Desert Skies

Tucson Amateur Astronomy Association

Observing our Desert Skies since 1954

Spring 2016 Volume LXII, Issue 1

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The Fireworks Galaxy in Cepheus and Cygnus

TAAA member Wendee Levy took this photo of NGC 6946 back in May of 2003 using the 20-inch Ritchey Chretien optical telescope at the Kitt Peak Visitor's Center under the guidance of her husband, David, and Adam Block. This photo also appeared as the back cover of the 2010 Observer's Handbook of the Royal Astronomical Society of Canada. © Wendee Levy. Used by permission.

NGC 6946 straddles the border between the constellations Cepheus and Cygnus. It's distance is between 10 and 20 million light years. It's prolific number of supernovae in the last 100 years has led to it being referred to as the Fireworks Galaxy. The galaxy is about a third the size of the Milky Way, so it would seem it would have fewer stars and fewer supernovae than the Milky Way. That's not the case. In the past 100 years, there have been nine supernovae in this galaxy. Compare that to the Milky Way's average of one or two supernovae per century (the last being 140 years ago). It's also very bright in the infrared indicating stars are forming at a fast pace. Learn more about this interesting galaxy at http://annesastronomynews.com/photo-gallery-ii/galaxies-clusters/the-fireworks-galaxy-by-robert-gendler/

Our mission is to provide opportunities for members and the public to share the joy and excitement of astronomy through observing, education and fun. We fulfill this by providing Astronomy Services to schools, church groups, scout troops, and convention organizers. We support many organizations in the Tucson area that are involved in Science, Technology, Engineering and Mathematics (STEM) programs. Our members enjoy observing the night sky under the dark skies that our observing sites offer. We are an all-volunteer, tax-exempt, non-profit, 501(c)(3) organization.

Frequency

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Publishing Guidelines

Desert Skies is published quarterly, near the dates of solstice and equinox. The deadlines for publication are March 1st, June 1st, Sept 1st, and Dec 1st. Submissions should be emailed to the editor at taaa-newsletter[at]tucsonastronomy.org. Submissions should be in the form of a text or Microsoft Word compatible file. Photos and artwork are encouraged. Please send these as separate attachments with resolution of at least 200 dpi (higher is preferred). Submissions are retained by the editor unless prior arrangements have been made. Copyrighted materials will not be accepted unless permission to use is clearly stated. We will not publish slanderous or libelous material. All copyrights retained by Tucson Amateur Astronomy Association, Inc. or the original author.

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From Our President

Happy Spring 2016 to all TAAA members! As the days lengthen and temperatures rise, viewing opportunities will be more frequent and we can spend more time outdoors. I hope you will take advantage of the fine skies we enjoy in Southern Arizona, especially at our fine facilities at TIMPA and CAC!

A couple of items of near term interest for the TAAA are the imminent launch of our new web site and the May Elections for our Board of Directors.

Past President Bob Gilroy and Webmaster Diane Neufeldt are putting the finishing touches on our new web site. Once complete, we should have an easy to navigate, very informative, website with the most up to date TAAA information. I commend Bob and Diane for their tireless work and look forward to the new website very much. You should be receiving updates and instructions for joining the new site in the very near future. Please respond to these and follow the instructions as soon as may be so that we can make the launch as successful as possible.

At the April General Meeting, the TAAA Nominating Committee will publicize the slate of candidates for the 2016-2017 TAAA Board of Directors. I want to personally thank the Committee for putting in the time to recruit the candidates for such a vital set of positions. Candidates for President, Vice-President, Secretary, Treasurer, and three Members At Large will be introduced. At the May meeting, you will be voting on these important positions for folks who will be guiding the TAAA for the next year. Please give every consideration to the candidates list and be sure to vote at the May General Meeting, either in person or by requesting an absentee ballot.

Finally, I want to recognize all the TAAA members who regularly volunteer their valuable time to help with the many activities that make TAAA tick. Without this dedicated set of folks, we could not accomplish nearly as much as we do and the TAAA experience wouldn't be as rich and rewarding. Thanks to You All!! If you are a TAAA member who would like to begin helping, please see any of the Board members or other TAAA Leaders. We will be glad to help you get started in a very valuable and personally satisfying activity. Let's all work together to make TAAA better!

