Volume 34 Issue 5

May 2020

The Observer

M82: Galaxy with a Supergalactic Wind - APOD 07/23/2019
Image Credit: NASA, ESA, Hubble; Copyright Daniel Nobre

Upcoming Events:

All events for May have been cancelled.

Inside this Issue:

From the Desk of the President

by Gordon Rosner

Greetings from your President.

I sure hope everyone is doing well and keeping healthy. Everyone is looking forward to seeing everyone else when we get back to somewhat normal operations. There are no indications that conditions are going to change soon to enable meetings to resume. Any prediction by anyone is just a guess at this time. However, our Board of Directors is looking into a virtual presentation in place of our meetings until regular meetings can resume. A short virtual test to our board members is being planned for their diverse inputs and suggestions. When tested and the process finalized, an EVAC-Announce will be published asking the subscribers if they have an interest in dialing in for the actual presentation. Depending on the interest, we may also consider expanding it to AZ-Observing subscribers. Your Vice President, Tom Mozdzen, is championing this process. So, if you have any comments, suggestions, or words of encouragement, you can send them directly to Tom at the Contact VP link at the bottom of the main page of our EVAC website at evaconline.org.

Your leadership team is considering moving our FreeList internet mailing

From the Desk of the President

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host to the Groups.io platform and is under discussions. This action is an example of our leadership team still searching for improvement opportunities for our club, even during these tough times. Even our treasurer, Brooks Scofield remains working at paying the bills and balancing the books. The Groups.io platform appears to be a modern, easy to use platform with more features for better dissemination of our club news and information. AZ-Observing and the Saguaro Astronomy Club's SAC-Forum has already committed to this move. So, if you get emails from FreeList groups regarding migration to this new platform, you can consider them legitimate. We will add information and updates on the top of our EVAC web site main page that you can check for the status of this migration consideration.

Who has a Dobsonian telescope? I bet a lot of you do. If you have more than one telescope, usually one is a Dobsonian. In my personal telescope collection I have two. A six inch and an eight inch. Both still get used a lot. In fact, our club has donated a few 4.5 inch Dobsonians to the Library for their customers to check out just as they would a library book. They're very popular and the last time I checked, there was a waiting list to check one out.

So, what is this Dobsonian all about. The Dobsonian telescope was created by John Dobson, an amateur astronomer who is well known for his efforts in promoting awareness of astronomy through public lectures and his 'Sidewalk Astronomy' performances in San Francisco. The telescope system he developed was a simple, low cost, portable and stable mount using a newtonian telescope tube. John is no longer with us, passing away at the age of 99 in 2014. These telescopes that bear his name are now commercially available and is believed by many, as do I, as an affordable and great first-time beginner telescope.

Well, in my internet searches hungry for more and more astronomy videos, I came across one well worth recommending to all of you. 'Telescope Building with John Dobson'. A 1992 video on YouTube about an hour and a half long. A little old and a bit long, yes. But the time flies by as you follow John through a complete Dobsonian telescope build. It shows him grinding his own mirror as he explains each step, describes and shows how focal length is determined, measured and changed, shows how the mirror is tested, gets it aluminized, and builds the mount from plywood and things that most of us either have in our garage or can easily get at a hardware store. Just watching the details of hand grinding the telescope mirror is well worth any of your time. Maybe some of our club members have ground their own mirrors. If so, this sure will be a walk down memory lane and the rest of us will get an appreciation for those who did. I think I'll watch it again.

As I mentioned, our leadership team has no reliable prediction about when our meetings will resume or when and how GRCO will re-open. As our state and city governments struggle with re-opening strategies, they must consider economics and safety. A risky balance. EVAC only has to consider safety. And as it stands now, your club's monthly General Membership Meetings remain cancelled until our leadership team can provide an acceptably safe environment for operations to resume. Please monitor our club's website for the latest information.

"Keep your feet on the ground and keep reaching for the stars."

Your President, Gordon Rosner

First Quarter Moon on May 29 at 23:30

Full Moon on May 7 at 06:45

Last Quarter Moon on May 14 at 10:03

New Moon on May 22 at 13:39

The Backard Astronomer

by Bill Dellinges (May 2020)

Things I Wonder About

As I walked along my dirt driveway to check my mail, I happened to glance down at my feet. It occurred to me that I was a living product of 4.6 billion years of evolution watching his feet strike the surface of an 8,000-mile diameter ball of rock, metals and water. I was actually strolling along the surface of a planet – one of eight in something called a solar system. The planet is teeming with billions of living things, but those plants, insects, birds, fish and mammals are oblivious to the fact they exist on a planet circling a star which gives them the heat and light to live. Only we humans are aware of that. And we can build something like the Golden Gate Bridge, rocket to the Moon and send space probes to other planets. We are also aware our star is only one of billions of stars in our galaxy, and there are billions of other galaxies out there.

