The High Desert Observer

February 2016

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 the *High Desert Observer*, our monthly newsletter, plus membership to the Astronomical League, including their quarterly publication, *Reflector*, in digital or paper format.

Individual Dues are $30.00 per year

Family Dues are $36.00 per year

Student (full-time) Dues are $24.00

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, PO Box 921, Las Cruces, NM 88004. Contact our Treasurer, Patricia Conley (treasurer@aslc-nm.org) for further information.

ASLC members receive electronic delivery of the HDO and are entitled to a $5.00 (per year) Sky and Telescope *magazine discount.*

ASLC Board of Directors, 2016

Board@aslc-nm.org

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Tombaugh: Steve Shaffer, sshaffer@zianet.com
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February Meeting --

Our next meeting will be on ***Friday, February 26***, at the DACC Main Campus, Room 141, Technical Studies Building, starting at 7:00 p.m. NOTE -This room is our OLD location.

The speaker will be Alex Woronow

Topic: Amateur Astro-Spectroscopy

Member Info Changes

All members need to keep the Society informed of changes to their basic information, such as name, address, phone number, or emai address. Please contact Treasurer@aslc-nm.org and jkile3916@gmail.com with any updates.

Outreach

Outreach is a very important part of ASLC. We are always looking for more volunteers to help us educate the public. Even if you do not have a portable telescope to bring to the events, please consider attending our public outreach programs to help answer questions, share knowledge and point out constellations in the sky.

Events

ASLC hosts deep-sky viewing and imaging at our dark sky location in Upham. We also have public in-town observing sessions at both the International Delights Cafe (1245 El Paseo) 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" Meade telescope is used to observe under rather dark skies. Please see *Calendar of Events* for specific dates and times.

Outreach Events

by Jerry McMahan

Leasburg, January 9, 2016

Dave Doctor ran the observatory. Chuck Sterling, Cristina Lugo, Danial Giron and Ed Montes were also in attendance. Sid Webb set up an 80mm refractor on his Celestron Mount. I had the 8 inch SC on the Meade LX 80 mount, which worked fine again.

It was very clear and very cold due to a slight breeze. The seeing was very good. Chuck pointed out that, other than Sirius which was still low in the sky, there was very little evidence of stars twinkling. Cristina brought me a cart to carry equipment. As a creature of habit, I still carried the eyepiece boxes over one at a time. I did get the hang if when putting things up. Dave had the assistance of the girl scout, who has, along with her mother, become a regular at the event.

Cold, but successful.

Moongaze, Saturday, January 16

Decent view of the Moon and the Pleiades's early, but clouds moved in later, blocking out the star cluster and making craters hard to see clearly. Chuck Sterling set up the 100mm refractor. I had the 8 inch on the LX80 mount since I took that scope to Leasburg the previous Saturday and just left it in the car.

Daniel Giron continued to give quizzes and prizes. Vice President Cristina Lugo came between work shifts and set up her Dobsonian. John McCullough joined us again. Ed Montes was shopping when he noticed we were there, so he came by to visit for a few minutes.

One of John's co-workers came to observe. One man who has done some work for a guy named Kramer (last name of Couch) also participated. He had some nice things to say about you and your dog, Ron.

Tombaugh Observatory Open House, Friday, January 22

Steve Shaffer broke the observatory dome! OK, OK, Steve didn't break it, I did. Here is how it happened. Trish Conley stopped by before the club meeting and she and I started to get things ready before Steve got there. I was raising the shutter for the slit and let it go too far. It slid down the other side of the dome and would not come back up electronically. Steve got on the roof with a jack and raised the shutter until he could move it the rest of the way by hand. This fixed the problem so I don't have to change my name and slip across the border.

It was unusual to have the open house a day before full Moon. I guess it was because it was the first week of the Spring semester. Steve had the scope on the Trapezium in the Orion Nebula and on the Moon. The telescopes in the other two domes were on the entire Orion Nebula and the Andromeda galaxy. Ann McFee came by to look through the scope.

A near disaster worked out to be a good session thanks to Steve's heroics. It really was Steve's fault, however. He should know better than to leave me un-supervised.

Highland Elementary School, Thursday, January 28

Rich Richins had a comet on a 10 inch Dobsonian. Tracy Stuart pointed his 8 inch LX 90 on the cluster M38. Chuck Sterling claimed the Pleiades for his 100mm refractor. Sid Web was on the stars of Orion's Belt. I had the 8 inch with the LX80 mount on the cluster M41 and the Orion Nebula.

We had a large, enthusiastic crowd of students, parents and teachers. We were scheduled to go from 5:30 pm to 7:00. We had spectators still observing until 7:30. Rich and Tracy were demanding overtime pay. I told them I would see that they get what they had coming.

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Calendar of Events (Mountain Time - 24 hr. clock)

Feb	08	07:39	New Moon
	11	18:30	OUTREACH; Tombaugh Elementary School
	12	19:00	NMSU: Tombaugh Observatory Open House
	13	18:00	OUTREACH; MoonGaze, International Delights Café
	15	12:47	First Quarter Moon
	18	18:00	OUTREACH; Desert Hills Elementary Schoo
	22	11:21	Full Moon
	22	14:22	Jupiter: Double transit, Io and Europa
	26	03:30	Jupiter: Double transit, Io and Europa
	26	19:00	ASLC Monthly Meeting; DACC Main Campus, Room 141
	29	15:45	Jupiter: Double transit, Io and Europa
Mar	01	16:11	Last Quarter Moon
	04	04:30	Jupiter: Double transit, Io and Europa
	05	18:00	Dark Sky Observing at Leesburg Dam State Park
	08	04:00	Jupiter at opposition
	08	18:54	New Moon
	11	06:19	Jupiter: Double transit, Io and Europa
	11	19:00	NMSU: Tombaugh Observatory Open House
	12	18:00	OUTREACH; MoonGaze, International Delights Café
	13	00:00	Daylight Saving Time begins
	14	20:12	Jupiter: Double transit, Io and Europa (Jup = 20º Alt)
	15	11:03	First Quarter Moon
	18	19:00	ASLC Monthly Meeting; DACC Main Campus, Room 141
	19	22:24	Spring Equinox
	21	21:56	Jupiter: Double transit, Io and Europa (Jup = 47º Alt)
	23	06:02	Full Moon
	23	06:20	Partial Lunar Eclipse (Moon = 11º Alt)
	28	23:58	Jupiter: Double transit, Io and Europa (Jup = 64º Alt)
	31	09:17	Last Quarter Moon

Be sure to visit our web site for the latest updates: *www.aslc-nm.org*

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Announcements

New (OLD) Meeting Room: We have been told that our old meeting room, Room 141, will be available to us until May 2016. We have decided to move back to this room because it is larger and the parking is more convenient.

Dave Doctor announced that the Leasburg Observatory operating manual is now available online in PDF format at: www.adrive.com/public/GwY3aS/Leasburg%20Observatory%20Operating%20Manual.pdf
If you have any questions or problems, contact Dave at: astrodoc71@gmail.com

February's ASLC speaker is Alex Woronow

Presentation: *Amateur Astro-Spectroscopy.* Facets of the physical and chemical attributes of stars, nebulae, and novae lie exposed to simple spectrographic equipment, affordable to many amateur astronomers. The spectrographic observations made by amateurs can contribute significantly to professional studies, and many "campaigns" organized through amateur interest-groups provide these contributions.

