The High Desert Observer

January 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, 2015

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Librarian: ***OPEN***
Loaner Telescope: Daniel Giron (Temporary) **OPEN***
Membership: Judy Kile; judykile3916@gmail.com
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Tombaugh: Steve Shaffer, sshaffer@zianet.com
Outreach: Chuck Sterling; csterlin@zianet.com
Web-Site: Steve Barkes; steve.barkes@gmail.com
HDO Editor: Charles Turner; turnerc@stellanova.com

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January Meeting --
Our next meeting will be on ***Friday, January 22***, 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 Rich Richins
Topic: Alaskan Aurora Adventure.

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.

From the Prez

January 2016

A New Year

As we begin the 65th year of the Astronomical Society of Las Cruces, I want to thank those who served last year as Officers, Board members or Committee Chair and are either outgoing or continuing to serve this year. They are: Steve Barkes - outgoing VP and Webmaster, Patricia Conley - Treasurer, John McCullough - Secretary, Tracy Stuart - outgoing Director, Ron Kramer - Director, outgoing HDO Editor and outgoing Apparel Chair, Rich Richins - Board member as Immediate Past President, Education Chair and Webmaster, Chuck Sterling - Outreach Chair, Howard Brewington - Apparel Chair, Charles Turner - HDO Editor, Steve Shafer - Tombaugh Observatory Chair,
Dave Doctor - Leasburg Dam State Park Observatory Chair, Judy Kile - Membership Chair, Frank Fiore - outgoing Telescope Loaner Program Chair.

I also want to thank and welcome two new incoming Officer and Board member: Cristina Lugo - VP and Sid Webb - Director. Also, thanks to Bert Stevens for his "The Night Sky" monthly column in the Las Cruces Sun-News. As a fitting conclusion to a great 2015, we had a spectacular Christmas Party, hosted by Rich Richins and his family. On behalf of everyone, I want to thank the Richins family for offering their home and being such great hosts. A good time was had by all.

As we move into this new year, we will be working together creating activities that will appeal to a variety of experience levels and hopefully make membership in the ASLC fun and interesting. We will continue to conduct outreach and open our meetings to the public to attract new members.

The speaker sessions are already off to a good start with ASLC members Rich Richins and Alex Woronow giving talks in January and February, respectively. Kyle Uckert, NMSU graduate student, will give a presentation in March on searching for microbial life in caves using a Near Infra-red spectrometer that has applications in detecting life on other worlds. In April, speleologist and astro-biologist Penny Boston, from New Mexico Tech will talk to us about her work on searching for life on Mars.

This year is full of opportunities and I am looking forward to having a great time with all of you.

Daniel Giron

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Outreach Events

by Jerry McMahan

Leasburg, November 14, 2015

Again, clouds, and the epidemic of mount problems continues. This time Sid Webb's Celestron mount was not getting power. Sid set up the park's 12 Dobsonian instead. Sid and I pointed the scopes at the Moon, but it was a thin phase and the clouds made it difficult to make out any details. Chuck Sterling brought his scope, but did not set up due to the lack of targets. He operated my ETX 125 when I was away from the scope. There only three people came to look at the Moon. Two others observed through the 16 inch.

The evening could have been considered a failure except for one thing. Dave Doctor was able to get a few things in the 16 inch. A girl, who was with the Girl Scouts the previous month, was at the park again with her

mother. Dave let her operate the goto on the scope. She had so much fun that the session was a success for that reason. She and her parents also attended the open house at the Tombaugh Observatory the next week.

Columbia Elementary, Tuesday, November 17
Chuck Sterling, Tracy Stuart, Ed Montes, Daniel Giron, Christina Lugo, Rich Richins and myself (sort of) attended this event. I arrived late, from my class at the community college and immediately got my car stuck in the sand. Some one from the school went after his truck and a chain, to pull me out of the sand. I assume that everyone else had a successful star party on a clear night. I really don't know since I spent most of the session being stuck and never got my scope out of the car.

Tombaugh Observatory, Friday, November 20
The open house coincided with meeting again. Steve Shaffer operated the scope. The seeing was pretty good so we had a good view of the Moon. It was the last day of classes before the week off for Thanksgiving, so many students were on their way home and it was not a very large group in attendance.

Moongaze, Saturday, November 21
We had clear skies, but it was the first cold night we have had in a while. A slight breeze made it seem even colder. Christina Lugo brought her portable propane heater. Don't believe her if she says I pushed her aside to get the the warmth. Daniel Giron gave away more prizes with his quizzes. Chuck Sterling was not feeling well, but stopped by to see if I was operating alone.

Christina set up her Dobsonian and I had the ETX 125. The ETX tracking was very good, even with a fake alignment. I never know what to expect from this scope from one session the the next.

Leasburg, Saturday, December 5, 2015
Two curses ended, at least for now. It was clear. Cold, but clear. My LX mount did not break a gear, much to Chuck's satisfaction. I did have to re-align, once when the power cord pulled loose and twice when the power cord got caught in the mount, but the gear held and the goto went to. Sid's Celestron mount also worked this time.

Sid Webb was present for a hydrogen-Alpha view of the Sun and used a refractor for the night session. Chuck Sterling set up his 100mm refractor and I had the 8 inch SC on the LX 80 mount. Dave Doctor ran the observatory. The girl scout and her family were in attendance again. They have become regular participates. Dave let her operate the goto, on the 16 inch, again. Daniel Giron was also present and providing more prizes with his quizzes. It was a pretty successful event for a change.

Moongaze, Saturday, December 19, 2015
I set up the ETX 125 before dark. The Moon was visible, but the clouds were moving from the West and it was obvious that there were no obvious breaks down to the horizon. Chuck Sterling came, but left his scope in the car since we could only see the Moon, and not even that for very long.

A couple of people did get to see the Moon before heavier clouds moved in front. From time to time the Moon could be seen, but not well enough to even get a good focus to see any craters. Only the out line was visible. We only stayed a couple of hours since it looked pretty hopeless. There were a few people that stopped to ask questions. One lady gave her young son a telescope, but said that she could not get it to focus on the Moon. It turned out that her only attempt on the Moon was during the total eclipse. I explained that that was a bad time to see craters on the Moon due to the lack of shadow contrast and she should try again at a less full Moon phase. The fact that she said she was getting pin point stars indicated that the scope was coming to focus.

As bad as the viewing was, it was better than the next Saturday. I am still trying to dig my car out of the snow.

Leasburg, Saturday, December 29, still 2015, barely.
Dela Montoya contacted Chuck Sterling about setting up a star party at Leasburg Dam State Park. She and her friends and family attended. Chuck operated the observatory. I brought the 8 inch SC and Tracy Stuart had his LX 90 8 inch. It is good to see that scope back in action after having its own gear problems.