The human mind is truly an amazing thing. The only downside to their imagination and engineering expertise is that they've done nothing positive for the planet they live on. How ironic. As a matter of fact, it could be argued Earth would be better off without them. Had that been the case, Earth would be a beautiful planet and natural zoo - without cages or poachers. I wonder if others might agree with that assessment?

We take the Sun for granted. We see it "rise" and "set" every day (of course we know it doesn't, it's the Earth's rotation that makes it seem to rise and set). It's mind-boggling when you stop to think about what it really is, a gigantic sphere of hydrogen gas 109 times the diameter of Earth and 330,000 times its mass. The pressure of that much mass on at the Sun's core produces high enough temperatures (at least 18 million degrees F) to generate nuclear fusion, the conversion of hydrogen into helium, 4 million tons of it each second (releasing the energy equivalent of 10 billion 1 - megaton H-bombs). And it has been doing that for 4.6 billion years and should continue the process for another 5 billion years, including late helium to carbon burning, say the astronomers. I wonder.

My final perplexing thought about the Sun is that even though it's 93 million miles away, it still holds us in its grip of gravity, this mysterious invisible force once called action at a distance. Now the accepted theory of gravity per Herr Einstein in his 1915 Theory of General Relativity is that mass bends space and other masses nearby follow this bent "Spacetime." OK, a little weird, but who am I to question the man? Still, it bends my mind to think that the Sun's mass created a gravity well in spacetime that keeps my planet revolving around it for billions of years.

I have observed galaxies in my telescope many times over the years. Most are not terribly impressive, mere smallish amorphous blobs. But I know they are galaxies just like our Milky Way galaxy and can't help wonder what is going on in that island universe? How many Orion Nebulae reside in its spiral arms? Among its many star clusters, is there one more impressive than M-7 in Scorpius or the Double Cluster in Perseus? Surely it has globular star clusters – more than our 150? Are any as impressive as our Omega Centauri (NGC 5139)? Most intriguingly, how much life is going on in there!? No doubt plenty, but the big question is, intelligent life? I wonder if someone is looking back at our Milky Way galaxy with their telescope?

Astronomers tell us the universe was created 13.8 billion years ago in a gigantic explosion called The Big Bang. In a nut shell, they propose all the material that makes up the universe we see now, with the exception of heavier elements created in the cores of stars following the Big Bang, were crunched down in a point, a cosmic egg or primeval atom, if you will. Then BOOM. This mixed cocktail of incredibly hot space, time, and matter expanded not into space (because there was no space before) but is space expanding itself, carrying along with it the matter which later cooled and formed galaxies. While there is some compelling evidence to support the theory, like the recession of the galaxies and the cosmic microwave background (CMB), I have a few nagging questions. What was there before the Big Bang. What was the nature of this cosmic egg? What size was it? Why did it "explode" when it did?

And as if astronomers didn't have enough problems, now they have to figure out why they're only seeing 4% of what's out there, the other 96% is evidently comprised of invisible dark matter and dark energy. What is the nature of this enigmatic "stuff"? I do wonder about that.….and wonder if I might be addicted to chocolate. I'm pretty sure I am.

Pair Instability, Black Holes, and Supernova

by Henry DeJonge IV

Introduction

A while ago I heard that there was a limit to how big a black hole, (BH) can grow and that they could not get any bigger than a certain size. Of course, I was intrigued and began to investigate things knowing that theoretically there was no limit to how big they can grow. In fact, at some recent lectures estimates can range up to E^{52} grams which is a bit smaller than the mass of our known universe! In studying this I quickly realized that they were thinking of pair-instability, (PI) limitations to stellar BH formation in terms of mass.

These potential formation limits have been discussed since the 1960's (mainly for supernova rather than for BH initially) but have just started to be taken seriously in the last decade or so, especially due to the detection of gravitational waves, (GW) via BH mergers from LIGO. These detections have given us the ability to estimate the masses of the involved BH, (components and resultant) and notice some interesting properties in their mass ranges. Current data from LIGO are mainly consistent with a maximum component stellar BH mass of about 45 solar masses which is also in line with what is called the PI mass gap. Currently we still believe that the mass of a stellar BH depends primarily upon the mass of the progenitor and the details of the supernova, (SN) explosion which is still very much a work in progress. In this article we will briefly examine the nature of PI in regards to BH, and supernova and discuss any potential mass limitations.

