. If you set your micrometer correctly when looking at the sun you should see 3 red emission lines in the eyepiece.



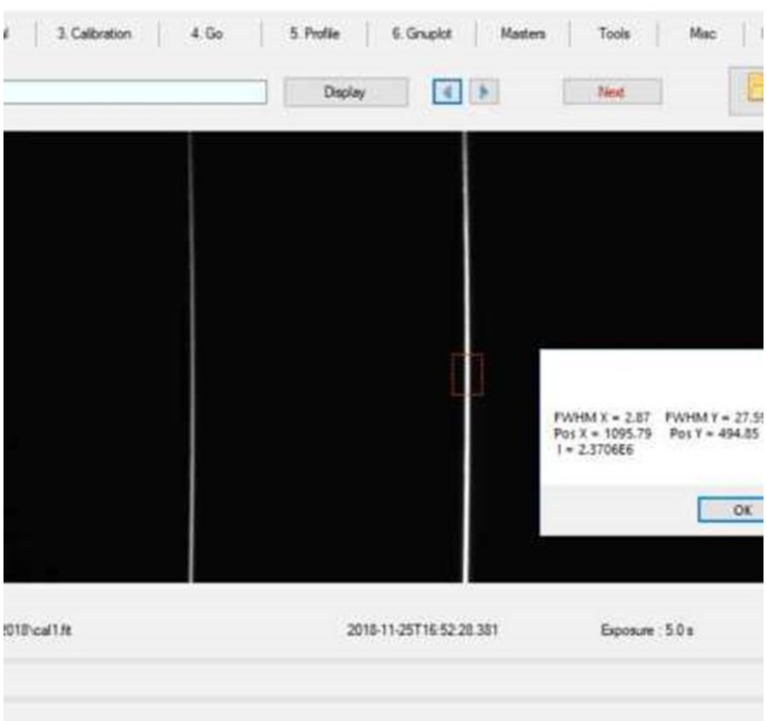
Now you are ready to attach the spectrograph to your telescope!

In this (next) example we're using a C14. The spectrograph threads directly onto the scope. Orientation of the spectrograph is not critical. No intervening focusers or anything else need to be connected. Shown here is the ASI ZWO 174 guider and the Atik 460EX main camera. The most challenging part of the camera setup is to make sure you have the correct backfocus distance. This has to be accurate to within 1-2mm. There is a spec diagram that tells you exactly the required distances so you can use the proper adaptors, similar to what you would do for regular imaging

Spectroscopy cont…

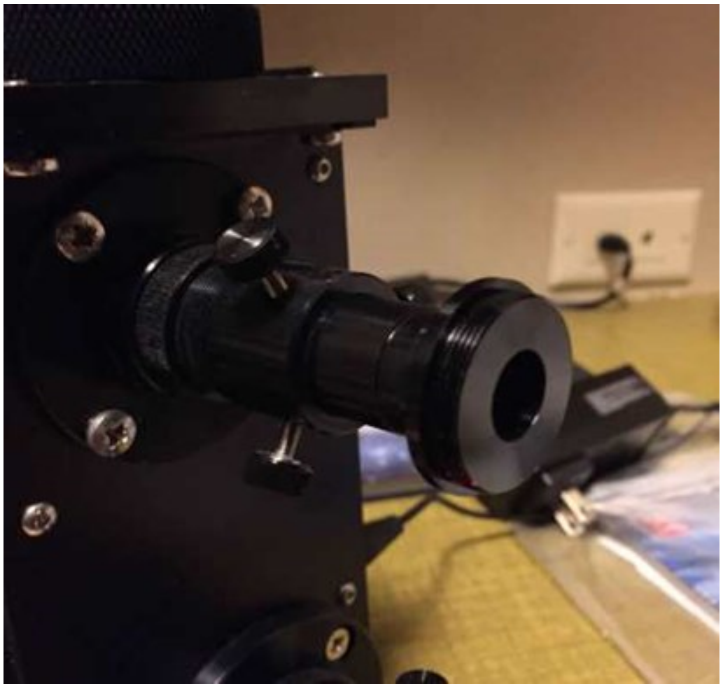


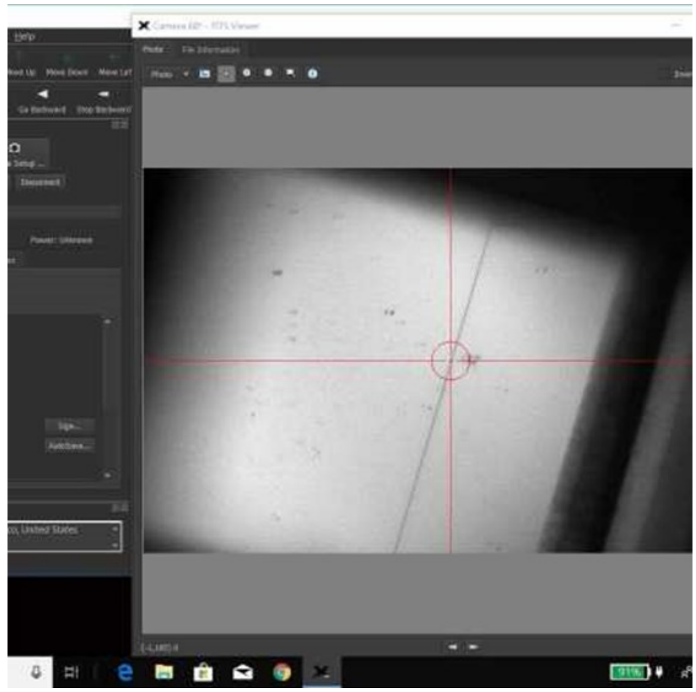
(Above Right) The next step is to point the telescope during the day, maybe toward the end of the day to a random area of sky, take an image and roughly center your H alpha line. This is actually a spectrum of the reflected sunlight! This will also confirm proper camera orientation. Red area of the spectrum is supposed to be on the right by convention and blue on the left. If you are turning the micrometer counterclockwise to increasing numbers you want to be seeing more of the red spectrum meaning your line should be moving to the left. If it's opposite of that your camera is upside down! I made that mistake the first time!



The next step is to focus the spectrograph. This is the key step in maximizing your resolution. Make sure the scope is covered. If you look at the image earlier showing the calibration lamp on, you will see just to the right of that ,the side door of the spectrograph is off and there is a white nylon screw there. That is where the focusing ring is. Make sure the doors on both sides are removed and the nylon screws are loosened so you can turn the ring. Take about 3 sec exposures and the goal is to turn the focusing ring small amounts until the calibration lamp line in the center is as narrow as possible. The spectrum processing software ISIS has a neat way of measuring the full width half max of the calibration line. You want this measurement to be less than 3 pixels for your "X" value assuming your pixel size is 9 microns. In this case we are binning 2x2 to get to about 9 microns.

Spectroscopy cont…





Now that your main camera is oriented and the spectrograph is focused you can set up your guide camera. This is also a daytime activity! The guide port uses C-mount threads. If you take an image during the day you will see the image of the slit shown on the right as a thin black line. The slit width should be no more than a pixel or 2. If it is more then the camera spacing is not correct and you will need to adjust the adaptor length.

At the telescope!