It started out cloudy, making it difficult to find alignment stars, but cleared up quickly providing us with excellent views for our last outreach event of the year. It was cold, but every one seemed to have a good time.

Della Montoya with family and friends at LDSP

Outreach Overview for 2015
Assuming a turnout for Ren Faire, similar to last year, the club contributed over 650 hours of public support. As usual, this number only reflects actual observing time, and does not include the time involved in setting up these events. Chuck Sterling, among others, deserve extra credit for their efforts. At least 30 people were involved, at least to some extent, with the various activities.

ED: And let's not forget ALCON. That was fun, let's do it again!

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

Jan	01	22:31	Last Quarter Moon
	09	17:24	Dark Sky Observing at Leesburg Dam State Park
	09	18:31	New Moon
	16	17:30	OUTREACH; MoonGaze, International Delights Café
	16	16:26	First Quarter Moon
	22	19:00	ASLC Monthly Meeting; DACC Main Campus, Room 141
	22	19:00	NMSU: Tombaugh Observatory Open House
	23	18:45	Full Moon
	30	17:43	Dark Sky Observing at Leesburg Dam State Park
	31	20:28	Last Quarter Moon
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

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 next May 2016. We have decided to move back to this room because it is larger and the parking is more convenient.

January's ASLC speaker is Rich Richins.The topic will be his Alaskan Aurora Adventure. 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 arrived.

Rich will share his aurora viewing/imaging experience and share a little info about aurorae in general.

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Meeting Minutes

by John McCullough

Minutes, November 2015 ASLC Meeting

Show & Tell:

Fred Pilcher began tonight's gathering by presenting the difference between "discovery" and "finding". Fred pointed out that member Bert Stevens has a number of asteroidal "discoveries" to his credit. Fred has a different focus and studies objects already known to "find" new information about them, primarily rotation periods of asteroids. Fred strives to be prepared for observing specific objects, e.g., 1016 Anitra, a main belt asteroid. He

also uses software to clean-up observations that may involve a secondary (satellite) object. Thus, Fred has discovered that 1016 Anitra has a secondary companion.

Alex Woronow displayed stereo images of the Tarantula Nebula from an Australian observatory. He explained how you can trick your mind to see depth or use depth maps and software (PhotoShop, etc.) to achieve depth-of-field simulations.

Daniel Giron presented an article published in this week's Sunday edition (15 November) of the Las Cruces Sun News Community Spotlight highlighting astronomy in the area. The article included photos of and interviews with members of the ASLC. Daniel also noted the Leonid meteor shower (peaked on 18 November) was a bit of a bust, but hoped the upcoming Geminids at Leasburg Dam State Park (LDSP) (peak 13 15 December) would be better.

Call to Order:

Daniel Giron, President, Astronomical Society of Las Cruces (ASLC, the Society), called the November business meeting to order at 7:30 pm, 20 November 2015, Room 141, Doña Ana Community College (DACC), Las Cruces, New Mexico.

President's Comments:

The President, Daniel Giron, welcomed the group to tonight's meeting and thanked Fred and Alex for their presentations. He also welcomed tonight's guests: Carol Roberts, Steve and Mika Vinson, and Karla Zajac. Daniel asked that all attendees register their presence on the available sign-in sheets and enter for the door prizes to be presented at the end of the meeting. Daniel asked if all members had received the latest edition of the Society newsletter, the High Desert Observer (HDO), had read it and had any comments or corrections to the contents. There being none, he moved that the October Minutes be approved, Sid Webb seconded. The October Minutes were accepted by acclamation.

Officer's Reports:

Secretary's Report:

The Secretary, John McCullough, had no additional Secretary's report.

Treasurer's Report:

The Treasurer, Trish Conley, had been present but was called away before her report. Daniel noted that the Society had received a check from the Astronomical League (AL) for its portion of the net income from ALCon 2015. There was no additional Treasurer's report.

Committee Reports:

Renaissance Arts Faire 2015:

Trish Conley, coordinator, was not present. Daniel reported he thought the Society's participation was a great success and that this year's Faire overall was very successful. Several members that supported the Society's booth over the weekend were present at tonight's meeting. Daniel thanked them for doing a great job.

Loaner Telescope Program:

Frank Fiore, program coordinator, was not present at tonight's meeting. Daniel announced that Frank will be moving after the first of next year and must resign this position. Daniel will fill in as coordinator pending another

member volunteering to coordinate this program. Any interested member should contact Daniel or Frank. Also, members should inform Daniel if they currently have a loaner telescope from the Society in their possession.

Old Business:

1. Activities - Daniel Giron reported that he has been considering possible activities appropriate for multiple levels of member observing expertise from beginner to experienced observer. He has assembled a list of options for members to review. He would like members to go over the list, mark activities that appeal to them and return the list to Daniel prior to the January 2016 meeting.

2. Holiday Dinner/December Meeting – The December meeting will be a potluck at 7:00 pm on 12 December at Rich Richins' home. Please contact Daniel as soon as possible regarding your attendance, what dish you'll bring, and whether or not you'll participate in the gift exchange ($25 limit).

No additional Old Business was offered for discussion.

New Business:

1. Yahoo group – It is now possible for members to join the ASLC yahoo group from the web page.

2. 2016 Speakers – Two (2) members have volunteered to make presentations at monthly meetings in 2016. Rich Richins will make the presentation at the January 2016 meeting on "Alaska Auroras". Alex Woronow will speak in February and May on spectroscopy and stellar evolution. Daniel asked that other members consider making presentations, or if they know of someone that would be a speaker of interest to the membership, let him know.

No additional New Business was offered for discussion.

Announcements:

Sid Webb is current President of the Friends of Leasburg Dam State Park organization. As its representative, he reminded the members of the next star gazing opportunity in conjunction with the Park's "Turn Back the Sun" event on 05 December. This will be a big event! Sid encourages all members and their families to come out and participate. The Park's "Music and the Stars" program has been a big success this year, thanks to Daniel Giron's efforts. In recognition of those efforts, Sid presented a plaque of appreciation and a $100 check to Daniel for outreach efforts. In accepting the recognition, Daniel described the quiz/participation/prize format he has been using successfully for public outreach but commented that it has been a group effort.

Upcoming Outreach activities include Moon Gazes at International Delights Café (IDC) on 21 November and 19 December. The "Turn Back the Sun" event at LDSP will be 05 December starting at 12:00 noon. Members should contact Daniel if they can bring telescopes.

Howard Brewington, Apparel Committee chair, announced the Apparel link on the ASLC web page is live.

Charles Turner inquired if a December issue of the HDO was common. Although this is usually left to the discretion of the newsletter editor, the consensus was affirmative.