Black Holes

Ever since LIGO first detected gravitational waves, (GW) there have been many questions raised. Two main questions arise, one being where do these relatively massive stellar produced, (or so mainly assumed) BH come from and the other is how they are brought close enough together to merge within the present age of the universe. We will address the first of these questions in this article.

As of late 2019, there are at least 35 confirmed binary BH events, (BBH) and about 80% of these BH, (including the primary, secondary, and remnant BH) are much more massive than the BH we see in X-ray binaries suggesting a distinctive evolutionary path for such merging BH binaries. Where do they come from? Could there be a new population category of BH that we have missed? The BH PI gap where a stellar BH could not form, has been traditionally defined as about 60-120 solar masses but at least 2 BBH events suggest that the primary stellar BH could be in the range of 40-120 solar masses, (maybe even up to 150 solar masses). Theoretical estimates show that as many as 2% of BBH merger events have at least one component in the PI mass gap and in the future, (due to greater sensitivity and range) this may rise to about 9%. How could this be? Remember that LIGO has only given us a relatively small number of BBH events and a small window of BH mass ranges that may originate from a single star.

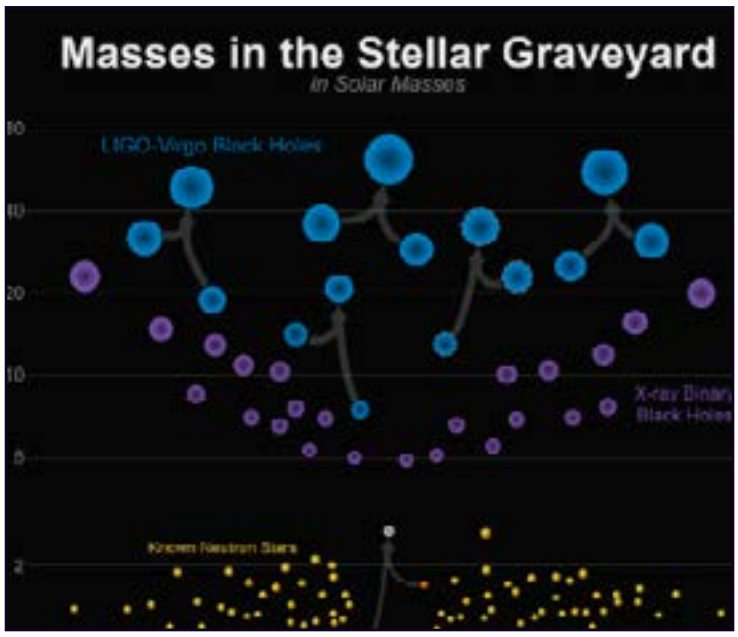

Figure 1. Masses of compact objects from various detectors as of 2017 with solar masses on the vertical axis.

Pair Instability

What is PI? In quantum mechanics and special relativity, we learn that matter can be converted to energy and energy into matter. We also know that when matter and antimatter meet, they produce pure energy and when matter is made from energy the particle and antiparticle pair are also always produced.

PI results from when the energy inside a stellar core reaches a sufficiently high temperature and therefore energy to produce photons that meet or exceed the internal energy, (rest mass) of an electron-positron pair so that the electron and positron pairs can be produced. This pair production takes away thermal photons, (energy) in the core of a star and thus allows the core to

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contract which in turn makes the temperature hotter and the density greater leading to more PI and so on, in a cycle that ends with the star going completely SN and destroying itself. Thus, forming no BH.

In pair production, the conservation laws of charge, energy, and momentum are maintained. The energy always forms a matter/antimatter pair that conserves charge. The incoming energy of the photon, (gamma ray) must meet or exceed the rest mass energy of the pair, which is for the electron/positron pair 1.022 Mev-forming each particle with a mass of at least 0.511 Mev. The momentum conservation comes from the slight recoil that a close by nucleus obtains from the pair production as the particles are sent flying away by the interaction. Thus, this PI process occurs nearby an atomic nucleus, and becomes the dominant process for photons with very high energies, especially for materials with a high atomic number, (no problem in these dense stellar cores!). Such lepton pair production is the dominant process at these very high photon energies in and near matter.

