The SAN MATEO COUNTY ASTRONOMICAL SOCIETY

May – July • 2021 Issue

777th General Meeting: May 15
778th General Meeting: June 12
779th General Meeting: TBD

EVENT HORIZON

Founded in 1960, the San Mateo County Astronomical Society is a 501(c)(3) non-profit organization for amateur astronomers and interested members of the public. In nonpandemic times, visitors may attend Society meetings and lectures on the first Friday of each month, September to June, and Star Parties two Saturdays a month. All events are free for visitors and guests. Family memberships are offered at a nominal annual cost. Detailed membership information is found at ***http://www.smcasas-tro.com/membership.html*** *where those who want can join via PayPal. Membership also includes access to our Event Horizon newsletter, discounted costs and subscriptions to calendars and magazines, monthly star parties of the Society and the College of San Mateo, use of loaner telescopes, field trips, social occasions and general meetings presenting guest speakers and programs. For additional information, please email us at* ***SMCAS@live.com*** *or call* ***(650) 678-2762****.*

Membership forms are available near the end of this newsletter. The Membership Application form is on the back page.

Total lunar eclipse August 28, 2007. The length of totality of this eclipse was 90 minutes. In contrast, the phase of totality of the upcoming May 26 lunar eclipse will only have a duration of just 14 minutes. It will be between 4:11am and 4:25am. Click here for more information about the upcoming lunar eclipse. (*Ken Lum)*

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PLEASE NOTE: CSM is still closed due to the pandemic. SMCAS events are online until further notice.

From the Prez

Hi All.

THE COVID-19 PANDEMIC

Well, the last SMCAS in-person general meeting I recall took place in February, so we are officially now a full year into virtual Zoom events. The novelty of it, along with the ease of attending, has, at times, actually improved attendance but I, at least, miss the cheerfulness and information-sharing of in-person encounters.

A major downside, of course, is the loss of the public outreach, whereby we have brought talks and telescopes to schools, scouts and occasional adult groups, as well as to public star parties. On the other hand, star party attendance has routinely increased since going virtual, especially on cold nights. And by having star parties follow our lectures, we hold fewer events, but often draw a wider, more diverse crowd.

We first started separate livestream star parties in June 2020, at the inspiring suggestion of member Inge Ruano. We began to integrate them with our general meetings starting in August of last year, and I think it brought the club a new infusion of enthusiasm. The online star parties were made possible by the innovative use, by Ed Pieret, of his new Unistellar eVscope, which lent itself well to the livestream viewing methodology.

He was soon joined enthusiastically by Chanan Greenberg (who also wrote and delivered four lecture programs for us), by Michael and Lisa Cooke, who generously edit and post our ads and archives on Facebook and YouTube), and now by Ken Lum (with Bill Lockman joining next), who has recently adapted similar or complementary equipment to the purpose.

I believe we all thought, last year, that we'd be back to in-person Society activities by now, and if it were solely up to me, we would be. In fact, Ed Pieret and I did re-institute on-site star parties at Crestview Park, and elsewhere, last June and July, but in the ZOOM era, those have proven unnecessary since the observers can complement one another from their homes.

I'm gratified to note that the pandemic appears to have entirely skipped, literally, everyone I know. And, despite the advanced average age and health issues affecting many of us in the Club, to my knowledge, all of us have been spared.

While the circumstances differ, it may be that Franklin Roosevelt also described us when he said, "The only thing we have to fear is fear itself."

But a lot of folks still have valid concerns in light of state policies, arbitrary business restrictions and continuing school closures, some of which deny us access to our traditional facilities. Of course, we all can take credit for knowing and maintaining healthy personal habits and nutritional intake, including supplements.

In addition, I think we've all taken vaccines as they've become available. I didn't even feel Walgreens inject my first shot. My wife had arm soreness for a few days, but I felt nothing but the second shot, though it may have caused me some fatigue.

So, until things change, continuing good luck and good health to you and yours.

From the Prez (cont'd)

PROGRAMS

I want to thank Marion Weiler for continuing to reliably recruit speakers for our meetings. The use of Zoom livestream makes it simple for them to appear and address us as well, and we have access to other similar programs from the UC Observatories to Professor Andy Fraknoi's Silicon Valley Lecture Series, among others. I'm trying to circulate word of them to our membership and guests over the SMCAS Newsgroup. Anyone else who receives such invitations is welcome to pass them on to the mailing list through the same portal; smcasnews@groups.io. Or send it to one of us Board members, and we'll do the honors if you'd rather not.

And, if any among you comes up with a presenter or topic that you think would be of interest to the group, please feel free to pass the info along to me (jmrastro@yahoo.com) or Marion (mgwe@pacbell.net) so that we can see when there's an open date in the presentation schedule. Once that's happened, if you'd prefer to be the primary point-of-contact, that can likely be arranged. Or we on the Board can do it if you choose.

ELECTIONS

Speaking of the Board members, the May general meeting, now set for Saturday, May 15, is when we open nominations for the exciting, dynamic, knock-down drag-out, rough-and-tumble donnybrook of our 2021-2022 Elections! (Well, maybe not so much). We will nominate and elect a slate of officers; president, vice-president, secretary and treasurer, as well as the five at-large board director positions. Nominations will be opened by majority vote of a quorum consisting of 30%+1 of the paid membership. Each member or member family, gets to cast a single vote for each office or position.

Once nominations are opened, any member in good standing (paid up!) may nominate or second either him/herself or another member, for any office or position. Nominations will remain open until the June General Meeting, also the Annual Meeting, set for Saturday, June 12. Nominations and seconds may be offered at any time from the opening through the closing of nominations and need not be done in person. Phone, text, email or letter will suffice.

Once nominations have closed, the Board will announce candidates for each office, likely by email via the members' newsgroup; smcas@groups.io. Note: This is NOT the same as the general newsgroup; smcasnews@groups.io, which is open to guests as well as members.

Members will then be asked, again by email to smcas@groups.io, to vote their preferred candidate for each office, and their top five candidates for the five directors-at-large. Total votes for each office or position must exceed a quorum. Candidates receiving the largest number of votes for each office will be declared elected.

One current board member will serve as point-of-contact to collect nominations, then later the votes for each office. Until one is selected, member responses, questions and votes may be directed to me, your current president, Mike Ryan, to share with the

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From the Prez (cont'd)

current Board, which will then make, and announce, the decision(s). Mike is reachable at (650) 678-2762 or at jmrastro@yahoo.com.

One thing more, SMCAS elections have, literally, *never* been contested. In fact, officeholders and nominees usually scramble to get away as quickly as possible. It's said that our president is chosen by an annual game of "Musical Chairs;" the last one standing has to become president. So, if you would really like to help serve the Society, your chances are excellent. And just think of the fringe benefits! … (What?)

Last year, we made up an elaborate set of ballots to nominate and elect candidates. However, they turned out to be more than most people could handle, and just confused most. So, while the means is not yet set, we'll try and simplify both the ballots and method this time. Members, please watch your smcas@groups.io emails for announcements.

And if all that doesn't work, we'll just flip a coin!

Mike Ryan
President, SMCAS

Upcoming Events

PLEASE NOTE: CSM is still closed due to the pandemic. SMCAS events are online until further notice.

Saturday, May 15: 777th General Meeting – Lecture Dr. Dan Weisz, "Resolving the Local Universe with the Hubble and James Webb Telescopes." The evenings will start at 7pm with a short SMCAS members meeting, then presentation, followed by the Star Party. See page 6 for more details. Zoom Meeting ID: 253 926 2920 Passcode: SMCAS

Saturday, June 12: 778th General Meeting – Annual Meeting where elections will take place. See page 4 for other details. Also look for additional details in your email.

779th General Meeting to be determined. Be sure to check your email or the Society's Facebook page for details.

San Mateo County Astronomical Society Presentations and Star Parties Continue Online, Together

To continue with keeping with the pandemic physical distancing requirements, the San Mateo County Astronomical Society has moved our normal first Friday general meetings and presentations to occur via Zoom teleconferencing in conjunction with a monthly Zoom Star Party. The evenings will start at 7pm with a short SMCAS members meeting, then presentation, followed by the Star Party. Our Zoom meetings and presentations are open to the public. Children are welcome although the subjects may be too advanced for some.