No additional announcements were made.

Items for Sale:

Bert Stevens has Royal Astronomy Society of Canada (RASC) Observer's Handbooks and calendars for those that requested them. He has one (1) unclaimed copy of the handbook if anyone wants to purchase it.

No additional items were offered for sale.

Recognitions/Awards:

No recognitions were announced although Master Observer John Kutney reported he is working on narrow band imaging.

The business portion of the meeting concluded at 7:49 pm.

Presentation:

This month's presentation was by Alex Mares, ranger and interpreter at LDSP, on Navajo astronomy. Alex began by noting how grateful he and other Park staff are for the partnership with ASLC and that the ASLC and LDSP should be a big part of an El Paso Scene article in December.

Alex noted that he is a storyteller with a background in anthropology, not an astronomer. He said that there are currently over 100 publicly accessible observatories in New Mexico. However, petroglyph sites associated with ancient star gazing in what is now New Mexico number in the 1000's. This from a time when astronomy really was available to all simply by looking up at the night sky. Many of these petroglyph sites and others throughout the southwestern US are also tied into the winter solstice. Certain Native American, especially Navajo or Diné, stories can only be related at certain times of the year and are considered winter stories or summer stories. Alex related synopses of several of the winter stories, many including the character, Coyote.

Alex went on to describe several remarkable correlations between the concepts of time in Native cultures and astrophysics and also how Native stories rely not just on annual celestial observations but many times on multi-year cycles, i.e., the 18-year Moon rise/set cycle that can be observed from the Two Buttes site in southern Colorado. This from a period when human lifespans were 30-40 years at best.

Alex closed by relating some of the stories associated with the Moon, including the "Rabbit on the Moon".

At the close of his presentation, Daniel presented a crystal paperweight of the solar system (minus Pluto) to Alex. He then conducted the drawing for door prizes. John Kutney received a book, Songs of the Sky; guest Carol Roberts received a History Channel DVD, Ancient Mayan Astronomy.

The next general meeting will be 22 January 2016. Don't forget the holiday dinner party. Happy Holidays!

The November 2015 meeting of the Astronomical Society of Las Cruces concluded at 8:53 pm.

-Respectfully submitted by John McCullough, ASLC Secretary

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Back at the Telescope

by Bert Stevens

The business of near earth asteroids is always changing. At one time, we could only cover small sections of the sky every month, and NEOs would slip through without ever being noticed. Astronomers would talk about the possibilities of a meteor impact, but since no one can remember one in their lifetime, it did not seem a threat.

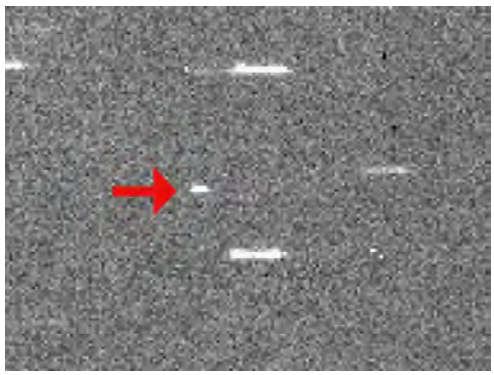
Hollywood, always looking for a theme has used the asteroid/comet threat on a number of occasions. In 1979, we had Sean Connery and Natalie Wood in Meteor!, a movie about an asteroid coming toward the Earth and the efforts of the Soviet Union and the United States to blow it out of the sky with their nuclear weapons. New York gets hammered, but our heroes survive.

Two big-budget movies of the 1990s were the more scientifically accurate Deep Impact! and the more action-packed Armageddon. These movies brought the concept of an asteroid impact to the forefront of the public consciousness. This allowed politicians to show how they were dealing with the possibility by giving NASA a directive to discover all the NEOs at least one kilometer across. NASA funded a number of programs to search the night sky for these interlopers.

With the ever-increasing size of the survey telescopes and the ever-larger CCD detectors at the focus of those telescopes, we covered more of the sky. We are still discovering more of these objects, but most of them are far enough from the Earth not to be a threat.

On October 3, 2015, the Catalina Sky Survey in Arizona was searching for NEOs and they came across a new object. Designating this object with a temporary designation of WT1190F, this object was posted on the Minor Planet Center's NEO Confirmation Page. As observations poured in from around the world, orbit computers like Project Pluto's Bill Gray discovered that this object was actually in orbit around the Earth.

This object's orbit was extremely elliptical, taking it from the geosynchronous satellite belt to twice the distance of the Moon. The gravitational effects of the Sun and Moon on WT1190F's orbit were changing the perigee (low point), sometimes up and sometimes down. For the last few orbits, the perigee had been moving downward. The perigee on November 13 would be the lowest yet, some 370 miles underground, implying an impact with the Earth on that date.

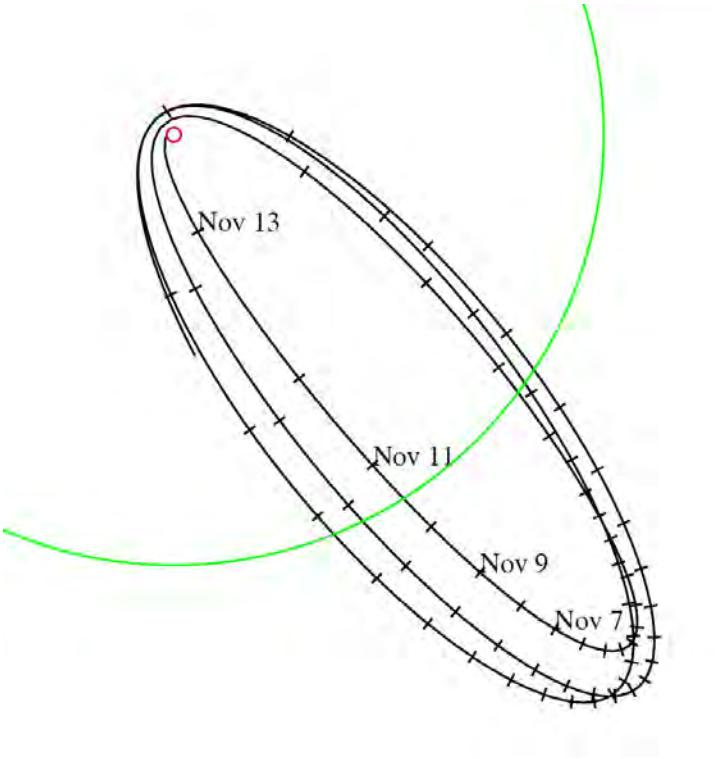


Asteroid WT1190F

The bright object in the center is WT1190F as imaged by the University of Hawaii 2.2-meter (88-inch) F/10 Cassegrain telescope. This telescope was the first one on Mauna Kea that proved this as a great site for telescopes..