Of course, these electron/positron pairs usually annihilate quickly and since annihilation reactions between matter and antimatter always produce new combinations of matter and energy the cycle can continue. Basically, a cascade of pair production is formed. The active electrons and positrons produced are very relativistic, creating with the photons, what is known as an electromagnetic shower. The numbers of high energy photons will be attenuated, (many "soft" photons will be created) in a material by pair production when creating these electromagnetic showers. The overall effect of this is an energy loss in the material which allows the core to collapse further and further.

Incidentally, this pair production process is also thought to occur on neutron stars, especially at their magnetic poles and contribute to the emitted radiation beams. It is also related to pair production around BH in Hawking radiation.

Supernova

In very massive stars after the central H burning dies out the He burning begins. It too eventually fades so that the star contracts and the pressure and temperature rise and C burning begins. Nuclear burning rates in stars are generally highly sensitive to temperature and turbulence, both of which are properties of massive stars. This higher temperature increases the kinetic energy and the turbulence increases the surface area subject to nuclear reactions, (turbulence enhancement).

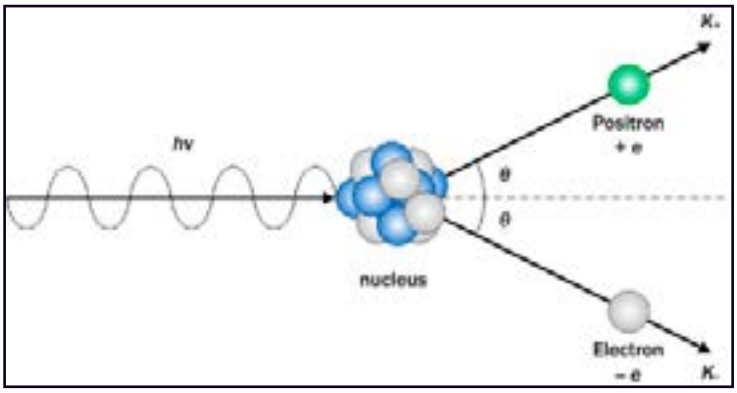

Figure 2. A schematic of pair production.

If the He core mass exceeds about 30 solar masses then the C burning begins very rapidly. When the core temperature is about 700 million degrees the pair production process can begin which in turn lowers the core pressure. This core contraction from the lower pressure increases the heat and allows the rapid and uncontrolled burning of neon, oxygen, and silicon, forming a catastrophic pair instability supernova, (PISN) explosion. The energy released raises the pressure enough to turn the contraction around into an energetic unbounded thermonuclear explosion, (E^{51}-E^{52} ergs)-a powerful supernova. This completely destroys the star forming no BH.

It has been suggested that in some cases if the He core is above about 32 solar masses but below 64 solar masses, (all approximate of course) then the star may also undergo pulsational PI. This means that it goes through a series of pulsations due to the release of energy from pair production not sufficient to blow up the super massive star, but causing mass loss on and off at a high rate until the core leaves this potentially unstable mass range. While these shock waves propagate outwards, the core can begin to cool, (via different mechanisms such as neutrino loss, etc.) and collapse beginning the cycle anew. The mass loss is confined to the outer envelope, and can be from tenths to tens of solar masses per pulse as shock waves propagate thru the envelope while the core of the star is able to continue nuclear burning up to forming iron. Then the star can become a "normal" core core collapse supernova and can potentially form a BH or be

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completely destroyed. This is a pulsational pair instability supernova or PPISN.

Pair instability supernova, (PISN) and pulsational PISN, (PPISN) directly influence the size of BH that can be produced from single stars. It is thought that these processes prevent the formation of stellar BH above 60 solar masses to about 120 solar masses as mentioned, thus the PI mass gap. Note that this total range is sometimes divided into a primary and secondary mass gap. Bear in mind also that these approximate limits are still very dependent on massive stellar evolution models and very complex SN/PI models.