The schedule for these combined lecture and Star Party events is listed on the previous page. The rest are still to be determined so look for details in emails about them. Be sure you are subscribed to SMCASNews@groups.io to receive the Zoom details to join these events.

We will resume our normal first Friday in-person meetings once CSM has reopened for public events.

Here are the Zoom details for Saturday, May 15 Meeting

https://us02web.zoom.us/j/2539262920?pwd=U1puVE1nQVZHUW1vaGUrbGczMGxwQT09

Meeting ID: 253 926 2920 Passcode: SMCAS. One tap mobile: (669) 900-9128

Resolving the Local Universe with the Hubble and James Webb Telescopes Lecture May 15

In his talk, Dr. Weisz highlights the amazing science and images produced by Hubble observations of local galaxies from the past three decades. The pinnacle of these studies is the Panchromatic Hubble Andromeda Treasury (PHAT) program, an 800-hour Hubble survey of our sibling galaxy Andromeda, and one of the largest Hubble programs ever conducted. Dr. Weisz will describe the PHAT survey and its scientific impact and discuss plans for the James Webb Space Telescope, which will succeed Hubble as the most sensitive telescope in existence following its launch in 2021.

Dr. Daniel Weisz is an Associate Professor of Astronomy at UC Berkeley, and an observational astronomer. His research is centered around the local Universe. He uses facilities such as the Hubble Space Telescope, Keck and (soon) the James Webb Space Telescope along with "archaeological" techniques to reconstruct the formation histories of local galaxies. He has been at the forefront of near-field cosmology, which connects that fossil record of local galaxies to our theoretical and observational knowledge of the very early Universe. He has received national and international recognition for his research, including an Alfred. P Sloan Fellowship, an Alexander von Humboldt Fellowship, and the 2019 Newton Lacy Pierce Prize for outstanding achievements in observational astronomy, awarded by the American Astronomical Society. As principal investigator of the James Webb Space Telescope Early Release Science Program for Resolved Stellar Populations, Weisz will be one of the first people to use the James Webb telescope.

Frank's Astrophotography Series

By Frank Seminaro

Over the next few issues of the Event Horizon, I am going to chronicle my experience with astrophotography. Hopefully, this will inspire others to explore this great hobby.

I was told by a very experienced member of the SMCAS club, "why take pictures of objects that have already been photographed by others and available online?" From a practical point of view, he's absolutely right. Astrophotography takes a commitment of time and resources. However, if you want a challenge and like gadgets, it's perfect.

I started over seven years ago at a Golden State Star Party with an Orion Atlas mount, Celestron 11 SCT, Atik CCD camera, and a HyperStar lens (more to come on this later). My first ever astrophotograph was of Messier 51 – The Whirlpool Galaxy under one of the darkest skies in California.

Frank's first attempt to photograph the Whirlpool Galaxy (M51) the July 2014 Golden State Star Party.

At the time, I thought it was great. Now that I look back seven years into my astrophotography effort, I see bloated stars, an out of focus object, the infamous green coloring and a lot of background noise in the black of space. A lot has changed over the past seven years including my experience level, my equipment and the supporting technology that enables astrophotography. During this time, I continued to upgrade my equipment that included the venerable, yet mostly hated, Losmandy G11 mount. Many who attended Crestview star parties may have seen me wandering around in the dark muttering to myself with my mount twisting itself into random positions. There were many nights where I wanted to go to my truck and fetch a hammer so I could rain down blows of despair on this maddening device. I came to the conclusion that it was the perfect over-engineered mount that tried to do too many things. All I wanted was a mount that was easy to set up, align, and point to the object I asked it to. I eventually solved many of the problems of the G11 (voltage, bad motor, firmware, etc.) but it ruined astrophotography for me. So, I took the previous astrophotography sage advice and started enjoying images other people posted on AstroBin.com. I even thought about selling the G11 and all of my astrophotography gear. I went back to visual only.

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Frank's Astrophotography Series (cont'd)

Old habits never really go away. I caught aperture fever on the way back to visual only.

I thought a 14-inch SCT would be the right replacement for my current 11-inch SCT. Previously, I enjoyed some of the nicest views ever while looking through a 14-inch Meade at the Nightfall Star Party in Borrego Springs. I was hooked. I started looking around and found a fellow board member interested in selling his Celestron 14-inch SCT. He thought it would look silly on my G11 even though it is rated for 90 pounds of equipment. He then offered up an Astro-Physics AP1200 mount to go along with it. The AP 1200 is a monster of a mount capable of swinging around 145 pounds of equipment. It is right on the edge of portability. These mounts rarely come up for sale and are built for a lifetime of use. When I picked it up, I swore up and down I was forever done with astrophotography. I wanted to spend my limited free time on visual observation only. I even sold all my astrophotography gear including the G11.

… Enter COVID-19

I am a gadget guy, always have been. I grew up in the trades and learned how to fix about anything including machining my own parts. My childhood friends and I were always taking things apart and rebuilding them into something else using our fathers' welders and other equipment. Someday you can ask me about the state highway, go-kart from a lawnmower and state-trooper thing.

COVID ensured one thing – boredom. No Crestview Star Parties required me to think about what to do stuck at home. It wasn't long before I looked at the C14 and AP1200 sitting in my home office and thought to myself, I bet that thing can take one heck of a picture. I started reading again about astrophotography every night. In my short time away from it, a lot changed and it seemed for the better. I started reading about a company named ZWO who specialized in astrophotography equipment. This company appeared to address many of the negative astrophotography issues I experienced earlier. I am not advocating for ZWO. There are other vendors who sell similar items. ZWO's products resonated with me and what I was considering doing. Just like looking at an IT vendor for your business, I wanted a single vendor across all of the required tools necessary for astrophotography. In the past I had a Frankenstein of a setup for software, focusing, alignment, guiding, camera, etc. A single vendor meant I may beat my 80% failure rate since it was designed to all work together and not fight each other (no hammers needed).

Over the past year, I rebuilt my imaging rig to fit my needs and learned to operate it in the limited confines of my backyard. It's not the best rig one could assemble, but it works for my needs which are simplicity, cost, quality of images, and time required. Over the next few Event Horizons, I will discuss the following topics:

- Equipment
- Setting up
- Imaging
- Processing Data
- Online tools and sources

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Frank's Astrophotography Series (cont'd)

Here is Messier 51 from March. This is the same object as the earlier picture shown, but you can clearly see the improvement in the image. This was taken from my light-polluted backyard in Belmont with my new setup. Until the next Event Horizon issue … ◆

Visiting Haleakalā Observatory in Hawaii

SMCAS Members Mary Ann McKay & Ed Pease are in Hawaii visiting the Haleakalā Observatories.

Where Did Mars' Liquid Water Go? A New Theory Holds Fresh Clues

By Ed Ching and Bill Lockman

Recently published were reports on Mars surface water, the best summary of which is described in the March edition of a National Geographic article by Robin George Andrews: "Where did Mars' liquid water go? A new theory holds fresh clues." The main aspects of this article are listed below as enumerated bullet points, followed by a summary of the original research report.

1. Many geological formations observed by both Mars orbiting and land rovers indicate that Mars may have had large quantities of surface water early on in its geological history.
2. Mars is currently and has been dry, with little atmosphere, for at least the last 3 billion years.
3. Prior theories held that most of Mars' water escaped into space as its atmosphere was stripped away by solar winds unaffected by a significant magnetic field. By examining the isotope ratio of deuterium to hydrogen (D:H) from the disassociation of deuterated — to undeuterated water vapor in the Martian atmosphere, as well as by measuring D:H in ancient Martian meteorites on Earth and in rocks on Mars by Martian rovers, scientists can work out how much water was lost through the Martian atmosphere over its history, using the fact that the heavier deuterium is less likely to escape the Martian atmosphere than the lighter hydrogen. The atmospheric loss mechanism is not nearly large enough to explain the amount of water present on Mars early on in its history, as inferred by surface geological formations caused by the actions of standing- and flowing liquid water.
4. A new study and publication by E. L. Scheller et al., "Long-term Drying of Mars by Sequestration of Ocean-scale Volumes of Water in the Crust" has proposed that substantial amounts of water are retained in hydrated minerals in the planet's crust.
5. By including a reservoir of hydrated minerals sequestering water, the authors of the Scheller et al. article were able to generate models incorporating various combinations of volcanic gassing, atmospheric escape, and crustal hydration over various geological epochs which better fit the observations and could estimate volumes of surface water on the planet.
6. While large errors in fitting data exist, they estimate some 30% to 99% of the planetary water was sequestered into geological minerals, which is consistent with the volumes necessary to create the observed geological formations.
7. The amount of water decreased significantly between -4.1 and -3.7 billion years as it was trapped in the crust minerals and clays, and Mars has been a dry arid desert for at least the last 3 billion years.