The most important thing for us to know when an object gets us in its sights is its size. If it is a large object, it could cause a major catastrophe. If it were small, it probably would not be a problem. We usually get an estimate of the size of the object from its brightness. Since this object is lit up by the Sun, we know how much light it hitting the object. The larger the object, the more light it will reflect at us.

Asteroids, unfortunately, do not all reflect light in the same way. Some have surfaces that are better at reflecting light, while some are worse. This makes it more difficult to estimate the size of the object.



WT1190F-Orbit
The final three orbits of WT1190F before it impacted the Earth. You can see the perigee (low point) getting lower on each orbit until impact. The lowering of perigee was caused by perturbations by the Sun and Moon. The Moon's orbit is marked in green.

A larger object with a less reflective surface would have the same brightness as a smaller object with a more reflective surface.

Most natural objects are fairly dark. Our own Moon reflects only eighteen percent of the sunlight that falls on it. That makes it almost as dark as a lump of coal. The surface of an asteroid is not much better and since we did not know the reflectivity of the surface of WT1190F, we could only make an estimate.

While natural objects are dark, man made objects are not. They often have white paint that reflects sunlight very well. This makes a small man-made object look like a larger asteroid. Therefore, we have to determine if it is man-made or natural before we can estimate its size from its brightness. So we must learn more about it before we can estimate its size.

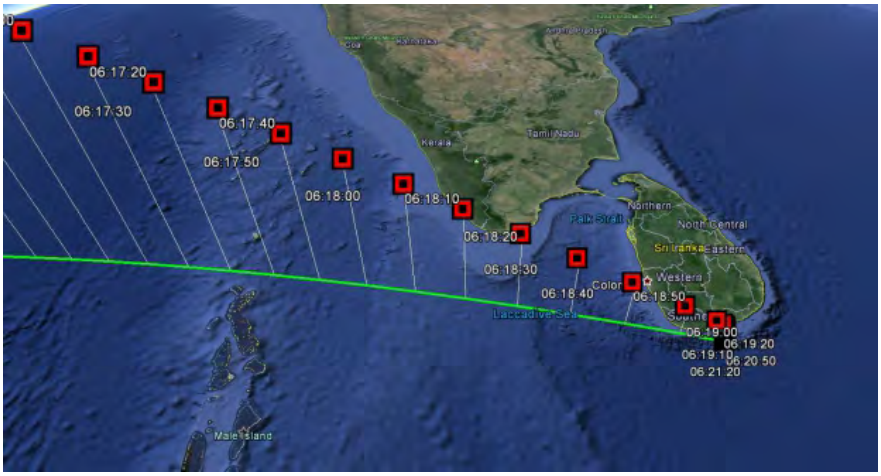
The astrometric observations showed that WT1190F was not following the path that an asteroid would. To accurately predict its motion, orbital computers had to take into account the non-gravitational effects. One of these is solar radiation pressure (SRP).

Reentry of WT1190F
WT1190F burns up in Earth's atmosphere on its final orbit. This image is from the Gulfstream 450 jet flying over the Indian Ocean on November 13.

SRP is a force that results from the object reflecting some of the Sun's light back toward it, cancelling out a slight bit of the Sun's gravity. The strength of this effect depends on the area of the object facing the Sun. A large area, like a solar sail will produce a large force. Since a given surface area results in a specific force, how much acceleration this force generates depends on the mass of the object (Netwon's Second Law says a=F/m).

The observed effect of solar radiation pressure on WT1190F indicated a low-mass object with a relatively large area. The required density was only about ten percent of the density of water. This low density would be typical of an empty fuel tank (basically, a hollow cylinder) or an upper stage of some spacecraft launch in the past. There are other non-gravitational effects that can change an object's orbit, such as the Yarkovsky effect.

With the nature of WT1190F determined, astronomers could plan for its reentry on November 13. The location of the impact was well determined from the orbit, a little south of Sri Lanka in the Indian Ocean. Observers on the ground in southern Sri Lanka would see it go over at an altitude of about thirty miles. To get a good view of this reentry, astronomers from the International Astronomical Center (IAC) and the United Arab Emirates Space Agency flew near the impact area in a Gulfstream 450 jet. They successfully observed the reentry, capturing it on video.



Reentry Path of WT1190F
The final few minutes of WT1190F as it entered the Earth's atmosphere. The ground track is the green line, and the vertical lines indicate the altitude at the indicated times (U.T.). This object was a spent rocket booster that was returning to the world that launched it.

The identification of this object is uncertain, partly because of the non-gravitational effects and partially because of its close approaches to the Moon. These close approaches can change the orbit in ways that can depend greatly on the distance from the Moon to the object. A slight difference makes a large change in the orbit. Conversely, a slight inaccuracy in the computed orbit can make a large difference in the orbit before the lunar close approach.

Nonetheless, Dr. Jonathan McDowell, author of Jonathan's Space Report and an astrophysicist working at the Harvard-Smithsonian Center for Astrophysics, thinks that WT1190F could have been the trans-lunar injection stage for the Lunar Prospector or the final stage rocket from Japan's Nozomi probe. Now that it has burned up in our atmosphere, we will never know for sure.

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Polar Alignment: When, Why, and How

Alex Woronow, ASLC & Black Range Observatory

Series Introduction: In this, and following installments, I hope to provide the rationale behind undertaking an accurate polar alignment of an equatorial mount and to review some of the ways that such an alignment might be accomplished. Polar alignment, as the name implies, consists of making the polar axis (aka, "right-ascension axis") of the telescope's equatorial mount lie accurately parallel to the rotational axis of the earth. With an accurate polar alignment, the telescope mount will keep a star centered in a field of view without interventions or adjustments by the user or by the mount's computer—well, almost no interventions. We will see why we must raise this caveat, eventually.

Note that I have used the word "accurate" to describe a good polar alignment, but what constitutes accurate enough? First ask, what is your objective in making the alignment in the first place? Do you seek to take long-exposure unguided images, or is it the less demanding quest of achieving accurate go-to-target operations for visual observing? The former might benefit from sub-arc-minute polar-alignment error, whereas the latter needs no polar alignment at all, as we shall find. For the former objective, the practicalities of the mount's construction ultimately limit the accuracy for most mounts. We all know that simply tightening a screw might cause a telescope's field of view to shift relative to the stars, but gear periodic error, backlash, instrument focal length, sky location of the target, and numerous other variables also limit the length of unguided exposures. We will ignore all of those, assigning them to "not my problem," and address the solitary issue of attaining the highest-quality polar alignment we can.