The initial stellar mass range for PISN are thought to be stars with an initial mass of approximately between 140 and 260 solar masses, (remember that these stars can eject many solar masses of material before collapsing). However, this initial stellar mass range also varies in some papers from approximately 85 to 200 solar masses. To further indicate the uncertainty in the PI mass gap ranges I noted that in some papers, (all the papers in this article are from 2018-2020) the gap is in the range between 65 and 135 solar masses. For comparison, theory tells us that to make a BH of about 10-30 solar masses you need to have a star typically in the range of 25-35 solar masses. These BH are considered below the PISN range and can be formed via "normal" core collapse supernova or CCSN. Interestingly enough these BH ranges are thought to be largely independent of the progenitor metallicity, which is assumed to be lower the older the BH formation. At the top end it is roughly assumed that the theoretical upper mass limit for star mass is about 1,000 solar masses. At these very large masses, (say above 260 to about 1,000 solar masses) the dying star can completely avoid the PI mass gap and collapse via say a hypernova into a BH, (see my article on hypernova from 11/2009).

PISN and PPISN are truly very powerful explosions for SN and are believed to possibly be beacons from the very early universe, (z about 25) which could help reveal the properties of the first primordial stars, (Pop III) from the cosmic dawn. There is still much work to do in resolving how to detect PISN and PPISN as the metallicity and other factors can heavily influence their spectra and light curves. So far there have been no confirmed observations of either a PISN or a PPISN although there are a few potential candidates under study.

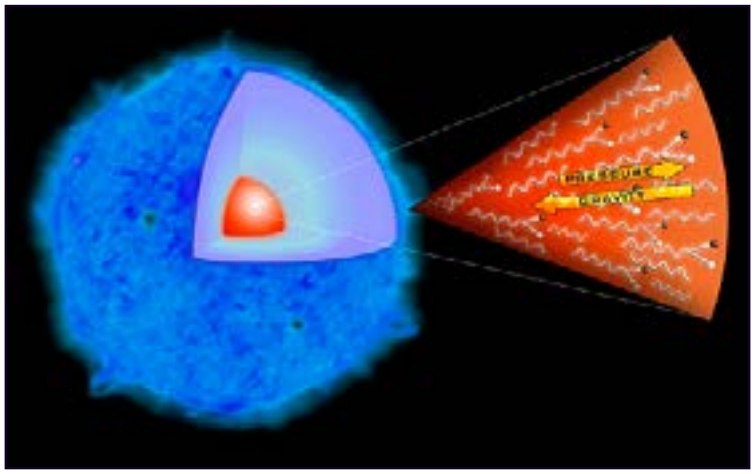

Figure 3. Core of a massive star

Other explanations

It is estimated that possibly 5% of all singular BH have a mass that exceeds the PI gap. One idea that may explain BH formation beyond the PI gap is that they form via merging stars, (which can happen multiple times) especially in such environments as dense young star clusters. In another vein of thought there could also be some exotic BH formation channels that have yet to be discovered that could populate the mass gap. Such scenarios may include primordial BH and their growth from the early universe. We will not discuss in depth how some of the gap may be filled by smaller merging BH.

Another interesting idea to fill in the gap is if a massive star with a He core would merge with a main sequence star and form a star with a supersized H envelope. Before the He core gets too large and if it does not lose too much mass in the envelope, this new stellar object could avoid PI and collapse directly into a BH and become a BH in the mass gap. This is also provided that the merged star collapses before its He core grows star. If the metallicity is relatively high the star has more efficient winds and can blow off more material from the envelope decreasing its chance to form a BH in the PI mass gap. Such massive stars in this type of merger can lose much of their outer envelopes in just a few million years. In fact, this scenario seems to be quite prevalent in the BH formation simulations going on at present. If this process occurs multiple times in a very short time it is known as a "runaway collision" and has been discussed over the

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years often in research.

The environment surrounding these alternative scenarios also plays a major role, especially if the progenitor stellar object is in a dense star cluster. Many of these young star clusters where massive stars are formed are seen to be very asymmetric and clumpy systems. In these types of massive cluster environments once a BH has formed it can more readily merge with another as the gravity of the large cluster prevents the relatively small BH from escaping so they can merge in time. This is especially true in globular clusters and nuclear star clusters.

It was recently reported, (Jan 2020) that a 70 solar mass BH had been discovered in a binary system. The companion 8 solar mass star had a relatively high metallicity, (about 2% solar) which if this same metallicity was true for the BH progenitor then the usual stellar models would limit the BH mass to about 20 solar masses due to strong stellar wind mass loss. However, some scientists theorize that a roughly 85 solar mass star could have produced such a massive BH if it had a very strong magnetic field, (which would tend to capture much of the mass lost from winds) which in turn would have greatly restricted the mass loss. This type of star would retain a massive hydrogen rich envelope. These factors would also have greatly restricted the mass loss from the PPISN process thus allowing the 70 solar mass BH to have formed. Until this time the most massive high metallicity stellar progenitor BH were about 15 and 16 solar masses. Obviously, this 70 solar mass BH exceeds the usual PISN and PPISN mass limits of 40-50 solar masses, even allowing for an extended range on the upper mass limit to about 55 solar masses as some variants suggest. The modeling of mass loss via strong stellar winds is still hotly debated and evolving and there are other explanations for this 70 solar mass BH than may explain things.

