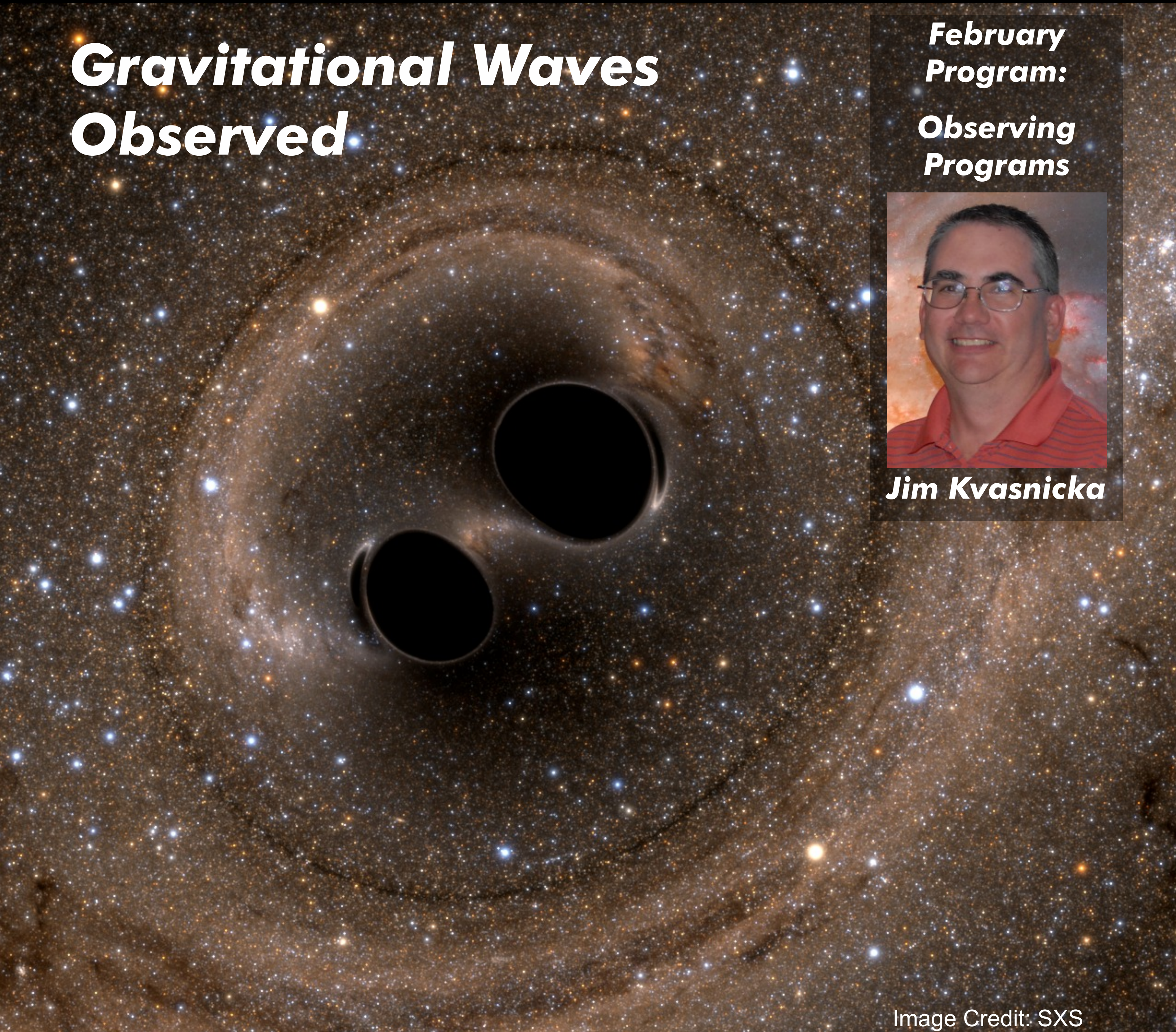
The Prairie Astronomer

February 2016 Volume 57, Issue #2



Gravitational Waves Observed

February Program:

Observing Programs

Jim Kvasnicka

Image Credit: SXS

Night Sky Network

The Newsletter of the Prairie Astronomy Club

The Prairie Astronomer

NEXT PAC MEETING: February 23, 7:30pm
at Hyde Observatory

PROGRAM

Observing Programs, by Jim Kvasnicka.

Jim will present an overview of the Astronomical League's observing programs. It will benefit any new members who are thinking of starting an observing program. It will cover how to get started, which program to start with. He will also review the observing awards earned by PAC members.

FUTURE PROGRAMS

March: Space Law Part I - Mark Ellis
April: Space Law Part II - Elsbeth Magilton & Prof Frans Von der Dunk
June: Solar Star Party
August: NSP Review

Buy the book! The Prairie Astronomy Club: Fifty Years of Amateur Astronomy.
Order online from Amazon or lulu.com.

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EVENTS

PAC Meeting

PAC Meeting
Tuesday February 23rd, 2016, 7:30pm
Hyde Observatory

PAC Meeting
Tuesday March 29th, 2016, 7:30pm
Hyde Observatory

Astronomy Day, Sunday, April 17 at Morrill Hall

PAC Meeting
Tuesday April 26th, 2016, 7:30pm
Hyde Observatory

Newsletter submission deadline March 19

2016 STAR PARTY DATES

Photo by Brian Sivill

	Star Party Date	Star Party Date	Lunar Party Date
January	Jan 1st	**Jan 8th**	
February	Jan 29th	**Feb 5th**	
March	Mar 4th	**Mar 11th**	
April	Apr 1st	**Apr 8th**	Apr 15th
May	Apr 29th	**May 6th**	May 13th
June	May 27th	**Jun 3rd**	
July	**Jul 1st**	Jul 8th	
NSP	**July 31st - Aug 5th**		
August	Jul 29th	**Aug 5th**	Aug 12th
August	Aug 26th	**Sep 2nd**	Sep 9th
September	Sep 23rd	**Sep 30th**	
October	Oct 21st	**Oct 28th**	
November	Nov 25th	**Dec 2nd**	
December	Dec 23rd	**Dec 30th**	

PAC E-MAIL:

info@prairieastronomyclub.org

PAC-LIST:

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To post messages to the list, send to the address:

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ADDRESS

The Prairie Astronomer
c/o The Prairie Astronomy Club, Inc.
P.O. Box 5585
Lincoln, NE 68505-0585

WEBSITES

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www.planetary.org/home/
http://www.darksky.org/

Night Sky Network

PAC Meeting Minutes

Minutes for the meeting of Tuesday January 26, 2016

President Jim Kvasnicka called the meeting to order. Welcome members and guests.

Jim reviewed upcoming events and activities.

The next PAC meeting will be Tuesday February 23, at Hyde. The next PAC star parties will be Jan 29,and February 5 at the Busboom farm.

Jim also reviewed benefits and opportunities for members.

Jim provided his monthly observing report.

Club business:

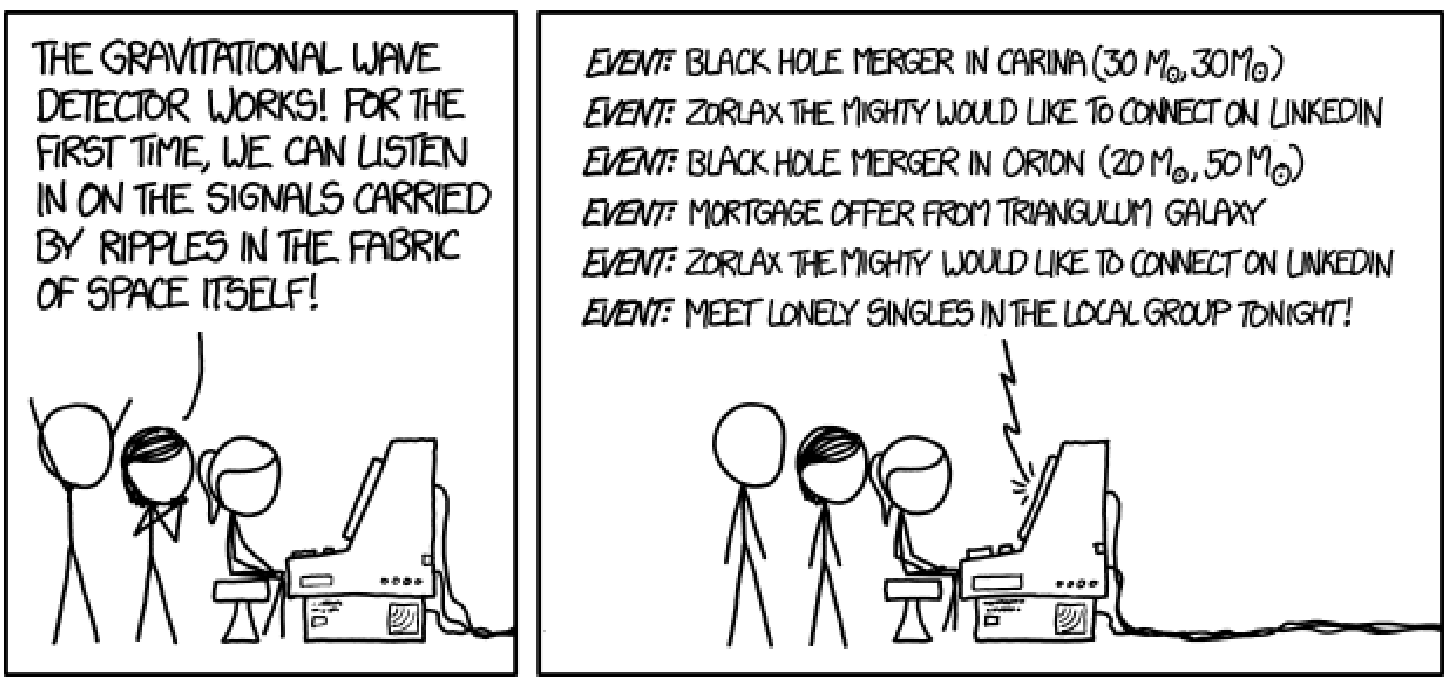
Zack Thompson mentioned that Morrill Hall will have its Sunday With A Scientist on April 17, which will be the annual Astronomy Day. Zack asked members who would like to volunteer for this event to contact him by March 1st to coordinate this event.

The club audit will occur Saturday February 6, 2016. The audit committee consists of Secretary, Lee Taylor, Mike Kearns and Rick Brown.

Adjourn to the program, How to Use Your Telescope.

Respectfully submitted by

Lee Taylor



xkcd.com

Common Double Stars with Significant Color Contrast

Dave Knisely

Positions, separations, and position angles for 2000

LEGEND: R.A. = Right Ascension (2000.0) Dec. = Declination
mag. = apparent visual magnitude sp. = spectral type
Sep. = separation (in arc seconds) P.A. = position angle

Otto Struve (STT) 254, R.A. 0h 1.3m Dec. +60d 21.3'
Primary: mag. 7.2~ (variable) Sp. C5p, Secondary mag. 8.3, sp. A Sep. 58" arc, P.A. 90 deg. (multiple optical double) Colors seen in 10 inch: deep reddish-orange and bluish-white.
(primary is Carbon star WZ Cas, other stars also nearby)

Sturve 3053, R.A. 0h 2.6m Dec. +66d 6.0'
Primary: mag. 5.9, sp. G9III, Secondary mag. 7.3, sp. A1V Sep. 15.0" arc, P.A. 70 deg.
Colors seen in 10 inch: Yellow and pale bluish.

Eta Cassiopeiae, R.A. 0h 49.10m Dec. +57d 49.0'
Primary: mag. 3.4, sp. G0V, Secondary: mag. 7.5, sp. dM0 Sep. 12.8" arc, P.A. 317 deg. (period: 480 years)
Colors seen in 10 inch: Off-white and faint reddish-orange.

ALMACH (Gamma And.), R.A. 2h 3.90m Dec. +42d 19.8'
Primary: mag. 2.2 sp. K3III, Secondary: mag. 4.8 sp. B8V Sep. 9.8" arc, P.A. 64 deg. (mag. 6.3 companion of Gamma-B at 0.4" arc, p.a. 103 deg., closing separation).
Colors seen in 10 inch: Yellow (Gold) and light blue.

6 Triangulae (Struve 227), R.A. 2h 12.37m Dec. +30d. 18.3'
Primary: mag. 4.9, Sp. G5III, Secondary: mag. 6.5, Sp. F6V Sep. 3.9" arc, P.A. 69 deg.
Colors seen in 9.25" SCT: Yellowish-white and bluish-white.

32 Eridani, R.A. 3h 54.29m Dec. -2d 57.3'
Primary: mag. 4.5, sp. G8III, Secondary: mag. 6.1, sp. A2V Sep. 6.9" arc, P.A. 348 deg.
Colors seen in 10 inch: Yellow and pale blue.

15 Geminorum, R.A. 6h 27.8m Dec. +20d 47.3'
Primary: mag. 4.6, sp. K0, Secondary: mag. 8.5, sp. G0 Sep. 6.9" arc, P.A. 64 deg.
Colors seen in 10 inch: Yellowish-orange and white.

Psi-5 Aurigae, R.A. 6h 46.75m Dec. +43d 34.6'
Primary: Mag. 5.3 sp. G0V, Secondary: mag. 8.5 sp. M0V Sep. 31.1" arc, P.A. 38 deg.
Colors seen in 10 inch: Off-white and faint orange.

38 Geminorum (STF 982), R.A. 6h 54.64m Dec. +13d 10.7'
Primary: mag. 4.7, sp. A8/F0V, Secondary: mag. 7.7, sp. G6V Sep. 7.1" arc, P.A. 144 deg.
Colors seen in 10 inch: White and faint orangish.

h3945 (ADS 5951, CMa), R.A. 7h 16.61m Dec. -23d 18.9'
Primary: mag. 4.8 sp. K4III, Secondary: mag. 6.8, sp. A5 Sep. 26.6" arc, P.A. 55 deg.
Colors seen in 10 inch: Orange and bluish-white.
"The Winter Albireo"

S 548 (ADS 6087, Gem), R.A. 7h 27.7m Dec. +22d 8.0'
Primary: mag. 6.9 sp. K5, Secondary mag. 8.9 sp. ?
Sep. 35.5" arc, P.A. 277 deg.
Colors: Orangish and bluish

Iota Cancri, R.A. 8h 46.70m Dec. +28d 45.6'
Primary: mag. 4.0 sp. G8II, Secondary: mag. 6.6 sp. A3V Sep. 30.5" arc, P.A. 307 deg.
Colors seen in 10 inch: Light yellow and pale blue.

Tau Leonis, R.A. 11h 27.94m Dec. +2d 51.3'
Primary: mag. 4.9 sp. G8Iab, Secondary: mag. 7.4 sp. G5 Sep. 89.7' arc, P.A. 180 deg.
Colors seen in 10 inch: Yellow and white.
*nice low power pair with double 83 Leonis 20' at P.A. 298 deg.

2 Canum Venaticorum, R.A. 12h 16.13m Dec. +40d 39.6'
Primary: mag. 5.7, sp. M1III, Secondary: mag. 8.7, sp. F7V Sep. 11.3" arc, P.A. 260 deg (2003).
Colors seen in 10 inch: Yellowish-orange and pale bluish-white.

24 Comae Berenices, R.A. 12h 35.13m Dec. +18d 22.6'
Primary: mag. 5.0 sp. K2III, Secondary: mag. 6.6 sp. A7V Sep. 20.3" arc, P.A. 271 deg.
Colors seen in 10 inch: Yellow and pale blue.

Cor Caroli (Alpha CVn), R.A. 12h 56.00m Dec. +38d 19.1'
Primary: mag. 2.9 sp. A0spe, Secondary: mag. 5.6, sp. F0V Sep. 18.8" arc, P.A. 230 deg.
Colors seen in 10 inch: Bluish-white and off-white (cream).

Izar (Epsilon Bootis), R.A. 14h 44.99m Dec. +27d 4.5'
Primary: mag. 2.4 sp. K0II, Secondary: mag. 5.1, sp. A2V Sep. 2.8" arc P.A. 339 deg.
Colors seen in 10 inch: Yellow and light blue.

Xi Bootis, R.A. 14h 51.39m Dec. +19d 6.0'
Primary: mag. 4.5, sp. G8V, Secondary: mag. 6.8, sp. K5V Sep. 6.8" arc P.A. 320 deg.
Colors seen in 10 inch: Pale yellowish white and orange.

Antares (Alpha Sco). R.A. 16h 29.41m Dec. -26d 25.9'
Primary: mag. 1.0v sp. M1I, Secondary: mag. 5.4 sp. B4 Sep. 2.6" arc P.A. 274 deg.
Colors seen in 10 inch: Orange and light blue.

Ras Algethi (Alpha Her) R.A. 17h 14.65m Dec. +14d 23.4'
Primary: mag. 3.2v sp. M5II Secondary: mag. 5.4, sp. F2/G3 Sep. 4.6" arc P.A. 104 deg.
Colors seen in 10 inch: Reddish-orange and pale bluish-white.