This essay could be distilled into a "then turn this screw" DIY video, I suppose. But I hope you will bear with me as we establish the rationale for actually turning this or that screw. To get there, we will start with a summary of celestial coordinate systems because, of course, we are trying to make our mount's axes one with those natural coordinate systems.

The issues surrounding polar alignment have been around for a long time, and, not surprisingly, many rituals for polar alignment have arisen. We will examine some of those. Some involve significant investment of time and patience, others claim to rest on mathematical rigor (as often as not, erroneously so), still others use mechanical aids (polar scopes, levels, clinometers), and others simplify the issue so greatly as to rapidly implement nothing more than significant inaccuracies. Obviously, we will have much to cover in this side-show of oddities and realities—so, let's get on with it!

Installment 1: Celestial Coordinate Systems & Telescope Mount Designs

Coordinate Systems in the Sky: Whether on the sky, on a planet, or on a sheet of paper, coordinate systems have a singular purpose: to locate objects. In the sky, the objects might be stars, planets, or galaxies. On earth, they might be continents, cities, or buildings. Of course, given multiple locations, distance and direction relationships among objects also devolve from the coordinate system. On the sky, or any sphere, angular measures describe both distances and directions. The distances most often relate to "great-circle" parameters. If the plane of a circle also contains the center of host sphere, then the circle is a "great circle." Circles whose planes do not contain the sphere's center define "small circles." On the earth, we use two sets of circles to locate objects on its surface: lines of *longitude* and lines of *latitude*. Lines of longitude constitute great circles, whereas lines of latitude generally inscribe small circles (Figure 1).

On the sky, we most commonly, and rather interchangeably, employ four different coordinate systems. Each consists of a set of great circles plus a set of small circles. Two general systems, "Horizon Coordinates" and "Equatorial Coordinates," host two variant systems each. The Horizon-Systems use altitude and azimuth axes, with a pair of different definitions for the direction to where azimuth = 0. One Equatorial system uses right-ascension and declination axes, and the other uses hour-angle and declination axes. Let's take a brief look at these two major types of coordinate systems.

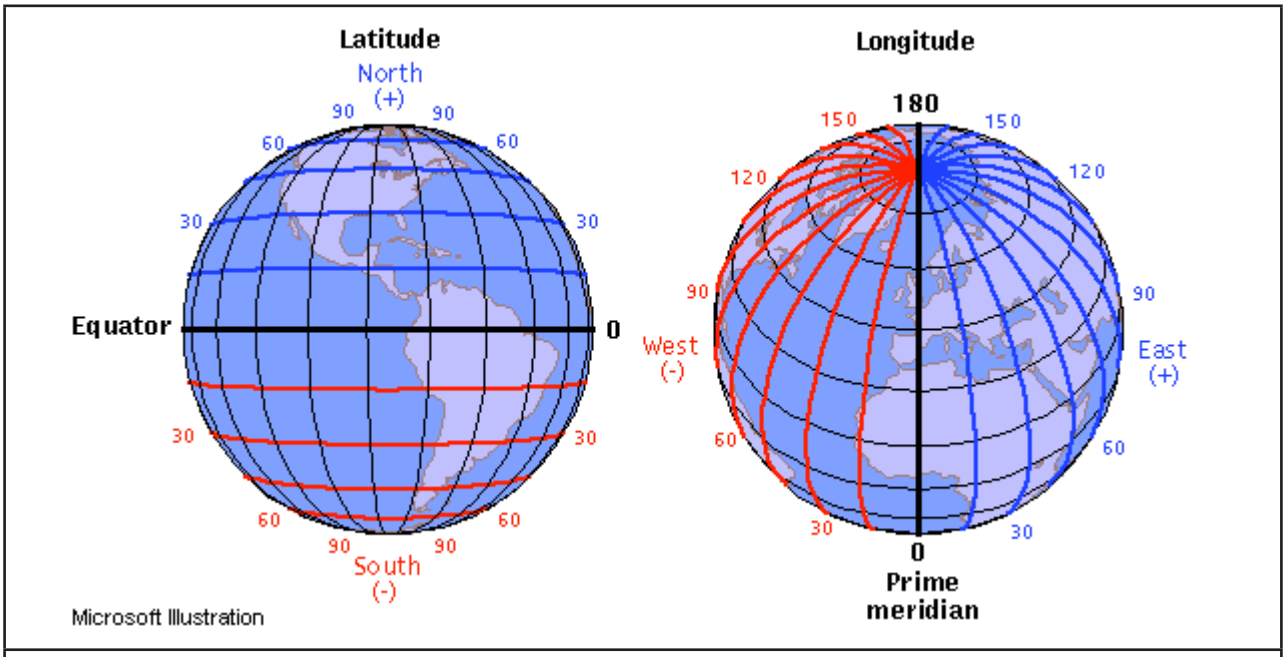

Figure 1: *Latitude lines (left) trace "small circles" because the plane that contains them generally does not pass through the center of the sphere (earth, in this case). Longitude lines trace "great circles" because their containing planes do pass through the center of the sphere. (Illinois St. U.)*

Horizon Coordinates: The Horizon Coordinate System, in a sense, depends upon the observer's location. The observer's latitude and longitude determine the instantaneous coordinates of celestial objects. Directly over the head of the observer is a point in the sky call the "zenith." For both variants of the horizon system, the zenith, by definition, has an altitude of 90°. Therefore, the nominal horizon for the observer has an altitude of 0°. The azimuth coordinate value is measured as an angle around the horizon. One variant measures the angle from the northern point on the horizon (azimuth = 0°), increasing in value in an eastward, or clockwise, direction. The other variant measures from the southern point on the horizon (azimuth = 0°) in a westward, also in clockwise, direction. Figure 2 shows the first, and most common, of these two variants. (For the record, the Sloan Digital Sky Survey is different still. It measures azimuth from the south in an eastward direction—why? Who knows!)

The horizon systems specify "instantaneous coordinates" in the following sense. As the earth rotates, the altitude of an object changes, and, in general, so does its azimuth. Therefore, the numerical values of the objects altitude and azimuth vary with time.