Primordial BH are those that theoretically formed right after the BB from a variety of possible mechanisms, (fluctuations perhaps). Primordial BH may also be part of the explanation for dark matter. However, if they exist then they are predicted to usually have slow spins, (which also connects them to single star BH in the PI mass gap) and are able to grow to arbitrarily high masses while not being affected by PI. Some models constrain the primordial BH mass range to 10-100 solar masses but I have been to recent presentations that do not share such limits. There is much work to be done in exploring this approach.

Thus, we see there are at least a few ways that stellar BH can be found in the PI mass gap range presumably from a single star. This of course does not count the ways such a BH could be formed from more than one object, especially in a close multiple star system.

The Future

In the future as LIGO becomes more sensitive and other detectors, (like LISA) become online in the next couple of decades, we will be able to detect several tens of BBH mergers from earlier times (from z between roughly 6 and 40) and get a much better handle on the masses of BBH mergers and their components. The JWST and extremely large earth-based telescopes will hopefully also give us wealth of information on PISN in the future, over a large variety of ages. This will enable us to learn more about the PI gap and also open up new ideas into the formation of such early BH and BBH events. We also know that the current limits on the PI mass gap have wide uncertainties which causes the range to vary considerably. Most models also do not account for any BH spin in their simulations as that is yet too complex and not fully understood. To date the models are still relatively simple.

Future observations and data will also hopefully shed more light on the very complex nuclear physics, turbulence theory, magnetohydrodynamical physics, chemistry, and BH physics that go into producing such strange and enigmatic objects.

Summary

Right now, based upon our current and very limited observations combined with rapidly developing theory, it appears that there is a limit to most single star BH with a size beyond approximately 60 solar masses to about 125 solar masses. However, as we have seen this stellar BH mass function is still highly uncertain and is a work in progress! We have also learned that the progenitor stars metallicity does not seem to be a roadblock to forming BH in the PI gap as originally thought.

This does not mean that single star BH cannot be formed with a greater mass, (indeed some models say this can happen definitely above 125 solar masses!) but that they

Pair Instability, Black Holes, and Supernova

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would become larger thru other mechanism such as single or multiple stellar, (or BH) mergers. The origin and details of current BH-BH mergers is still very much unknown and currently cannot contribute much to constraining single star BH formation masses. We only have at most a handful of potential PISN candidates and until confirmations can be made most theories will remain just that. Maybe the PISN will be even brighter than the models predict, there are still many unknowns. There is a lot of Universe out there we have yet to examine!

EVAC Outreach Events

by Gordon Rosner

Unfortunately, another very short column this month. All outreach events remain cancelled due to supporting the public health concerns and directives.

Just like our club operations, I have no reliable predictions on when outreach activities will resume. Schools we support are still closed. Even when schools reopen, they may not schedule the events we normally support Plus the safety of our volunteers must also be considered.

Looking very forward to our outreach program getting back and to hearing all those "OH WOW's" we so love to hear.

Gordon Rosner

EVAC Outreach Events Coordinator

Find Out What's Happening – Join EVAC-Announce List

If you would like to receive email announcements about EVAC meetings and activities, please join the EVAC–Announce mailing list. Click on the link below to subscribe. Enter your full email address in the box titled User Options and press OK. You will receive a confirmation email. Your privacy is respected by EVAC and we will never sell your email address, or use it for non-club relevant solicitations. This mailing list is designed for communication from EVAC, and does not enable users to respond to the message. If you wish to contact club officers, please use the list in the Contact-Us area on the Home page of our EVAC website. To subscribe to the EVAC–Announce mail group click: http://www.freelists.org/list/evac-announce. To unsubscribe use the same link, enter your email address and select Unsubscribe from the "Choose An Action" list. Another list to consder is AZ-Observing@groups.io, simply click on this link https://groups.io/g/AZ-Observing and follow the instructions on the page. EVAC also has a Facebook Group where members may share ideas, photos, and Astronomy related information. To join: EVAC Facebook Group.