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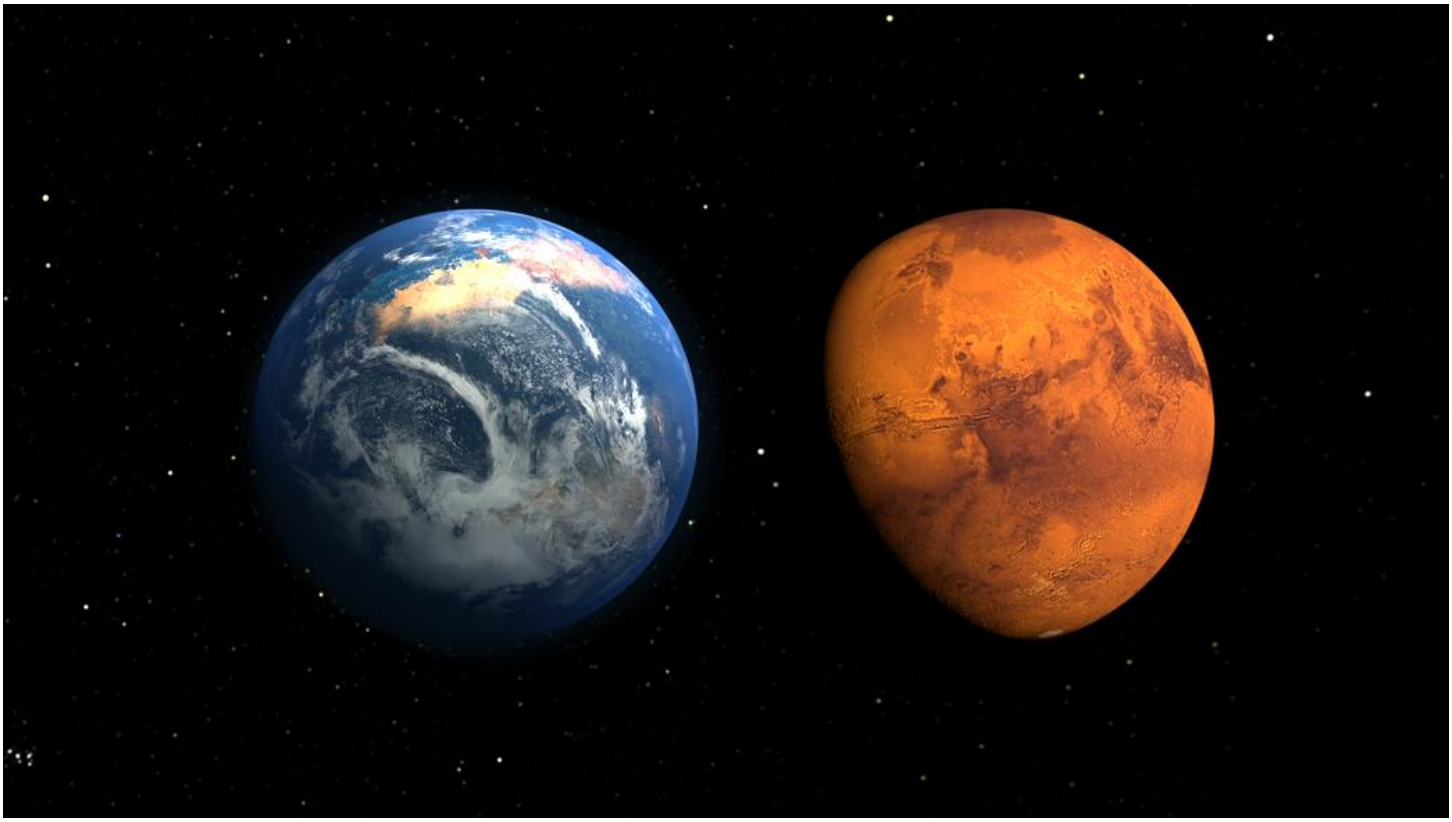
Where Did Mars' Liquid Water Go? (cont'd)

The E. L. Scheller et al. article is notable in proposing a heretofore ignored water reservoir capable of harboring some 2.5 times to 20 times as much water as accounted for in ice, polar ice caps, and water vapor. This accounts for much, if not all, of the discrepancy between the currently "observed" water total and the presumed amount required for hydrological cycle (e.g., erosion, flooding, and such geological formations) remnants observed today. This larger amount of liquid surface water on Mars existed at a time contemporaneous with the emergence of (simple microbial) life on Earth. ◆

See also:

1. H. Kurokawa, "Perspectives: Hydrated crust stores Mars' missing water," *Science* Vol. 372, Issue 6537, pp. 27-28, 02 Apr. 2021.
2. M. Temming, "Most of Mars' missing water may lurk in its crust," Science News, March 16, 2021.
3. C. Q. Choi, "Wet Mars: Red Planet Lost Ocean's Worth of Water, New Maps Reveal," Space.com, March 5, 2015.
4. R. M. Wilson, "New," Physics Today Vol. 68, Issue 5, page 12 (2015).



An artist's rendering of the early Martian environment (left) with liquid water and a thicker atmosphere, versus Mars today (right), with a cold, dry environment. © NASA Goddard Space Flight Center.

NASA's Stratospheric Observatory for Infrared Astronomy

By Ken Lum

Figure 1 – NASA's SOFIA airborne observatory with telescope visible in the observing portal. *(NASA)*

Dr. Dana Backman of the SETI Institute, Search for Extraterrestrial Intelligence, very generously came on February 20, to give a Zoom talk on the **Stratospheric Observatory for Infrared Astronomy (SOFIA)** airborne observatory which NASA and the **German Aerospace Center (DLR)** have been operating jointly since 2010. The SOFIA observatory consists of a 2.7-meter reflecting telescope built into a modified 747-SP aircraft with an openable side portal through which the telescope observes. (Figure 1) It replaces the similar, but smaller Gerard P. Kuiper Airborne Observatory which flew until 1995 and is now preserved at NASA Ames.

The SOFIA observatory flies into the lower stratosphere where it can access infrared parts of the electromagnetic spectrum that cannot be observed from the ground due to excess infrared radiation-absorbing water vapor. As so many astronomical phenomena and objects radiate in the infrared, this asset has been a valuable part of a suite of infrared observatories that have been operational during the last several decades.

SOFIA is one of a suite of infrared-capable observatories that range from ground-based telescopes on Mauna Kea, to the SOFIA observatory itself, and to the Spitzer Space telescope which was decommissioned last year after 16 years of operation. The upcoming **James Webb Space Telescope** will also observe in the infrared range which speaks to the importance of this part of the electromagnetic spectrum.

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NASA's SOFIA (cont'd)

SOFIA flies for seven to eight hours at a time, at an altitude between 35,000 and 45,000 feet. During its observing runs, it is in the dry air of the lower stratosphere which is above 99% of the atmosphere's water vapor.

The SOFIA observatory utilizes a Cassegrain telescope which is mounted on a spherical floating oil bearing. The focal plane is accessible in the crew compartment through its Nasmyth focus where observing instrumentation is mounted. (Figure 2) The telescope observes at wavelengths from 0.3 microns to 1.6 millimeters in the mid to far-infrared portion of the electromagnetic spectrum, much of which is not accessible to Mauna Kea telescopes located at just 13,000 feet above sea level. Gyroscopes keep the SOFIA telescope properly pointed at its observing targets.