95 Herculis. R.A. 18h 1.5m Dec. +21 deg. 36'
Primary: mag. 4.9, Sp. A5III, Secondary: Mag. 5.2 sp. G5?
Sep. 6.3" arc P.A. 256 deg.
Colors seen in 10 inch: pale bluish-white and gold.

59 Serpentis, R.A. 18h 27.2m Dec. +0d 45.9'
Primary: mag. 5.2, Sp. GOIII, Secondary: mag. 7.4, sp. ?
Sep. 3.9" arc P.A. 320 deg.
Colors seen in 10 inch: Yellowish-white and pale bluish-white

Omicron Draconis, R.A. 18h 51.20m Dec. +59d 23.3'
Primary: mag. 4.6, Sp. G9III, Secondary: mag. 8.1, sp. K3III Sep. 36.5" arc P.A. 319 deg.
Colors seen in 10 inch: Yellow and faint orangish

SHJ 282 (O. Struve 525), Lyra), R.A. 18h 54.90m Dec. +33d 58.0'
Primary: mag. 6.1, sp. G8III Secondary(s): mag. 9.1, sp. A8 B component Sep. 1.8" arc, P.A. 129 deg . (O. Str 525) C component: mag. 7.7 Sp. A1, Sep. 45.4" arc P.A. 350 deg.
Colors seen in 10 inch: Yellowish-white and bluish-white.

Albireo (Beta Cyg) 19h 30.72m Dec. +27d 57.6'
Primary: mag. 3.1 sp. K3II Secondary: mag. 5.1 sp. B8V Sep. 34.3" arc P.A. 54 deg.
Colors seen in 10 inch: Yellow and light blue.

ADS 12900 (Cyg). 19h 45.86m Dec. +35d 0.77'
Primary: mag. 6.1 sp. K2? Secondary: mag. 8.6 sp. A2V Sep. 37.5" arc P.A. 25 deg.
Colors seen in 10 inch: Yellow and blue.

Gamma Delphini, R.A. 20h 46.73m Dec. +16 deg. 7.8'
Primary: mag. 4.4 sp. K1IV, Secondary: mag. 5.0 sp. F7V.
Sep. 9.6" arc P.A. 268 deg.
Colors seen in 10 inch: Yellowish and white (hint of blue)?

12 Aquari, R.A. 21h 4.1m Dec. -5 deg. 49'
Primary: mag. 5.8 sp. G4III, Secondary: mag. 7.5 sp.?
Sep. 2.5" arc P.A. 196 deg. (2003)
Colors seen in 10 inch: Yellowish-white and pale bluish-white.

Delta Cephei R.A. 22h 29.20m Dec. +58d 25'
Prmary: mag. 4.07 (variable) sp. F5-G3 Secondary: mag. 6.27 sp. B7 Sep. 40.8" arc P.A. 191 deg.
Colors seen in 10 inch: Yellowish-white and light blue.

Close Encounters of the Bovine Kind

Rick Johnson

Editor's note: for the benefit of newcomers to the club, I'm re-printing this story from the PAC 50th Anniversary History Book (available in the club library or on lulu.com or Amazon). It's one of my favorite PAC stories.

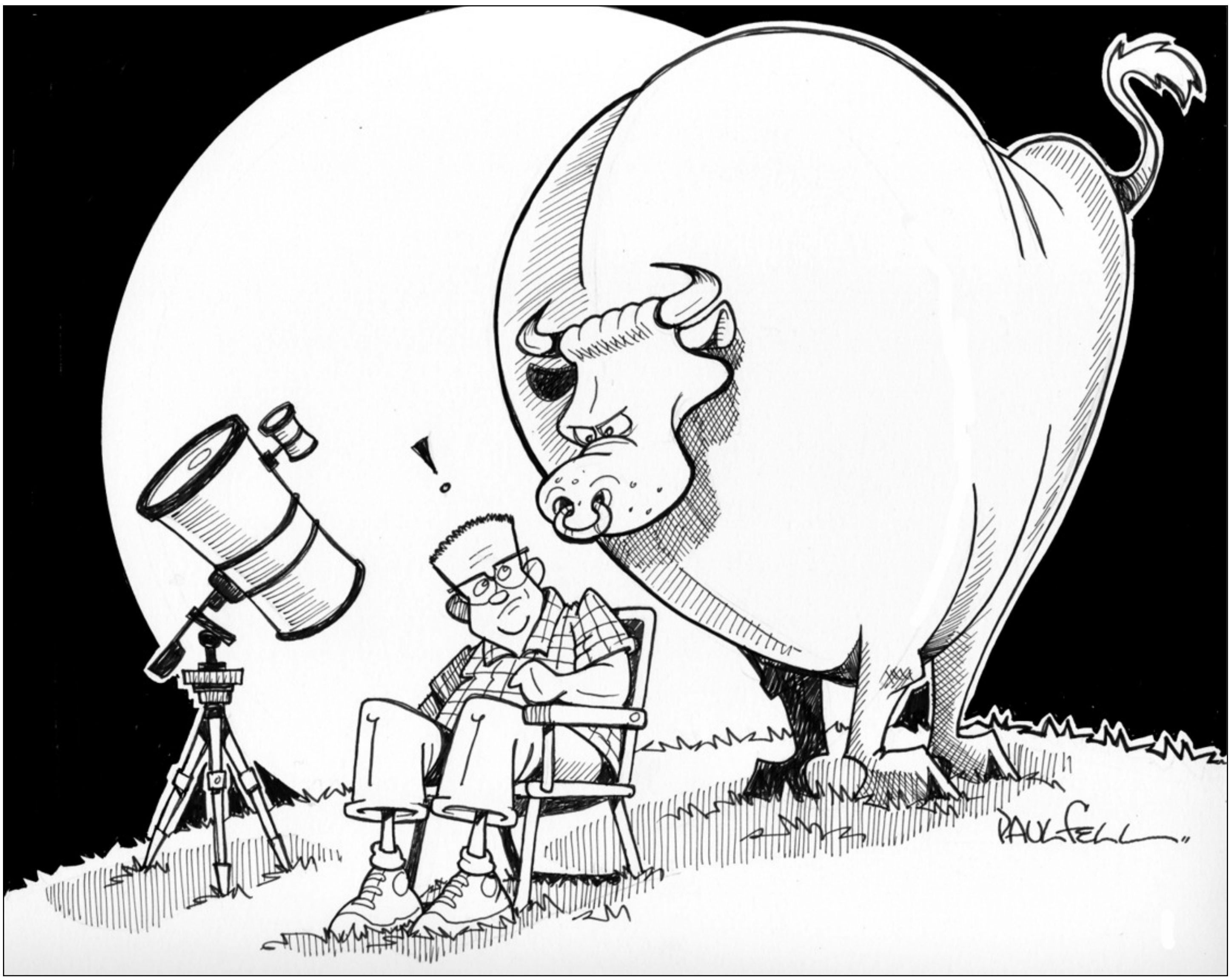
One cool summer night in the mid 60's we were using the hill top cow pasture of Earl Moser's father as our viewing site. It was by far the darkest night I can recall. I believe we were there for the Perseid Meteor Shower. Earlier in the evening a cow had gotten loose from the pen. Earl simply shooed it away and back down the hill. It was so dark I didn't see the cow but only heard it. By this time nearly everyone but Pete Schultz and I had left. I was in a reclining lawn chair wrapped in a blanket counting meteors. Pete was on the other side of the hill crest taking wide angle images of the sky hoping to catch some great Meteors.

He worked at the Miller and Paine Camera store at the time and had ordered in some fantastic Linhof cameras and lenses which he then tested by shooting the meteor shower with a medium format camera with fish eye lens.