In Astronomy the accessible frequencies of light lie between the near infrared and the violet, bounded by the absorption of more extreme frequencies by the earth's atmosphere, at least for the earth-bound amateur astronomers. To a first approximation, stars emit light continuously across the visible spectrum, but ions, atoms, and molecules punctuate the continuum. Some of the ions and atoms, and a few molecules, may be near the stellar surface, in what is called the "reversing layer," or just below that, where the photons originate, in the stellar photosphere. Others may be in interstellar clouds that lie between us and a star. These three regions, and some significant others, lie open to spectroscopic analyses of pressures, temperatures, large- and small-scale motions, as well as chemical compositions.

This presentation will renew our understanding of light's interaction with its environment, look at the range of the equipment and software that amateurs use in their spectrographic observations, and survey some of the recent campaigns amateurs have undertaken in support of professional spectrographic studies.

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Meeting Minutes

by John McCullough

Minutes, January 2016 ASLC Meeting

Show & Tell:

John Gilkison, ASLC member and founder of the National Public Observatory (NPO), made a brief presentation on the Las Cruces lighting ordinance that he was very involved with creating. When work on the ordinance began in 2000, full color LEDs were not an issue. John reported that the City is now considering using 4000ºK(elvin) LEDs in new street lighting instead of 3000ºK or lower units (higher unit is "bluer"). He noted that the hotter, bluer lights increase atmospheric back scatter and can cause as much or more light pollution as unshielded incandescent lighting. John proceeded to demonstrate the difference between the different temperatures using lights that are available from Home Depot. Fred Pilcher pointed out that the bluer light can have effects on human health (disturbed sleep patterns) as well as affecting wildlife. John will meet with the City streets department at 1501 Hadley, at 10:00, Tuesday, 26 January, and asked if any other ASLC members would agree to accompany him. Sid Webb volunteered to accompany John. John said that a letter writing and publicity campaign may be necessary if something can't be worked out with the City to select lighting that meets both the letter and intent of the ordinance. John Kutney stated that lighting at several City facilities, particularly the waste water treatment facility on the west side, are currently significant sources of light pollution. There was additional discussion of light pollution in the surrounding area. John Gilkison closed by stating he will provide a report on his 26 January meeting.

Bert Stevens reported he has RASC Observers Handbooks and calendars for those that requested them. Trish Conley has "Year in Space" calendars to pick up if members ordered them.

Call to Order:

Daniel Giron, President, Astronomical Society of Las Cruces (ASLC), called the business meeting to order at 7:30 pm., 22 January 2016, Room 141, Doña Ana Community College, Las Cruces, New Mexico.

President's Comments:

Daniel Giron, President, welcomed the group to tonight's meeting. He thanked John Gilkison for his discussion of the lighting ordinance in the "Show and Tell" session. Daniel noted that attendance sign in sheets and door prize entries are available for members and guests. He asked if all members had received the Society newsletter, the

High Desert Observer (HDO), and if there were any questions or issues with the content. None were stated and Bert Stevens moved to accept the November 2015 meeting minutes as published in the HDO; Alex Woronow seconded. The minutes were accepted by acclamation. Daniel noted that there will not be a public event at Leasburg Dam State Park (LDSP) on 30 January as stated in other places, however, there will be events on 06 February, the first Saturday in February, and 05 March, the first Saturday in March. Planning needs to begin for any public viewing of the Mercury transit on 09 May. Possibilities include viewings at local schools before the start of classes that day or setting up additional telescopes at LDSP.

Treasurer's Report:

The Treasurer, Trish Conley, provided a status of the Society's accounts. She noted that 2016 membership dues are now due. She also noted that the Society insurance premium is due. There was not an additional Treasurer's report.

Committee Reports:

Outreach Committee:

Chuck Sterling, Outreach Coordinator, reported on upcoming events. Star parties will be held at Highland Elementary on 28 January, at Tombaugh Elementary on 11 February (volunteers needed), and at Desert Hills Elementary on 18 February. There will be a Moon Gaze at International Delights Café (IDC) on 13 February. Members can volunteer via the yahoo group.

Apparel Committee:

Howard Brewington, Committee chair, was present with items of apparel available for purchase after the meeting. Members can now access the link on the web page to request specific items.

Membership:

Judy Kile, Committee Chairman, was not present at tonight's meeting.

Leasburg Dam State Park (LDSP) Observatory Committee:

David Doctor, Committee Co-Chair, was not present at tonight's meeting.

Loaner Telescope Program:

Frank Fiore has had to resign as Committee Chairman. Daniel Giron will serve as acting Chairman but will need a replacement very soon.

Additional committee and officer reports will be published in the HDO.

Old Business:

1. Officers – Daniel Giron thanked the members that had served as Society officers in 2015, particularly Steve Barkes, Tracy Stuart and Ron Kramer. He also wanted to thank the members that had volunteered to serve as officers and committee chairs for 2016. Cristina Lugo and Sid Webb will be new members of the Board of Directors in 2016.

2. Holiday Party – Daniel thanked Rich Richins and his wife for hosting the annual party last month. It was very enjoyable and an excellent time was had by all who could attend.

3. Yahoo group – Daniel noted that a lot of news is reported and announcements get made on the ASLC yahoo group between monthly meetings. Steve Shaffer is the moderator and members should contact him to sign up for the group to stay in contact.

4. Presentations – Daniel has six (6) speakers arranged for monthly meetings this year: Alex Woronow will speak in February on spectroscopy; Kyle Uckert, NMSU astronomy grad student, in March; Penny Boston from NM Tech in April; Alex Woronow in May; and Loretta Hall in July. Speakers are still needed for the other months.

5. Activities input – Daniel has gotten only limited responses so far, but is still receiving input for teaching and learning opportunities.

There was no additional old business discussed.

New Business:

1. March meeting – The March meeting will be on 18 March because of Spring Break.

2. TAAS – Rich Richins noted The Albuquerque Astronomical Society (TAAS) has a telescope viewing area near Socorro and suggests ASLC work something out with TAAS for a group viewing opportunity. This could be in conjunction with a visit to Magdalena Ridge Observatory.

3. Messier Marathon – Steve Barkes suggests 02 April as the date for the 2016 Marathon. This could be in conjunction with a "sky tour" public event and be held at LDSP.

There was no additional new business for discussion.

Announcements:

1. Trish Conley shared a note from member Robert Liefeld.

2. Ann Grauer announced that the Cosmic Campground has been designated as an International Dark Sky Sanctuary, the first in the United States, second in the world. A celebration is planned for 04 June. A press release and announcement is pending. ***ED-***See the announcement at the end of this HDO

Items for Sale:

No items were announced for sale.

Recognitions/Achievements:

John Kutney continues to work on his imaging skills. No recognitions are in the offing.

There were no other recognitions or achievements announced at tonight's meeting.

