FIRST LIGHT

*Journal of the South Bay Astronomical Society – March 2024*
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## Monthly General Meeting: Friday March 1st 7:30 PM

## "Interplanetary Navigation for Dummies"

## Ken Munson

# *The February 2 Meeting*

President Steve Pedersen rang the meeting to order at 7:35, and asked for observing reports. Steven Morris passed around a photograph of himself and twenty-two other hikers observing the October 14, 2023 partial solar eclipse through solar eclipse glasses, taken at Portuguese Point on the Palos Verdes Peninsula. Gerald Gmoser reported seeing five meteors while looking out over the ocean during the Geminid meteor shower last December. Steven Morris also pointed out that sometime in the next few months, he will give the SBAS a lecture about black holes.

After a six-minute social break, the rest of the meeting was spent watching the Youtube video "Journey to the Edge of the Universe". Light travels at the speed of 'only' 300 million meters per second, so we do not see astronomical objects as they look now, but as they looked at an earlier time, when the light was emitted. A telescope acts as a sort of time machine; as we look at objects that are at greater distances, we see the Universe as it appeared earlier in its existence.

The Big Bang occurred 13.6 billion years ago, and the Universe has been expanding and evolving ever since. When we look at objects in the Local Universe, we see galaxies like our Milky Way, containing billions of stars and grouped into clusters, superclusters and filaments. We know that these objects are relatively nearby, because they have redshifts ($z < 0.1$) that are relatively small. The redshift indicates the fractional increase of the wavelength of the observed light, caused by the expansion of the Universe.

Past $z = 0.1$, we see objects as they existed more than one billion years ago, when the massive black holes at the center of many galaxies were more active, giving rise to quasars and gamma ray bursts. At $z = 2$, star formation in these primordial galaxies was at its most rapid, and the James Webb space telescope is being used to study the details of these objects, that appear too small and faint to us to be studied by Earth-based observatories.

At $z = 6$, about one billion years after the Big Bang, we see the end of the Era of Reionization, as the light from the earliest stars in the Universe finished turning the interstellar gas back into plasma. The youngest galaxy we have observed from this era, named HD1, has a redshift of $z = 13.27$, and we see it as it existed only 330 million years after the Big Bang.

At $z = 20$, our optical view of the Universe ends, as no stars existed, only un-ionized gas. However, with radio and microwave detectors, we can see when the primordial plasma first became transparent as it turned into un-ionized gas, at $z = 1090$, when the Universe was only 380,000 years old. This Cosmic Microwave Background Radiation is the oldest radiation we can see, and the gas that emitted it when the gas was less than half a million light years from

us, is now 46 billion light years from us due to the expansion of the Universe.

After the audience of six finished this mind-expanding tour of the Universe, the meeting was adjourned at 8:32.

***-Dr. Steven Morris***

# *Outreach Events*

**Victor Elementary School –** We had two, back-to-back, star parties at Victor Elementary School in Torrance at the end of January. Unfortunately, we also had two very bad weather systems bearing down on us in the same week. The events had been scheduled in support of the school's science fair. The first night, January 31st, was the 3rd through 5th grades. The second night was for 1st and 2nd grades. The school didn't want to have to cancel so, Ken Lehmer and Ken Munson bravely brought their telescopes and began setting up around 4 PM on the 31st.

As had been expected, the weather was pretty cloudy with only a few patches of clear sky. Luckily, we did get enough of the Sun to get at least one initial alignment point for our Nexstar telescopes. We had a brief period of clear sky and I was able to find Jupiter for a second alignment point. As the Sun was setting, more clouds moved in and threatened to really ruin the night.

It was, indeed, a very difficult and frustrating night as we struggle with thick cloud cover for most of the 1st hour of the event. Quite frequently, we had only a few seconds for one person or another to get a look at Jupiter through the occasional small openings we were getting. Then, amazingly, at about 6:45 PM, the sky began to clear up and we had a long period of reasonably clear sky for the families to get at least a look at Jupiter.