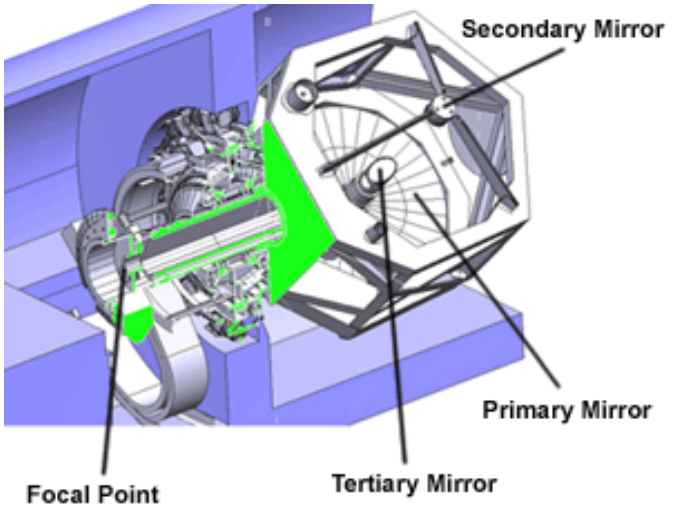

Figure 2 – The SOFIA 2.7-meter IR telescope in its mounting. *(NASA)*

Focal plane instruments available to astronomers include an infrared radiation photometer, multiple spectrometers, an infrared radiation camera, and a polarimeter, all of which can be swapped out and exchanged while on the ground.

SOFIA mainly flies out of NASA's **Armstrong Flight Research Center** in Southern California when in the U.S, and out of Christchurch airport in New Zealand to observe objects in the southern sky. SOPHIA's administrative offices are at NASA Ames.

Highlights of SOFIA's Observing Activities

Dr. Backman reviewed some highlights of SOFIA's observing activities. I include them here:

1. Observing the planet Jupiter in infrared radiation shows where the heat energy from its interior is being released. This is an interesting finding about thermal activity in the interior of the planet as it generates more energy than it receives from the sun. (Figure 3)

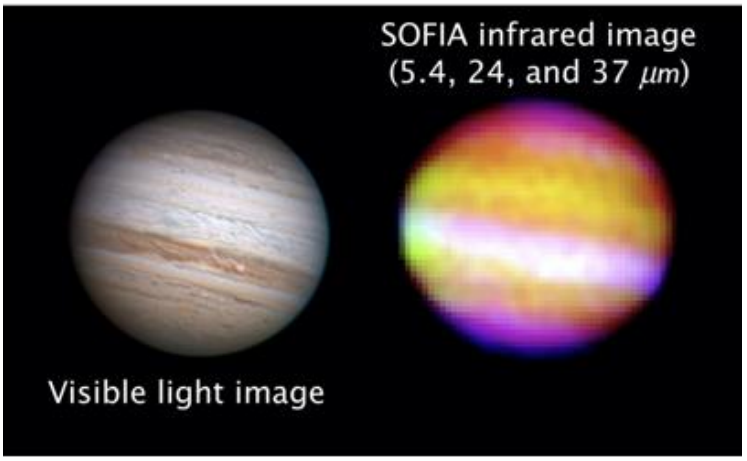

Figure 3 – (left) Jupiter photographed in visible light. *(Anthony Wesley.)*
(right) Jupiter photographed with infrared radiation. *(NASA)*

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NASA's SOFIA (cont'd)

2. Methane monitoring on Mars. A team, now at UC Davis, confirmed the finding of methane in the Martian atmosphere which was detected periodically by the Curiosity rover. Mysteriously, this signal has not been confirmed by the ESA/Russian **Exo Mars Trace Gas Orbiter**, which began operations in 2018. The reason for these contradictory results remains unknown. In the meantime, SOFIA continues to monitor Martian methane. The presence of methane could be an indication of life on Mars, but an inorganic origin has not yet been completely ruled out.

3. Two stellar occultations by the dwarf planet, Pluto, have been observed in 2012 and 2015. Both these observations produced light curves where the starlight initially diminished when Pluto passed in front of the star (Figure 4). There was a central flash when the detected starlight signal increased as Pluto's atmosphere lined up exactly with the occulted star. Curiously, the central flash was weaker in 2012 than in 2015 suggesting that Pluto's atmosphere in 2015 was denser than in 2012. As the dwarf planet is moving away from the sun in its orbit, it was expected that the atmosphere would be denser in 2012 as it should have frozen out more by 2015. The stronger central flash signal in 2015 suggested that Pluto might be outgassing into its atmosphere from internal geologic activity, which was confirmed shortly later by the **New Horizons** space probe.

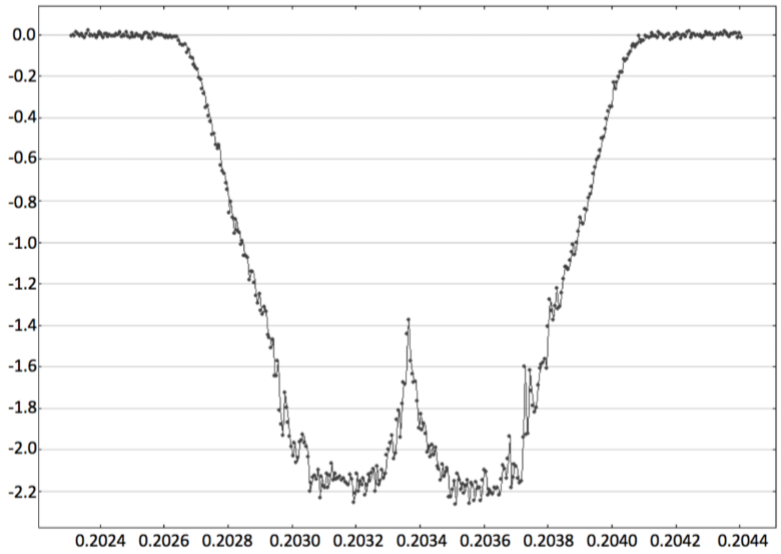

Figure 4 – Pluto stellar occultation light curve with central flash caused by Pluto's atmosphere in 2015. *(NASA)*

4. Because observing in infrared radiation allows penetration through gas and dust clouds, SOPHIA was able to image a ring of molecular clouds orbiting the central supermassive black hole (Sagittarius A*) in our Milky Way galaxy and the central T-shape of gas falling into that black hole. (Figure 5)

Figure 5 – Gas and dust falling into the Milky Way's central black hole. *(NASA)*

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NASA's SOFIA (cont'd)

5. **German Receiver for Astronomy at Terahertz Frequencies (GREAT)** is a spectrometer which was used to find evidence in the planetary nebula NGC 7027 for the cation, **helium hydride ion (HeH+)**. Helium hydride is an unusual ion made with the noble gas helium that is not normally predisposed to forming such compounds except under extreme conditions. Astronomers had predicted that helium hydride should have formed in the extremely hot conditions of the early universe, making it the first compound to form right after the Big Bang. This was the first detection of helium hydride in space and suggested that NGC 7027 has conditions similar to that found in the early universe. (Figure 6) Helium hydride in the early universe would have interacted with hydrogen to form hydrogen gas, which became the molecule from which stars and everything else eventually formed.

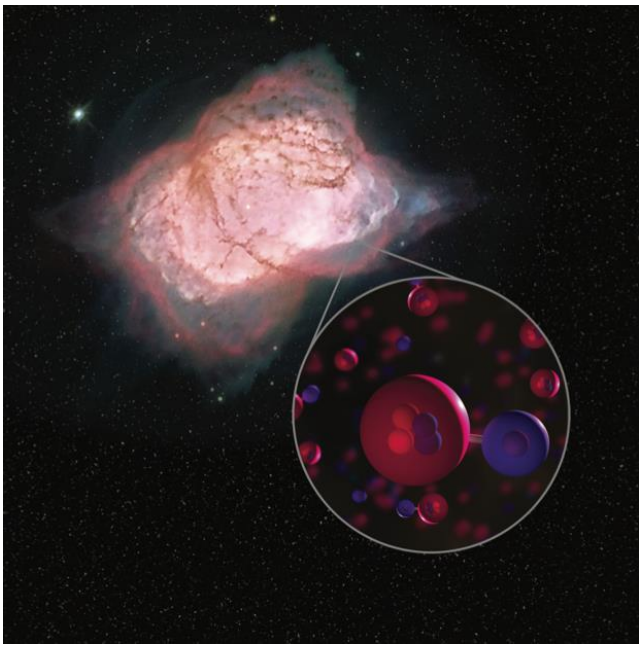

Figure 6 – The planetary nebula, NGC 7027, was found to have conditions compatible with the formation of helium hydride ion. *(NASA)*

6. **High-Resolution Airborne Wideband Camera Plus (HAWC+)** is a far-infrared camera and imaging polarimeter**.** This instrument was used to map the magnetic fields of star-forming nebulae and galaxies. Most recently, the magnetic field of the Whirlpool Galaxy, M51, was mapped as explained in the May 2021 issue of Sky and Telescope. (Figure 7) Although magnetic field lines follow the spiral structure in the center of M51, the field lines are more chaotic in the outer spiral arms, possibly due to active star formation in these regions and interaction with the companion galaxy, NGC 5195.