The business portion of the meeting concluded at 7:52 pm

Presentation:

This month's speaker was ASLC member and immediate Past-President, Rich Richins. His presentation was "Alaskan Aurora Adventure". Rich observed his first aurora at the 2011 Okie Tex Star Party and wanted to learn more. Northern lights don't appear in our borderland skies very often, so Rich and his wife headed off to Alaska (their 50th visited State) to take in the sights and try to see some aurora before Alaska's early winter set in. Rich shared his aurora viewing/imaging experience and shared a little info about aurora in general.

Daniel Giron presented Rich a crystal paperweight of the Hubble Space Telescope in thanks for his presentation.

Robert Fuller received the Guest door prize, a DVD on auroras.
Janet Stevens received the Member door prize, a book on the Northern Lights.

The January meeting of the Astronomical Society of Las Cruces concluded at 8:55 pm.

-Respectfully submitted by John McCullough, ASLC Secretary

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Back at the Telescope

by Bert Stevens

When I was first learning astronomy, there was still an argument going on trying to determine if the craters on the Moon were volcanic or the result of impacts by asteroid-sized objects. There were also those pesky Marias that looked smooth and were thought to be the result of lava pouring out of volcanoes, as frequently happens here on Earth. The argument against the impact theory of crater formation was that there were many fewer craters on the Earth as we could easily see on the Moon. In fact, there were craters on top of craters. Telescopically, we could see the remains of older craters that had been partially destroyed by newer craters. If the rate of crater formation was constant, we should see many more craters on Earth, since new ones would form before the old ones could be eroded away. If these lunar craters were from impacts, why were the Earth's craters?

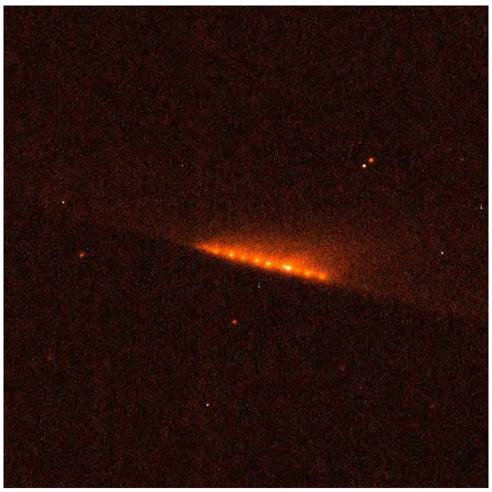
When we finally got to the Moon, astronomers were able to determine from the samples that were returned that the craters had indeed been formed by impacts. The Maria were indeed lava, but lava that came not from volcanoes, but had come to the surface after a small asteroid impact. Following the orbit of these mapping spacecraft as they passed over the Maria, we were able to determine that below the Maria were mascons (mass concentrations), the leftover remains of asteroid that had buried themselves under the Maria.

Since there were far fewer craters on Earth, it became obvious that the rate of crater formation was not constant. Craters impacts began as soon as the Moon formed and climaxed in the later heavy bombardment era (4.1 to 3.8 billion years ago). The Earth was also hit, but in the intervening billions of years, impacts have been far fewer and the craters on Earth have had time to erode away, while those on the Moon have been preserved in their original state. The change in the rate of crater formation was due to the dramatic reduction in the number of objects available to strike the Earth and Moon. Planetesimals, asteroids and meteors were plentiful in the early solar system, but over time, these loose chunks of rock either stabilized in the asteroid belt between Mars and Jupiter, or impacted one of the planets (especially the gas giants of Jupiter and Saturn). While we still find plenty of Near Earth Asteroids (NEA), they seldom actually hit the Earth to form a crater.

Searching for these NEA had started to become serious business in the early 1990s. Astrogeologist Eugene (Gene) Shoemaker was already interested in impact craters and was learning more about the impactors with an 18-inch Schmidt camera at Mount Palomar Observatory. Gene's wife, Carolyn, was adept at scanning the photographic plates and discovering new asteroids. Gene and Carolyn enlisted noted comet discoverer David Levy to help with the project.

Levy became very adept at loading and reloading the film canisters to make the best utilization of the limited telescope time. They would alternate roles of observer and measurer, taking photos of an area of the sky and then coming back a while later and rephotographing the same area. After a third photo was taken, they would develop the film and then compare the films, looking for moving objects. If a moving object was found, they would check the third photograph to confirm that it was a real object and not just fortuitously placed defects on the first two plates that masqueraded as a moving object.

On March 24, 1993, they were photographing an area of the sky just four minutes-of-arc from Jupiter. The images on the plates were highly unusual. The object appeared to be a 50-second-of-arc-long streak moving through the sky. The object's discovery was soon confirmed by other astronomers. Additional images with larger telescopes showed that there were at least seventeen subnuclei strung out like a string of pearls embedded in a general nebulosity, with each pearl (subnuclei) with a tail coming off it like a comet.



String of Pearls

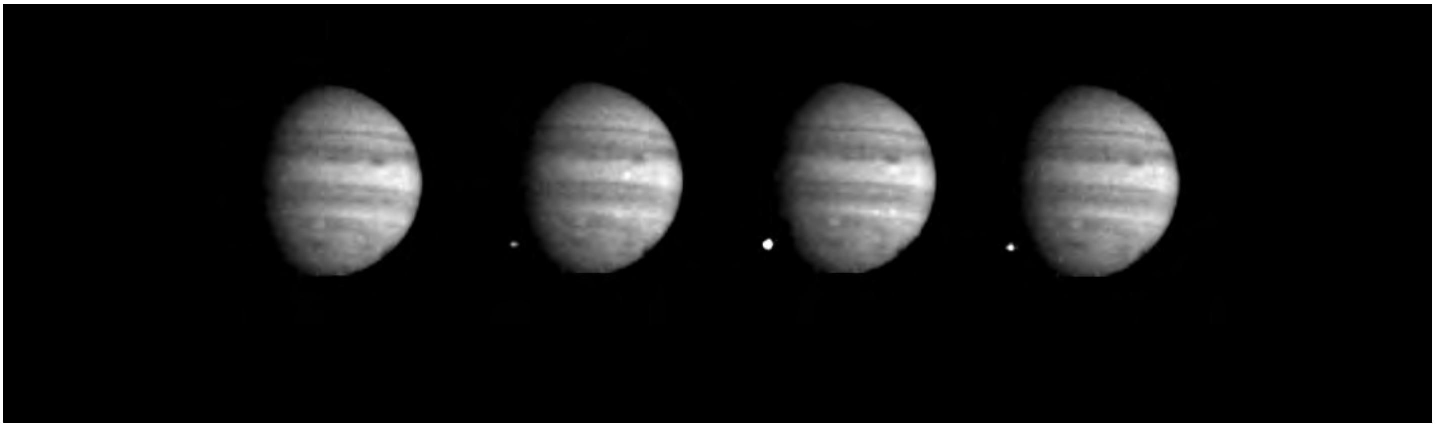
Comet Shoemaker-Levy 9 imaged just four days after discovery. The image was taken by Mats Lindgren at the European Southern Observatory in Chile. Eventually, twenty-one separate fragments were identified and lettered A through W. Fragment P broke into two parts, P1 and P2. Three of the fragments (J, M, and P1) evaporated before the comet impacted on Jupiter.