Ben Bailey

Community Involvement & Outreach

Fun in the Sun at the UA ScienceCity

Text and Photos by Terri Lappin, Starry Messengers SIG Chairperson (terrilappin[at]tucsonastronomy.org), unless noted

The UA ScienceCity is a very successful outreach event for the TAAA, giving us the opportunity to make our presence known in the community. This annual event is part of the Tucson Festival of Books (TFOB). The entire TFOB- UA ScienceCity event stretches along the UA Mall from Old Main to the Curving Arcade sculpture near Campbell, and reaches into and around the buildings that line the UA mall.

The theme is not limited to books and reading. At the ScienceCity, learning while having fun is a key ingredient to this successful event.

ScienceCity, which consists of six large tents and several other venues, is coordinated by the UA College of Sciences. Many UA science programs are featured, but the UA also invites local groups like Pima Air & Space Museum, the Desert Museum, Native Seeds/SEARCH, and Tohono Chul Park. Since 2013, the TAAA has been honored to be included in this prestigious group. This year, the TAAA was one of sixteen exhibitors in the Science of Tomorrow tent.

The Starry Messengers Special Interest Group (SMSIG) started planning for ScienceCity last fall. We knew our theme would be The Sun and that we'd have solar scopes. We brainstormed ideas for the exhibit. We wanted to include an activity suitable for young people. Kids' activities for events like TFOB need to be a quick project. That's because there's so much to see at the Festival that families move quickly from one exhibit to the next. Our kid's activity also needed to be small – something the kids could take home. A Sundial was the answer.

Sara Liberty-Laylin shows a group of young people how to use their sundials.

Arizona Daily Star Tucson Festival of Books THE UNIVERSITY OF ARIZONA.

ScienceCity Tucson Festival of Books at the University of Arizona

Susan O'Connor and Peter Morse at the display Saturday morning, before the crowds arrived.

Festival weekend started very early (especially for astronomy-types). At 6:30 AM, I met Susan and Jim O'Connor and Mae Smith on the UA Mall at our designated corner of the Science of Tomorrow tent. We quickly went to work setting up our display. Jim started setting up his solar video equipment and was soon joined by Joe Statkevicus (with a few Boy Scouts) and Rik Hill.

The UA Mall was abuzz with activity as ScienceCity exhibits from over 80 groups came to life – and that

Above: A horseshoe magnet and metal filings simulates a sunspot group. Left: A young man views sunspots through Pat Droll's solar scope.

(Continued on page 4, ScienceCity)

(Continued from page 3, ScienceCity)

A beautiful solar prominence on Sunday, taken with a Samsung Galaxy 6 phone through Jim Knoll's solar scope.

doesn't include food vendors, the Science Stage, Science Café, nor any of the hundreds of other Festival of Books participants.

The public began arriving at 9 AM Saturday morning. We were kept busy both Saturday and Sunday with a steady stream of people visiting the exhibit and looking through the scopes. In addition to Jim O'Connor, Joe Statkevicus, and Rik Hill, solar scopes were also brought by Pat Droll and Jim Knoll. TAAA members who joined Susan O'Connor and I at the exhibit were Stephanie Cortes, Sara Liberty-Laylin, Karen Liptak, Peter Morse, and Brian O'Connell. Each volunteer was issued a counter to help tally the number of people they talked to or who looked through their scopes. Over 3600 eyeballs viewed the sun through the solar scopes and we interacted with over 1300 people at the exhibit, giving us a total of 4966 public interactions for the weekend. About 325 kids made sundials – and they all worked! The Sun performed well during the event. Even though the sunspot count was low, there was a beautiful prominence off the limb on Sunday.

The SMSIG meeting a week later was a recap of the ScienceCity event. We're already thinking about next year. We hope more TAAA members will be inspired to get involved in this very rewarding experience.

Save the Date!

Obsessed with Science

March 11-12, 2017 | 9:30am-5:30pm

Photo by Brian O'Connell

OUR VOLUNTEERS

Stephanie Cortes

Pat Droll

Rik Hill

*Jim Knoll

*Terri Lappin †

Sara Liberty-Laylin

*Karen Liptak

Peter Morse

*Brian O'Connell

*Jim O'Connor †

*Susan O'Connor †

Mae Smith

*Joe Statkevicus and his boy scouts

* Starry Messenger SIG members

† Terri Lappin and Jim & Susan O'Connor were present both days, all day long

Community News

Electronic Billboards Bill Imperils Arizona Dark Skies

Text an images provided by John Barentine, International Dark-Sky Association (john[at]darksky.org)

Dark nighttime conditions in Arizona are endangered by a push to expand the reach of digital billboards into western and northwestern parts of the state. Also known as electronic message centers (EMCs), they are an updated form of conventional advertising enabled by the rapidly maturing technology of LED lighting. In contrast to most conventional billboards, EMCs display dynamic messages, enabling advertisers to sell effectively more ad space. Messages can be timed according to particular constraints, and can even perform a public service in relaying amber alerts and other information.