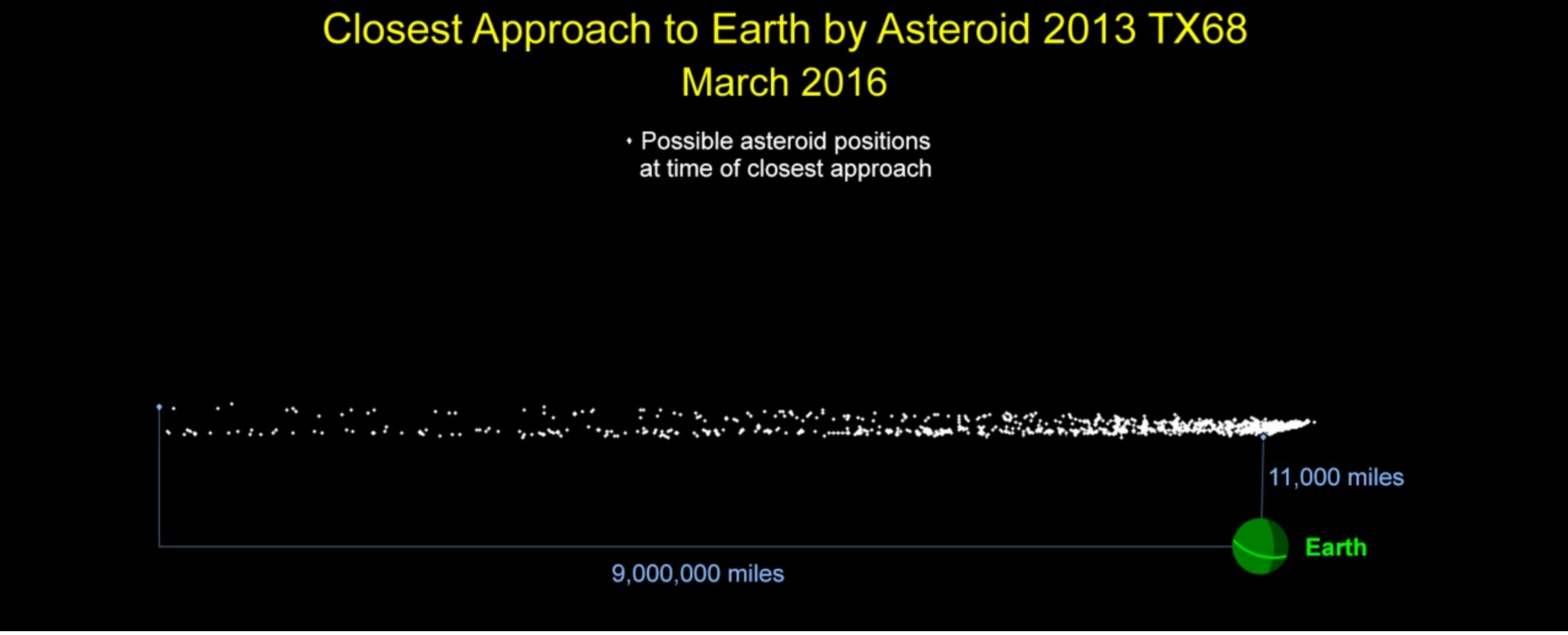
Earl went to drive back down to his house for cocoa or something like that. He tried driving out without his lights so as not to bother Pete's imaging nor my dark adaption. But the night was so dark he managed to drive over his camera and tripod. The tripod was toast but the tires missed the camera.

While Earl was gone, with Pete concentrating on his guiding and me counting meteors I suddenly heard Pete breathing hard right behind my chair. He didn't say anything. Just breathed heavily. I finally asked what he was doing. Pete's voice came, not from right behind me but from over the hill that he was still guiding an exposure. Now I don't believe in ghosts, especially those that breathe so I turned away from my meteor counting to see who was behind me. No one. At least I didn't see anyone but the breathing came from only a foot or so behind the chair. I jumped up to see what the heck was going on. My face went right into the snotty nose of a very large animal of the bovine clan. My glasses were a mess but I somehow recovered and while I only saw the barest outline of the animal I decided if Earl could shoo a cow without a problem so could I.

I tried to imitate Earl's earlier action but to no avail. It just stood there breathing deeply. I started to try again when from far down the hill I heard Earl's panicked scream "NO! NO!" Seems he was walking back rather than risk running over something again. How he knew what was happening I don't know but his urgency stopped me instantly. He came running up at a sprinter's speed. Seems he knew this bovine was a very nasty bull and it would likely shoo me into the hospital, or worse, if I continued in my Quixotic cause. Earl quickly grabbed its nose ring and led it back to the pen from which it had escaped. After I restarted my heart I also had to restart my meteor count from the beginning. Pete continued his astrophotography without missing a beat. My heart missed many however.



Note: Mark Dahmke felt that this story needed an accompanying illustration, so he asked cartoonist Paul Fell to capture the moment of Rick's "close encounter."



A small asteroid that two years ago flew past Earth at a comfortable distance of about 1.3 million miles (2 million kilometers) will safely fly by our planet again in a few weeks, though this time it may be much closer.

During the upcoming March 5 flyby, asteroid 2013 TX68 could fly past Earth as far out as 9 million miles (14 million kilometers) or as close as 11,000 miles (17,000 kilometers). The variation in possible closest approach distances is due to the wide range of possible trajectories for this object, since it was tracked for only a short time after discovery.

Scientists at NASA's Center for NEO Studies (CNEOS) at the Jet Propulsion Laboratory in Pasadena, California, have determined there is no possibility that this object could impact Earth during the flyby next month. But they have identified an extremely remote chance that this small asteroid could impact on Sep. 28, 2017, with odds of no more than 1-in-250-million. Flybys in 2046 and 2097 have an even lower probability of impact.

"The possibilities of collision on any of the three future flyby dates are far too small to be of any real concern," said Paul Chodas, manager of CNEOS. "I fully expect any future observations to reduce the probability even more."

Asteroid 2013 TX68 is estimated to be about 100 feet (30 meters) in diameter. By comparison, the asteroid that broke up in the atmosphere over Chelyabinsk, Russia, three years ago was approximately 65 feet (20 meters) wide. If an asteroid the size of 2013 TX68 were to enter Earth's atmosphere, it would likely produce an air burst with about twice the energy of the Chelyabinsk event.

The asteroid was discovered by the NASA-funded Catalina Sky Survey on Oct. 6, 2013, as it approached Earth on the nighttime side. After three days of tracking, the asteroid passed into the daytime sky and could no longer be observed. Because it was not tracked for very long, scientists cannot predict its precise orbit around the sun, but they do know that it cannot impact Earth during its flyby next month.

"This asteroid's orbit is quite uncertain, and it will be hard to predict where to look for it," said Chodas. "There is a chance that the asteroid will be picked up by our asteroid search telescopes when it safely flies past us next month, providing us with data to more precisely define its orbit around the sun."

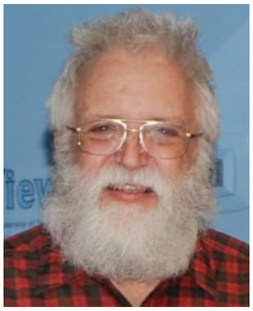
For regular updates on passing asteroids, NASA has a list of the next five close approaches to Earth; it links to the CNEOS website with a complete list of recent and upcoming close approaches, as well as all other data on the orbits of known NEOs, so scientists and members of the media and public can track information on known objects.

For more information on NASA's Planetary Defense Coordination Office, visit: http://www.nasa.gov/planetarydefense

For asteroid news and updates, follow AsteroidWatch on Twitter: twitter.com/AsteroidWatch

5 Major Galaxies, 9 Minor Asteroids

Rick Johnson



OK most wouldn't consider this 5 galaxies "major" but compared to the others in the image they are.

This field of 5 galaxies at a distance of about 220 million light-years lies in southern Pisces only a couple minutes of arc above Aquarius. The ecliptic runs diagonally through the upper right corner of my image. This may account for all the asteroids the photo bombed the image.

My main target was MCG -01-60-005. While NED gives it the rather normal classification of SB(s)d it appears more like a mess to me. It has a blue blob at the start of an "arm" at the west end of the bar and another not really connected to anything above the bar a bit east of center. Could this be what's left of a disturbing galaxy? The blue color may argue against this or the interaction caused a star burst in the core. Usually these are behind a dust cloud so not seen in visible light. So this is unlikely at best but why else is it so disturbed looking? A

Annotated

couple Tully-Fisher distance estimates puts it a bit closer at 180 million light-years. Considering its redshift pretty well matches the other 4 galaxies with redshift data at NED I think it may be more reliable. I measure it at about 75,000 light-years in size. Larger than most galaxies that look like it.

While odd looking MCG -01-60-005 has a normal classification it's just the opposite for IC 1501. It looks pretty much like a classic grand design spiral but has the classification of

SAB(s)bc pec: with HII emission. It too has a redshift determined distance of 220 million light-years but its Tully-Fisher measurement says 230 million light-years. Again I'll go with the redshift here. What about it gives it the pec label? It looks darned ordinary to me. Must be either in the HII or other features not seen in visual light. It is a rather large spiral of 120,000 light-years in diameter. It was discovered on October 19, 1892 by Stephane Javelle.