The Gilbert Rotary Centennial Observatory (GRCO) also has a Facebook Group where members may share ideas, photos, and Astronomy related information. To visit, please click on Gilbert Rotary Centennial Observatory - GRCO.

Looking for that perfect weekend activity?

Why not resolve to getting involved?

Contact Claude Haynes to join the staff at GRCO

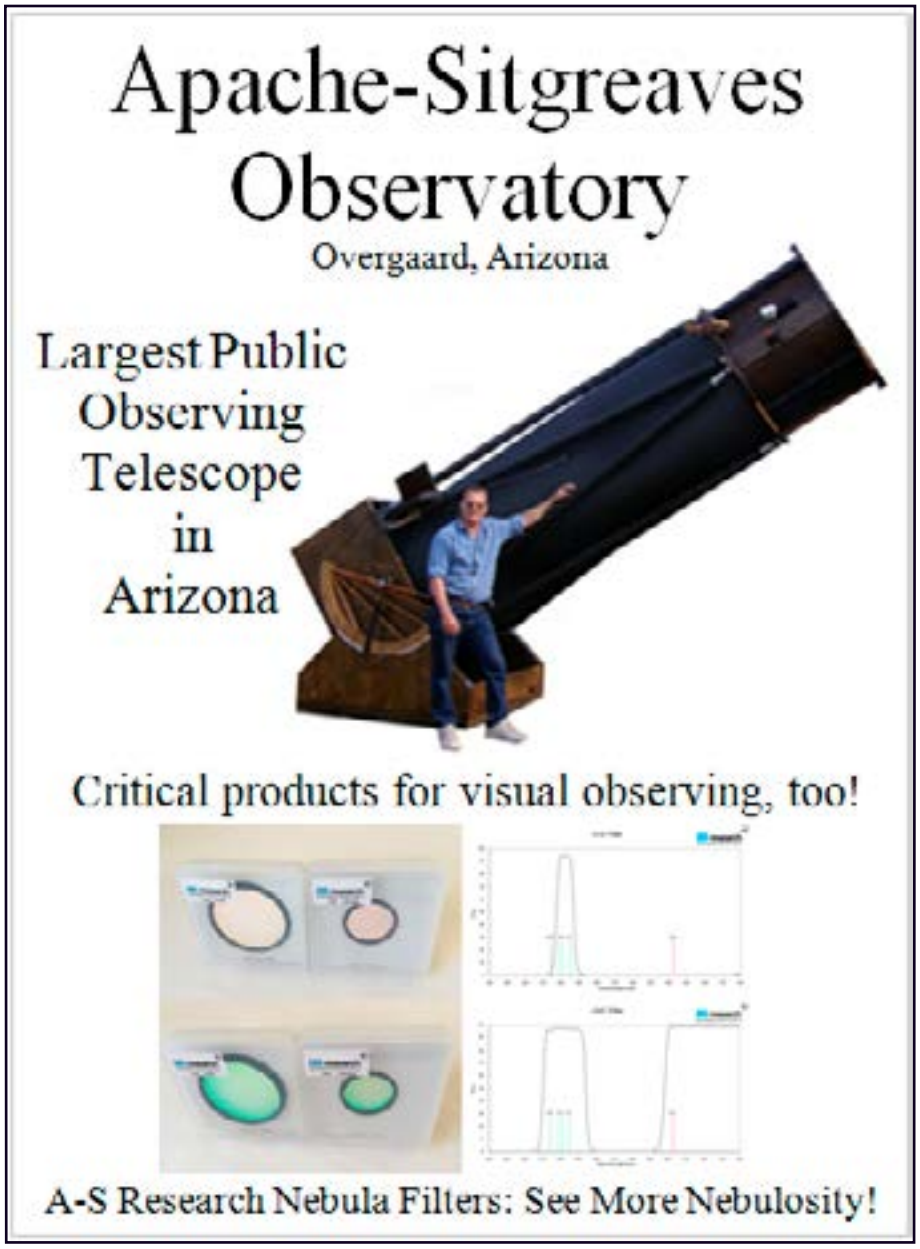
Email: grco@evaconline.org

EVAC Logoed Clothing

We now have clothing inventory of polo shirts in various sizes and colors and hats. If you ordered clothing, it will be available at the next meeting. If you didn't order, you can select an item at the next meeting and get immediate delivery. We have one 2XL navy-blue hoodie for sale. Please see Brooks or Tom at the next meeting.