But EMCs also represent a new source of artificial light at night whose design characteristics make them impossible to effectively shield. Light emitted from EMCs is directed horizontally, resulting in the scattering of a significant fraction upward into the night sky. The rapid proliferation of EMCs threatens to displace conventional billboards, whose external illumination is subject to effective shielding. The International Dark-Sky Association generally opposes public policies that permit EMCs, given that their design makes it impossible to mitigate the emission of stray light at angles above the horizontal.

EMCs are currently only allowed in parts of Arizona as the result of a 2012 agreement between the outdoor advertising industry and the professional astronomy community. An initial proposal to allow EMCs throughout Arizona was approved by the Arizona Legislature but vetoed by then-Governor Jan Brewer, who wrote in the letter to the Legislature accompanying the veto that "the astronomy industry has invested $1.2 billion in Arizona, represents more than 3,300 jobs and has an estimated economic impact of $250 million a year. I simply refuse to place all of this in jeopardy." Advertisers hammered out a compromise with the astronomers later in the same legislative session that allowed EMCs, but placed several important constraints on their distribution and operation:

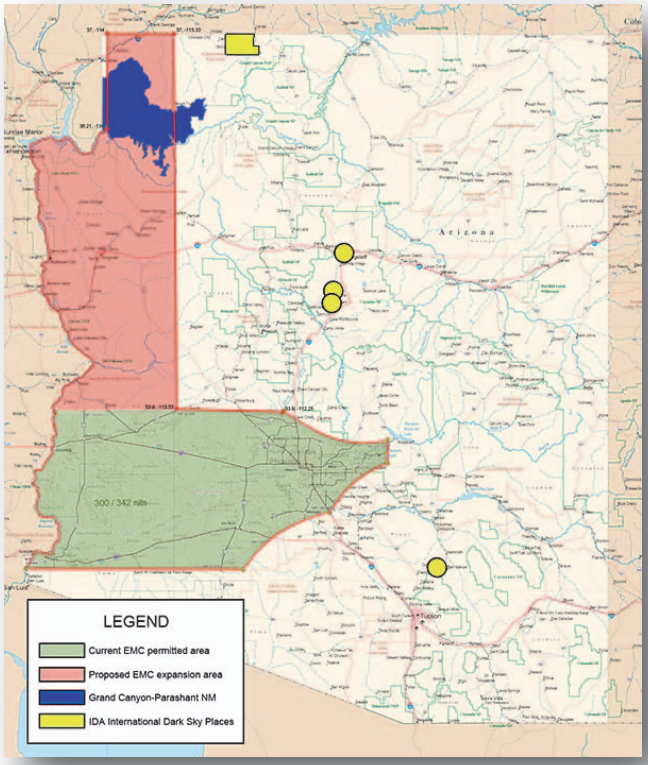
EMCs cannot feature animated images;

Images displayed must be static for at least eight seconds, and transitions between images can last for no longer than two seconds;

Limits on the display brightness, depending on size, between sunset and 11PM;

EMCs may only be erected in a restricted region of Arizona including the greater Phoenix metro area and the Interstate 8 and 10 corridors, running west to the Colorado River, in which they do not threaten operations at certain professional astronomical observatories.

As I write this, Arizona lawmakers are currently considering House Bill 2507, a proposal that would increase the territory in western Arizona in which EMCs are permitted under the restrictions of the 2012 compromise. On the map here, the green-shaded region shows the part of Arizona in which EMCs are allowed under the compromise, while the red-shaded region indicates new territory in which EMCs would be allowed if the bill becomes law. The other requirements of the 2012 compromise would still apply to EMCs erected in this new region, but HB 2507 would effectively double the land area where EMCs are permitted. Expanding the zone in which EMCs are permitted will add new sources of unshielded artificial light at night to one of the naturally darkest regions of Arizona, including Grand Canyon-Parashant National Monument (blue shaded region), an IDA International Dark-Sky Park.