NGC 7699 is the smallest of the NGC galaxies in this group. It's redshift distance is 230 million light-years. It is shown as SBa? by NED, Sa by the NGC project and Sa? by Seligman. So is it barred or not? While my image shows the star clouds often seen at the ends of a bar my resolution isn't sufficient. The SLOAN image however does show a faint bar so I'm going with NED on this one. I measure its size as 44,000 light-years making it by far the smallest of the 5. It was discovered by Albert Marth on November 18, 1864.

NGC 7700 is an edge on spiral that NED lists as S0+, Seligman and the NGC project say S0/a? and S0-a respectively. With such a prominent dust lane I'd go with Sa myself. It is 123,000 light-years across by my measurement. It too S0+was discovered by Albert Marth that November 18th night. Just to its west is the small round galaxy APMUKS(BJ) B233154.49-031351.7. It has no redshift data so it may be a companion or a distant spherical galaxy. I'd vote for the latter since neither galaxy looks disturbed in the slightest.

The last galaxy with distance data is NGC 7701. While it too looks rather normal for a elliptical like galaxy NED classifies it a S0o pec:. While it doesn't appear peculiar it is peculiar that the NGC project says it is Sb. I hope that's a typo! Seligman says So. Redshift puts it at 230 million light-years while Tully-Fisher says 200 million. Using the former I get a size of just over 100,000 light-years. You might suspect Albert Marth found it the same night as the others but this time William Herschel beat him to it on September 20, 1784. The two Marth found were apparently too faint for Herschel's scope. Marth used a 48" to find the other two. It isn't in either of the two Herschel 400 object observing programs.

For some time now asteroids have been few and far between in my images. Mostly because I've been working well away from the ecliptic. While not as confined to it as the planets they do usually stick within 20 degrees of it and get more common as you approach the ecliptic. Since the ecliptic runs though this field it isn't surprising there are 9 asteroids noted in the annotated image. A couple more should be there but this was a very poor night greatly reducing transparency. The nine that survived the bright skies and seeing are detailed in the annotated image.

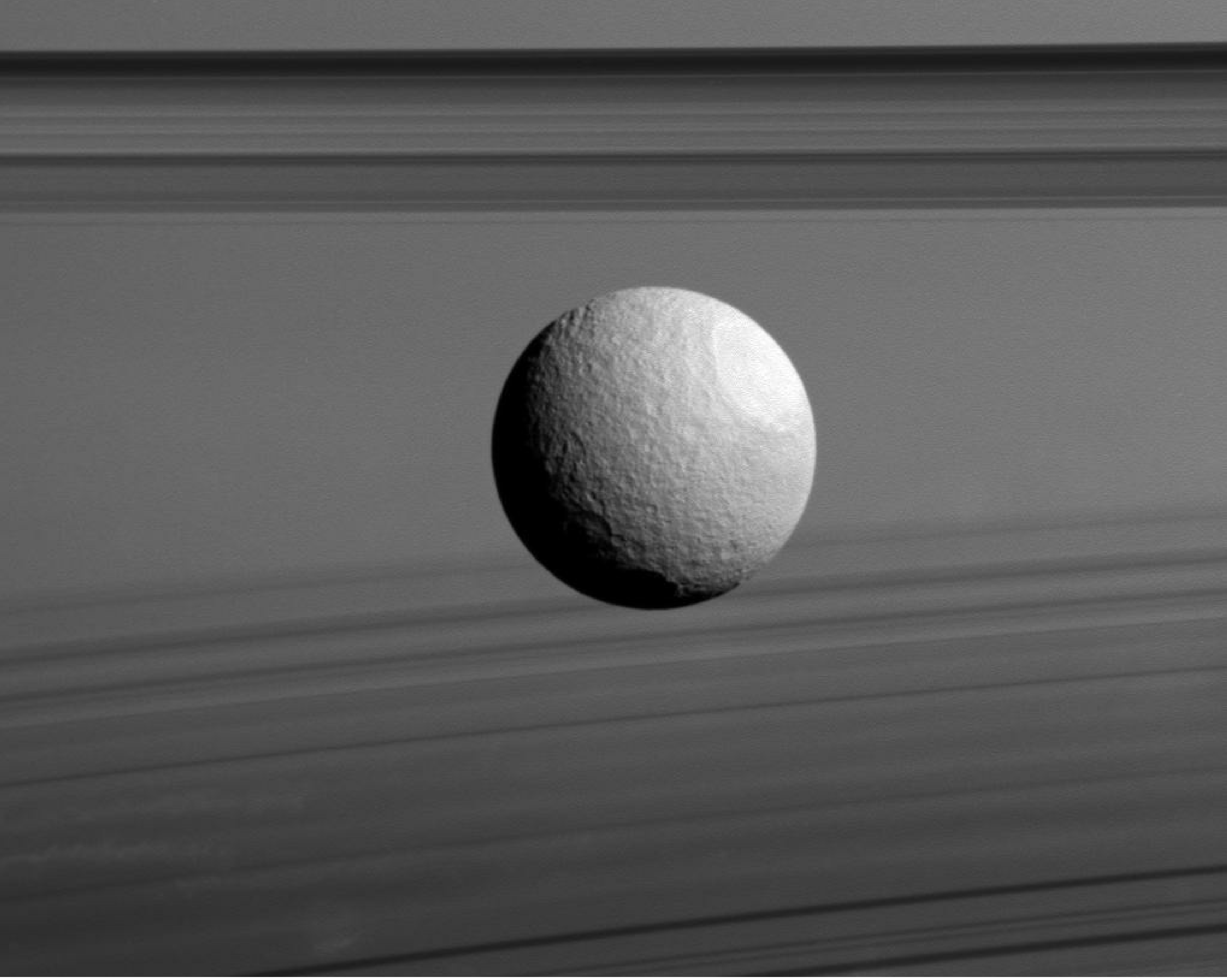
The poor conditions got far worse when the color data was taken. It had to be blurred far more than I like which likely distorted color of stars seen against galaxies. The red data was so strong compared to blue and green that I suspect the red color of NGC 7700 and 7701 is too strong but I don't like adjusting features for color so left them as they came out. I really should have tried again for the color data. It looks "nice" but is highly suspect.

News Brief: Thirty Meter Telescope Status

February 11, 2016:

The TMT International Observatory Board of Governors met last week to discuss the future of TMT on Maunakea. To follow is a statement from Henry Yang, Chair of the TMT International Observatory Board:

"At this time, Hawaii remains our first choice for the location of TMT, and we are very grateful for all of our supporters. Given the enormous investment and potential challenges ahead, it is necessary to also carry out a review of alternate sites."



Saturn's moon Tethys appears to float between two sets of rings in this view from NASA's Cassini spacecraft, but it's just a trick of geometry. The rings, which are seen nearly edge-on, are the dark bands above Tethys, while their curving shadows paint the planet at the bottom of the image.

Tethys (660 miles or 1,062 kilometers across) has a surface composed mostly of water ice, much like Saturn's rings. Water ice dominates the icy surfaces in the the far reaches of our solar system, but ammonia and methane ices also can be found.

The image was taken in visible light with the Cassini spacecraft wide-angle camera on Nov. 23, 2015. North on Tethys is up. The view was obtained at a distance of approximately 40,000 miles (65,000 kilometers) from Tethys. Image scale is 2.4 miles (4 kilometers) per pixel.

The Cassini mission is a cooperative project of NASA, ESA (the European Space Agency) and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington. The Cassini orbiter and its two onboard cameras were designed, developed and assembled at JPL. The imaging operations center is based at the Space Science Institute in Boulder, Colorado.

For more information about the Cassini-Huygens mission visit http://saturn.jpl.nasa.gov and http://www.nasa.gov/cassini. The Cassini imaging team homepage is at http://ciclops.org.

What Happens When LIGO Texts You to Say It's Detected One of Einstein's Predicted Gravitational Waves

Chad Hanna
Assistant Professor of Physics,
Pennsylvania State University

THE CONVERSATION

The best thing about a day in my life on the lookout for gravitational waves is that I never know when it will begin.

Like many of my colleagues working for the Laser Interferometer Gravitational-Wave Observatory (LIGO), the morning of Monday, September 14, 2015 caught me completely off-guard. For years, we've been joking that Advanced LIGO would be so sensitive we might just detect one the very first day it turns on. In retrospect, it's remarkable how close to reality that joke turned out to be.