The comet was named Comet Shoemaker-Levy 9 (S-L 9), the ninth comet that the team had found. With enough astrometric positions, Brian G. Marsden of the Minor Planet Center determined that S-L 9 was not orbiting the Sun, but was orbiting Jupiter. It took even more observations to determine that S-L 9 had made a close approach to Jupiter on July 7, 1992 and Jupiter's tidal forces tore the comet apart. The fragments from the breakup passed through Jupiter's gravitational field along slightly different paths, moving them into slightly different orbits. The assorted orbits slowly spread the fragments out, so by the time that David Levy and the Shoemakers found it, the fragments were well separated, forming the sting of pearls.

S-L 9 had been in Jupiter orbit since the mid-1960s or 1970s. Each time it reached perijove (the closest point in its orbit to Jupiter), it slowed down a little bit more, lowering the perijove even more. The July 8, 1992 pass was just 16,000 miles above the cloud tops, and at next perijove, the fragments would impact Jupiter. Their various orbits meant that they would hit the planet at different times, one after another over almost six days. While this provided a great opportunity to see the results of the impacts on Jupiter's South South Temperate Belt, the actual impacts would take place just out of our view on the other side of Jupiter. The good news was that the Galileo spacecraft that was on its way to Jupiter would be able to observe the impacts directly, but from about 150 million miles away.

Astronomers had no idea what would happen. Some thought that Jupiter would simply swallow each fragment of S-L 9 without leaving any evidence of the impact. Others thought there would be an explosion, much like the Tunguska meteor in 1908. No one knew for sure.

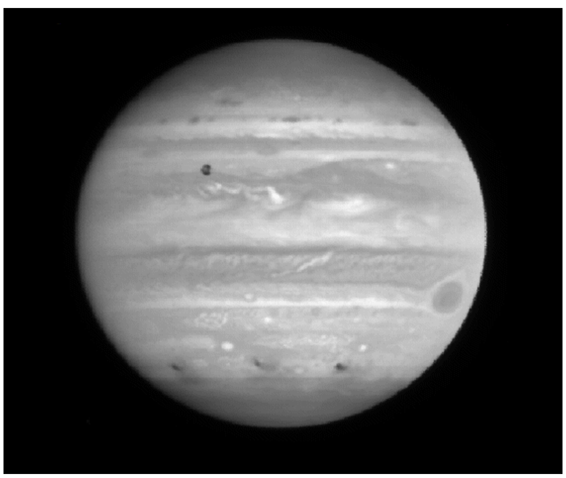
Excitement was building both in the professional and amateur astronomical community as the time for the first impact approached. Even the public was interested, with David Levy and the Shoemakers being interviewed frequently in the media. Professional astronomers reserved telescope time and amateurs



Comet Shoemaker-Levy 9

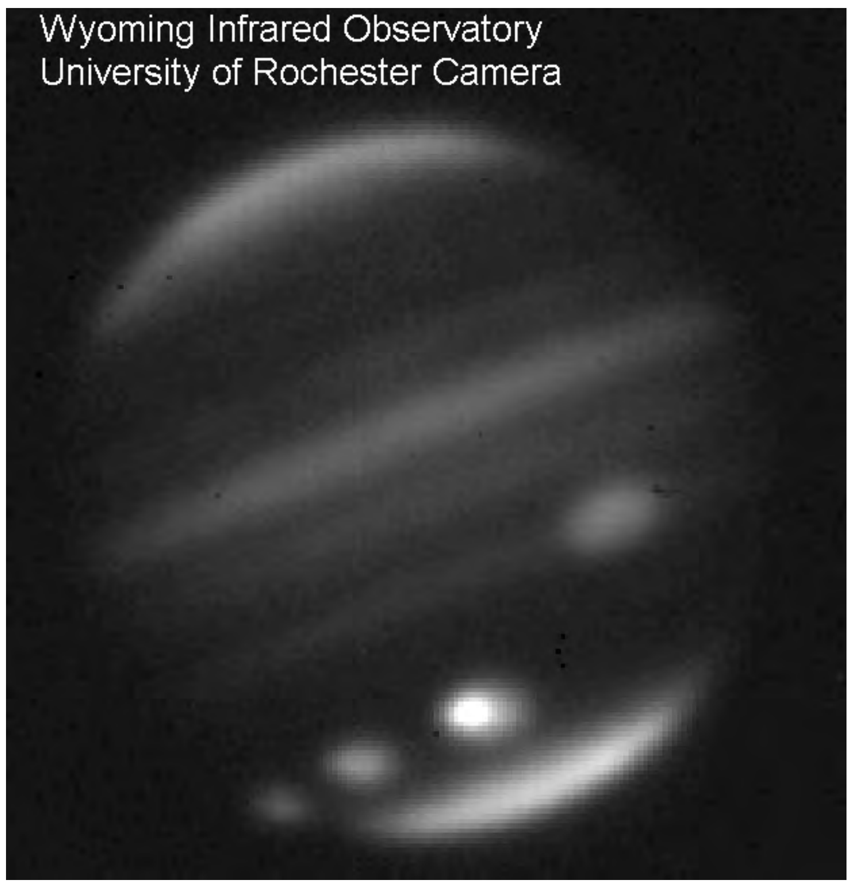
Fragment W (lower left-hand side of each image) impacts Jupiter's dark side. Fragment "W" was the last fragment of S-L 9, impacting Jupiter on July 22, 1994. While it was just out of sight from Earth, the Galileo spacecraft was able to observe the impacts from about 1.6 A.U. away, Galileo was on its was to Jupiter to make a series of close-up observations of the giant planet and its moons.

arranged star parties for the days of the impacts. Everyone was getting ready for the big event. The times that each fragment would impact Jupiter had been computed and appeared in the astronomy magazines (the World Wide Web had just been invented, and very few people had a browser on their computer, so information would only flow via e-mail or on forums like CompuServe's Astronomy Forum (Astroforum).



Jupiter Impact from HST

The Hubble Space telescope provided this image of Jupiter in near-ultraviolet light on July 17, 1994. The impact sites of fragments C, A and E (left to right) show as dark spots across the lower part of the disc. Fragment A had impacted the surface 23 hours before this image was taken, while C and E are 12 and 5 hours old respectively. The dark spot in the northern hemisphere is Io.



Infrared View of Impact

The 2.3-meter Wyoming Infrared Observatory telescope near Laramie, WY, took this infrared image of Jupiter on July 17, 1994. It shows three bright spots near the lower left that are the impact sites of (from left to right) fragments C, A, and E. The bright nature of the impact spots indicates the presence of high altitude haze or clouds, material carried up from the lower atmosphere by the fireball and plume from the comet impact.