UPDATE

Since John Barentine wrote this article, House Bill 2507 was defeated by the Arizona Senate Commerce and Workforce Development Committee in a vote of 3 to 6. IDA continues to monitor legislative actions that threat our dark skies. The TAAA's position is to protect our dark skies.

(Continued on page 6, Electric Billboards)

(Continued from page 5, Electric Bilboards)

Furthermore, if HB 2507 is successfully enacted into law, the outdoor advertising industry will certainly return during future legislative sessions seeking to further expand the reach of EMCs into other presently dark corners of the state. Such a move would endanger other IDA-designated Dark Sky Places in Arizona, shown on the map in yellow, and directly imperils the state's burgeoning "astrotourism" industry. It may also harm efforts to bring future professional astronomy facilities, and their associated economic activity, to Arizona.

EMCs add more unnecessary light to the nighttime environment, and contrary to advertising industry claims, EMCs may be distracting to drivers, even with no animation, long message dwell times and quick transitions. It is simply not established scientifically whether EMCs present a public safety hazard. Furthermore, we believe HB 2507 is a bad-faith effort on the part of the outdoor advertising industry, which previously agreed to halt the expansion of EMCs into new parts of Arizona.

IDA opposes this legislation. We are joined in our opposition by the editorial board of the Lake Havasu News-Herald, the Arizona Astronomy and Planetary and Space Sciences sector, the Arizona Optics Industry Association, and the National Park Service. Anyone concerned about dark skies in Arizona should similarly oppose the advance of EMCs into new corners of the state represented by HB 2507 until their impact is better understood.

Upcoming Globe at Night Campaigns

April 29 - May 8

May 29 - June 7

June 27 - July 6

http://www.globeatnight.org/

Spring 2016 TAAA General Meetings

TAAA Meetings
Location:
Steward Observatory
(933 N Cherry Ave)

Open to the public.

Date	Introductory Presentation (6:30 PM)	Invited Lecture (7:30 PM)
Apr 1	Mary Turner, PhD, TAAA Chief Observer Seasonal Objects	Tom Polakis Time-lapse Imaging with Three Very Different Cameras
May 6	TBA	Tim Swindle, PhD, UA Lunar & Planetary Lab A History of LPL
Jun 3	TBA	TBA

Classified Ads

Fantastic Items Here!

For Sale: Meade Nebula Filter $40; **The Night Sky Observer's Guide**—large, two volume hardbound set containing over 5500 celestial objects w/photos, descriptions and recommended sizes of binocular/scopes for viewing. $50; **Celestron HD Wedge adapter** for Astrophotography with select older Celestron telescopes, i.e. Ultima 2000, etc. $65 (cost $300 new). Contact Jim at 520-744-3858 or 520-401-6769

For Sale: Orion EQ-1 Tripod Mount w/ EQ-1M Motor Drive & Hand Controller (complete system). Excellent for tracking objects using a smaller telescope and for DSLR astrophotography. As new, partially assembled. Manuals included. $95. If not sold, I am interested in compensating someone to complete the assembly for me. Contact Jim at 520-744-3858 or 520-401-6769.

For Sale: Celestron CGEM mount with Explore Scientific AR152 refractor telescope with both straight thru and right angle finder scope and 2" focuser. Right angle finder can work as a polar axis scope. See it at Starizona, 5757 N. Oracle Rd., Suite 103, Tucson; phone: 520-292-5010.

Featured Article

Text by Rik Hill (rhill[at]lpl.arizona.edu)

After a few years of a hiatus due to many commitments, Terri asked me if I would revive this column. Now that I'm retired I have more time available for this kind of thing, and agreed. But I will need help from you. What are the topics that interest you? What kind of cyber and software things do you want to know about? As in the past, I will try to bring things to you that will be inexpensive or freeware for your computer. I will not be evaluating apps as there are just too many, the quality varies widely and I can't test them all. However, I will highlight some of the things available on the internet. Again, the idea is to enjoy our hobby, not deplete our bank accounts and endanger our marriages and partnerships!