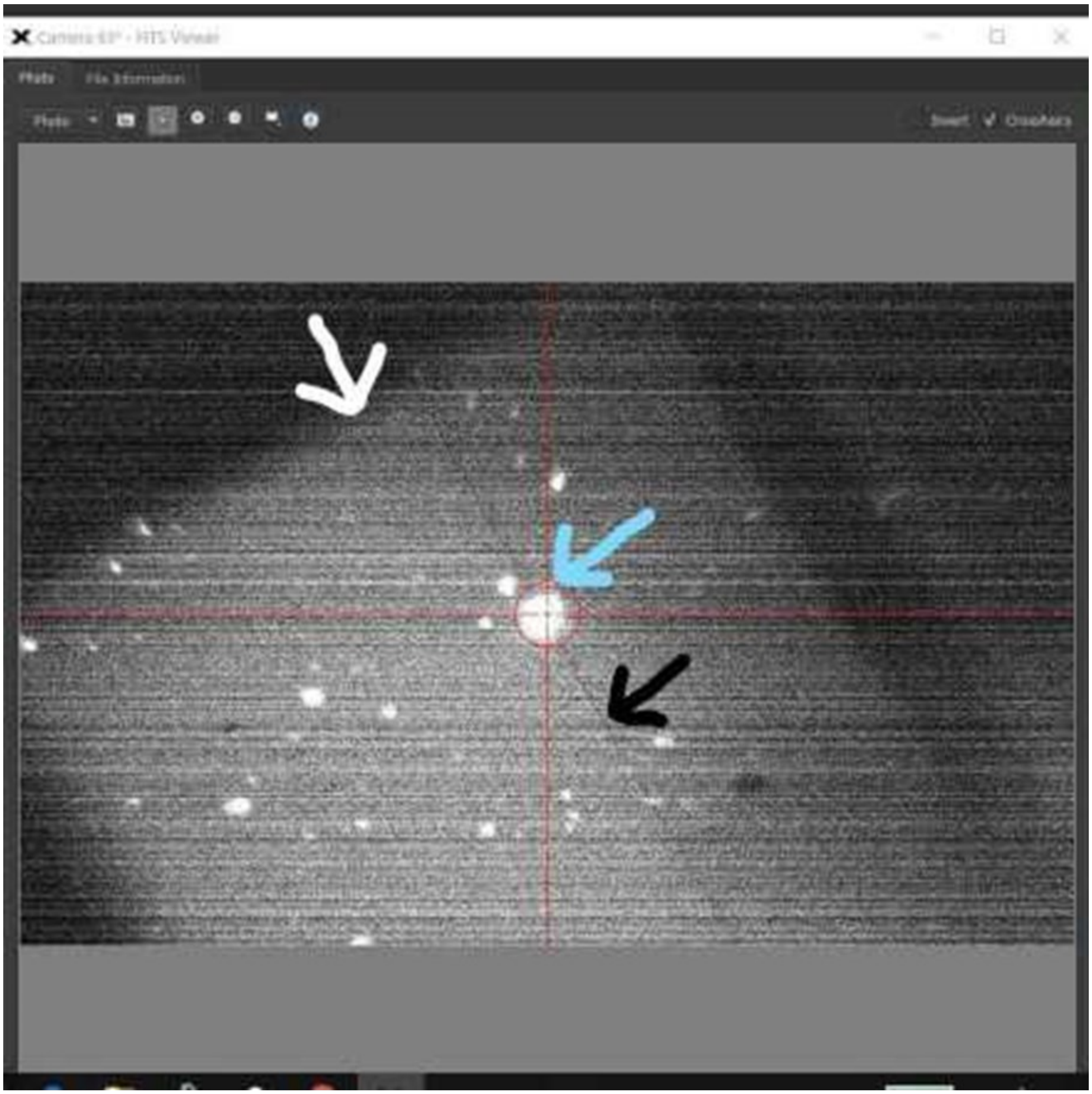
We are now ready to take a spectrum! The steps are as follows:

Slew to a bright calibration star. It is recommended to use a spectral type A star because this has strong hydrogen alpha absorption . You have to create what is called an "instrument response" by taking a "calibration spectrum" which is then applied as a correction to your target spectrum accounting for peculiarities in the optical setup and observing site. The calibration spectrum is compared to a known validated professionally acquired spectrum. Take 8-10 spectra. Typical exposures might be a minute or so. This also is the time to focus the telescope which I find is very straightforward using the knob on the SCT only. I do not use any intervening focusers. Use the small stars in the field to help confirm you are close. Once you are in focus take a test image with your main camera and make sure you can see the H alpha line in the center of your sensor or close to the center. It will take some trial and error positioning the star along the slit using a joystick for example to find out where on the slit is the center of the main sensor. It is not going to necessarily coincide with the center of the cross hair on the guider!

I should point out that this activity is generally hands on, kind of "old school" in the sense that you are out there with the telescope doing the focusing by hand, using a joystick to position your star on the slit etc. The typical spectroscopy project especially with high res equipment is going to be very short, maybe 1-2 hours maximum including all the calibration frames. Also of note is that your guider image is going to look weird.

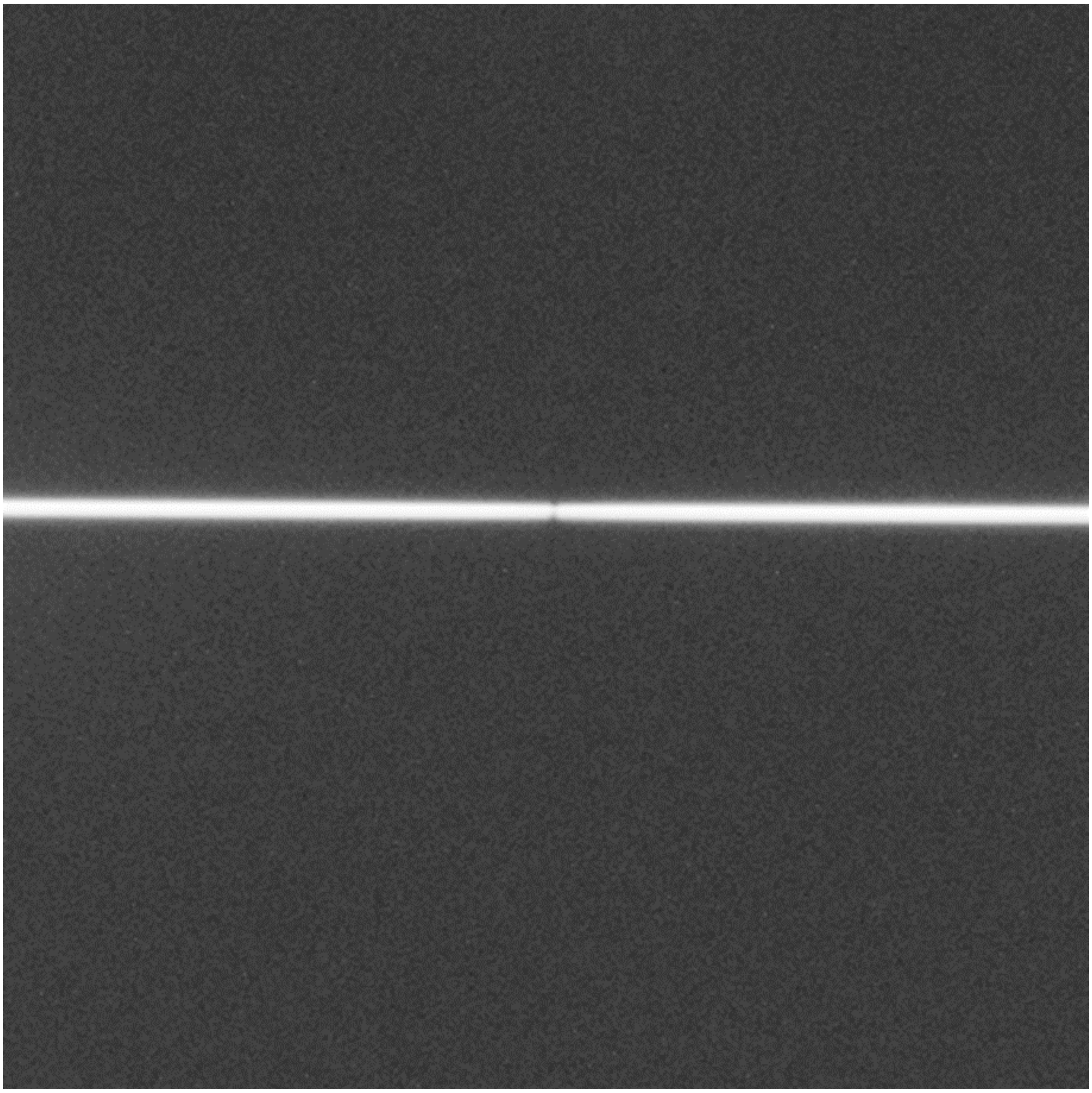
Spectroscopy cont…

There are a ton of internal reflections and the stars even a tiny bit outside of the center of the field are going to look awful with terrible coma etc. You will cringe especially if you do any imaging but don't worry. All you are trying to do is center the target star on the slit and keep it on there. Select stars away from the target for guiding and you can test different ones for their efficacy. Also if you are imaging a bright star, mag 1-3 for example you may not even need to guide.