Thursday dawned with heavy rain as the atmospheric river swept through the LA area. A check of the weather prediction and satellite images showed more open sky would be coming in behind it by late afternoon. Once again, Ken Lehmer and Ken Munson set up their scopes around 4 PM, this time with much more clear sky. A few patchy clouds were passing by but not so bad that we were as badly blocked as the previous night. We were able to again use the Sun as an initial alignment point and Jupiter as a second point. With two points, it was then pretty easy to find a couple of stars even with the Sun still in the sky. Aldebaran was easily visible with its red color against the deep blue background. Deneb was a bit more of a challenge as it was a white star and closer to the part of the sky where to Sun was.

With my telescope fully aligned, I put it on Jupiter and talked to one of the teachers supervising some very young students in the afterschool program and invited them to take a look at Jupiter. The kids were really thrilled to see a big planet and thought the stripes on it were cute. One little girl really struggled to figure out how to look through the eyepiece. When she finally saw Jupiter, she was ecstatic!

Then, I swung the scope up to Aldebaran to show them that, if you knew exactly where to look, you could see a star in daylight. That really amazed them.

As the evening science fair/star party got under way at 6 PM, we had more patchy clouds but also long periods of open sky. It was a much more successful evening that the previous one with more and more people lined up at the scopes. I had mine on Saturn for as long as I could while Ken Lehmer tracked Jupiter. For a while, once Saturn was too low, I put mine on Jupiter as well. One girl, who was maybe in 2nd Grade, wanted to see a nebula. So, I put my OIII filter in the 40mm eyepiece and swung over to M42, the Great Nebula of Orion. She gasped when she saw it. And then she didn't want to leave the scope! Her mom had to coax her away to let others get a look. She did come back later and again, spent several minutes gazing at the nebula.

The evening came to an end about 7:30 PM as planned. It was just moments after the last visitors looked through the scopes that the sky was suddenly fully overcast. We began putting the equipment away. Just as we were finishing put all our gear back into our cars, it began to sprinkle. Talk about good timing!

On Thursday, February 15th, we were again back at Victor Elementary School in support of their STEAM Fair Science Night. This was a night for students to show off their own "inventions" and other projects. This night was probably the best night we had a Victor with more clear sky than the previous two occasions. Again, Ken Lehmer and I, joined by Larry Kinney, set up our scopes at 4 PM and offered an early look for the afterschool program kids.

The STEAM Fair started a bit earlier than expected which made it fortunate that we were able to set up so early. The one downside was that the crowd wasn't as big this time around. But that did allow us to show a few more objects besides Jupiter and Saturn. This time we had the Moon up in the sky and it made a fine target for those who wanted to take pictures through my telescope with their cell phones. As usual, that was really popular. It turned out to be another very successful night.

**York Elementary School –** The very next night we had a star party at York Elementary School in Hawthorne. It's been many years since the last time we did a star party at this school and the teachers and students were really looking forward to it. This was an evening with what was the best weather so far in February. Beautifully clear skies offered really good seeing. Ken Lehmer, Larry Kinney and I set up our scopes about 4 PM and offered an early look for the afterschool program students. Unlike other schools, this school has part of its campus across the street, on the far side of the quad where we were set up. So, it took a while for the teachers supervising those kids to walk them over but they certainly enjoyed getting a look at the Sun, then Moon and Jupiter.

The crowd was really big and a long line wrapped around the area where we were set up. I set my scope on the Moon and attached my NexYZ cell phone adapter. Ken Lehmer put his scope on Jupiter and Larry Kinney also put his on the Moon. Once again, almost everybody seemed to want to get their very own pictures of the Moon through a telescope. Jupiter was very nice with all four of the Galilean moons stacked to one side of the planet.