I suppose the first thing you need to know is what is happening in the sky on a daily basis. Both of the major magazines have pages for this. For Sky & Telescope it's:

http://www.skyandtelescope.com/observing/sky-at-a-glance/

and for Astronomy it can be found at:

http://www.astronomy.com/observing/sky-this-week

Most of you probably know this. But did you know about another fantastic resource for daily observing called Heavens-Above:

http://heavens-above.com/main.aspx

This site is largely geared towards satellite observing, which I will discuss in a future article, but has an excellent section covering the Sun, Moon, planets, the brighter comets and asteroids and each of the constellations.

Orion Telescopes & Binoculars also has a nice column on their website called "The Night Sky Tonight" that highlights events in the sky with some really nice sky maps:

http://www.telescope.com/content.jsp?pageName=The-Night-Sky-Tonight

While not exactly "online" the Abrams Planetarium in East Lansing, Michigan, has an excellent Sky Calendar that has been published for over 40 years now. Check it out:

http://www.pa.msu.edu/abrams/SkyCalendar/index.html

For the paltry sum of $12/yr they send you sets of monthly calendars four times a year. These will keep you up on all the goings on in the night sky, especially in the twilight skies!

Lastly, there's a great interactive website that will let you specifically plan your observing for any night. This is Tonight's Sky. You can choose from where you plan to observe, when you plan to observe, what you plan to observe and it will lay out your observing time and then save your settings for future use. Try it out at:

http://tonightssky.com/MainPage.php

So there's a start and a beginning to this column again. If you have suggestions, ideas or complaints (be gentle) please do not hesitate to send them to me.

Image Credit: NASA, ESA, and J. Maíz Apellániz (Institute of Astrophysics of Andalusia, Spain)

Observing and Imaging

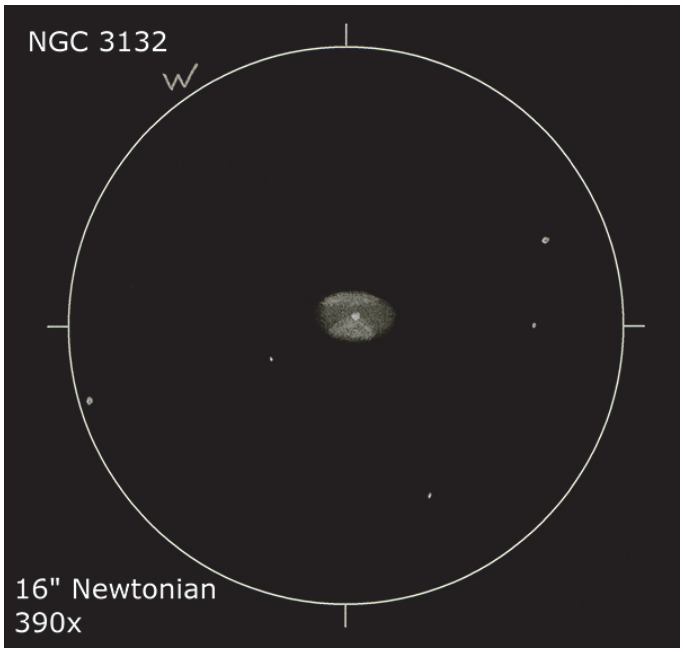
Planetary Nebulae of the Quarter – Spring 2016

Text and Drawings by Christian Weis (weis[at]astroweis.de)

Planetary nebulae (PN) are fascinating objects which come in numerous forms or appearances. Besides the well-known grand four Messiers (M27, M57, M76 and M97), there are hundreds more to explore. This article suggests two PNs, a pretty bright and easy-to-observe one, and a harder one for the more ambitious observer who is equipped with a bigger scope.