This is an example of what a typical guider image looks like. You can see the image of the slit going through the center of the cross hair as a black diagonal line. The white arrow shows the reflected edge of the slit mirror. The blue arrow shows the center of the guider indicated by the cross hair. The black arrow shows the actual location of the center of the main camera sensor as I have determined it, so I have to move the star to this position on the slit before I take the spectrum.

(Below) This is an example of the calibration star spectrum. You want the H-alpha absorption line (dark vertical line above) to be close to the center. Also you want to check the rotation and make sure the spectrum is close to level. Doesn't have to be perfect as the software can correct



Take your calibration lamp image. Cover the telescope, turn the calibration lamp on and take a 3 second image

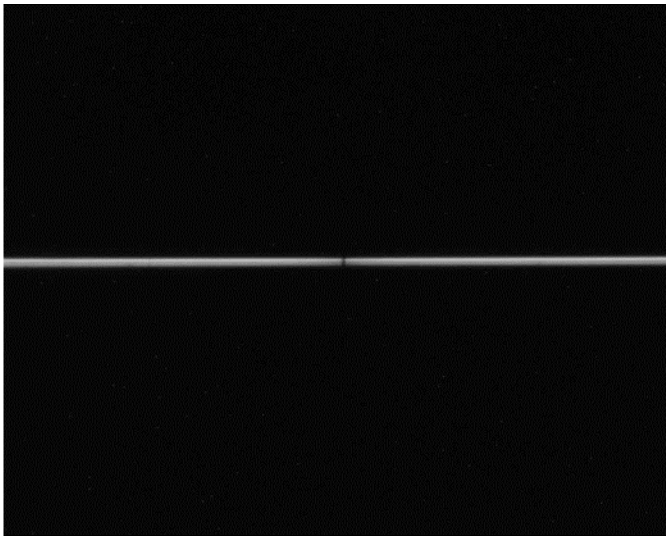
Slew to the target star, center on the slit as above and take a total of 1 hour of exposures. Mag 4-5 stars require about 5 minute exposures. 6-8 need 10 minutes. Make sure the spectrum is close to center

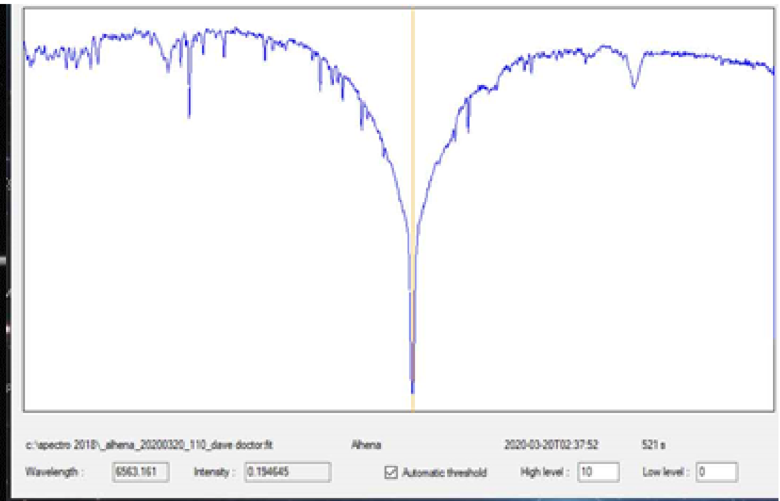
Park the scope and take your bias, flat and dark images. The Lhires has a flat lamp labeled "flat" and is a tungsten lamp. I take about 10-12 of these and shoot for maximum ADU about 80% of saturation of the sensor. Bias frames are just exposure time of zero with the scope covered. Dark frames are also taken with scope covered and you can take 5 minute darks or 10 minute as long as your max exposure times are less than or equal to dark frame expsoures.

Now you're ready for processing! The great news is that spectral processing is the easiest part of the whole project. While beyond the scope of this article, several processing programs exist as freeware and the tutorials are superb. In about ½ hour you will have your spectrum processed!

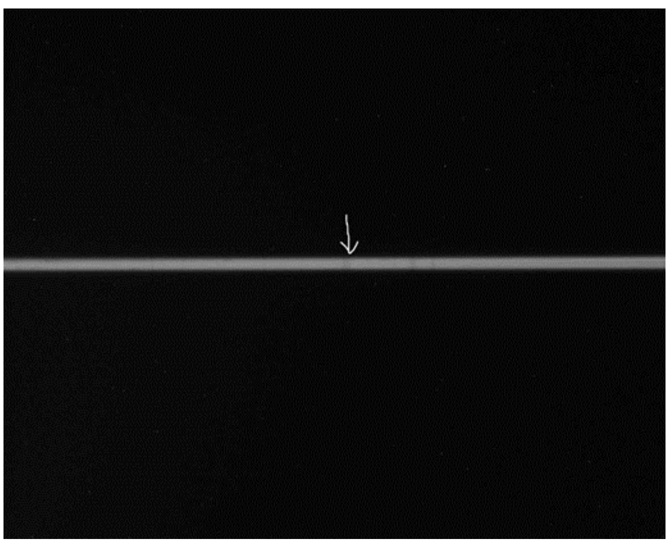
In summary then, high resolution spectroscopy is best suited for detailed analysis of single spectral line profiles such as H-alpha and can reveal physical properties and parameters of binary star systems and variable stars such as Be stars. You are going to be looking at narrow segments of the spectrum, on the order of 100 angstroms. It is not suited for observations of extended objects, whole spectra or any objects dimmer than about 8th magnitude. Hopefully you can see that the data acquisition may not be as complex as you thought!