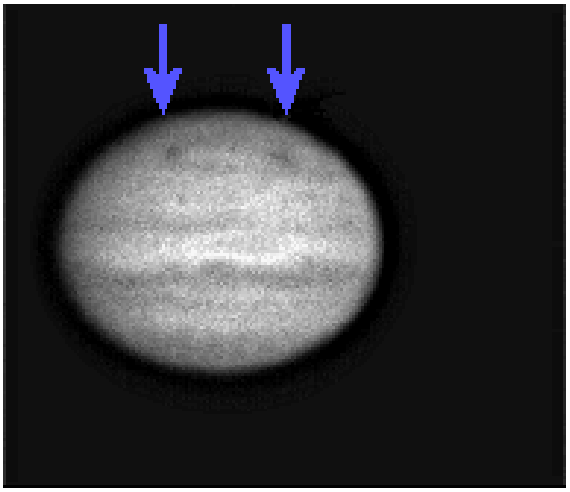
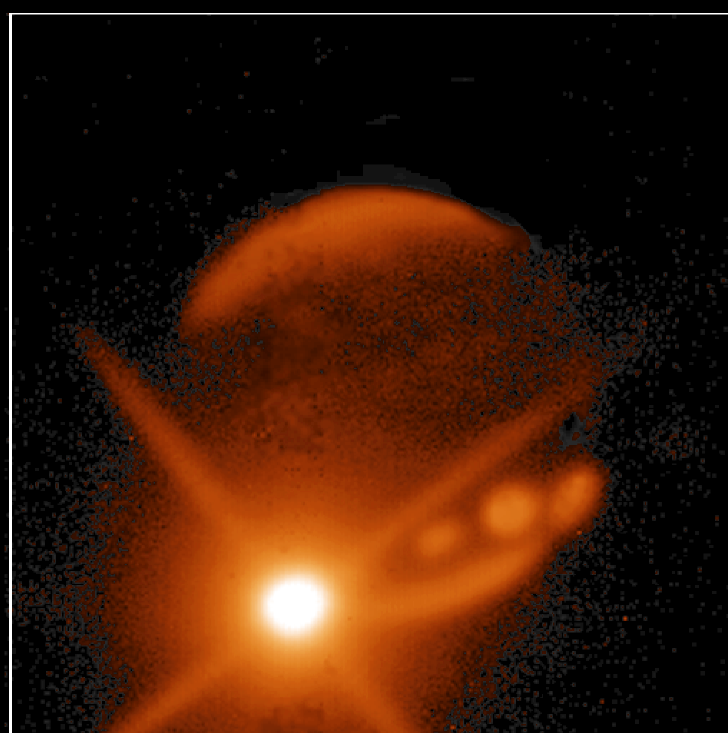


Image of Jupiter Impact by Amateur Astronomer
This image of Jupiter was taken at 9:26 p.m. MDT on July 22, 1994 by the author. The image was taken with the Racine Astronomical Society's 16-inch f/20 Cassegrain telescope near Racine, WI. An SBIG ST-4 CCD was used to capture the image. Additional processing was applied to increase contrast and sharpen the image. Two impact sites are marked by arrows.

The first impact happened in daylight for the United States. Jupiter was low in the south as it got dark and set around midnight. This gave each site a little less than five hours each night to observe the impacts on Jupiter. The time of impact predicted for each of the fragments was only accurate to within thirty minutes. When it finally got dark, everyone had their telescopes pointed at Jupiter in the evening sky.

Jupiter was the most imaged/photographed astronomical object from July 16 through July 22, 1994. The images showed each impact created a blemish on Jupiter's South South Temperate Belt. Not only were their blemishes on the surface, but telescopes observing the limb of Jupiter in infrared light were able to see the fireball of the impact just over the limb on Jupiter's dark side.

Galileo was not the only spacecraft to observe the result of the impacts. When the Hubble Space Telescope first observed S-L 9, it had not been repaired and provided only blurry images of the comet. By the time of the impact, the first servicing mission was completed and detailed images of the impacts were available from the HST. Images showed the impact points and allowed tracking of the evolution of the impact site blemishes as the winds slowly tore them apart.



Impact of Fragment K of Comet Shoemaker-Levy on Jupiter.
The scars of three previous impacts can be seen on the planetary disk.

Image from Peter McGregor and Mark Allen, ANU 2.3m telescope.
Instrument: CASPIR at 2.34μm. Colour image Mt Stromlo Observatories.

Thousands of images of Jupiter were taken during and after the impacts. They showed that the fragments were smaller than a mile in diameter. The impact sites showed evidence of water, possible brought to Jupiter by the Comet. Sulfur was dredged up from the lower atmosphere by the impacts. The dark material had signatures of diatomic sulfur (S2), carbon disulfide (CS2), and hydrogen sulfide (H2S). Ammonia (NH3) absorption also was detected.

Emissions from silicon, magnesium and iron were found near the limb, which could only have come from comet. The impact marks lasted for months before fading from view.

Comet Shoemaker-Levy 9's impacts on Jupiter proved beyond a doubt that there were still impacts occurring on planets in our Solar System. Two additional impacts have been seen on Jupiter since then. A very recent impact crater was discovered on the Moon providing even more proof that the craters on the Moon came from impacts and not volcanoes. It is clear from these events that the Earth is still in danger from an asteroid or comet impacting it. For the time being, all we can do is keep an eye out for a possible Earth destroyer. Maybe someday we will be able to divert such an object away from the Earth, but for now, we are vulnerable.

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Polar Alignment: When, Why, and How

Alex Woronow, ASLC & Black Range Observatory

Installment 2: "Star Alignment," "Mount Modeling" and Non-computer Polar-Alignment

Recall that in Installment 1 we had a quick review of the differences between Equatorial and Altitude-Azimuth coordinate systems as well as mounts that conform to each system: the equatorial mount and the Alt-Az mount. We found the latter suffers from field rotation, which makes long-exposure imaging virtually impossible. We also found that a misaligned equatorial mount also suffers from field rotation. To progress our discussion of polar-aligning an equatorial mount, in this installment we will distinguish polar alignment from star alignment and describe some approaches for accomplishing the former.

Installment 1, and ultimately this and the final installment can be found in the Files section of our Yahoo site, in the folder Files/AlexW/PolarAlign.

A quick clarification of the word "sync:" The act of syncing a telescope may mean different things to different software and hardware manufacturers. Regardless, I will use the term to denote the singular act of setting the telescope mount's software values for right ascension and declination to specific, known values. For instance, if a star of known coordinates is centered in an eyepiece, then setting the handbox of the mount to read those coordinates constitutes the syncing operation.

Now, let us start with the relatively modest goal of establishing a "star alignment" for our mount. Star alignment allows accurate go-to operations for both Alt-Az mounts and equatorial mounts. I suppose it is the one-step-up from star hopping as a way to locate faint targets.

Star Alignment and Mount Modeling: A "star alignment" facilitates accurate go-to operations in order to put celestial objects, given their celestial coordinates (e.g., right ascensions and declinations) in a telescope's eyepiece. Star alignments, in general, do not require the user to align the mount's polar axis with the rotational axis of the earth. In fact, most modern computer-driven equatorial, as well as altitude-azimuth, mounts have built-in programs for doing star alignment. These star-alignment programs usually require the user to sequentially point the scope to some set of stars and to "sync" the scope while it points to each of those stars. The programs usually require at least three alignment stars, and some programs can accumulate positions of a hundred or more stars to achieve maximum pointing accuracy. The technology behind these star-alignment algorithms usually involves a simple statistical estimation of fitted coefficients, say of spherical harmonics. More elaborate algorithms (e.g., ***MaxPoint*** and ***TPoint***) model mount deficiencies (e.g., sag of the optical tube with pointing direction, gear backlash, and geometric errors in the relationship between axes or with the axis of the optical system). ***MaxPoint*** and ***TPoint*** call their outputs "pointing models."