The event was scheduled from 5 – 6:30 PM and there was such a long line that we had to star urging people to spend less time looking and I had to detach the NexYZ. Kind of hated to have to do that as I'd gotten really good at sliding cell phones into it and having the owners snap a couple of quick pics.

We finished off the last people who'd waited patiently in line and by about 6:45 began tearing the scopes down. It was a real nice treat that we did get some dinner as part of this star party. Once again, a very successful evening.

**Carr Elementary –** Ken Lehmer, Larry Kinney, Gerry Stowe and Ken Munson brought their scopes to Carr Elementary School in Torrance on February 22nd. In what has been really rare this month, the weather was spectacularly clear. A light breeze did make things a tad chilly, though. We did this school, located near El Camino College, for the first time last year about this same time.

I'd had difficulty getting my initial alignments in this and the previous star party. Normally, an initial alignment on the Sun is good enough to get the scope to be very close to Jupiter. But it wasn't even going to the Moon accurately. After some checking things, I powered down and reran the alignment and finally realized what was wrong. I was starting my first alignment on the Sun before the on-board computer had fully locked onto the GPS time signal. Once I waited and then aligned on the Sun, the hop to Jupiter ended with Jupiter in the FOV of the main telescope.

Once again, we offered an early look to the afterschool kids. There were some activities going on in the classrooms for them so teachers brought them out to the playground. We gave them a look at the Sun and the Moon, which was just rising in the east as the Sun was setting.

This was also their STEAM Fair night. The event ran from 5 PM to 6:30 PM. It wasn't a huge crowd so it did allow more time for more people to photograph the Moon through my telescope using the NexYZ adapter. That's always a big attraction. I was very impressed by one dad who showed me what his Galaxy phone could do. He was able to get nearly as good an image just using his hand-held cell phone as what people were getting through the telescope. His phone seemed to do a really good job of zooming way in and removing all muscle jitter so that he ended up with a nicely focused image. My iPhone 14 was not nearly as good. He couldn't do so good with Jupiter though. So, we tried his phone and my telescope. With that, he was able to get Jupiter dimmed down enough so that he could clearly see the equatorial cloud belts and still see the four Galilean moons.

Kids, parents, teachers and even the custodian had a great time that evening!

- ***Ken Munson***

# SBAS Executive Board

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# Monthly General Meetings

We normally meet on the first Friday of each month at 7:30 p.m. in the Planetarium at El Camino College (16007 Crenshaw Bl. In Torrance). If the first Friday is on or close to a holiday, we usually defer the meeting until the second Friday of the month. The Planetarium is on the south side of Manhattan Beach Blvd., one block west of Crenshaw Blvd. (near the center of the map at left).

The planetarium is the only round, domed building on campus. There is on-street parking, and we can often use campus parking: check inside to see if you need a FREE parking permit for your car.

We enjoy the planetarium facilities through the courtesy of the El Camino College Administration and have several faculty members of the Astronomy Department as members of our Club. Our meetings always include an informal opening, when new attendees are invited to introduce themselves and let us know about their interests in astronomy. Members share their latest news and observations at this time. The rest of the evening is devoted to guest speakers, who range from amateur astronomers to professional astronomers to representatives from local aerospace companies to college professors. We are fortunate to have all these talented people in our area, willing to come and talk to us.

# Monthly Planning Meeting

Committee members (and anyone else with an interest in Society activities) meet each month, usually on the Monday following the general meeting. Meetings are sometimes rescheduled due to travel and other circumstances. Exact date and time of each month's meeting will be announced in the monthly meeting. The February planning

meeting will be held at the home of TBA.