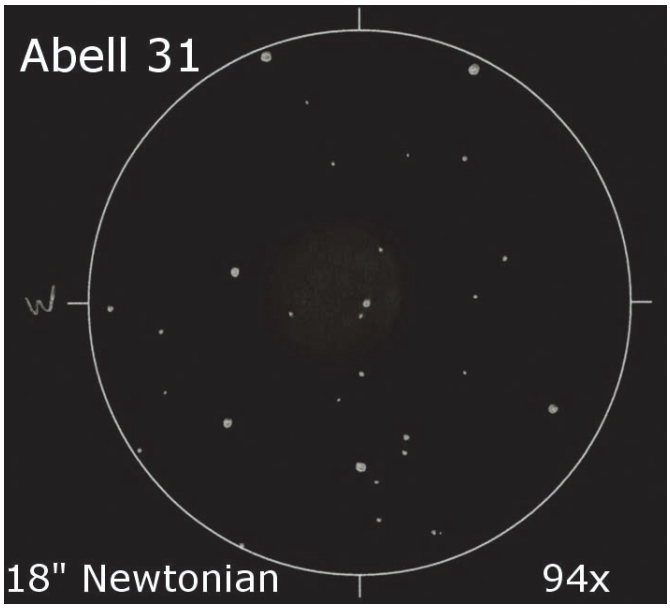
This quarter's easy object truly is an eye-catcher. NGC 3132 in the southern constellation Vela is quite a bright (9m2) planetary nebula which is 2,600 light-years away (another source gives a value of 2,000 ly). Due to its appearance it is also called the southern ring nebula or the eight-burst nebula. NGC 3132 was discovered by William Herschel in 1835. The central star's brightness is 10m0, so it can easily be seen in any scope. The APOD from June 7th, 2015, however, states, that the central star is not the bright and obvious one in (or close) the center but a rather dim one which is probably impossible to observe with a medium-sized telescope. I observed the southern ring nebula on May 21st, 2012 from Kitt Peak and noted: Very conspicuous nebula surrounding bright central star which is the brightest star in the field of view, 76x: NW-SE elongated (approx. 1:1,3), 390x: without filter a little brighter in the SW, using [[OIII]] or UHC it is brighter in the SW and also in NE, NW-end seems to be a little tattered, pretty diffuse; fst 6m6; 76x and 390x

NGC 3132
RA: 10h 7.0min
Dec: -40° 26´
Constellation: Vela
Brightness: 9m2
Central star: 10m0
Size: 1.4 x 0.9 arcmin
Distance: 3200 ly



PK 219+31.1 or more simply Abell 31 is a dim planetary nebula in cancer. Even though a brightness of 12m2 does not sound spectacularly difficult, its size of 17' results in a very low surface brightness. This means one will definitely need dark skies and an [OIII] or UHC- filter to be successful. Abell 31 was published as a planetary nebula in George Abell's famous paper in 1966. I observed this object on March 17th, 2012, from my home in southern Germany and noted: Very difficult object, only seen with an [OIII]-filter and a black cloth preventing ambient light to reach my eyes and 40x and 94x. There are no structures or variations in brightness; the brighter star off-center most likely is not the central star, so no central star was seen; the size was determined making use of the field-sweeping technique and using averted vision; fst 6m8, 40x and 94x

PK 219+31.1 (=Abell 31)
RA: 8h 54.2min
Dec: 8°55´
Constellation: Cancer
Brightness: 12m2
Central star: 15m5
Size: 17 arcmin
Distance: 2,000 ly



Observing and Imaging

Constellation of the Season: Cancer - The Crab

Text and artwork provided by Chris Lancaster

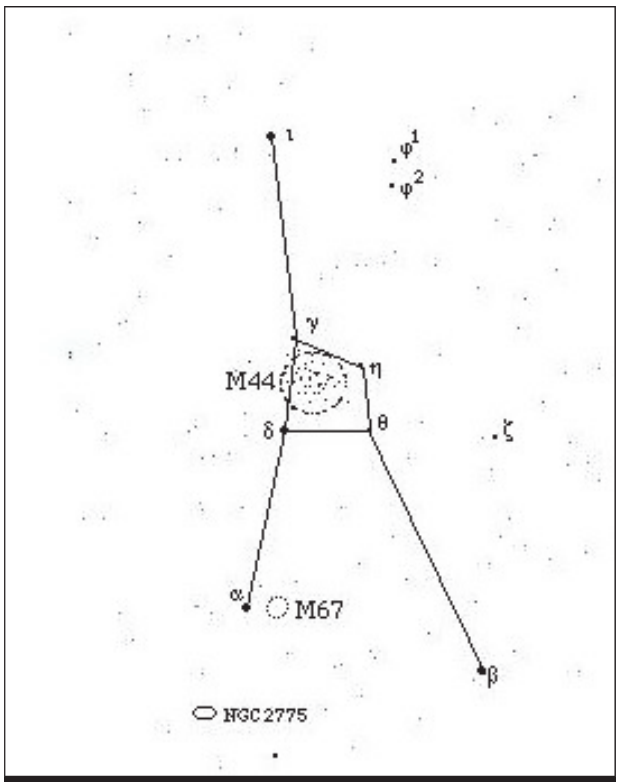
If it were not for two attributes--its membership among the 12 signs of the zodiac and possession of a premier star cluster--Cancer may otherwise be a little noticed constellation. Its dim stars rise after the winter heavyweights Orion, Gemini, and Auriga, and before those heralding spring like Leo and Bootes.