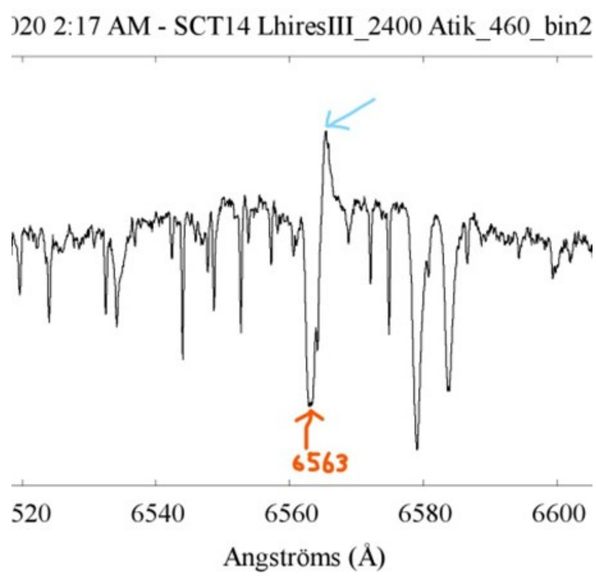
Spectroscopy cont…



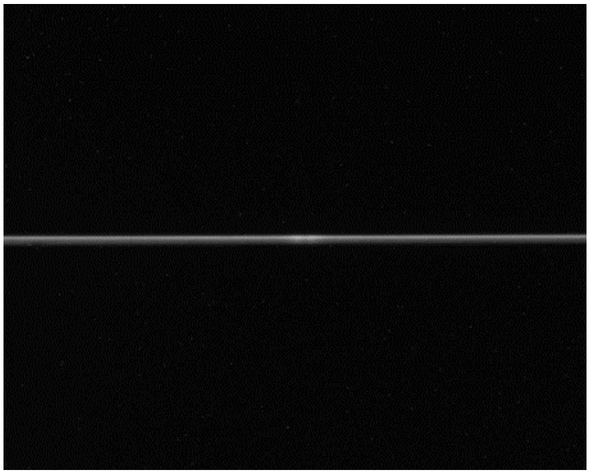


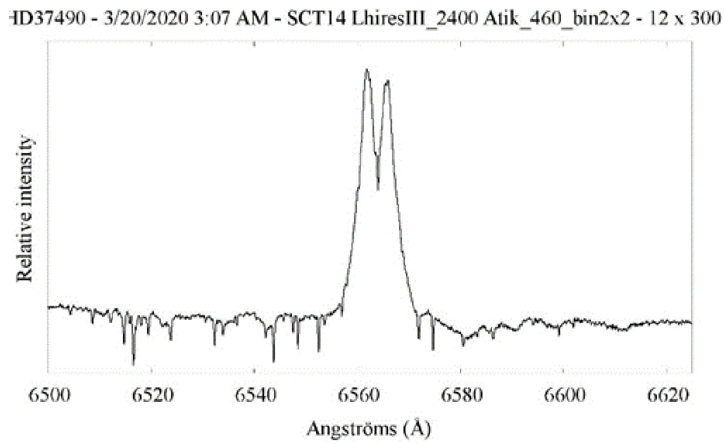
(Above) Typical spectral type A star showing strong H alpha absorption line and pretty normal spectral profile shown on the right.





This is a spectrum of Rigel centered on H alpha which shows a washed out appearance to what should be a very solid dark absorption line typical for a "normal" late B spectral type star. The reason for this appearance is that it isn't normal! The H-alpha line has both emission and absorption features in the same line! The blue arrow indicates the emission component while the red arrow shows absorption but note that the absorption line is slightly irregular where the lowest portion is blue-shifted. The emission line arises from a dense stellar wind near to the star, while the blue-shifted absorption lobe is created where the radiation passes through circum-stellar material rapidly expanding in the direction of the observer. These profiles are useful in the study of stellar winds in many types of stars





This is a typical emission spectrum for a Be star (B emission). The typical B emission star has a shell of gas surrounding it which gives rise to the emission component seen as the double peak in the profile on the right. The depth of the central absorption depends on the orientation of the gas envelope relative to the observer.

Thanks for reading! —Dave Doctor

One Small Patch Of Sky

By Alex Woronow

After processing an image to the best of my ability, I turn to searching for published information about the target object. Reading the Wikipedia entry often sets the stage by quickly summarizing 'what,' 'where,' and 'when.' But more importantly, Wikipedia sometimes offers a 'why'…why the object has scientific interest, when it does. Assuming it does, I hunt down peer-reviewed articles on the subject, or at least their abstracts, and compare those studies with what appears in my images—just to see how well I did. For M 83, something special happened. Unusual features I captured had not been described or discussed by professional astronomers or anyone else, as far as I can discover: an opportunity for me to describe and speculate—what fun!

Messier 83 (Southern Pinwheel Galaxy)

The "Grand Design" spiral galaxy, Messier 83 (Fig 1), has well-defined spiral arms showing simple structures, just as an archetypical Grand Design galaxy should. However, I have found that M 83 sports several abnormalities that the simplifying tag "Grand Design Galaxy" might not suggest. Referring to the numbers on the image in Fig 2, the newly discovered, unusual features/structures visible in this image include:

1) A hazy, Bright Halo, with smeared spiral-arm structure, surrounds, and is continuous with, the main galaxy. This halo is not entirely symmetrical, appearing wider at the right side of the galaxy (near the number "2" in Fig 2) and narrower on the left side.

2) A Dark Halo encircles the Bright Halo and wraps the entire galaxy. (This halo can be difficult to see. Move back from this image, relax your vision, and the dark halo becomes more clearly apparent.) A true image of M 83, which better shows all the features, is here: https://tinyurl.com/M83jpg100)
3) Beyond the Dark Halo, a faint bright arc appears from around 7 to 9 o'clock (Fig 2). It presents as if it were a portion of a spiral arm decoupled from the main galactic pinwheel.
4) Still farther out, spanning from about 6 to 8 o'clock (Fig 2) lies another smear of brightness, again mimicking a disarticulated spiral arm. It may join feature 3 at around 8 o'clock.
5) This feature covers the rest of the image; the background has luminosity above that expected for

For you to accept the validity of the image and the features listed above you should know some facts about the processing of the image in Fig 1 (and available at the link cited above). Fig 1's caption gives a few of the standard facts, but the processing methods most critically dictate what it reveals or doesn't. So …

No mask, other than a simple star mask, was employed.

No free-hand or other painting for enhancement or other reason was applied.

All images were drizzled within PixInsight onto a 2x grid with a 0.8 droplet size.

The luminosity channel was augmented by the RGB channels according to the equation L'=L+ (R+G+B)/3. (L' is often referred to as a "Super Luminosity or "Super_L".") Features 1, 2, 4 and clearly appear in the unprocessed Super_L image, without much squinting, if you know where to look. Feature 3 is more difficult to see, but histogram stretching alone makes it visible.

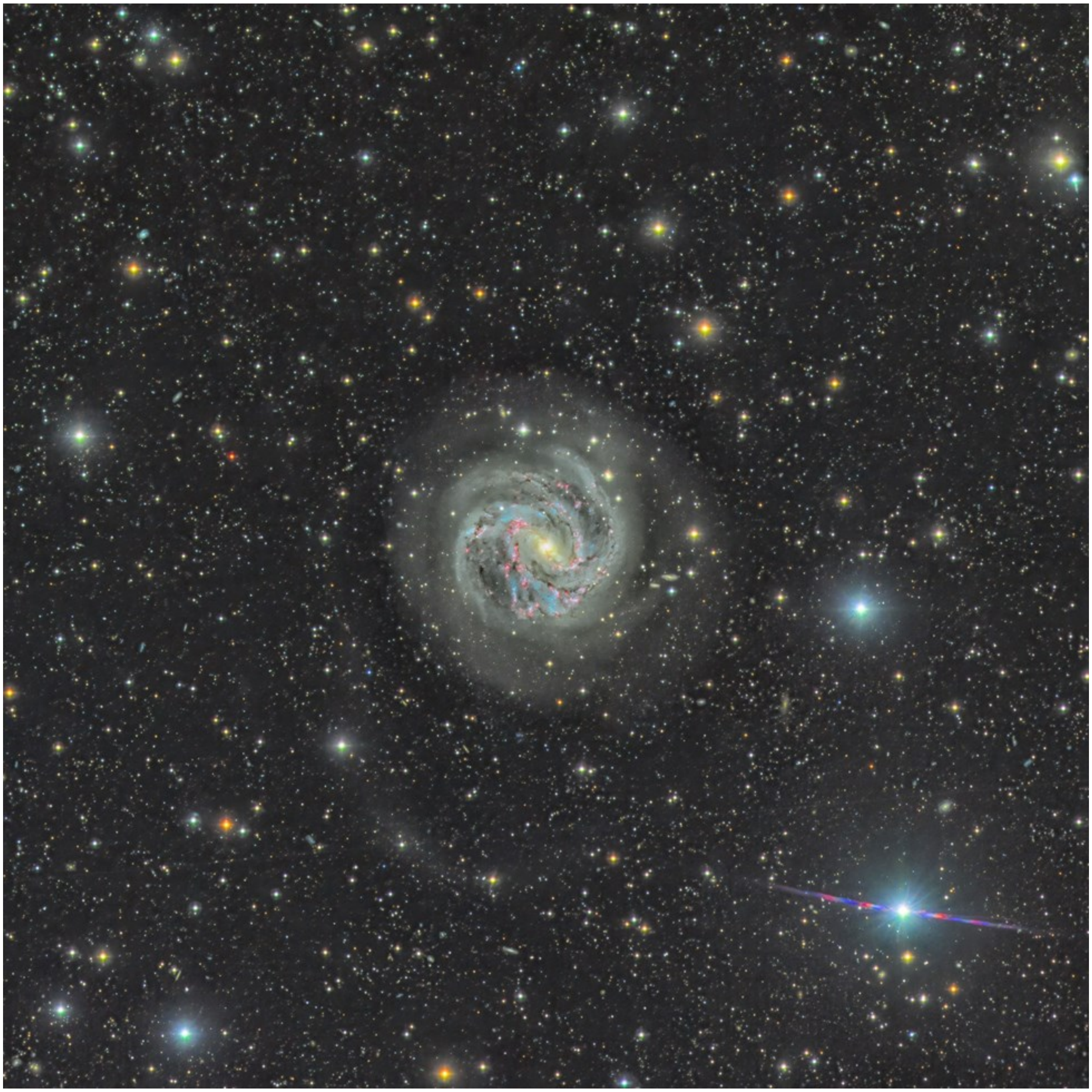
The Ha data were incorporated into the R channel according to the method described by Woronow[1]. Ha was not separately blended with the L channel because the R channel already has the correct intensity of Ha in it.