# *SBAS Dues*

| Month Join/Due | Member (Family) | Student | Expires |
|---|---|---|---|
| January | $40.00 | $25.00 | Dec |
| February | $36.67 | $22.92 | Dec |
| March | $33.33 | $18.75 | Dec |
| April | $30.00 | $20.83 | Dec |
| May | $26.67 | $18.75 | Dec |
| June | $23.33 | $16.67 | Dec |
| July | $20.00 | $14.58 | Dec |
| August | $16.67 | $12.50 | Dec |
| September | $13.33 | $10.42 | Dec |
| October | $10.00 | $8.33 | Dec |
| November | $6.67 | $6.25 | Dec |

To simplify the dues, we suggest that all membership expire in December. Dues are $40.00/year ($25.00/year for students) and expire on December 31, of the current year. The First Light is now only available via email notification and on our web site. Make checks payable to the South Bay Astronomical Society. Dues may be paid at the general meeting or mailed to:

**South Bay Astronomical Society**
**Attn: Gary Inouye**
**P.O. Box 1244**
**Redondo Beach, CA 90278**

# *SBAS Membership Benefits*

Contact TBD for magazine subscriptions at club rates: “Sky & Telescope” $32.95 and “Astronomy” $34.00/1 year or $60.00/2 years!
Note: S&T subscribers at the club rate renew their subscriptions by mailing their renewal notice and check or calling the 800# on the renewal notice.
Only new subscribers or subscribers converting their subscription to the club rate need to contact Arnie or send a check to the PO Box. Astronomy subscriptions and renewals still go via the PO Box.

Astronomy Technology Today has become a digital only magazine. They have stated that current print subscribers will continue to be able to access digital issues without any cost. New subscribers should check their website for ordering details and subscription costs (www.astronomytechnologytoday.com).

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## *Astronomical League Observing Clubs*

All SBAS members in good standing are also members of the Astronomical League and are eligible to participate in the League's Observing Clubs. The Astronomical League provides many different observing programs (clubs). These programs are designed to provide a direction for your observations and to provide a goal. The programs have certificates and pins to recognize the observers' accomplishments and for demonstrating their observing skills with a variety of instruments and objects. For more information, go to:
http://www.astroleague.org/observing.html.

## *New Free Astronomy Technology Today Subscription Offer*

Astronomy Technology Today offers a free 12-month online subscription for members. Go to the following URL for instructions on how to subscribe: http://www.cnyo.org/2016/02/01/12-free-months-of-astronomy-technology-today-tellem-cnyo-or-your-own-club-sent-you/

# *Useful and Interesting Astronomy Websites*

| Website | Description |
|---|---|
| http://www.calsky.com/ | A useful site for planning an evening's star gazing if you don't have your own planetarium software. |
| https://www.aavso.org/ | Information for observers with an interest in tracking variable stars. |
| http://www.cleardarksky.com/csk/prov/California_clocks.html | Good site to check to know what the weather will be like where you might be planning on going. |
| http://ssd.jpl.nasa.gov/horizons.cgi | Great site to use when you want to find a new comet or asteroid that isn't already in your planetarium software's list. See the Ephemeris Generator file on the SBAS Yahoo group site for instructions. |
| https://ssd.jpl.nasa.gov/horizons.cgi | NASA website for generating an ephemeris for any solar system object from any point on the Earth's surface. |
| http://heavens-above.com | Check this site to find out what satellites are visible in your sky. |
| http://www.lunar-occultations.com/iota/iotandx.htm | Website for the International Occultation Timing Association. Good place to find information on asteroid occultations of background stars. |
| http://pictures.ed-morana.com/ISSTransits/predictions/ | Find out when the ISS will transit in front of the Sun or Moon as seen from your location. |
| http://www.aerith.net/comet/weekly/current.html | Weekly information on bright comets. Good place to learn where there are bright comets to be seen. Refer to the Horizons website above to generate ephemerides. |
| http://sohowww.nascom.nasa.gov/ | See the sun in ways you might never have imagined! You can even create your own movies of the sun in different the different frequencies imaged by the SOHO spacecraft. |

# *Bright Galaxies Put Dark Matter to the Test*

***Science Daily – 31 January 2024 -*** For the past year and a half, the James Webb Space Telescope has delivered astonishing images of distant galaxies formed not long after the Big Bang, giving scientists their first glimpses of the infant universe. Now, a group of astrophysicists has upped the ante: Find the tiniest, brightest galaxies near the beginning of time itself, or scientists will have to totally rethink their theories about dark matter.