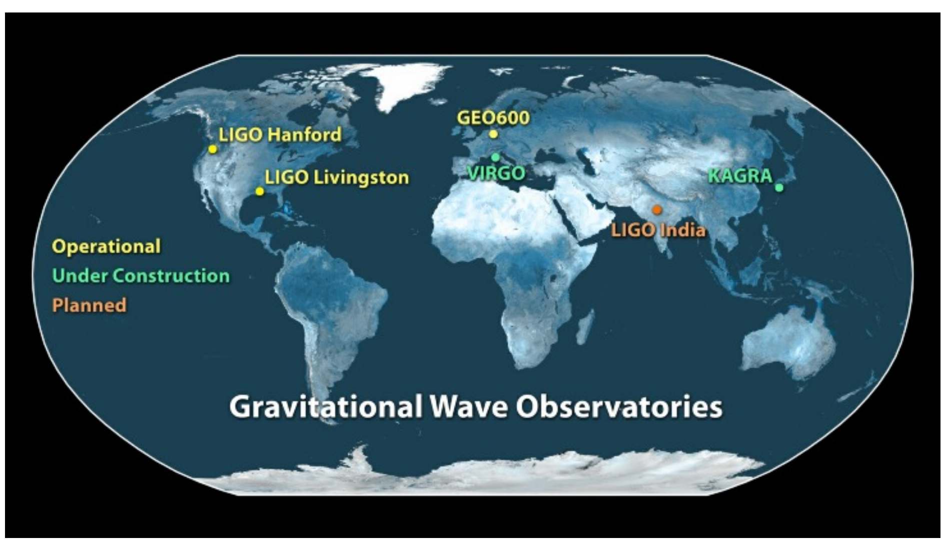
LIGO is listening for gravitational waves – one of the last unproven predictions of Einstein's theory of general relativity. In his view of the universe, space and time are fluid things that depend on an observer's frame of reference. For example, time passes just a (very) little bit more slowly for those who work on the ground floor of an office building as compared to their peers on the 101st floor. Why? They're deeper in Earth's gravitational pull.

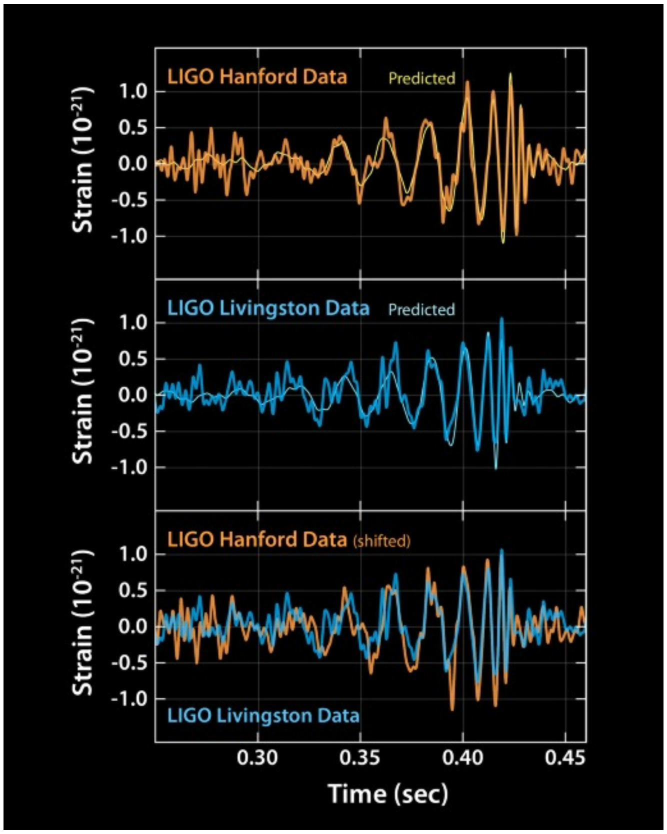
Einstein predicted that gravitational waves are formed when matter and energy warp space and time. Their effects – until now unseen – sound bizarre. As a gravitational wave passes by, an observer will see the distance between objects change. All around us space is oscillating, distances are changing and we are being stretched and squeezed by passing gravitational waves. Only the most extreme objects in the universe can bend space enough to produce ripples that are measurable here on Earth. The effect is so tiny that we fail to notice it even with the most sensitive measurements – but Advanced LIGO was designed to change all that by directly measuring tiny ripples in space itself.

Although Advanced LIGO had collected data off and on over the summer of 2015, September 14 was slated to be the first official day of its first observing run. From those who built and commissioned the advanced LIGO detectors to those who characterized and analyzed the data, we'd all been preparing for decades to make this kind of discovery, but I don't know if any of us was truly ready for a detection – and on Day One, as luck would have it.

Hearing what we were listening for

Like others on the team, I should have been woken up in the middle of the night when LIGO heard that first gravitational wave – but it was so early in the run that I hadn't even had a chance to enable my text message alerts! Instead, I read about the event, termed GW150914, on my phone as I walked to campus hours after it had been observed. It is difficult to describe the level of





These plots show the signals of gravitational waves detected by the twin LIGO observatories at Livingston, Louisiana, and Hanford, Washington. The signals came from two merging black holes, each about 30 times the mass of our sun, lying 1.3 billion light-years away. LIGO, CC BY-ND

anticipation regarding a possible event. But I can say that if you have waited for over 12 years for such a discovery, as I have, it certainly is not something to take lightly when it happens.

Like everyone else at the time, though, I thought this signal was just a test of the analysis system, called a hardware injection. I spent the rest of the morning assuming as much. But minutes before a 2:00 p.m. seminar that same day, we received word from each LIGO observatory that no tests had been performed. My student, two postdocs and I all went to our seminar looking like we had seen a ghost! The rest of our colleagues in attendance were not part of LIGO, so we couldn't say a word. Our silence stood for months to come.

The LIGO Scientific Collaboration (LSC), of which I am a member, is currently made up of more than 1,000 people from dozens of institutions and 15 countries worldwide. There are two LIGO instruments, one in Louisiana and one in Washington. And we work with the Virgo Collaboration that operates a detector in Italy and the GEO600 detector team in Germany. Since we are all so far apart, we met by teleconference so folks who are at the observatories and folks who are analyzing the data could all discuss what was happening and whether or not to share the information more broadly.

At first it was unclear which of many possibilities could be responsible for the GW150914 signal. It would have to be a major astronomical event that released immense amounts of energy – such as a binary merger, a nearby supernova or some completely unforeseen occurrence. Initial investigations indicated that it could be a binary black hole merger – two black holes that are driven to smash together as they release energy in the form of gravitational waves.

Over the next few weeks, we worked to assess the significance of GW150914. Its probability of being the real thing was simply off the charts and had virtually no plausible explanation as anything but a gravitational wave. There was just no way random noise could have caused such a loud, consistent signal between detectors that matched the expectation of general relativity so perfectly.

From then on, the collaboration shifted into high gear, preparing additional scientific publications to provide all the juicy details about the detection and

interpretation of GW150914. We now know that gravitational waves can be measured, binary black holes exist and that there are perhaps far more detectable sources of gravitational waves than we had anticipated.

LIGO logistics

GW150914 stretched and squeezed our nearby space by about 1 part in 10^{21}. This is equivalent to squeezing the entire Milky Way galaxy by a typical person's height. As you might imagine, it is nearly impossible to measure such a small change in distance. To do so, LIGO uses high-power lasers, ultra high vacuum and some of the most advanced optics ever built.

The basic idea is simple: LIGO has two 4-km-long arms built at 90 degrees with respect to one another. A high-power laser beam is split in two to travel down each arm separately. When the laser gets to the end, it's reflected back by a mirror. If one arm is longer than another, due to the change in space caused by a gravitational wave, then the laser light won't arrive back at the same time in each arm.

We continuously record the recombined laser light; it encodes how the gravitational wave causes space to stretch and squeeze at frequencies that are very similar to what the human ear can hear. That's why we often think of LIGO as listening to the universe. In fact, LIGO records its data as what's basically an audio file. You can literally listen to the gravitational waves detected with LIGO using headphones.