The legend of the crab goes back several hundred years. A crab was said to have followed Hera's orders to distract Hercules while he was battling Hydra, the sea serpent, but the poor crustacean was killed during the attempt. It nevertheless was awarded a place in the sky, although with dim stars because of its failure to fulfill the assignment. That place it occupies was prominent as it contained the point where the sun reached its most northern spot before moving south again, or backwards like a crab, on the summer solstice. Because of precession, that spot is now near the border of Gemini and Taurus, but we still keep the name of the circle of 23.5 degrees north latitude over which the sun hangs on the solstice as the tropic of Cancer.

In a dark sky, the star cluster M44, also called Praesepe or the Beehive cluster, can be seen with the naked eye as a fuzzy patch of light in the center of the constellation. This is one of the largest and brightest clusters visible from Earth. It glows with a magnitude of 4.5 and covers an area of 80', or almost 3 times the diameter of the moon. It is best viewed with binoculars or a wide field telescope. Ancient stargazers, notably Hipparchus and Aratus in the 2nd and 3rd century BC, made observations of Praesepe which was frequently described as "cloudy" or "misty." Some thought that it was a gateway between Heaven and Earth through which souls descended before being born. It wasn't until Galileo pointed his telescope toward it that this "cloud" was discovered to be a collection of individual stars, which modern observations show to number about 200 with magnitudes ranging from 6.3 to 14.

A second star cluster is M67, magnitude 7.4 and about 25' in diameter. This is a breathtaking cluster of a few hundred stars at RA: 8h 51m Dec: +11d 48' or about 8' west in RA of Alpha Cancri. Unlike most open clusters which are mainly located along the galactic plane, M67 is displaced by almost 1500 light years. Spectra and magnitude studies of M67 show that its stars exhibit characteristics shared by those in many globular clusters and suggest that this cluster may be as old as 10 billion years; however, stars here are richer in metals. This is more typical of sun-like stars than for stars in the average globular cluster.

There are about half a dozen galaxies in Cancer, but most are too dim for most amateur telescopes. The brightest one, which should be within reach of at least medium sized telescopes, is NGC2775, a magnitude



Cancer

11.5 spiral located at RA: 9h 10.2' Dec: +7d 01' (or 4.8 degrees south and 12 minutes east of Alpha Cancri.) It's a small oval smudge measuring about 2.2' by 1.5'.

Cancer also offers some pleasing double stars of varying difficulty. The best is Iota Cancri, marking one of the crab's right legs or claw. This star is composed of a yellow G8 and a blue A3 pair separated by 30.5 arc seconds and a nearly fixed PA of 307 degrees. Low power is all that is necessary to split this double. A much closer pair is Phi2 Cancri. This is a closely matched bluish white A3 and A4 pair separated by 5.1", and a PA of 217 degrees.

The last double star to mention, or in this case triple star, is Zeta Cancri. The wider pair of yellow-orange stars is separated by 5.8" and a PA of 77 degrees, but if you have the aperture (10 or more inches), the optics, and the steady seeing required, try separating the closer pair at a mere 0.9". At Zeta's distance from Earth, this is similar to the separation of the Sun and Uranus.

Though Cancer is not marked by bright stars, it is well worth looking at the treasures it has to offer.

The Constellation of the Season, written by Chris Lancaster, is the basis of his book, "Under Dark Skies - A Guide to the Constellations, Trafford Publishing (http://bookstore.trafford.com/Products/SKU-000158114/Under-Dark-Skies.aspx). While the information was accurate at the time of the original writing, the reader should be aware that the sky does change over time. In particular, separation and position angles of double stars may have increased or decreased. This article is presented as originally written. Consult current observing resources for correct separations and position angles. ©2008 Used by permission.

Featured Article

Gravitational Wave Astronomy Will Be The Next Great Scientific Frontier

By Dr. Ethan Siegel

Permission to use this article granted by the NASA's Space Place.

Imagine a world very different from our own: permanently shrouded in clouds, where the sky was never seen. Never had anyone see the Sun, the Moon, the stars or planets, until one night, a single bright object shone through. Imagine that you saw not only a bright point of light against a dark backdrop of sky, but that you could see a banded structure, a ringed system around it and perhaps even a bright satellite: a moon. That's the magnitude of what LIGO (the Laser Interferometer Gravitational-wave Observatory) saw, when it directly detected gravitational waves for the first time.