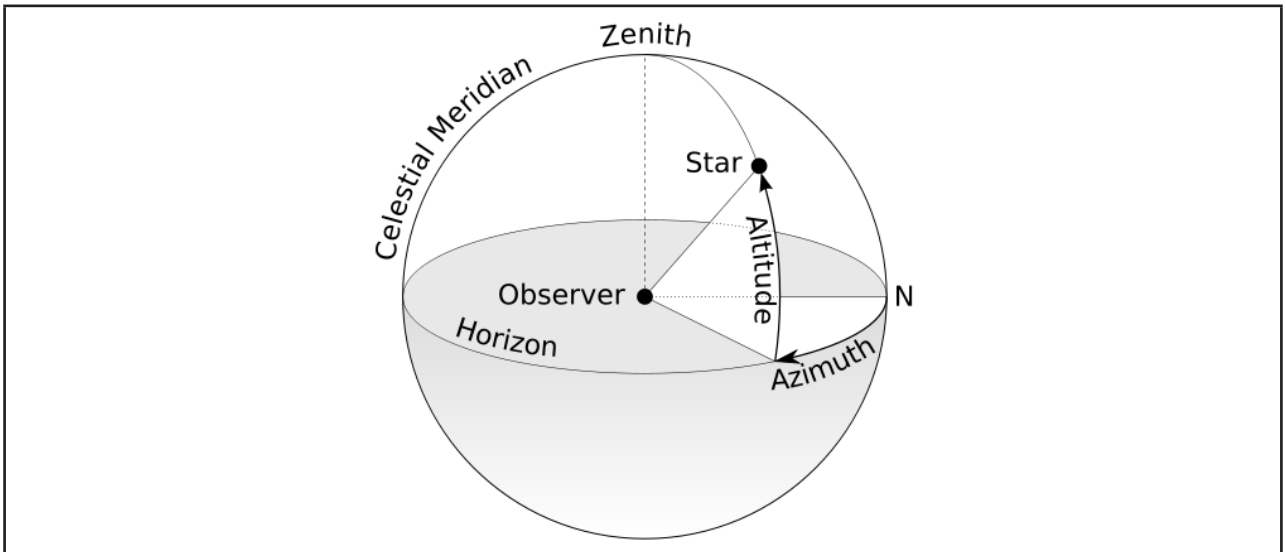

Figure 2: *The location of a star measured in the Horizon coordinate system. The star's coordinates would be reported as its Altitude and Azimuth, which change as the earth rotates. (Wikipedia)*

Right Ascension - Declination System: The Equatorial Right Ascension (RA) – Declination coordinate system does not depend upon the observer's location. It remains fixed to the sky so that as the earth rotates the coordinate system rotates (in right ascension) along with it. The declination axis has a value of 90º at the celestial North Pole, and 0º at the celestial equator, similar to latitudes on earth (Figure 3). The RA axis commonly has units of hours, with one hour spanning 15º on the sky (so that 360º = 24hrs). If we set a telescope looking skyward with tracking turned off, then whatever star was centered in our eyepiece when we started, after one hour it will have moved westward and been replaced in the eyepiece by a star whose RA value is one hour (15º) greater than that of our initial star. The lines of RA define great circles that pass through the celestial North and South Poles and numerically increase eastward. The lines of constant Dec follow small circles circumscribed around the poles.

Hour Angle - Declination System: The Hour Angle (HA) – Declination system bears a simple algebraic relationship to the RA - Dec system and shares the brand "equatorial coordinate system." The declinations of objects have identical numerical values in both systems, and

HA = Local Sidereal Time – RA.

Therefore, HA increases westward and has a value of zero along the celestial meridian (See Figure 3), which lies along a great circle passing through the North and South Celestial Poles and through the zenith.

The bottom line: given a few easily determined parameters, the location of an object in any one coordinate system suffices to calculate its coordinates in any of the other coordinate systems. The required equations are easily uncovered on the internet. If you ever have doubts about the relationship between the equatorial and horizon coordinate systems, consult a computer planetarium program, such as the freeware Stellarium program.

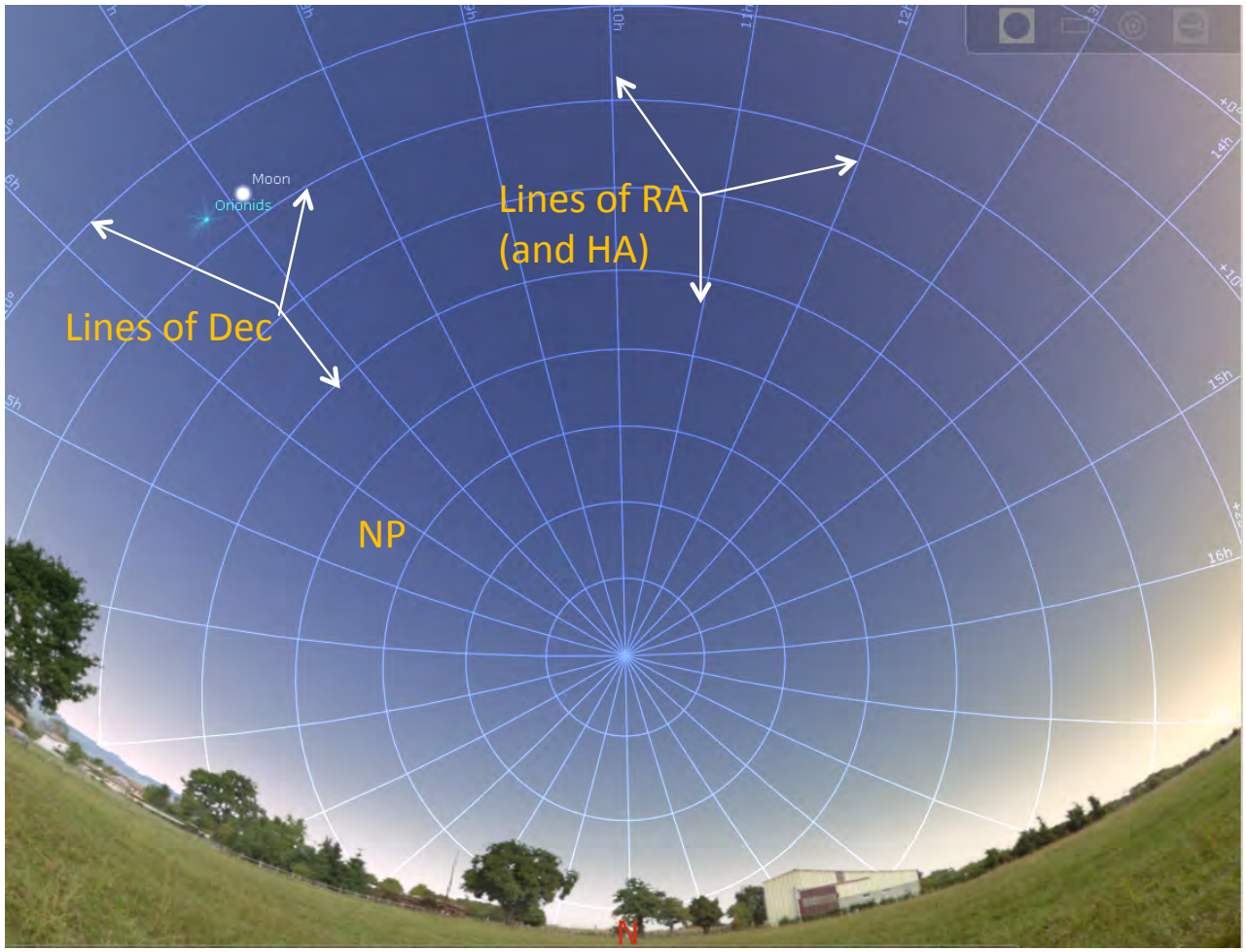

Figure 3: *The Equatorial, Right Ascension – Declination system. "NP" indicates the North Pole of the earth (its rotational axis) projected to the sky. (Stellarium)*