Regardless of the approach used, at best, the final product consists of a telescope capable of slewing accurately to any user-specified coordinate. In general, drift and rotation of the target are not corrected by the mount-modeling because the polar alignment remains in error. Imaging quality, in general, will not be improved, nor will the maximum unguided imaging time be increased, by a simple star alignment or a pointing model, no matter how accurately executed. Nonetheless, be aware: procedures for "star alignment" often, mistakenly, receive references as "polar-alignment" procedures. They are not!

Polar Alignment: A polar alignment is just that: the adjustment of an equatorial mount's right-ascension axis (aka "polar axis") to bring it parallel to the earth's rotation axis. Doing this makes it possible for the mount accurately to counter-act the apparent motion of the sky, from east to west, as the earth rotates. Although the earth's rotation axis wobbles and precesses, these slight variations cannot be perceived over a few nights of observation and do not affect telescope tracking accuracy. However, one effect greatly disrupts a single night's tracking, even a couple of hours of tracking. That effect is atmospheric refraction (Figure 6).

Not uncommonly, modern equatorial mounts compensate for atmospheric refraction by adjusting their tracking rate. If need be, most mounts allow the user to disable automatic refraction compensation. But the amount of atmospheric refraction depends upon the vertical temperature structure of the atmosphere as well as the atmospheric pressure. The former often is not known and both are generally ignored by setting them to some nominal values. In any case, atmospheric refraction becomes nonexistent at the zenith, and reaches a maximum at the horizon.

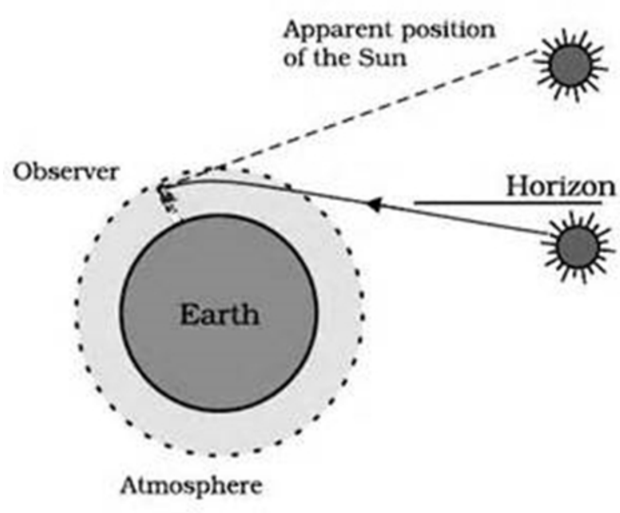


Figure 6: *Basic geometry of atmospheric refraction, which causes a celestial object to appear higher in the sky than it is. At the horizon, the refraction angle may exceed 35 arc minutes, but rapidly decrease with altitude.*

Many methods exist to achieve at least some minimal polar alignment. Several of them do not require sophisticated computer programs, either as stand-alone computers communicating with a mount or from the mount's own handbox. Optical "polar scopes" may do well, but often with a substantial investment of time, money and chiropractor fees. A compass and an inclinometer (aka "clinometer") may enable a coarse polar alignment and one method requires only a short spirit level. The most commonly employed method of polar alignment, drift alignment, requires no computer either, but can be time consuming and, for me anyway, frustratingly iterative.

But before further describing some of these methods, let us revisit the equatorial mount pictured in Figure 4. In addition to the declination and polar axes, that mount has an altitude and azimuth axis. To make polar alignment a less onerous task, from the get-go, **the mount's**

equatorial head should be leveled so that the azimuth axis points vertically upward. Often mounts have leveling bubbles on the heads to facilitate this initial leveling step with reasonably accuracy. When this is the case, an adjustment to the altitude of the polar axis, for instance, does not change the azimuth of the polar axis, and vice versa. The two adjustments are mutually independent; otherwise adjusting the altitude would alter the azimuth of the polar axis and the interacting adjustments would become tiresomely iterative.

Compass and Inclinometer Alignment: A good first-cut at polar alignment requires no more than an accurate compass and inclinometer (e.g., the ***AccuMaster 7434***). Of course, the compass fixes the azimuth of polar axis and the inclinometer fixes its elevation (altitude)—but not without some complications. First, most mounts have a considerable mass of steel components, which deflects compasses from magnetic north. This means that one must stand away from the mount to get an accurate reading of the axis pointing direction…not ideal! Second, a compass does not point to the rotational axis of the earth, but to its magnetic north axis, which currently lies in the region of Ellesmere Island. Corrections for this "magnetic declination" can be found on the internet, of course. Third, simple compasses and inclinometers seldom produce jaw-dropping accuracy; however, compass/inclinometer alignment suffices as a first cut for more accurate polar-alignment procedures.

Maybe it is obvious, but the elevation of the polar axis should be set to the latitude of the observing site. An inexpensive inclinometer can be purchased from a home-improvement store as they are often used to set the cut angle on table saws. Less satisfactory are inclinometer and compass apps available for smart phones. Many of those lose accuracy, or never attain it, for reasons that do not appear obvious to me. Finally, most mounts' hosting adjustments of the polar axis have a scale of axis elevations engraved on or near the corresponding axis. However, those read-outs really seem more of an after-thought than a precision scale. I have not seen any of these that consistently provide elevation accuracies better than a few degrees, probably because of interplay between this adjustment and the one that levels the equatorial head. Here is a place mount makers could improve, for sure!

Alignment by Polar Scope: Many equatorial mounts have, or can have, small telescopes within their polar axes. Looking through such a scope rather precisely (but not necessarily accurately) indicates where the right-ascension (polar) axis currently points, with some caveats. First, the polar scope must accurately align with the polar axis. This may require inconveniently lowering the inclination of that axis to nearly horizontal and iteratively adjusting the scope's axis while repeatedly flipping the mount from the east- to the west-side of the mount and back again to fix a spot under the crosshairs regardless of the mount's orientation. The polar scope should have instructions about this procedure. Second, polar scopes work by indicating positions of some other stars in the circumpolar field of view at the time the alignment is undertaken. Because the time of the alignment translates into the locations of the reference stars (think constantly rotating earth), which have notably small displacements with time (because of their proximity to the pole), those reference locations have limited positional resolution, translating to limited alignment accuracy. Although the alignment accuracy generally exceeds that achievable by compass and inclinometer, it seldom reaches the level required for moderately long unguided exposures through a moderate focal-length telescope.

Drift Alignment: The drift-alignment method probably dominates all other methods of polar alignment, measured in number of times used. It is simple, but iterative and time consuming. Variations on it utilize imaging to lessen both of these burdens, but it does have other limitations. Nonetheless, it has the capability of achieving very accurate polar alignment when completely implemented.