Figure 7 – Orientation of magnetic field lines in the galaxy, M51, as mapped by SOFIA. *(NASA)*

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NASA's SOFIA (cont'd)

7. Water on the moon has been hinted at by the Lunar Prospector mission observations and actually detected by the Lunar Crater Observation and Sensing Satellite (LCROSS) mission. Also, hydroxide was detected on the moon using ground-based telescopes. But to confirm whether the detected hydroxide was actually from water, SOFIA needed to access the unique 6-micron water-specific infrared emission line. This detection confirmed that the hydroxide moiety initially found actually came from water in shadowed lunar crater soil. The estimated amount of water could be as much as 10 ounces (about 300 grams) per cubic meter of lunar soil, which could be a resource for astronauts traveling to the moon in the future.

Finally, Dr. Backman mentioned that NASA has a SOFIA Airborne Astronomy Ambassadors Program that allows up to six high school teachers on board each flight to participate in observations with SOFIA. These teachers bring this valuable experience with them back to their classroom teaching activities. Applications for this program may be made through the SOFIA Office at NASA Ames.

Click here to watch Dr. Dana Backman's lecture on SMCAS's YouTube channel. ◆

Hertzsprung-Russell Diagram and the Life Cycle of Stars

By Ken Lum

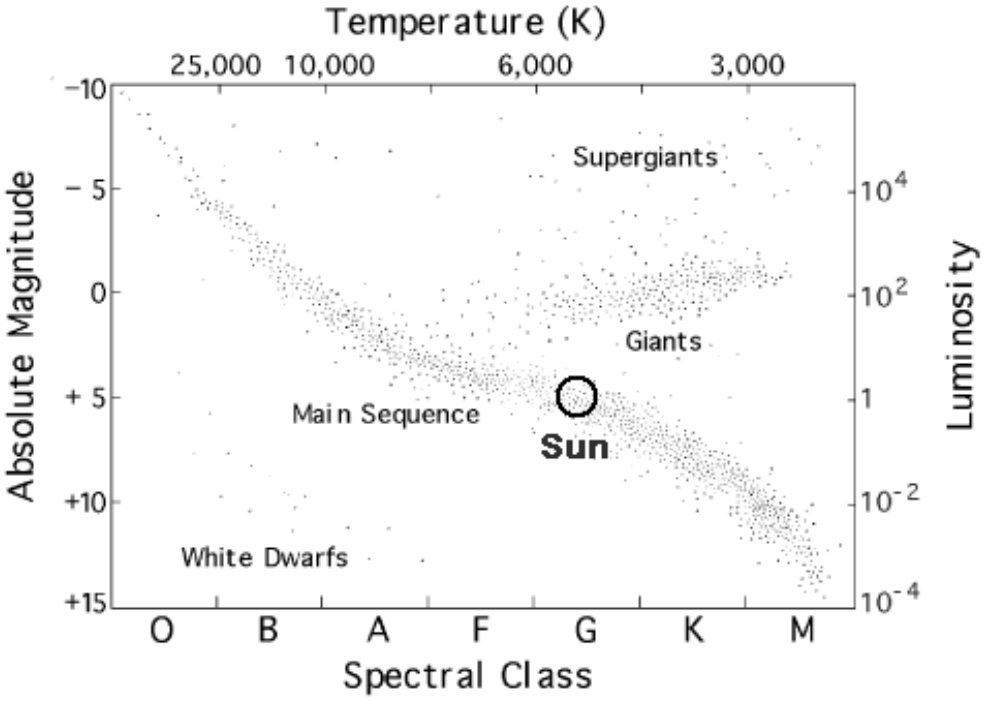


Figure 1 – Hertzsprung–Russell diagram shows where various star types are located on the plot. Spectral type is an indicator of surface temperature so the two characteristics can be used interchangeably. *(NASA)*

Hertzsprung-Russell Diagram and the Life Cycle of Stars (cont'd)

The **Hertzsprung-Russell (HR) diagram** is an indispensable tool for understanding how stars evolve through their life cycles. This tool was invented independently by the Danish astronomer Ejnar Hertzsprung and the American astronomer Henry Norris Russell in the early 1900s. It is a plot of the surface temperature versus the absolute magnitude (intrinsic luminosity) of stars. (See Figure 1 on page 16.) When stars of differing luminosities and surface temperatures are plotted on the HR diagram, they are found to bunch up in different regions of the diagram depending on the star type.

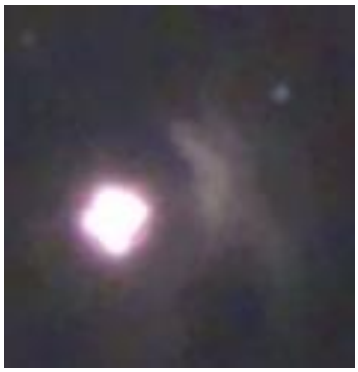


Figure 2 – T Tauri protostar with its nebula of origin, NGC 1555. *(Ken Lum)*

Stars form from the collapse of mostly hydrogen gas clouds to form protostars. (Figure 2) As protostars heat up during collapse, nuclear fusion of hydrogen into helium begins when their cores reach temperatures of around 100 million Kelvin degrees. The young stars take on luminosities and surface temperatures that make them bunch together along a diagonal distribution that snakes from upper left to lower right called the **Main Sequence.** (See Figure 1 on page 16.)

Once nuclear fusion starts, the star spends most of its lifetime on this diagonal distribution and is called a **Main Sequence star**. Where it ends up on this distribution depends on the mass of the star. Less massive stars (sun-like and smaller) shine fainter and cooler so they tend to gather in the lower right. More massive stars shine brighter and hotter making them occupy more the upper left of the Main Sequence. Stars of intermediate mass, such as our sun (spectral type G), end up in the middle of the graph. (See Figure 1 on page 16.)

As a star ages and runs out of hydrogen fuel, its core accumulates mostly the fusion products helium and other heavier elements. The core starts to shrink under its gravity causing an increase in pressure and temperature. When the core temperature gets high enough, fusing helium and those heavier elements can generate even more energy.

This causes the star to expand into a **red giant** or **supergiant** stage where it has a lower surface temperature but remains intrinsically bright because it is so large. When this happens, the star moves into the upper right of the HR diagram where red giants and super giants are located. (See Figure 1 on page 16.) Both stars of lower (sun-like) and higher mass undergo this giant stage in their later development. (Figure 3)

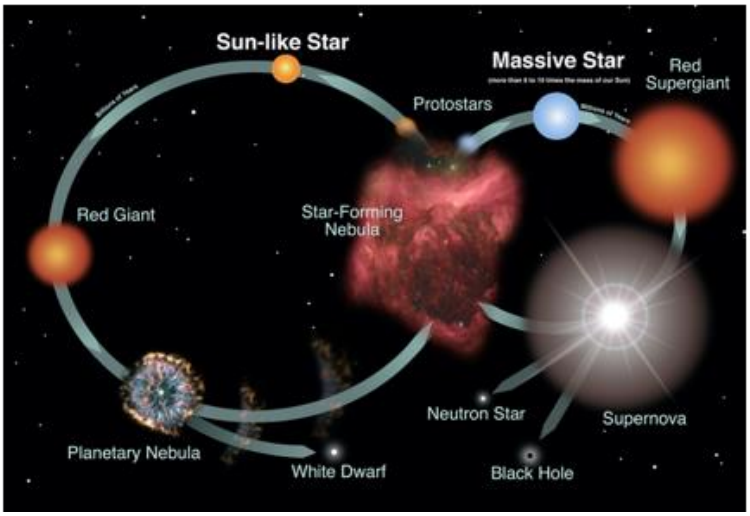


Figure 3 – Diagram shows the lifecycles of stars. The left side illustrates the pathway of less massive sun-like stars while the right shows the path for more massive stars. *(NASA and Night Sky Network)*

(continued on page 18)

Hertzsprung-Russell Diagram and the Life Cycle of Stars (cont'd)

The Fate of Less Massive Sun-like Stars

Less massive sun-like stars of eight solar masses or less eventually use up their core helium and convert most of it to carbon. The outer layers of its atmosphere then drift off into space forming an object known as a **planetary nebula**. Its core gradually cools and shrinks by its gravity to an end state called a **white dwarf** which cannot shrink any more due to the incompressibility of its electrons.