The Topaz programs (Denoise and Studio2) employ artificial intelligence algorithms as does Luminar4 by Skylum. These programs were, obviously, used in the image processing.

No painting of any kind, no elaborate or unusual PixelMath altered this image...no jiggery-pokery— period! In the end, however, this seems to be a virtually unique image. I could not find a single professional image showing all, or even most, of the five features listed above. A survey of the archives of AstroBin, assessing the M 83 "Top Pick" and "Image of the Day" selections, uncovered these statistics: Of 47 images; 14 had none of the listed features, 24 had indications of the Bright Halo; 1 showed a vague indication of the Dark Halo; 2 showed indications of features 3 and 4 (the possible detached spiral arms) and 1 image showed a hint of a bright background sky in the vicinity of the galaxy. (There is some significant fuzzy judgement involved, of course, in assessing the presence/absence of these faint-fuzzy things.)

My take-away is that the image in Fig 1 is nearly unique in its revelation of the unusual features in and around M 83. Those features became apparent largely due to the emerging technology of image processing using artificial-intelligence algorithms. The biggest uplift came from *Topaz Denoise AI*.

Fig 1. The Messier 83 image showing the features described in the text and labeled in Fig 2. A better quality version can be accessed at https://tinyurl.com/M83jpg100.



OTA: TAO 150 (f/7.3)
Camera: FLI - ML16200 (1.13"/pixel)
Observatory: Deep Sky West, Chile
EXPOSURES: Red: 10 x 600", Blue: 12 x 600", Green: 12 x 600", Lum: 12 x 600", Ha: 12 x 1800"
Image Width: ~1 deg
Processed by Alex Woronow (2020) using PixInsight, Skylum, Topaz, SWT
The only mask used in processing this image was a star mask

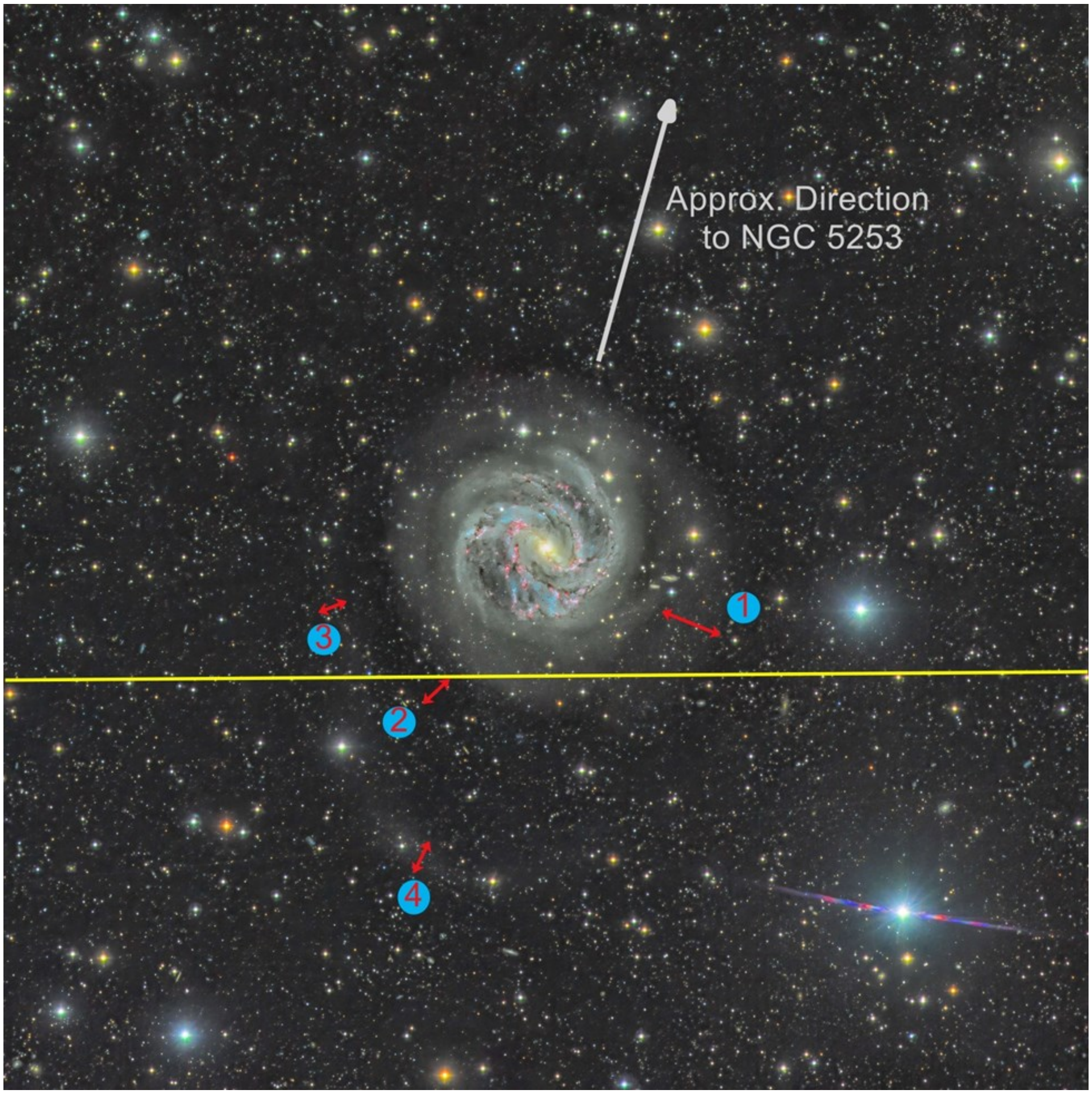


Fig 2. Features 1 to 4 discussed in the text. The red arrows span the inner-to-outer extent of the features. Feature 5 is not labeled but occupies the entirety of the background of the image (and beyond?). The yellow line approximately locates the brightness profile shown in Fig 3.

Additional Observations about each Feature-Working from Feature 1, proximal to the spiral arms, outward, some of the important attributes of each feature will be described. A discussion of the compositions and origins of the features will follow. Viewing the image at https://tinyurl.com/M83jpg100 will be helpful here (and throughout the rest of the discussions).

The Bright Halo: Almost featureless and presenting an obvious bulge toward the right-bottom of the image (Fig 1). It displays some smeared dark structures toward its inner edge and its brightness tapers down outward from the galaxy. Its outer edge is better defined than its inner edge, abutting against the Dark Halo, 2 in many places. The Bright Halo encloses the entire circumference of the Grand Design part of M 83.

The Dark Halo: its inner edge contacts the Bright Halo and it encircles the entire galaxy. This edge is relatively easily delineated. Its outer edge is most distinct at the left, where it abuts Feature 3, and least distinct towards its lower right, where the bulge in the Bright Halo occurs. It appears, vaguely, also to bulge toward the lower right and bottom of the image, although the outer edge is indistinct in this region.