Telescope Mounts and the Equatorial and Horizon Coordinate Systems: A computer-driven telescope mount, regardless of whether it is Alt-Az or Equatorial, can track the stars across the sky and programmatically "go to" faint deep-sky objects—thanks to the equations mentioned above. Nonetheless, an Alt-Az mount has simplicity of operation and design but an equatorial mount is more suited for deep-sky astrophotography. Examples of both types of mounts appear in Figure 4. Equatorial mounts come in a variety of implementations, but amateurs usually have the German Equatorial Mount (GEM) as shown in Figure 4. These GEM mounts often have motor-driven axes, and when the right ascension (RA) axis accurately points parallel to the earth's axis of rotation (Figure 3), they track sky objects with rotation around that single axis.

Alt-Az mounts requires simultaneous rotations of both axes in order to track a celestial target, but as they track, the image appears to rotate in the field of view. This phenomenon, termed "image rotation," virtually prevents Alt-Az mounts from doing high-quality deep-sky imaging, unless fitted with an expensive "image de-rotator." Figure 5 illustrates the problem.

An accurately aligned equatorial mount does not exhibit image rotation. The operative words are "accurately aligned." A poorly aligned equatorial mount also may suffer from image rotation. Accurate guiding during an exposure does not compensate for any blurring caused by image rotation because image rotation is a differential motion of the objects in the field of view.

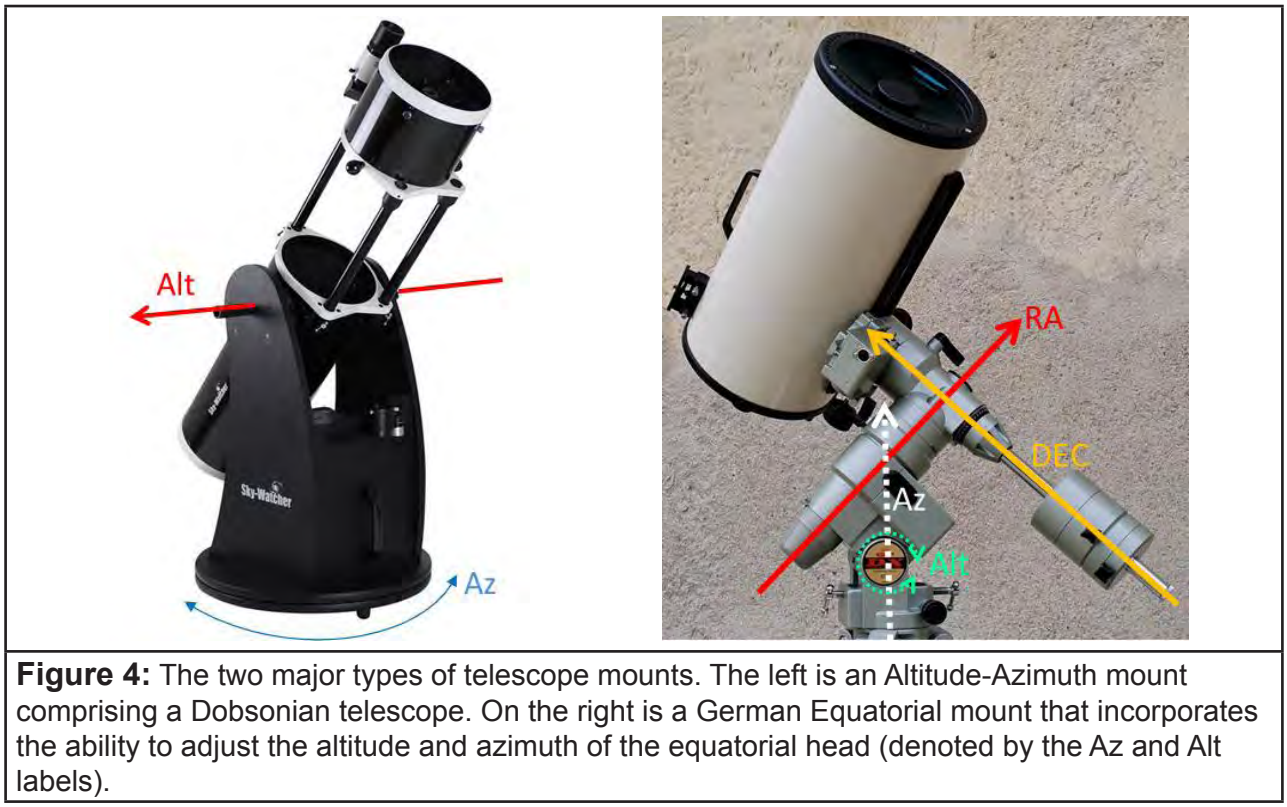

Figure 4: The two major types of telescope mounts. The left is an Altitude-Azimuth mount comprising a Dobsonian telescope. On the right is a German Equatorial mount that incorporates the ability to adjust the altitude and azimuth of the equatorial head (denoted by the Az and Alt labels).

With this reprise of mounts and coordinate systems, we conclude the first installment of discussions about equatorial-mount polar alignment. Next time we will compare "polar alignment" with "star alignment" and "sky modeling." Also, we broach the practical issues of how to achieve an accurate polar alignment of an equatorial mount.