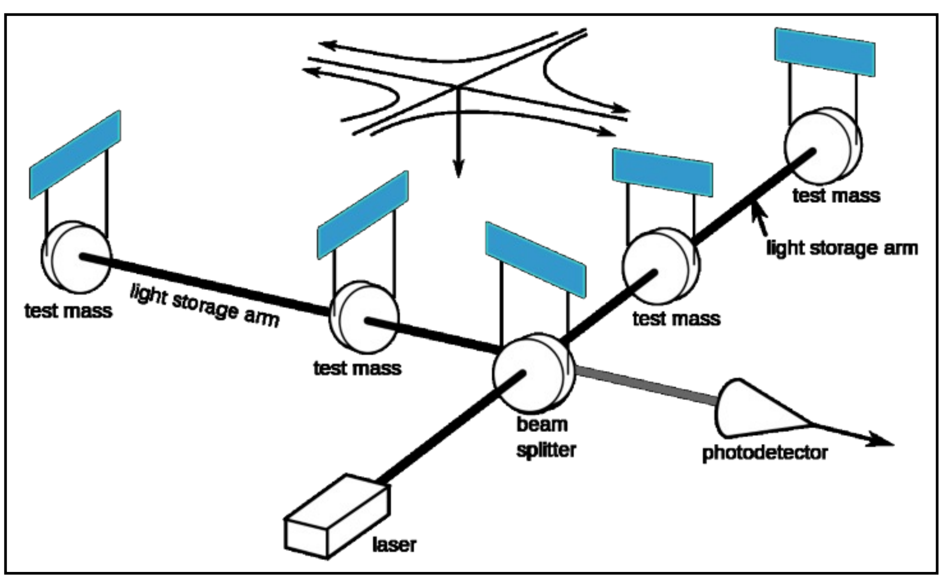
Colliding black holes and neutron stars are some of LIGO's primary targets, though we also search for supernovae, spinning isolated neuron stars and gravitational waves left over from the birth of the universe. The LIGO detectors, for the most part, are sensitive to sources all over the sky, which means a single detector can't tell from which direction a gravitational wave arrived. However, using multiple detectors we can localize the source. All the gravitational wave detectors across the globe work together to make observations of the same signals at the same time (within tens of milliseconds).

I'm part of a team that is searching for merging neutron stars and black holes in near real time. We hope to know within seconds that a gravitational wave has reached the Earth. With this knowledge, we can inform other astronomers who can point their telescopes in the direction of the event in the hope that the gravitational wave will have an electromagnetic counterpart. Having information from both channels is a bit like having both sound and picture when watching a film. The movie would be far less interesting with only one and not the other.

Unlike many telescopes, LIGO can observe at any time of day, though it is sensitive to environmental noise that's often caused by human beings working nearby. Observing at night tends to be easier, when most people are in bed. The team I work with is always on call. If a gravitational wave event is detected, we should know within a minute and receive a call to our cellphones as well as a text message with details about the event – just as happened on September 14.

Beginning of a new era

Detecting this first gravitational wave event has changed the world. It confirms the last great prediction of a revolutionary theory that's now over 100 years old. But it doesn't stop there. We're still listening for more gravitational waves; soon Advanced LIGO will detect them regularly –



and each one will tell us something new about the universe.

As observations become commonplace, we will enter a new era of gravitational wave astronomy and start to map out just how black holes and neutron stars are born, evolve and eventually die. Someday we might even be surprised to detect something we never expected. From now on, every time my phone rings, that's what I will be hoping for.

March Observing: What to View

Jim Kvasnicka

This is a partial list of objects visible for the upcoming month.

Planets

Jupiter: Reaches opposition on March 8th at magnitude -2.5 with a disk 44" wide.
Uranus: By mid-March it will be too low for observation.
Neptune: Not visible this month.
Mars: Rises around midnight and increases in brightness from 0.3 to -0.5 at months end.
Saturn: In southern Ophiuchus at magnitude 0.5 with a disk 17" wide. The rings are tilted 26° from edge on with a span of 38".
Venus: Rises an hour before the Sun at its maximum magnitude for the year at -3.8.
Mercury: Reaches superior conjunction on March 23rd and is not visible this month.

Messier List

M41: Open cluster in Canis Major.
M44: The Beehive Cluster in Cancer.
M46/M47: Open clusters in Puppis.
M48: Open cluster in Hydra.
M50: Open cluster in Monoceros.
M67: Open cluster in Cancer.
M81/M82: Galaxy pair in Ursa Major.
M93: Open cluster in Puppis.
Last Month: M1, M35, M36, M37, M38, M42, M43, M45, M78, M79
Next Month: M40, M65, M66, M95, M96, M105, M106, M108, M109

NGC and other Deep Sky Objects

Melotte 71: Open cluster Puppis.
NGC 2423: Open cluster in Puppis.
NGC 2438: Planetary nebula within M46 in Puppis.
NGC 2440: Planetary nebula in Puppis.
NGC 2672: Galaxy in Cancer.
NGC 2775: Galaxy in Cancer.

Double Star Program List

Epsilon Canis Majoris: Bright white and pale blue pair.
Delta Geminorum: Wasat, yellow and pale red stars.
Alpha Geminorum: Castor, White primary with a yellow secondary.
12 Lyncis: Close yellow-white pair.
19 Lyncis: White pair.
38 Lyncis: White and yellow stars.
Zeta Cancri: Yellow primary with a pale yellow secondary.
Iota Cancri: Yellow and pale blue pair.

Challenge Object

NGC 2749: The brightest member in a galaxy group in Cancer. Other galaxies include NGC 2744, NGC 2751, and NGC 2752.

Focus on Constellations: Puppis

Jim Kvasnicka

Puppis

Puppis, the Ship's Stern, was once part of the ancient Greek constellation Argo Navis, the Ship. Due to its size it was divided in the 1750's into Puppis, the Ship's Stern; Pyxis, the Compass; Vela, the Sails; and Carina, the Keel. Puppis alone still covers 673 square degrees. Puppis is east and southeast of Canis Major and it contains an exceptionally star-rich portion of the Milky Way. Because of this Puppis is rich in open clusters including three Messier objects in M46, M47, and M93. The open clusters in Puppis vary a great deal. Several are large and loose, some are large and rich and a number are faint and require a medium to large telescope to be seen. The constellation Puppis is best seen in March.

Showpiece Objects

Open Clusters: M46, M47, M93, NGC 2477, NGC 2539
Planetary Nebulae: NGC 2438, NGC 2440, NGC 2452

Mythology

In Greek mythology the ship Argo was the vessel commanded by Jason and his fifty Argonauts in search of the Golden Fleece. When they returned with the Fleece, Athens commemorated the event by placing the ship Argo in the heavens.

Number of Objects Magnitude 12.0 and Brighter

Galaxies: 7
Open Clusters: 46
Planetary Nebulae: 3
Globular Clusters: 1

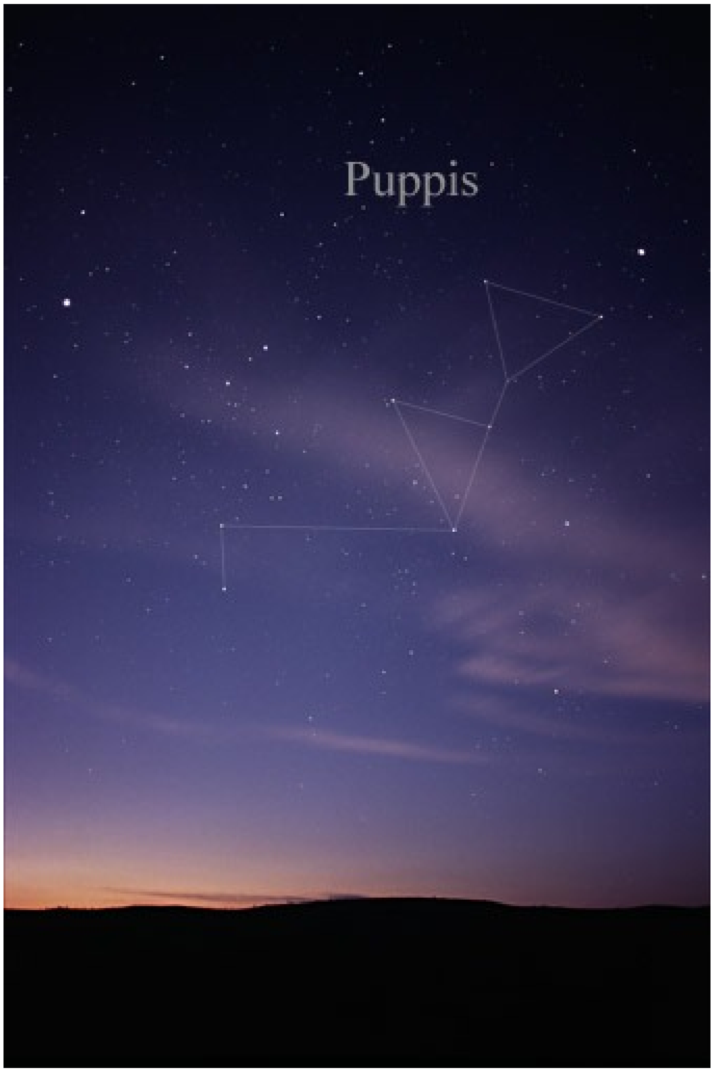


Photo: Till Credner - Own work: AlltheSky.com

The Closest New Stars to Earth

This article is provided by NASA Space Place.
With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit spaceplace.nasa.gov to explore space and Earth science!