The team, led by UCLA astrophysicists, ran simulations that track the formation of small galaxies after the Big Bang and included, for the first time, previously neglected interactions between gas and dark matter. They found that the galaxies created are very tiny, much brighter, and form more quickly than they do in typical simulations that don't take these interactions into account, instead revealing much fainter galaxies.

Small galaxies, also called dwarf galaxies, are present throughout the universe, and are often thought to represent the earliest type of galaxy. Small galaxies are thus especially interesting to scientists studying the origins of the universe. But the small galaxies they find don't always match what they think they should find. Those closest to the Milky Way spin quicker or are not as dense as in simulations, indicating that the models might have omitted something, such as these gas-dark matter interactions.

The new research, published in *The Astrophysical Journal Letters,* improves the simulations by adding dark matter interactions with gas and finds that these faint galaxies may have been much brighter than expected early in the universe's history, when they were just beginning to form. The authors suggest scientists should try to find small galaxies that are much brighter than expected using telescopes like the Webb telescope. If they only find faint ones, then some of their ideas about dark matter might be wrong.

Dark matter is a type of hypothetical matter that does not interact with electromagnetism or light. Thus, it is impossible to observe using optics, electricity or magnetism. But dark matter does interact with gravity, and its presence has been inferred from the gravitational effects it has on ordinary matter -- the stuff that makes up all the observable universe. Even though 84% of the matter in the universe is thought to be made of dark matter, it has never been detected directly.

All galaxies are surrounded by a vast halo of dark matter, and scientists think that dark matter was essential to their formation. The "standard cosmological model" astrophysicists use to understand galaxy formation describes how clumps of dark matter in the very early universe drew in ordinary matter through gravity, causing the formation of stars and creating the galaxies we see today. Because most dark matter particles -- called cold dark matter -- are thought to move much slower than the speed of light, this process of accumulation would have occurred gradually.

But over 13 billion years ago, prior to the formation of the first galaxies, ordinary matter, consisting of hydrogen and helium gas from the Big Bang, and dark matter were moving relative to one another. The gas streamed at supersonic velocities past dense thickets of more slowly moving dark matter that should have pulled it in to form galaxies

"Indeed, in models that do not take streaming into account, this is exactly what happens," said Claire Williams, a UCLA doctoral student and the paper's first author. "Gas is attracted to the gravitational pull of dark matter, forms clumps and knots so dense that hydrogen fusion can occur, and thus forms stars like our sun."

But Williams and co-authors on the Supersonic Project team, a group of astrophysicists from the United States, Italy and Japan led by UCLA physics and astronomy professor Smadar Naoz, found if they added the streaming effect of different velocities between dark and ordinary matter to the simulations, the gas landed far away from the dark matter and was prevented from forming stars right away. When the accumulated gas fell back into the galaxy millions of years later, a massive burst of star formation occurred all at once. Because these galaxies had many more young, hot, luminous stars than ordinary small galaxies for a time, they shone much brighter.

"While the streaming suppressed star formation in the smallest galaxies, it also boosted star formation in dwarf galaxies, causing them to outshine the non-streaming patches of the universe," Williams said. "We predict that the Webb telescope will be able to find regions of the universe where galaxies will be brighter, heightened by this velocity. The fact that they should be so bright might make it easier for the telescope to discover these small galaxies, which are typically extremely hard to detect only 375 million years after the Big Bang."

Because dark matter is impossible to study directly, searching for bright patches of galaxies in the early universe could offer an effective test for theories about dark matter, which has been fruitless so far.