White dwarfs typically have a size about that of the Earth but have a mass about half that of the sun. This makes them about 200,000 times denser than the Earth. They are very faint but also have very hot surfaces, so they gather in the extreme lower left part of the HR diagram. (See Figure 1 on page 16.) Eventually they cool to the point where they no longer emit any radiation and become **black dwarfs**. But it is estimated that black dwarfs actually do not exist as yet as it takes longer than the current age of the universe to form these objects.

Figure 4 shows the path of a sun-like star on the HR diagram as it evolves along its life cycle from initial gravitational collapse as a protostar. Then it starts thermonuclear fusion of hydrogen as a Main Sequence star. This is followed by expansion as a red giant star as it fuses helium after running out of hydrogen. It subsequently heats up, then cools down to become a white dwarf and then possibly a black dwarf.

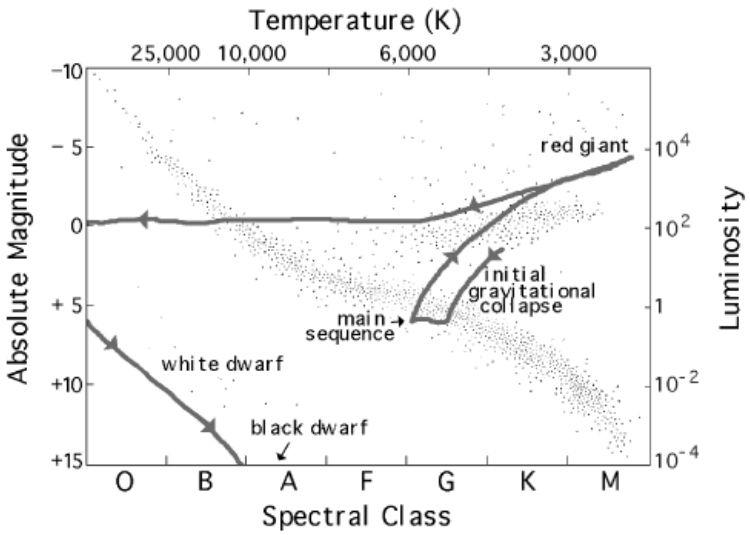


Figure 4 – Evolutionary path of a sun-like star on the HR Diagram. The movement of the star off the temperature scale and to the left, means the star has achieved very high surface temperatures that may exceed 100,000 Kelvin degrees before cooling down. *(NASA)*

The Fate of More Massive Stars

Stars of eight to 25 solar masses have core temperatures and pressures high enough to fuse hydrogen to helium, then, helium to carbon, oxygen, neon all the way up the periodic table to iron during the supergiant phase. But iron cannot be fused any further as the reaction requires more energy than it produces. Due to a lack of energy from further elemental fusion, the entire star collapses in a few seconds and explodes violently as a **Type II supernova**. The final remnant of this process is usually a **neutron star**.

(*continued on page 19*)

Hertzsprung-Russell Diagram and the Life Cycle of Stars (cont'd)

Neutron stars have extremely hot surface temperatures in the hundreds of thousands of degrees but low visual luminosity. They can be plotted on an HR diagram but mainly at very high temperatures and low luminosities way to the lower left side of the graph.

Should the star's mass be in the range of 25 to 100 solar masses, the remnant is likely to be a **(stellar mass) black hole**. (Figure 3) Such a black hole emits no radiation except at its event horizon and accretion disk. Stellar-mass black holes have very low temperatures, near absolute zero, and so are not plottable on an HR diagram.

Extremely massive stars of 100 or more solar masses are extremely rare but may have been more common right after the Big Bang when they were the first stars. A supernova from such a massive star is estimated to be so violent as to completely obliterate the star, leaving only a cloud of gaseous and fragmentary debris behind.

What can be learned from an HR Diagram.

A star's luminosity and surface temperature are measured directly with a telescope and spectrograph. Once the star's luminosity is plotted versus its surface temperature on the HR diagram, the following stellar properties can be determined:

1. Where it is in its stage of evolution.
2. How large it might be.
3. How massive and dense it might be.
4. Its age.
5. The distance of its location.

So, this simple diagram can reveal many fundamental characteristics of stars. Much of the material for this article comes from Chanan Greenberg's talk in January on the Life Cycles of Stars. Click here to see the lecture on The Society's YouTube channel. It is well worth watching if you did not attend the original talk or want to review this topic further.◆

Different Types of Stars

By Michelle Morales Torres

Published April 10 in the San Mateo Daily Journal. Look Up is an astronomy column that is published every Saturday.

Since it's been so cloudy it seems like the appropriate time to look at the different types of stars. Particularly since we learned about a new type last week. If you recall, we were exploring the constellations of Perseus. Its most famous star is Algol, better known as the Demon Star, and is a "variable star," meaning it brightens and dims with regularity and it's visible to the naked eye. So some stars actually do appear to twinkle.

Back in September we looked at the different main sequence stars but didn't explore the different types of stars, such as variable stars. According to PhysicsOfTheUniverse.com, the other types of stars are brown, red, yellow, white and black dwarfs, white stars, red and blue giants and neutron stars.

Brown dwarfs are also called "failed stars," since they never reach sufficient mass, density and internal heat to start the nuclear fusion process. They may glow dimly when newly formed and are actually red not brown, they start to cool soon after and so are very difficult to spot. They may be among the most common type of stars.

While red dwarfs are small and relatively cool stars but bigger than brown dwarfs. They have less than 40% to 50% of the mass of our sun. Most of the stars in our galaxy are red dwarfs and are much dimmer than our sun. Even the largest red dwarf only has about 10% of the sun's luminosity. They burn much more slowly and typically live much longer.

Yellow dwarfs are main sequence stars, like our own sun. Some are actually more white than yellow.

White dwarfs are small, dense, burnt-out husks of stars. They are no longer undergoing a fusion reaction and represent the final evolutionary state of most of the stars in our galaxy. When a red giant has used up its helium to produce carbon and oxygen and also has insufficient mass to generate the core temperatures required to fuse carbon, it sheds its outer layers to form a planetary nebula, that leaves behind an inert mass of carbon and oxygen. A white dwarf is typically only the size of the Earth, but 200,000 times denser.

Whereas black dwarfs are actually hypothetical stellar remnants created when a white dwarf becomes cool and dark, after about 10 billion years of life. Black dwarfs are very hard to detect and very few would exist anyway in a universe only 13.7 billion years old.

White stars are bright, main sequence stars with masses from 1.4 to 2.1 times of the sun and are actually hotter than our sun, too.

Red giants are luminous giant stars of low or intermediate mass in a late phase of stellar evolution. When a main sequence star has fused all its hydrogen into helium, it then starts to burn its helium to produce carbon and oxygen causing it to expand to many times its previous volume to become a red giant.

(continued on page 21)

Different Types of Stars (cont'd)

After about 200 hundred million years, the red giant puffs out its outer layers in a gas cloud called a nebula and collapses in on itself to form a white dwarf. The largest red giants are known as red super giants and are the largest stars in the universe in terms of volume.

Blue giants are bright, giant stars that are between 10 and 100 times the size of the sun and have a luminosity between 10 and 1,000 times. Because of their mass and hotness, they are relatively short-lived and quickly exhausting their hydrogen fuel, ending as red super giants or neutron stars. The biggest and most luminous stars are referred to as blue super giants and hypergiants.