Procedures for drift alignment are well documented on numerous web pages, so I will not repeat all the procedures, insights, and details here. We will simply strive to provide an overview. For this overview, we rely on Figure 7, which illustrates a relationship between the true equatorial coordinate system and the one presumed by a misaligned polar mount. Please read the caption for Figure 7. Now, imagine what happens to the orientation of an object in an eyepiece as an accurately aligned telescope tracks it across the sky. The object neither drifts nor rotates. And, if there were two stars in the eyepiece, one directly north of the other, and a crosshair ran through each one, then neither would deviate from that crosshair as the mount tracked them across the sky. In other words, neither star would drift eastward nor westward. Furthermore, a crosshair perpendicular to the first would reveal that neither star drifts northward nor southward. However, if the telescope is not accurately aligned with the North Pole, then both stars would drift in both the east-west and north-south directions.

In Figure 7, if we begin tracking on a star located at the position of the white circle, then we wander away from the scope, perhaps to grab a snack, and return 3 hours later, we would find the eyepiece centered at the location of the green circle and the star once in the eyepiece center would have drifted westward and southward. Numerous internet pages tell us what to do to correct such a drift

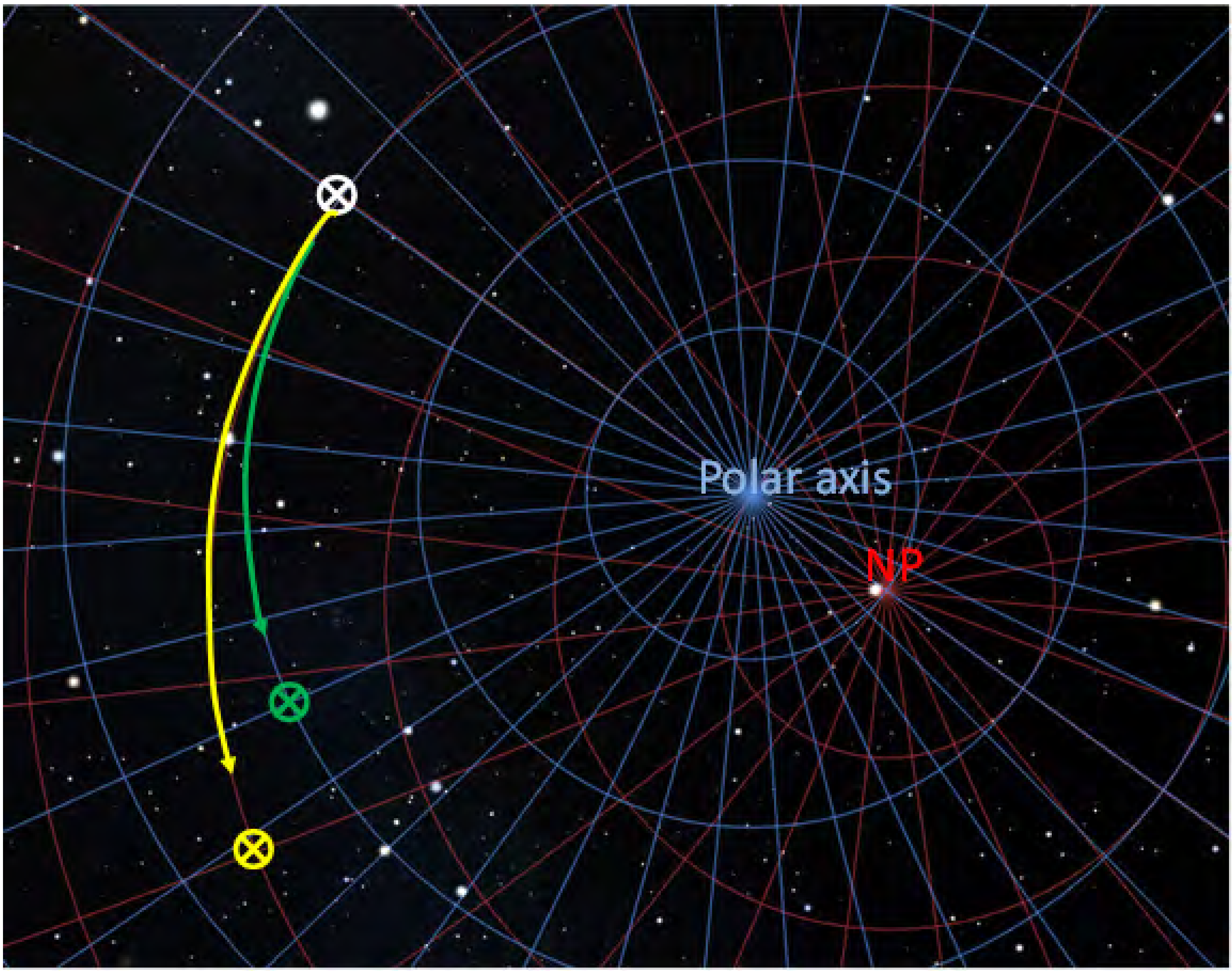


Figure 7: *The effect of having a misalignment between the true North Pole (NP) and a mount's polar axis is a displacement of the two coordinate systems. An object initially at the white circle follows a path (yellow) of constant declination around the North Pole to the location of the yellow circle, as the earth rotates. However the misaligned mount expects the object will follow the path indicated in the blue coordinates and follow the green path. Important! The RED grid shows 1hr = 15° increments in right ascension whereas the BLUE grid shows 10° increments.* (***Stellarium***)

direction, and by iteratively re-centering the star, snacking, and re-adjusting, we can bring the mount quite close to its perfect alignment. Of course, atmospheric refraction and other physical perturbations in the procedure and mount mechanics may work against us. Actually, snacking constitutes a vital part of the alignment procedure—in a way. We must allow drift to occur for a reasonable length of time before making an adjustment; otherwise, we may mistake gear-train periodic error for misalignment error. Additionally, drift-alignment protocols dictate that one component of misalignment be treated by observing drift near the eastern or western horizon. First, at those locations, atmospheric refraction confounds the drift patterns. Additionally, if the observing site is not at the equator, the assumed drift pattern for a given alignment error is only approximately correct, becoming totally in error at sites near the earth's poles. Still, given enough time and enough patience, most observers could probably succeed in attaining a quality polar alignment.

Several imaging programs (e.g., ***PHD Guiding***, ***MetaGuide***, ***BYE***) display drift data to assist in drift alignment. If you must do drift alignment, you should research this option to improve the efficiency of the procedure.

A Final Method: This method has no specific name. I developed it back in the early '60s in the days of setting circles. (If you don't know what setting circles are, more power to you.) I suppose others discovered this approach too, although I, personally, have not encountered it elsewhere. Most of this setup procedure can be done during daylight and the method consistently puts DSOs too faint to see in a finder in a 40 arc-minute FOV eyepiece. (I had a Starliner mount with 1.75" solid steel shafts, 8" brass setting circles, and great back muscles!) I'm not saying toss out that handbox and buy some old setting circles. The handbox will substitute nicely for the setting circles, as we shall see below.

The daylight activity dominates the effort and sets the elevation of the polar axis. You will need a short level (I use a line level) or an inclinometer, some "cipherin'" pencil and paper (á la Jethro Bowdine), and that's all, although I have placed a useful spreadsheet (PolarAxis_Align.xlsx) in our Yahoo file area, which may aid the calculations and alignment.