An unavoidable prediction of Einstein's General Relativity, gravitational waves emerge whenever a mass gets accelerated. For most systems -- like Earth orbiting the Sun -- the waves are so weak that it would take many times the age of the Universe to notice. But when very massive objects orbit at very short distances, the orbits decay noticeably and rapidly, producing potentially observable gravitational waves. Systems such as the binary pulsar PSR B1913+16 [the subtlety here is that binary pulsars may contain a single neutron star, so it's best to be specific], where two neutron stars orbit one another at very short distances, had previously shown this phenomenon of orbital decay, but gravitational waves had never been directly detected until now.

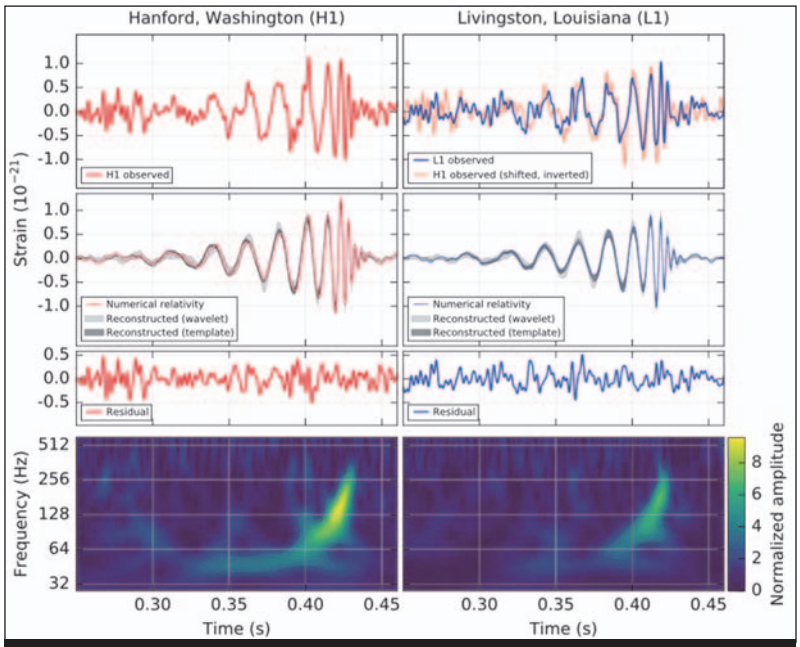


Image credit: Observation of Gravitational Waves from a Binary Black Hole Merger B. P. Abbott et al., (LIGO Scientific Collaboration and Virgo Collaboration), Physical Review Letters 116, 061102 (2016). This figure shows the data (top panels) at the Washington and Louisiana LIGO stations, the predicted signal from Einstein's theory (middle panels), and the inferred signals (bottom panels). The signals matched perfectly in both detectors.

When a gravitational wave passes through an objects, it simultaneously stretches and compresses space along mutually perpendicular directions: first horizontally, then vertically, in an oscillating fashion. The LIGO detectors work by splitting a laser beam into perpendicular "arms," letting the beams reflect back and forth in each arm hundreds of times (for an effective path lengths of hundreds of km), and then recombining them at a photodetector. The interference pattern seen there will shift, predictably, if gravitational waves pass through and change the effective path lengths of the arms. Over a span of 20 milliseconds on September 14, 2015, both LIGO detectors (in Louisiana and Washington) saw identical stretching-and-compressing patterns. From that tiny amount of data, scientists were able to conclude that two black holes, of 36 and 29 solar masses apiece, merged together, emitting 5% of their total mass into gravitational wave energy, via Einstein's E = mc2.

During that event, more energy was emitted in gravitational waves than by all the stars in the observable Universe combined. The entire Earth was compressed by less than the width of a proton during this event, yet thanks to LIGO's incredible precision, we were able to detect it. At least a handful of these events are expected every year. In the future, different observatories, such as NANOGrav (which uses radiotelescopes to the delay caused by gravitational waves on pulsar radiation) and the space mission LISA will detect gravitational waves from supermassive black holes and many other sources. We've just seen our first event using a new type of astronomy, and can now test black holes and gravity like never before.

This article is provided by NASA Space Place.

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