Neutron stars are stellar remnants that can result from the gravitational collapse of massive stars during a supernova event. They are composed almost entirely of crushed neutrons and are very hot and very dense. Although a typical neutron star has a mass of only between 1.35 and about 2.1 times that of our sun, it is 60,000 times smaller than it. Because of its huge density, it has a gravity of over 200 billion times than we experience on Earth. They rotate very fast, especially soon after the supernova explosion and some emit regular pulses of radiation called pulsars. Smaller collapsed stars will usually become white dwarfs, and larger ones will collapse completely into a black hole singularity.

Lastly, are binary stars. We have also discussed those previously. They are two stars that orbit around a common center of mass. In fact, the majority of stars are part of binary, triplet or multiple star systems. Stars that orbit around each other are considered a star system, regardless of the number of stars. ◆

Member Astrophoto

The Leo Triplet group of galaxies in the constellation Leo is about 35 million light years away. M65 is at the right top, M66 is at the right bottom and NGC 3628 is on the left. It was taken by stacking 30 5-minute frames for a total exposure of 2.5 hours. Taken on April 1 by member Kumar Srinivasan from his deck in Redwood Shores. He used a Canon T3i DSLR camera attached to SkyWatcher Evostar 100ED 4-inch refractor, mounted on a SkyWatcher HEQ5 equatorial mount. Processed with PixInsight. More photos can be seen on his website, www.thestarryknight.net.

NASA Night Sky Notes
Virgo's Galactic Harvest

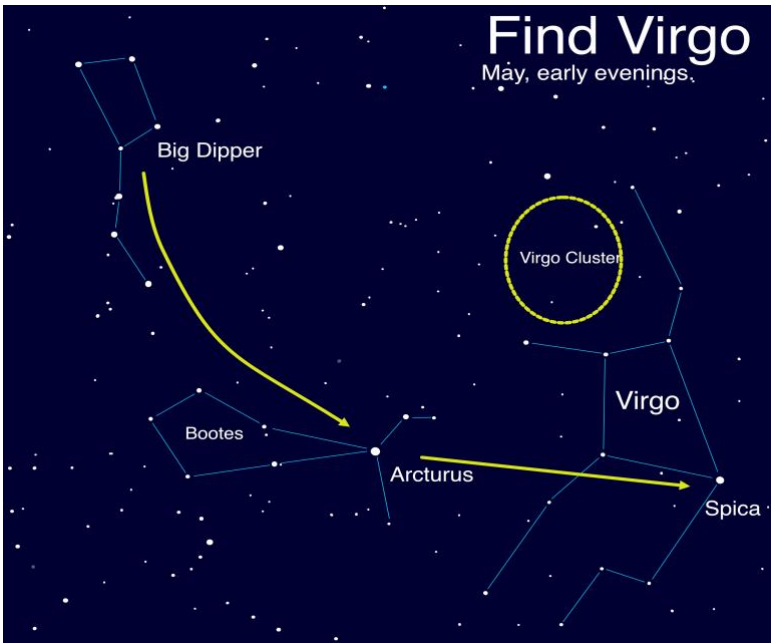
By David Prosper

May is a good month for fans of galaxies, since the constellation Virgo is up after sunset and for most of the night, following Leo across the night sky. Featured in some ancient societies as a goddess of agriculture and fertility, Virgo offers a bounty of galaxies as its celestial harvest for curious stargazers and professional astronomers alike.

Virgo is the second-largest constellation and largest in the Zodiac, and easily spotted once you know how to spot Spica, its brightest star. How can you find it? Look to the North and start with the Big Dipper! Follow the general curve of the Dipper's handle away from its "ladle" and towards the bright orange-red star Arcturus, in Boötes – and from there continue straight until you meet the next bright star, Spica! This particular star-hopping trick is summed up by the famous phrase, "arc to Arcturus, and spike to Spica."

This large constellation is home to the Virgo Cluster, a massive group of galaxies. While the individual stars in Virgo are a part of our own galaxy, known as the Milky Way, the Virgo Cluster's members exist far beyond our own galaxy's borders. Teeming with around 2,000 known members, this massive group of galaxies are all gravitationally bound to each other, and are themselves members of the even larger Virgo Supercluster of galaxies, a sort of "super-group" made up of groups of galaxies. Our own Milky Way is a member of the "Local Group" of galaxies, which in turn is *also* a member of the Virgo Supercluster! In a sense, when we gaze upon the galaxies of the Virgo Cluster, we are looking at some of our most distant cosmic neighbors. At an average distance of over 65 million light years away, the light from these galaxies first started towards our planet when the dinosaurs were enjoying their last moments as Earth's dominant land animals! Dark clear skies and a telescope with a mirror of six inches or more will reveal many of the cluster's brightest and largest members, and it lends itself well to stunning astrophotos.

Virgo is naturally host to numerous studies of galaxies and cosmological research, which have revealed much about the structure of our universe and the evolution of stars and galaxies. The "Universe of Galaxies" activity can help you visualize the scale of the universe, starting with our home in the Milky Way Galaxy before heading out to the Local Group, Virgo Cluster and well beyond! You can find it at bit.ly/universeofgalaxies. You can further explore the science of galaxies across the Universe, along with the latest discoveries and mission news, at nasa.gov.



Directions to SMCAS Public Star Parties (Weather Permitting)

From Hwy 101 or El Camino: take Brittan Avenue in San Carlos, west (toward the hills). Follow Brittan 2.3 miles (from El Camino) to Crestview Drive. Turn right on Crestview. In half-a-block, you will see a small, blue-posted sign with an arrow, indicating the entry road into Crestview Park. It lies between houses with addresses #998 and #1000 Crestview Drive.

From Highway 280: take Edgewood Road exit. Go east (toward the Bay) about 0.8 miles. Turn left at Crestview Drive. Go 0.5-mile uphill to where Crestview meets Brittan. Again, drive the half-block, to the small blue sign on the right, and the entry road on the left.

From Hastings and Club Drives: From Belmont, take Carlmont Drive to Hastings Drive. Follow Hastings about 1.5 miles, first uphill, then down, to San Carlos where it becomes Witheridge Road, then ends a block later at Club Drive. Turn right and climb Club Drive to Crestview Drive. Turn left and continue some 2 miles, first up, then down past Leslie Drive, to the small blue Crestview Park sign on the left. Turn right into the Crestview Park entry road.

Crestview Park - San Carlos

Come on out, and bring the kids, for a mind-blowing look at the Universe!

Bring your binoculars, telescopes, star guides, and lounge chairs for some informal star gazing at Crestview Park.

Dress warmly and wear a hat. Only visitors with telescopes should drive in. Others should park on the street and walk in or arrive before dark so that car headlights don't affect the observers' dark adaptation. Bring small flashlights only, covered with red cellophane or red balloon.

These measures avoid safety issues of maneuvering in the dark, as well as ruining the night vision of the viewers.

Please don't touch a telescope without permission. And parents, please don't let children run around in the dark.

Note: If bringing a telescope and arriving after dark, please enter the Park with your headlamps and white interior lights off. If you aren't bringing a telescope, whether before or after dark, please park along Crestview Drive, and walk in.