This quite faint bright-arc bounds the Dark Halo at the left to lower left in Figs 1 and 3. Its extent toward the top of the image becomes difficult to trace as three bright stars may lead one to imagine it extends farther than it does.

This streak, brighter than Feature 3, but fainter than the Bright Halo, by-and-large, lies a considerable distance outside the main galaxy. It is arcuate in shape, and may trace inward and connect with Feature 3 at about 7:00. Again a bright star interferes with the ability to trace the upper part of the feature. At about 5:00 a faint smudge appears to pinch the Dark Halo against the bulge of the Bright Halo. This smudge may be the clockwise extension of Feature 4.

The rest of the background of this image (and undoubtedly to some extent beyond) is brighter than deep space generally is. A patchy haziness can be sensed over the entire area with occasionally hazy, ill-defined patches of clouds pervading the area. The background is clearly brighter than the Dark Halo; otherwise, the Dark Halo would not be distinguishable against it.

Classically, galaxies have none of the features or structures just described. But, then, as far as was known until now, neither did M 83. Amateurs may have something to contribute to science by surveying more face-on galaxies with image fields that extend beyond the galaxy's arms and deeper processing using AI to suppress noise and enhance structures and contrasts.

The Setting of M 83- M 83 is a member of "M83 Group" of galaxies and in close proximity to the Centaurus A group. The known members of the M83 Group total 15—mostly dwarf galaxies. The nearest galaxy to M 83 is NGC 5253, a "blue dwarf" galaxy. The current distance between these two galaxies is only 1.6 $\pm$ 1.3[2] Mly. M 83 and NGC 5253 are thought to have had significant gravitational interactions within the last billion years, which set-off star-burst activity in both, and most likely precipitated the formation of the features being discussed.

Speculations on the Bright-Halo's Origin- Plausibly, the Bright Halo arose from the effects of gravitational pull by NGC 5253. A spectrographic study[2] suggests that ionized gas occurs abundantly in a layer above the galactic plane of M 83. But that study did not tie the observed gas layer to the Bright Halo described here. However the study validates the general concept that something, probably a gravitational interaction has disrupted the normal distribution of mass found in a spiral galaxy.

Naturally, gravitational effects from a companion galaxy would be greater on the outer reaches of the spiral arms than they would be closer to M 83's center. This might generate disorder in the outer spiral arms, smearing them into the nearly featureless halo we observe as Feature 1. This smeared halo is not entirely featureless, as noted before, and some darker features may be what remains to delineate the now-smeared spiral arms.

If M 83's rotation period were similar to the Milky Way's, a few hundred-million years, then the gravitational smearing may have interacted strongly around the entire galaxy as M 83 rotated and NGC 5253 passed by. The asymmetry, the bulge, in the Bright Halo could have arisen at the time when the two galaxies were at their nearest approach. Subsequently, the bulge would rotate from its initial azimuth to its current location, as rotation of M 83 carries it along.

One Small Patch Of Sky cont…

Speculations on the Origin of Features 3 and 4- Features 3 and 4 may be just as they appear: distorted and displaced spiral arms caused by the gravitational interaction with NGC 5253. The outward displacement of the inner-most feature, Feature 3, may not place it at an unusual distance for a spiral-galaxy arm, but Feature 4 probably lies abnormally distant from the core galaxy. (I am not aware of any studies that substantiate this speculation, however.) Also perplexing, the extreme smearing of the bright halo seems at odds with a reasonably coherent nature of Features 3 and 4. But, perhaps most enigmatic is that these two features lie beyond the Dark Halo, and appear detached from the galaxy proper. Perhaps these enigmas point to these features not being detached spiral arms but something else?

Origin of the Dark Halo- Tautologically, the Dark Halo appears darker than the surrounding background sky. Bearing in mind that the stars we see are in the foreground, within the Milky Way, and not in the background sky, two alternative scenarios might explain the Dark Halo - background relationship:

A plethora of dark clouds comprises the Dark Halo and hides the background sky behind it, which, at least locally, is brighter than the Dark Halo.

The Dark Halo simply lacks the bright elements present in the background sky, with some minor exceptions, perhaps.

Let us first establish that patchy, faintly bright clouds pervade the background, 5, of this image and that they do lie beyond our Milky Way. The evidence for these assertions is simple: The existence of the Dark Halo, being darker than the rest of the sky, implies that the rest of the sky is not as dark as it could be. Furthermore, the bright component of the background sky lies beyond the Milky Way or it would cover the Dark Halo as it does the rest of the image. Fig 3 shows a brightness transect across the image (see Fig 2 for the transect location). Note that toward the left side of Fig 3, the darkest dabs of the background sky (in this transect, anyway) are not as dark as the darkest dabs in the Dark Halo. How far beyond the limits of the imaged area this elevated background sky-brightness extends remains unknown.

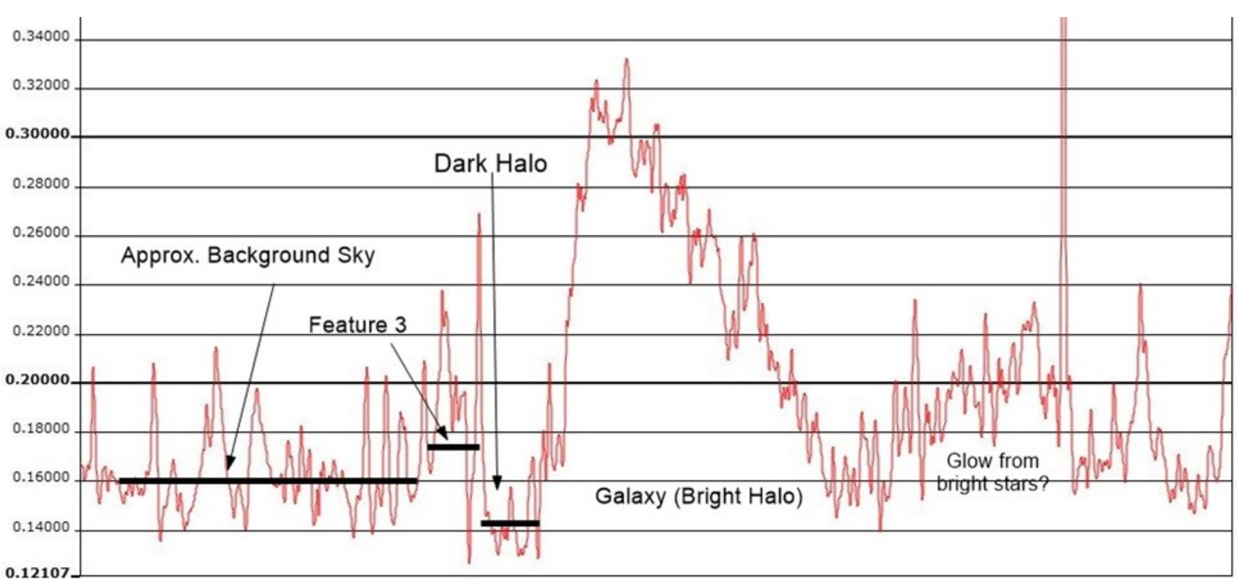


Fig 3. A brightness profile horizontally across the image in Fig 2. The source image had suppressed star intensities and was smoothed using a Gaussian blur, both to suppress noise in the graph.

As to how the Dark Halo arose, I can postulate two alternatives:

The Dark Halo consists of gas and dust bled from the Bright Halo by some form of gravitational sorting that left the stars behind. The dust and gas formed into clouds: dark clouds because no stars were drawn into the zone of Feature 2.

The Dark Halo is dark because bright background clouds covering the rest of the image either never formed there or were once there but were swept from the Dark Halo as Features 3 and 4 (and others) moved outward, under the influence of gravitational attraction by NGC 5253, and took the stars, dust and gas with them. Thus, the Dark Halo is dark simply because it does not have the components generating the lightness prevailing across the local background.