Contact Tom Mozdzen at vp@evaconline.org if you have questions.

Classified Ads



Classified Ads

The darkest, most Pristine, sky in the continental U.S. !

At the site: Bathroom facilities, running water, 5 pads w110v, wifi, acres of grassy camp sites.

From the site: Very Large Array 42mi E, The Astronomical Lyceum 55mi E, MRO Observatory 80mi E

IC 405

Insight Observatory
16" ATEO 1 Telescope

SkyPi Remote Observatory

Upcoming Meetings

All events are on hold until health concerns are resolved.

The monthly general meeting is your chance to find out what other club members are up to, learn about upcoming club events and listen to presentations by professional and well-known amateur astronomers.

Our meetings are held on the third Friday of each month at the Southeast Regional Library in Gilbert. The library is located at 775 N. Greenfield Road; on the southeast corner of Greenfield and Guadalupe Roads. Meetings begin at 7:30 pm.

Visitors are always welcome!

Southeast Regional Library
775 N. Greenfield Road
Gilbert, Az. 85234

May 2020

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4	5	6	7	*8	9
10	11	12	13	14	*15	*16
17	18	19	20	21	22	*23
24	25	26	27	28	29	30

May 8 - Public Star Party

May 15 - EVAC Monthly Meeting

May 16- EVAC Star Party

May 23- EVAC Star Party

***All meetings and events have been cancelled until further notice.**

June 2020

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6
7	8	9	10	11	*12	*13
14	15	16	17	18	*19	*20
21	22	23	24	25	26	27
28	29	30				

June 12 - Public Star Party

June 13 - EVAC Star Party

June 19 - EVAC Monthly Meeting

June 20- EVAC Star Party

***All meetings and events have been cancelled until further notice.**

East Valley Astronomy Club -- 2020 Membership Form.

IMPORTANT: All memberships expire on December 31 of each year

New Member Dues (select according to the month you are joining the club)

	Individual	Family	
January, Feburary & March	**$30.00**	**$35.00**	
April, May & June	**$22.50**	**$26.25**	
July, August & September	**$15.00**	**$17.50**	
October, November & December	**$37.50**	**$43.75**	(*Includes following year)*

Renewal (current members only):

☐ **$30.00 Individual** ☐ **$35.00 Family**

☐ **Astronomical League:** $7.50 Annually (per person)

Name Badges: Quantity: _____

☐ **$10.00** Each

Name to imprint: _____

Total amount enclosed:

Please make check or money order payable to EVAC

Payment will be made using PayPal ☐

Name: | Phone:

Address: | Email:

City State Zip | URL For website

Would you be interested in our outreach program? ☐ Yes ☐ No

How did you discover East Valley Astronomy Club?

Liability Release Form

In consideration of attending any publicized Star Party hosted by the East Valley Astronomy Club (hereinafter referred to as "EVAC"), the receipt and sufficiency of which is hereby acknowledged, I hereby affirm that I and any related entities, predecessors, successors, affiliates, attorneys, guarantors, insurers, transferees, assigns, parents, spouses, children, subsidiaries, accountants, officers, directors, employees, agents, shareholders, members, and trustees, past and present, hereby forever release, acquit and discharge to hold EVAC and its related entities, predecessors, successors, affiliates, attorneys, guarantors, insurers, transferees, assigns, parents, spouses, subsidiaries, accountants, officers, directors, employees, agents, shareholders, members, and trustees, past and present, from any and all causes of action, claims, losses, damages, liabilities, expenses (including attorneys' fees) and demands of any nature whatsoever, known or unknown, that in any way relate to, arise out of, or concern EVAC and/or my presence on the premises of any EVAC Star Party and related areas, whether or not those causes of action, claims, damages, liabilities, and demands are part of the specific subject matter of EVAC or any EVAC Star Party. This release is intended to and does cover all injuries and damages, and the consequences thereof, whether known or unknown at the time of the execution of this release, which have occurred or may hereafter occur or which may hereafter be discovered, and which may have been caused or may be claimed to have been caused by the said incident, and specifically includes, but is not limited to, bodily injuries, mental and emotional injury, pain and suffering, medical treatments, and loss of earnings or income.

My signature upon this form also indicates agreement and acceptance on behalf of all minor children (under 18 years of age) under my care in attendance. EVAC only recognizes those who are members or invitees and who also have a signed Liability Release Form on file as participants at an EVAC Star Party.

Signature _____ Date _____

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