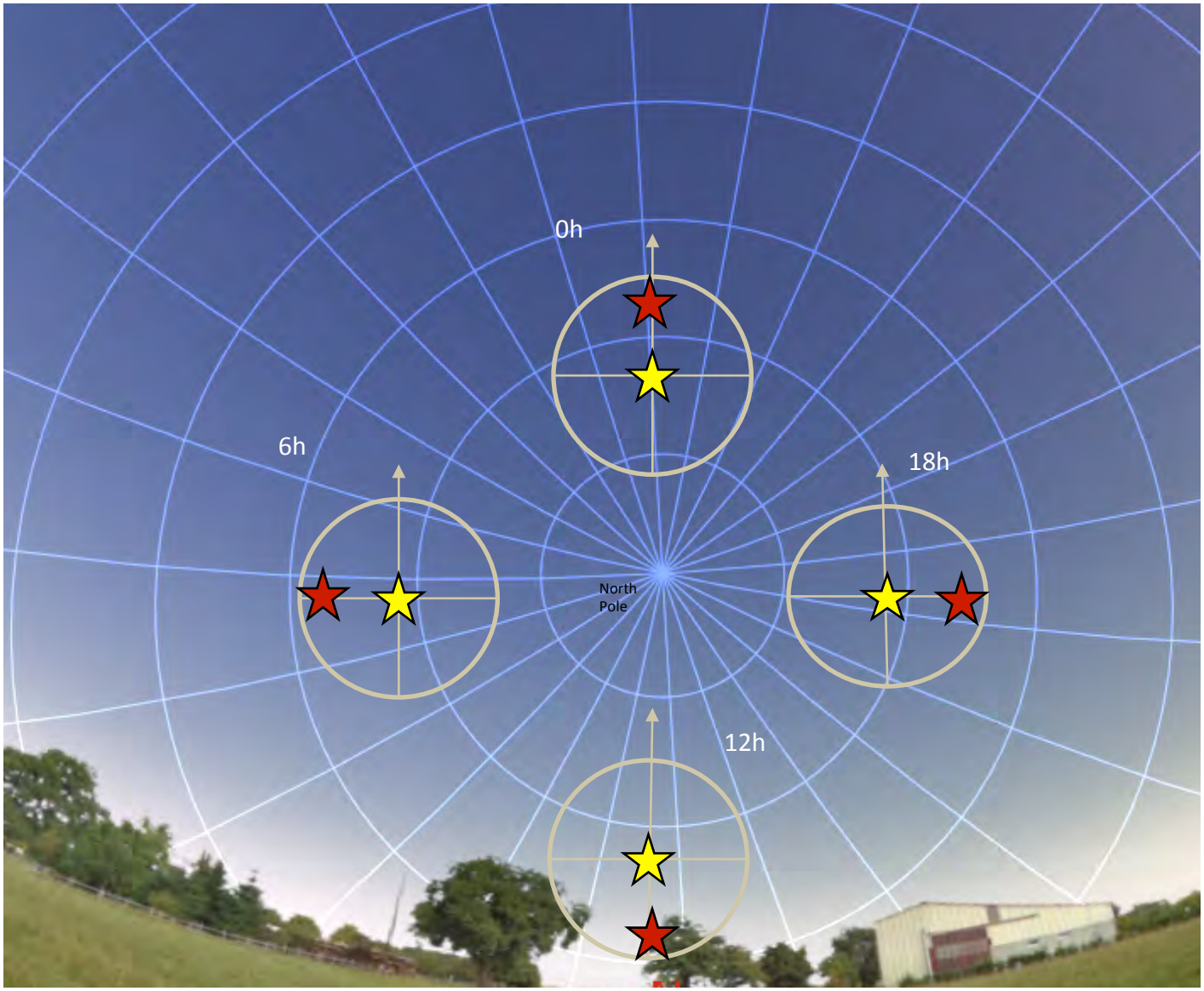

Figure 5: *An Alt-Az mount is centered on, and tracking on, the yellow star. Other stars (e.g., the red one) in the field-of-view would generate complete circular paths around the yellow star every 24 hours. This effect is called "image rotation." The arrows, extending each reticle, point along lines of constant azimuth and toward the zenith. In a sense, these arrows could be thought of as indicating "up" in an eyepiece. Therefore, the red star rotates 90o in the eyepiece for every 6 hours of passing time. (background grid from Stellarium)*

Photo of the Month

OBJECT: Jellyfish Nebula (IC 433 / Sharpless 248 (Sh2-248)) Distance: 5,000 light years
Telescope: Takahashi FS-60C @ f/6.2
Mount:Takahashi EM200 Temma II
Camera: QSI 540wsg @ -10C
Filters: Astrodon Ha (3nm), Astrodon Tru-Balance I-Series LRGB Gen 2
Guider: SX Lodestar
Settings: 7x20min Ha, 3x5min L (bin1x1); 3x5min ea RGB (bin2x2); AstroArt5, CS4 (slightly cropped, 10xdarks/flats/fdarks/bias)
Date/Location: 13 October 2015 - Las Cruces, NM http://jeffjastro.com/dso/IC433_13Oct15.htm

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What's Up With the Astronomical League January 2016

Compiled by Carroll Iorg, Media Officer

Greeting from Edgar Castro Bathen, President of the Guatemala Astronomical Association

"The old Dobsonian, a telescope that has made hundreds of Guatemalan people see the planets, stars and galaxies, was donated to our society by the … Astronomical League in the year 2000. We have made good use of it."

Inside This Issue:

Youth Astro-Imagers!
Enter Your Favorite Shot Into the 2016 Horkheimer/Parker Youth Imaging Competition!

Are you 18 years or younger and do you enjoy the challenges of astro-imaging, whether it be using a smartphone, a handheld digital camera, or a telescope CCD imager? Have you captured an astro-image that you are particularly proud of?

Why not enter your shot into the Astronomical League's Horkheimer/Parker Youth Imaging competition? **After all, the first-place winner receives $1,000, second place $500, and third place $250!**

Submitted images can be of any astronomical themed subject: an interesting perspective of a planet, a captivating lunar crater, a wondrous deep-sky object, or a wide field scene of the sky at night.

For all the details and rules of the competition, please see https://www.astroleague.org/al/awards/horkhmr/horkhmrs.html. The entry deadline is March 31, 2016.

The Astronomical League's *Astronomics* Sketching Award

Sketching the impressions of a celestial scene allows the observer to see more detail and to better enjoy our amazing avocation. Why not try your hand at sketching tonight?

The Astronomical League launches a new award program, the *Astronomics* Sketching Award. First place sketcher receives a cash prize of $250, second place $125, and third place $75!

For all the exciting details, please visit the Astronomical League awards page, www.astroleague.org/al/awards/awards.html

This program is made possible through the vision and generosity of *Astronomics*!

Happy New Year

ACEAP 2016

Are you a K through college educator or an amateur astronomer who does outreach, or do you work at a planetarium, science center, or other informal science venue? Are you interested in traveling to Chile to learn about the major U.S. observatories? Here's your chance!

Please share this email/link with others who you think might be interested, via email list serves, newsletters, Facebook Pages, other social media, etc.!

Astronomy in Chile Educator Ambassador's Program (ACEAP): http://www.aui.edu/news/applications-being-accepted-for-the-2016-astronomy-in-chile-educator-ambassadors-program/

Thanks and good luck!!
Tim Spuck

New plaque now on display at the A.L. National Office, commemorating the 2015 NYAA winner, compliments of Explore Scientific, National Young Astronomer Award sponsor.

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