Ethan Siegel

When you think about the new stars forming in the Milky Way, you probably think of the giant star-forming regions like the Orion Nebula, containing thousands of new stars with light so bright it's visible to the naked eye. At over 400 parsecs (1,300 light years) distant, it's one of the most spectacular sights in the night sky, and the vast majority of the light from galaxies originates from nebulae like this one. But its great luminosity and relative proximity makes it easy to overlook the fact that there are a slew of much closer star-forming regions than the Orion Nebula; they're just much, much fainter.

If you get a collapsing molecular cloud many hundreds of thousands (or more) times the mass of our sun, you'll get a nebula like Orion. But if your cloud is only a few thousand times the sun's mass, it's going to be much fainter. In most instances, the clumps of matter within will grow slowly, the neutral matter will block more light than it reflects or emits, and only a tiny fraction of the stars that form—the most massive, brightest ones—will be visible at all. Between just 400 and 500 light years away are the closest such regions to Earth: the molecular clouds in the constellations of Chamaeleon and Corona Australis. Along with the Lupus molecular clouds (about 600 light years distant), these dark, light-blocking patches are virtually unknown to most sky watchers in the northern hemisphere, as they're all southern hemisphere objects.

In visible light, these clouds appear predominantly as dark patches, obscuring and reddening the light of background stars. In the infrared, though, the gas glows brilliantly as it forms new stars inside. Combined near-infrared and visible light observations, such as those taken by the Hubble Space Telescope, can reveal the structure of the clouds as well as the young stars inside. In the Chameleon cloud, for example, there are between 200 and 300 new stars, including over 100 X-ray

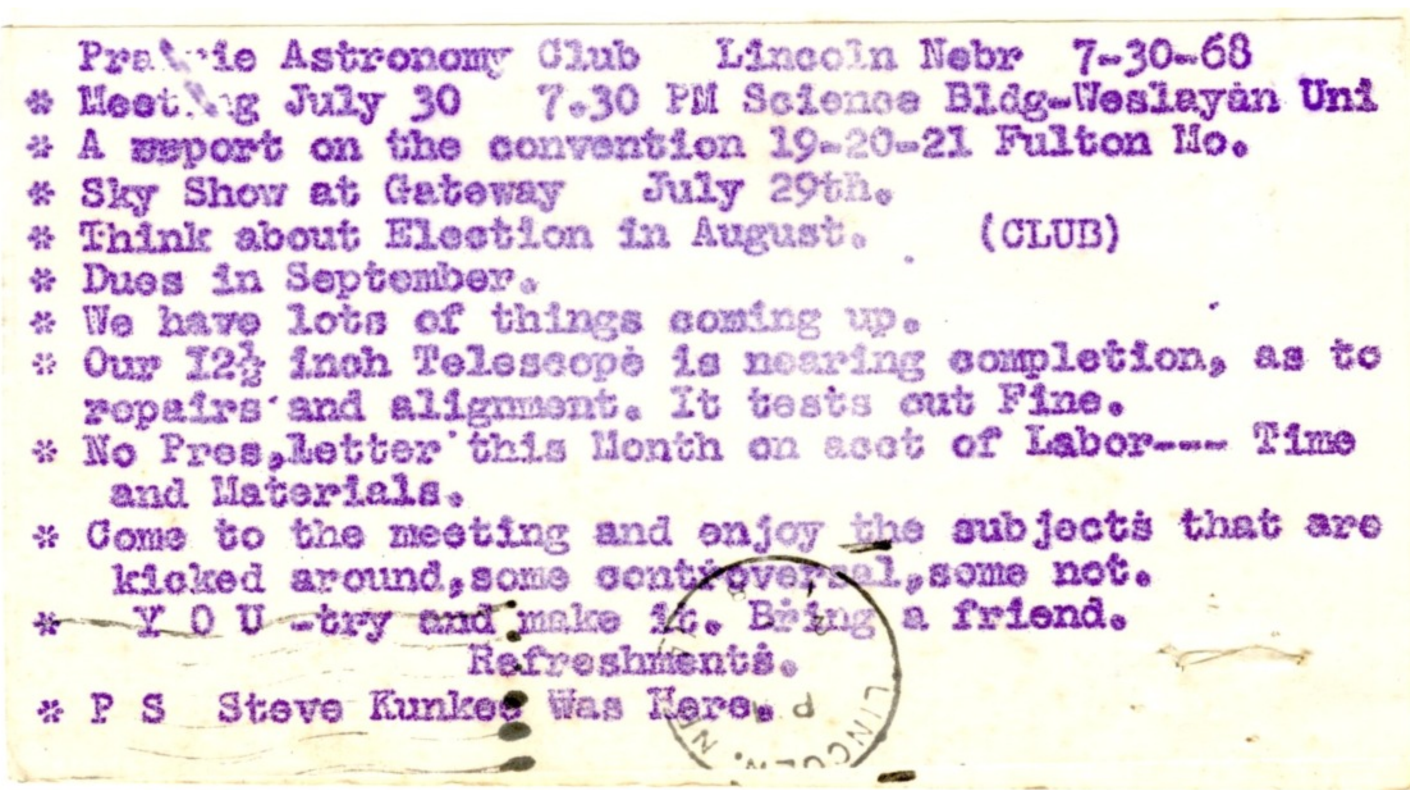
Image credit: NASA and ESA Hubble Space Telescope. Acknowledgements: Kevin Luhman (Pennsylvania State University), and Judy Schmidt, of the Chamaeleon cloud and a newly-forming star within it—HH 909A—emitting narrow streams of gas from its poles.

sources (between the Chamaeleon I and II clouds), approximately 50 T-Tauri stars and just a couple of massive, B-class stars. There's a third dark, molecular cloud (Chamaeleon III) that has not yet formed any stars at all.

While the majority of new stars form in large molecular clouds, the closest new stars form in much smaller, more abundant ones. As we reach out to the most distant quasars and galaxies in the universe, remember that there are still star-forming mysteries to be solved right here in our own backyard.

From the Archives: July, 1968

Possibly the shortest PAC newsletter ever - a postcard.



Prairie Astronomy Club Lincoln Nebr 7-30-68
* Meeting July 30 7.30 PM Science Bldg-Wesleyan Uni
* A report on the convention 19-20-21 Fulton Mo.
* Sky Show at Gateway July 29th.
* Think about Election in August. (CLUB)
* Dues in September.
* We have lots of things coming up.
* Our 12½ inch Telescope is nearing completion, as to repairs and alignment. It tests out Fine.
* No Pres,Letter this Month on acct of Labor--- Time and Materials.
* Come to the meeting and enjoy the subjects that are kicked around,some controversal,some not.
* Y O U -try and make it. Bring a friend. Refreshments.
* P S Steve Kunkee Was Here.

CLUB MEMBERSHIP INFO

REGULAR MEMBER - $30.00 per year. Includes club newsletter, and 1 vote at club meetings, plus all other standard club privileges.

FAMILY MEMBER - $35.00 per year. Same as regular member except gets 2 votes at club meetings.

STUDENT MEMBER - $10.00 per year with volunteer requirement.

If you renew your membership prior to your annual renewal date, you will receive a 10% discount.

Club members are also eligible for special subscription discounts on Sky & Telescope Magazine.

CLUB TELESCOPES

To check out one of the club telescopes, please contact a club officer. Scopes can be checked out at a regular club meeting and kept for one month. Checkout can be extended for another month if there are no other requests for the telescope, but you must notify a club officer in advance.

100mm Orion refractor: Checked out to Beth J.
10 inch Meade Dobsonian: Available
13 inch Truss Dobsonian: Available

CLUB APPAREL

Order club apparel from cafepress.com:

Shop through Amazon Smile to automatically donate to PAC:

CLUB OFFICERS

President	Jim Kvasnicka (402) 423-7390 jim.kvasnicka@yahoo.com
Vice President	Brett Boller proboller86@yahoo.com
2nd VP (Program Chair)	Beth Jenckes beth.jenckes@yahoo.com
Secretary	Lee Taylor otaylor88@gmail.com
Treasurer	John Reinert jr6@aol.com
Club Observing Chair	Jim Kvasnicka jim.kvasnicka@yahoo.com
Outreach Coordinator	Dan Delzell dan@delzell.net
Website and Newsletter Editor	Mark Dahmke mark@dahmke.com

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