Origin of the Background Brightness- The brightness of the background must arise from gas, dust, and the stars to illuminate them. These may be remnants from a disrupted dwarf galaxy (or more than one) consumed by M 83 or chunks torn from M83 and/or NGC 5352 in their close encounter. Most likely, deep, broad-field images will reveal that this feature forms another halo around M 83.

Conclusions- Gravitational interactions between M 83 and NGC 5253 have sculpted significant large-scale structures in M 83. The existence of these structures does not appear to have been reported previously, although some amateur images show, or hint at, their existence.

The inner-most feature or structure, the “Bright Halo”, lies just exterior to the structurally defined spiral-arms of the galaxy. This inner-most feature is bright with some vague residual spiral-arm structures. It is not perfectly round, but exhibits a bulge that could be a tidal bulge.

A Dark Halo fully encloses the Bright Halo and is darker than the surrounding sky. This region probably owes its darkness to clouds of gas and dust and a dearth of stars to illuminate them. These clouds prevail in the Dark Halo, but do not uniformly or completely cover it; some brighter patches occur. The gasses that accumulated into this halo may have escaped from the more central regions of M 83, or from the Bright Halo itself, under the gravitational influence of NGC 5352.

Exterior to the Dark Halo lie two elongate clouds, noticeably arcuate in shape. They cover only a limited proportion of the circumference of the galaxy, and have the rough appearance of galactic spiral arms. If and where they may join with the main galaxy or with the Bright Halo is unresolved in this image. If they do not connect, then they may have ‘escaped’ tight association with M 83 with the assistance of the antipodal or direct gravitational attraction of NGC 5352.

Dust, gas and stars scatter around the background of this M 83 image. Perhaps they recall the consumption of one or more dwarf galaxies by M 83, or they are debris dragged from M 83 and NGC 5352 during their last close encounter. I suspect they form a faint, extended halo around M 83.

One Small Patch Of Sky cont…

Things it would be nice to know:

The rotational-velocity profile of M 83 and its associated features
The path of NGC 5253 relative to M83 over the last billion years or so
The extent of the faint bright background (halo?) in the broader vicinity of M 83
The physical state and composition of the Dark Halo
The components (stars and/or gas?) of objects 3 and 4.

Coda- This article contains a great amount of speculation. But without ready access to professional journals, an impressive professional telescope with spectrographic equipment, and a research grant to run it, that's about what this small-town amateur can do. In any case, it has been great fun and greatly satisfying to identify and ponder the characteristics of this deep-sky object and to be able to ponder the origins of M 83's strange features. If you have images, information, or ideas, I would certainly like to hear about them.

REFERENCES

Woronow, A. (2017) Blending Ha with Red…a New Approach https://tinyurl.com/yckx9jyw
Thim, F, et al. (2003) https://tinyurl.com/thim2003
Bottcher, E, et al. (1218) https://arxiv.org/pdf/1707.08126.pdf

Acknowledgements
I thank Kent DeGroff and John Kutney, who both reviewed this article and offered important and useful commented and resources.

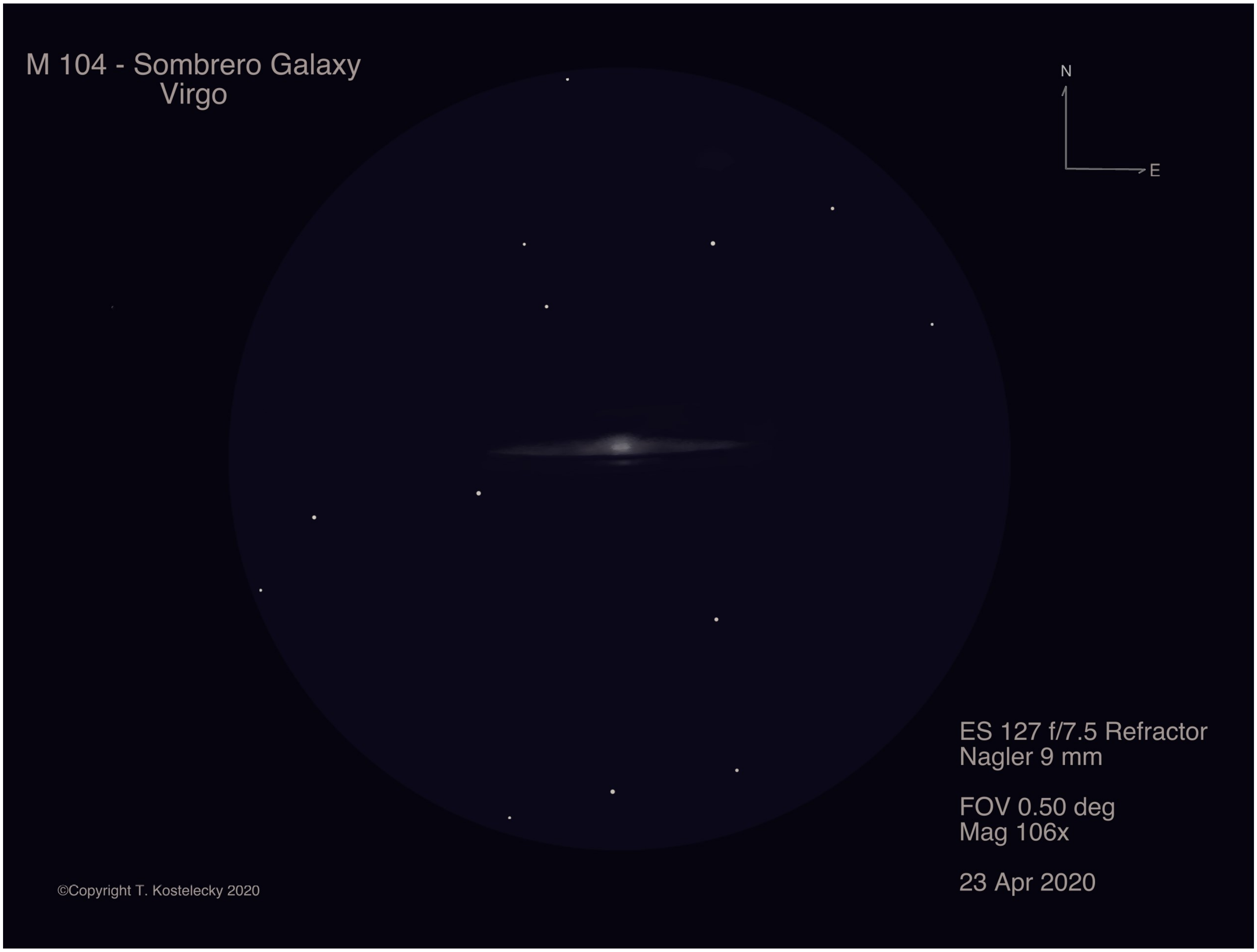
Member Astrophotos

Here is one I am still working... nearly complete.
I added more data last Saturday to this... could not believe how much it improved. This is just a center crop of the "deep view" and I will complete the full image likely in the coming weeks. Total LUM data here is 20x10min + 19x15min (the latter I collected last Saturday, 25 Apr). M81 (Bode's w/Holmberg IX) and M82 (Cigar) (and NGC 3077, bottom right) FS-60C, EM200, QSI690wsg.