"The discovery of patches of small, bright galaxies in the early universe would confirm that we are on the right track with the cold dark matter model because only the velocity between two kinds of matter can produce the type of galaxy we're looking for," said Naoz, the Howard and Astrid Preston Professor of Astrophysics. "If dark matter does not behave like standard cold dark matter and the streaming effect isn't present, then these bright dwarf galaxies won't be found and we need to go back to the drawing board."

# Mimas' Surprise: Tiny Moon of Saturn Holds Young Ocean Beneath Icy Shell

***Science Daily – 7 February 2024 -*** Hidden beneath the heavily cratered surface of Mimas, one of Saturn's smallest moons, lies a secret: a global ocean of liquid water. This astonishing discovery, led by Dr. Valéry Lainey of the Observatoire de Paris-PSL and published in the journal *Nature*, reveals a "young" ocean formed just 5 to 15 million years ago, making Mimas a prime target for studying the origins of life in our Solar System.

"Mimas is a small moon, only about 400 kilometers in diameter, and its heavily cratered surface gave no hint of the hidden ocean beneath," says Dr Nick Cooper, a co-author of the study and Honorary Research Fellow in the Astronomy Unit of the School of Physical and Chemical Sciences at Queen Mary University of London.

"This discovery adds Mimas to an exclusive club of moons with internal oceans, including Enceladus and Europa, but with a unique difference: its ocean is remarkably young, estimated to be only 5 to 15 million years old."

This young age, determined through detailed analysis of Mimas's tidal interactions with Saturn, suggests the ocean formed recently, based on the discovery of an unexpected irregularity in its orbit.

As a result, Mimas provides a unique window into the early stages of ocean formation and the potential for life to emerge.

"The existence of a recently formed liquid water ocean makes Mimas a prime candidate for study, for researchers investigating the origin of life," explains Dr Cooper.

The discovery was made possible by analysing data from NASA's Cassini spacecraft, which meticulously studied Saturn and its moons for over a decade.

By closely examining the subtle changes in Mimas's orbit, the researchers were able to infer the presence of a hidden ocean and estimate its size and depth.

Dr Cooper continues: "This has been a great team effort, with colleagues from five different institutions and three different countries coming together under the leadership of Dr Valéry Lainey to unlock another fascinating and unexpected feature of the Saturn system, using data from the Cassini mission."

The discovery of Mimas's young ocean has significant implications for our understanding of the potential for life beyond Earth. It suggests that even small, seemingly inactive moons can harbor hidden oceans capable of supporting life-essential conditions. This opens up exciting new avenues for future exploration, potentially leading us closer to answering the age-old question: are we alone in the universe?

# Diverse Ancient Volcanoes on Mars Discovered by Planetary Scientist May Hold Clues to Pre-Plate Tectonic Activity on Earth

***Science Daily – 15 February 2024 -*** Volcanoes are a common feature on the surfaces of solid planets within the solar system, resulting from magmatic activity occurring within the planetary crust. On Earth, volcanism is driven primarily by heat and crustal recycling associated with plate tectonics, but Mars lacks plate tectonics and the driver of volcanism is not well understood.

Recent research by Professor Joseph MICHALSKI, a geologist in the Department of Earth Sciences at The University of Hong Kong (HKU), has revealed intriguing insights into the volcanic activity on Mars.

He proposes that Mars has significantly more diverse volcanism than previously realized, driven by an early form of crust recycling called vertical tectonics.

The findings, recently published in *Nature Astronomy,* shed light on the ancient crust of Mars and its potential implications for understanding early crustal recycling on both Mars and Earth.

Traditionally, Mars has been known to have large shield volcanoes similar to those in Hawaii.

However, it was not known that Mars also possessed the diverse, explosive volcanoes that form on Earth due to crustal recycling.

The recent research conducted by Professor Michalski and his international team discover a vast number of diverse volcanoes in the ancient crust of Mars.