1. As usual, carefully level the equatorial head of the telescope mount. This is not optional! (However, there is no need to do any star alignment before starting. All adjustments rely on relative values of declinations, not absolute values.)

a. It is best to turn off tracking, and probably any atmospheric-refraction compensation, although not essential in order to obtain good results.

2. Use the telescope's handbox to move the scope to a position such that the OTA is on the west side of the mount, with the declination axis level and the OTA level, and pointing toward the north horizon.

a. Read and record the declination on the handbox when all leveling is accomplished. Call this reading R1.

3. Using the handbox, slew to the east side of the mount and again level the declination axis and OTA (as shown in Figure 8).

a. Read and record the declination on the handbox when all leveling is accomplished. Call this reading R2.

4. Use this equation to calculate a new declination value, D_new, to slew to (all values in degrees):

$$D\_new = 90^\circ + \{(R_2 - R_1) / 2\} - (\text{site latitude})$$

5. Slew to D_new using the handbox.

6. Re-level the OTA by adjusting the altitude of the polar axis (make only that adjustment!). It is always a good idea to run through the procedure again to check and refine your results.

At this point, we have the altitude of the polar axis set to the correct position. I would think getting within 15’ should be possible with a level, and within 6’ with a good inclinometer. Next we need to get the azimuth of the polar axis set. This is done at night. Select a star that will serve as our alignment star: a star that is high in the sky, but not very near the zenith and with RA and Dec known. Now,

Figure 8: *Telescope leveled on east side of mount during alignment.*

Rotate around the declination axis to set the star’s declination on the setting circle.

Center the star in the eyepiece by rotating around the Az axis and RA axes only—ONLY! Recall, the azimuth axis is the one that rotates the entire equatorial head around in a horizontal plane. (See Figure 4 from part 1.)

When the star is centered, the polar axis has the correct azimuth and the mount is polar-aligned. The handbox, which already has the star’s Dec, can be set to the star’s RA, and the mount is sync’d to the sky as well. Turn on tracking. If the polar axis has accurate alignment, only this one star is required to accurately sync to the sky. QED!

As a final word to this installment, notice that only the polar-scope alignment method requires direct observation of Polaris. The other two methods will function quite well even around buildings and trees. Unfortunately, no simple method exists for measuring the achieved accuracy—but the methods described in the next installment usually give the magnitude and direction of any alignment error.

In that next, and final, installment we will look at a couple of computer-assisted approaches to polar alignment, focusing on those in the public domain. There are very few of these. Sometimes you may see some advertisement for a program to help in polar alignment. More often than not, though, the programs simply show a planetarium view illustrating the relationship between circumpolar stars and True North. Not much in the way of “computer” assistance, I’m afraid

Photo of the Month

M15

What is it? A globular cluster of over 100,000 stars in the constellation Pegasus. One of the oldest clusters (12 billion years) and one of the most densely packed. 175 light years in diameter and 34,000 light years distant.

Capture data: Astrotech AT12RCT, Paramount, SBIG STXL 6303E, LRGB: 2, 2, 3, 4 hours. Pixinsight processing

Las Cruces NM Sept 2015

IDA Designates First U.S. International Dark Sky Sanctuary In New Mexico

TUCSON, Ariz. (14 January 2016) – The International Dark-Sky Association is pleased to announce the designation of the Cosmic Campground as an International Dark Sky Sanctuary. It is the first such designation in the U.S., and the first IDA International Dark Sky Place designation of a U.S. Forest Service location.

“We are very excited to announce the inaugural designation of an IDA Dark Sky Place on Forest Service land, and hope to strengthen our ties with this important public land management agency,” said IDA Executive Director J. Scott Feierabend.

International Dark Sky Sanctuaries are public or private lands possessing an exceptional or distinguished quality of starry nights. Their dark nighttime conditions are specifically protected for their scientific, natural, educational or cultural value, and are often located in some of the most remote and undeveloped parts of the world. Sanctuary designations are made by IDA to increase awareness of these fragile sites and promote their long-term conservation.

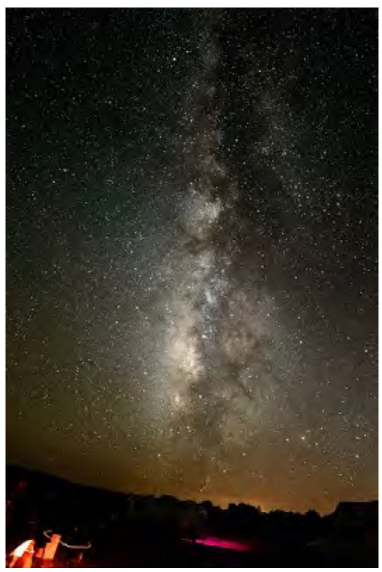
The new International Dark Sky Sanctuary is a 3.5 acre (1.42 hectare) site in the Gila National Forest of western New Mexico, U.S. Located between the Gila Wilderness and the Blue Range Primitive Area, the Cosmic Campground is situated in an exceptionally dark part of the lower 48 U.S. states. It features a basic infrastructure to support campers and offers a 360-degree, unobstructed view night sky.

The nearest significant source of electric light to the site is more than 40 miles (65 km) away and across the border of neighboring Arizona. Coupled with ready accessibility by road and typically clear, dry weather conditions at moderate altitude, the Campground could become a new mecca for amateur astronomers and casual stargazers seeking a one-of-a-kind experience under the stars.

“The Cosmic Campground, a peaceful, natural night sky place is ideal as an International Dark Sky Sanctuary in the Gila National Forest of New Mexico, the United States, and the Earth,” explained Ann Grauer of Friends of the Cosmic Campground. “We are honored to help preserve and protect this small, dark place for present and future generations to connect with their inherent fascination and attraction to our night sky.”

There is no permanent, artificial lighting installed at the Cosmic Campground, and the Forest Service’s plans do not call for any such lighting in the future. Rather, the Campground is to be maintained in a state that allows visitors to experience nighttime conditions close to those before the introduction of electric lighting in the late nineteenth century. At the same time, visitors can access modern conveniences, such as wi-fi network connectivity via a cell tower located 15 miles to the south of the Cosmic Campground.

Officials see the potential for the Cosmic Campground’s new IDA status to yield a positive economic benefit for western New Mexico. Tourists who come for the extremely remote character of the nearby Gila Wilderness may well find that the Campground extends the sense of the area’s primitive quality past sunset.



The Milky Way sets over the Cosmic Campground. (Credit: David Thornburg)

About the IDA Dark Sky Places Program
IDA established the International Dark Sky Places conservation program in 2001 to recognize excellent stewardship of the night sky. Designations are based on stringent outdoor lighting standards and innovative community outreach. Since the program began, 12 Communities, 30 Parks, 10 Reserves, two Sanctuaries, and three Dark Sky Friendly Developments of Distinction have received International Dark Sky designations. For more information about the International Dark Sky Places Program, visit http://darksky.org/idsp.

About IDA
The International Dark Sky Association, a 501(c)(3) nonprofit organization based in Tucson, Arizona, advocates for the protection of the nighttime environment and dark night skies by educat- ing policymakers and the public about night sky conservation and promoting environmentally responsible outdoor lighting. More information about IDA and its mission may be found at http://www.darksky.org.

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