Jeffrey O. Johnson

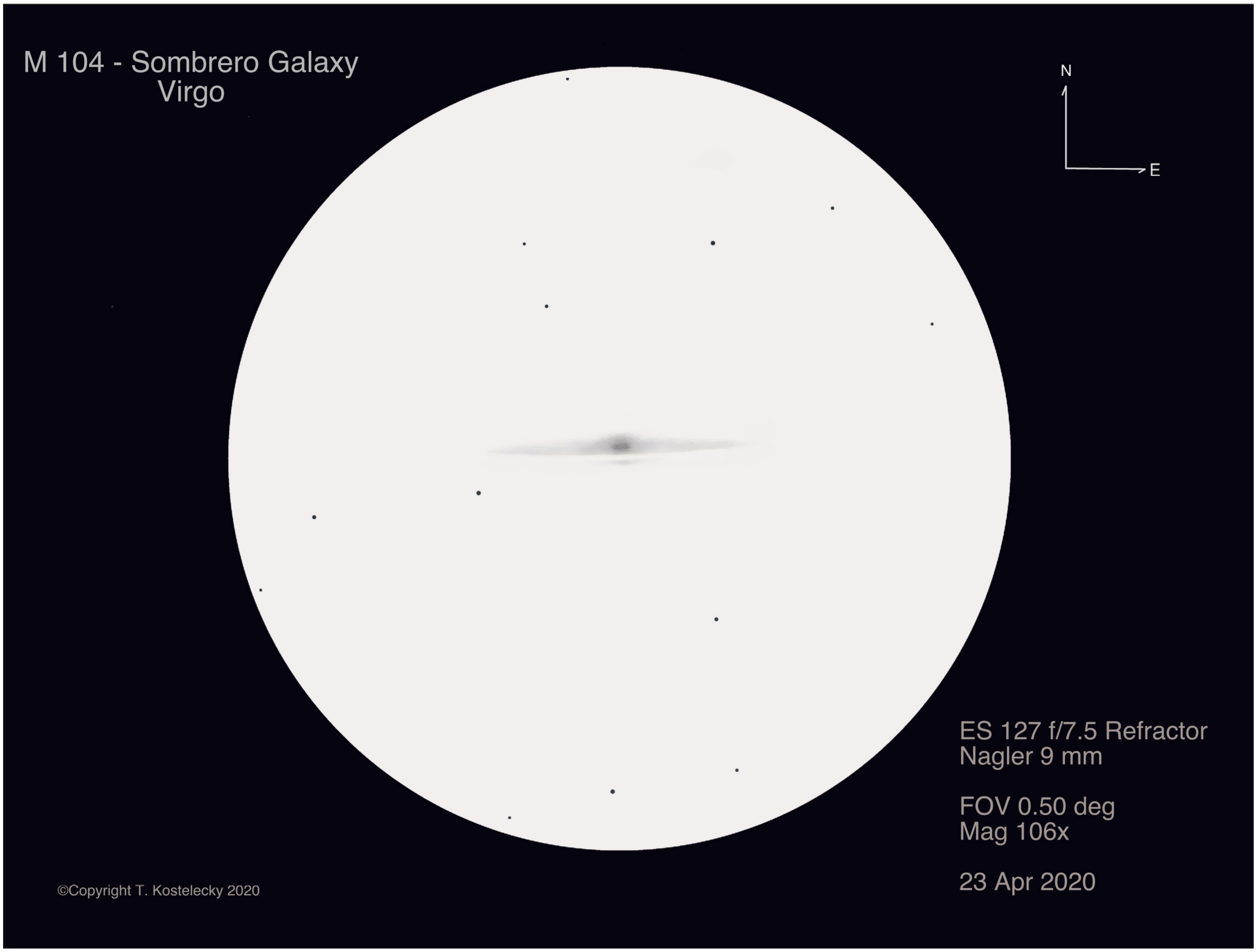
M 104
Sombrero Galaxy shot with RCOS 12.5"in Australia (Heaven's Mirror) Alex Woronow

Member Astrophotos cont...



Two images, one is the refined digitized version of my pencil drawing - black on white. Then the "negative" with the best representation of what I saw through the scope - white on black. I started with an old-school pencil sketch and transferred it to an image file. I then dropped the file into Corel Painter software as a trace that I can compose on top of. Using the software's "pencil" tools, as well as charcoal brushes and diffusers, I composed the image with greater refinement than the original pencil drawing. I then flipped the image to negative…white on black…and further refined as to what I saw in my mind's eye through the scope. With the limited light grasp of my 127mm refractor, the galaxy's nucleus was certainly prominent, but the outer stretches of the arms took averted vision to pick up well. However, the dust lane was quite evident. My goal is to provide as accurate a representation as I can of what I saw at the eyepiece. I've just starting doing this, and M104 was my first attempt. Pretty cool stuff. More to come with this and my bigger scopes.– Tim Kostelecky

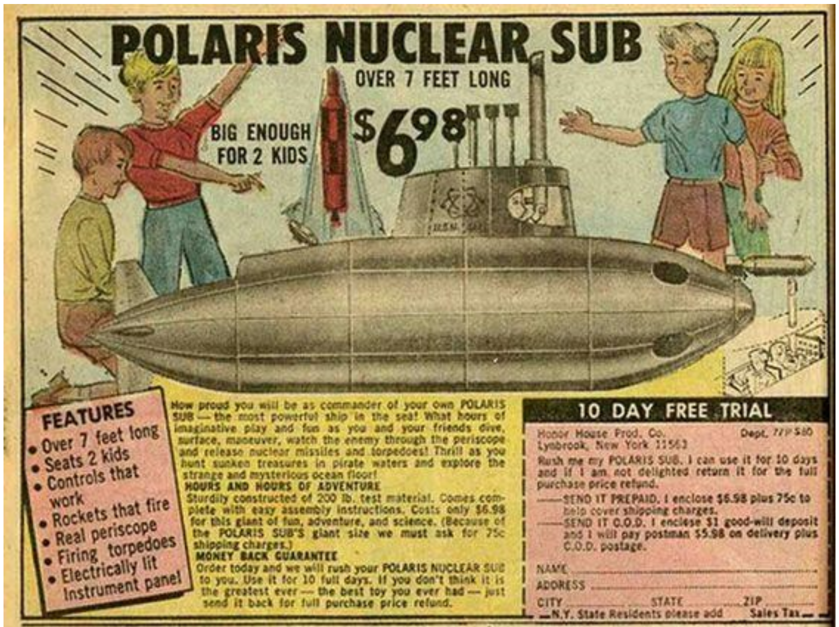
Member Astrophotos cont...



Tim Kostelecky

WOW!!! Great contributions, everybody! Thank you for making this edition chock full of info and pics! Well done!

Hope you all stay safe and see you at our next meeting! (Or in 2022, whichever comes first..)



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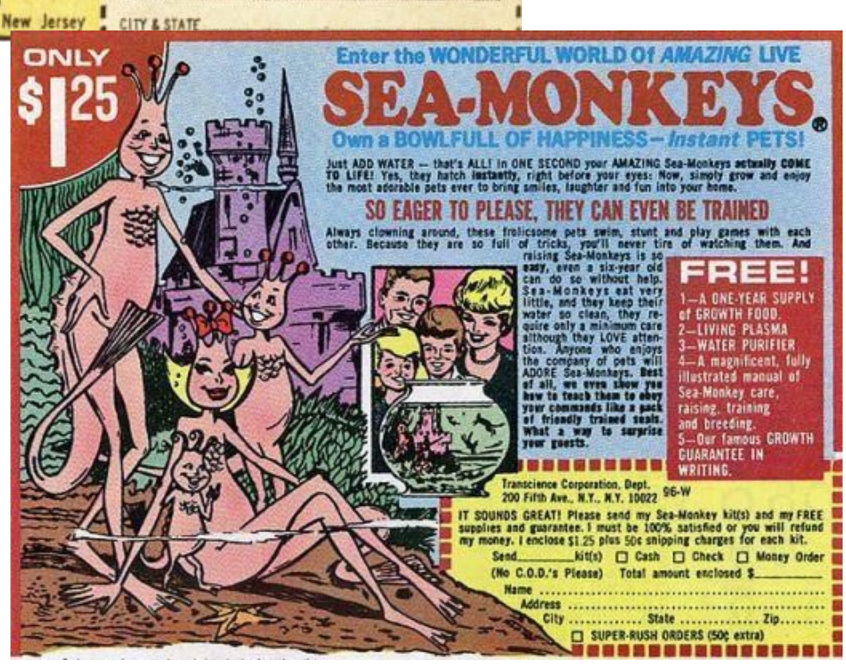

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