Crestview Park is residential, adjacent to homes and backyards. Before inviting potentially noisy groups, please call Ed Pieret at (650) 595-3691 for advice and advisories**. Call Ed also to check the weather and 'sky clock' and to see whether the Star Party is still scheduled.**

Crestview Star Party schedule is here:
http://www.smcasastro.com/crestview-park.html

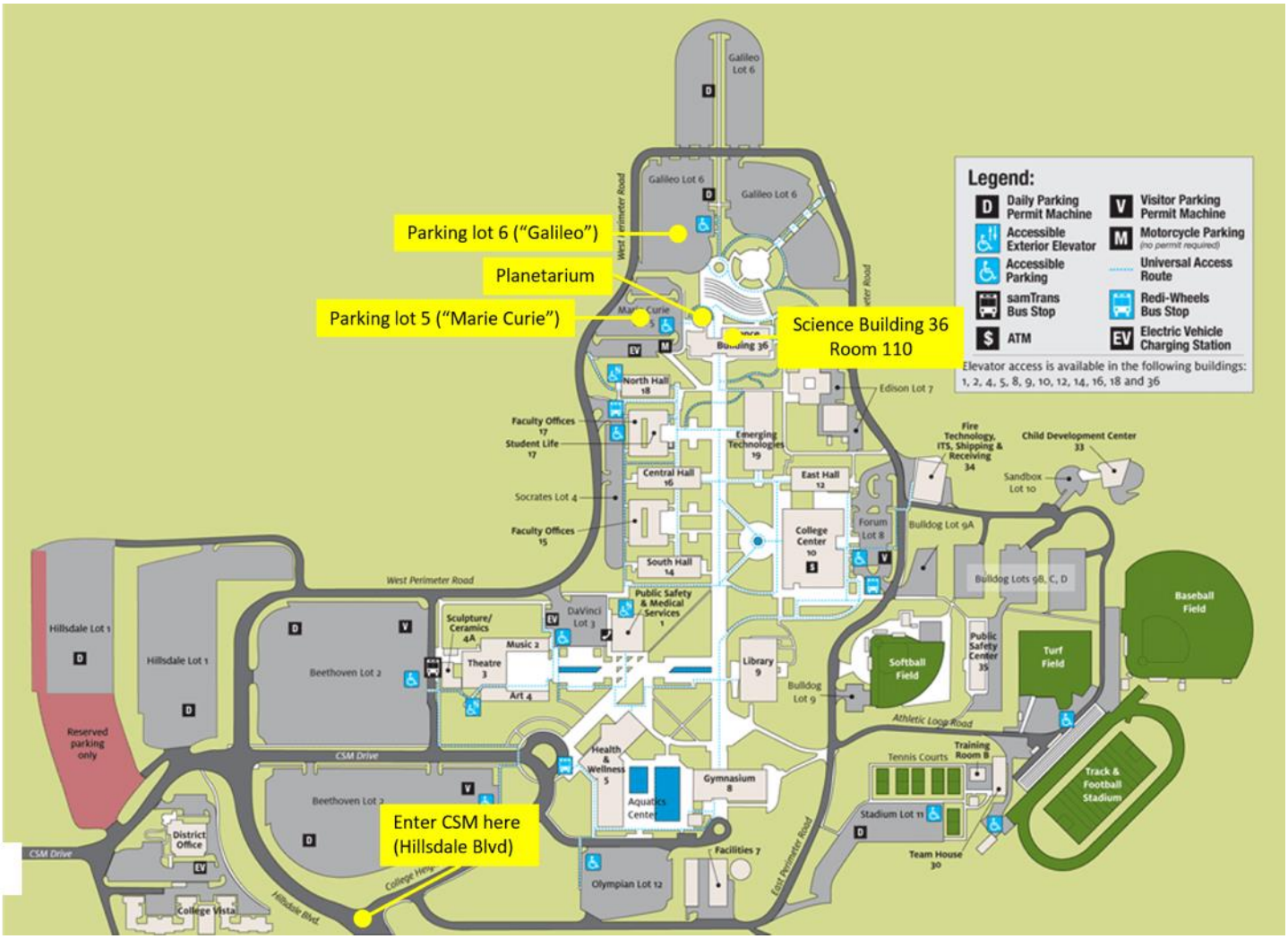
From San Carlos, take San Carlos Avenue to Club Drive, and climb to the 5-way intersection. Take the half-right to continue on Club Drive past Witheridge Road to Crestview Drive. Proceed as above to Crestview Park.

Directions to SMCAS Meetings at The College of San Mateo:

NOTE: CSM is closed due to the pandemic.

SMCAS events are online until further notice.

Directions to the CSM Planetarium for Meetings:
After exiting Hwy 92 at Hillsdale Blvd, climb the hill towards CSM, passing two traffic lights to the stop sign at the top of Hillsdale Blvd. Continue straight onto West Perimeter Road and follow it until you reach Lot 5, "Marie Curie", or Lot 6, "Galileo." Science (ISC) Bldg. (36) and the Planetarium lie straight ahead. Enter Bldg. 36 either through the door facing the lot or walk around the dome to the courtyard entrance. We meet in ISC room 110 for pizza and soft drinks one hour prior to the talk in the Planetarium (Pictured below.)



Become an SMCAS Member Today! Here's what you get:

- **Members Community**

Friendly advice and guidance from experienced recreational astronomers; access to SMCAS group emails, which provide general orientation information, announcements of astronomy events, file access and exchange.

- **SMCAS Events**

General meetings are held the first Friday of most months, at 7pm in the Integrated Science Center (ISC) Room and Planetarium in the Science Center (Bldg. 36) at the College of San Mateo (CSM), 1700 W. Hillsdale Blvd., San Mateo. Meetings include lectures and presentations on space science, an activity session, and refreshments (usually pizza).

We also offer stargazing two Saturdays a month, weather permitting. Visitors and those without telescopes are welcome; members are glad to share! SMCAS also has sponsored dark-sky campouts at Fremont Peak State Park, field trips to SLAC, KIPAC and Lick Observatory, plus **member-only events, including Star-B-Ques and quarterly potlucks.**

- **Subscriptions** (free with your membership)

The Event Horizon, SMCAS' newsletter, with SMCAS and member information, viewing tips and articles.

The Reflector, published quarterly by the Astronomical League, a national alliance of astronomy groups like SMCAS.

- **Significant Discounts on Equipment and Publications**

Discounts on purchases at Bay Area astronomical equipment retailer Orion Telescope Center, on sky calendars and ephemerides, and on such periodicals as *Sky & Telescope* and *Astronomy*.

- **Access to Loaner Equipment**

Use of SMCAS loaner telescopes and other astronomy equipment.

- **Sharing your Appreciation of Astronomy and Space Science with the General Public.**

Your SMCAS membership helps bring astronomy to interested lay people, especially students and children

Annual Dues: (SMCAS is a tax-exempt non-profit 501(c)(3). Dues may be tax deductible; consult your tax advisor):

$30 Regular Family Membership; $15 Student Membership

Every membership includes all members of your immediate family, (including your kids).

To join you can:

Send application (see reverse side), with payment, to: SMCAS, P.O. Box 974, Station A, San Mateo CA 94403.

- Bring the completed application and payment to a meeting or event and give it to any SMCAS officer.
- Go online at http://www.smcasastro.com, click on the Membership tab and pay via PayPal.

Membership Application on next page

San Mateo County Astronomical Society
Membership Application

SMCAS@live.com; P.O. Box 974, Station A, San Mateo CA 94403; (650) 678-2762

rev 02272020

Date: _____ Please check one: [ ] New Member or [ ] Renewal

[ ] $30 Regular Family Membership; [ ] $15 Student Membership

All members, please indicate areas of interest below. New members, please complete entire form. Renewing members, please provide your name and any information that has changed in the last year.

We will list your name, address, email address, and phone number(s) in our membership roster unless you have checked the box preceding that information. The membership roster is distributed to active members only.

Each member's name and mailing address must be provided to the Astronomical League (AL), SMCAS' umbrella organization. If you don't want AL to have your phone number and email address, indicate below.

[ ] Name(s) _____ [ ] Email Address _____

[ ] Address _____

[ ] City & Zip Code _____

[ ] Phone Number(s): _____ [ ] Do not provide my phone number(s) to the AL.

[ ] Don't provide my email address to the AL. (Checking this means you can ONLY get ***The Reflector*** by regular mail)

Please check one: send ***The Reflector*** [ ] by mail, or [ ] by email.

Areas of Interest:

SMCAS encourages member involvement. We invite you to provide additional information about your interests, skills, occupation and prior experience. Please identify SMCAS projects and functions that you might like to help facilitate.

_____

Please indicate which of the following activities might be of interest to you:

____ **Star Parties - Do you own a telescope you can bring: Yes ( ) No ( )**

____ **General Meetings - Finding (or being) a Speaker. Official greeter. Set up or take down ISC or refreshments.**

____ **Family Science Day & Astronomy Festival (Usually at CSM the first Saturday in October).**

____ **Social Events - Equinoctial and Summer Solstice potlucks, Summer Star-B-Que, Holiday Potluck.**

____ **SMCAS Membership and Promotional Drives**

____ **Communications – 'Event Horizon' Newsletter, Website(s), Facebook page, group email, Publicity posting.**

____ **Educational Programs – School, museum and library star parties, Bay Area Astro teacher assistants.**

Other/Comments: _____