'We have known for decades that Mars has volcanoes, but most of the recognized volcanoes correspond to large basaltic shield volcanoes similar to the ones that make up Hawaii,' he explains.

'In this work, we show that the ancient crust has many other types of volcanoes such as lava domes, stratovolcanoes, calderas and large shields of ash, not lava.

Further, most scientists see Mars as a planet composed of basalt, which has low silica content and represents little crustal evolution, but these volcanoes have high silica content which means they formed from a complex process of magma evolution not known before.'

The paper suggests that intense volcanism occurred on ancient Mars, causing the crust to collapse into the mantle, where the rocks re-melted, resulting in magmas that have high silica.

This tectonic process, called vertical tectonics, is hypothesized to have occurred on the ancient Earth, but rocks on Earth from that period (the Archean, more than 3 billion years ago) are highly modified by later geological activity, so we cannot see evidence for this process clearly on this planet.

Therefore, exploring other planets like Mars, which has volcanism but no plate tectonics, can help reveal the mysteries of early crustal recycling on both the Red Planet, and by analogy, on early Earth.

Professor Michalski concluded, 'Mars contains critical geological puzzle pieces that help us understand not only that planet, but the Earth as well.

Martian volcanism is much more complex and diverse than has been previously thought.'

'This is a significant discovery because it has revealed that crustal recycling can occur not only in plate tectonic regimes dominated by horizontal movements, but can also occur in pre-plate tectonic regimes dominated by vertical movements. This finding can help earth scientists revolve the long-term controversial issues of how and when felsic continents formed in our planet (Earth)', said Professor Guochun ZHAO, the Chair Professor of HKU Earth Sciences.

# Black Hole at Center of the Milky Way Resembles a Football

***Science Daily – 21 February 2024 -*** The supermassive black hole in the center of the Milky Way is spinning so quickly it is warping the spacetime surrounding it into a shape that can look like a football, according to a new study using data from NASA's Chandra X-ray Observatory and the U.S. National Science Foundation's Karl G. Jansky Very Large Array (VLA). That football shape suggests the black hole is spinning at a substantial speed, which researchers estimated to be about 60% of its potential limit.

The work, led by Penn State Berks Professor of Physics Ruth Daly, was published in the *Monthly Notices of the Royal Astronomical Society.*

Astronomers call this giant black hole Sagittarius A* (Sgr A*). It is located about 26,000 light-years away from Earth in the center of the galaxy. To determine how quickly Sgr A* is spinning -- one of its fundamental properties, along with mass -- the researchers applied a method that uses X-ray and radio data to assess how material is flowing towards and away from the black hole. The method was developed and published by Daly in 2019 in *The Astrophysical Journal.*

"Our work may help settle the question of how fast our galaxy's supermassive black hole is spinning," Daly said. "Our results indicate that Sgr A* is spinning very rapidly, which is interesting and has far-reaching implications."

The team found the angular velocity -- the number of revolutions per second -- of Sgr A*'s spin is about 60% of the maximum possible value, a limit set because material cannot travel faster than the speed of light.

Past estimations of Sgr A*'s speed have been made with different techniques and by other astronomers, with results ranging from no rotation at all to spinning at almost the maximum rate.

"This work, however, shows that this could change if the amount of material in the vicinity of Sgr A* increases," Daly said.

As a black hole rotates, it pulls "spacetime" -- the combination of time and the three dimensions of space -- and nearby matter. The gravitational pull also squashes the spacetime, altering its shape depending on how it's observed. Spacetime appears circular if the black hole is viewed from the top. From the side, however, the spacetime is shaped like a football. The faster the spin, the flatter the football.

The spin can also serve as an energy source, Daly said, if matter -- such as gas or the remnants of a star that wanders too close -- exists in the vicinity of the black hole. As the black hole spins, matter can escape in the form of narrow jets called collimated outflows. However, Sgr A* currently has limited nearby matter, so the black hole has been relatively quiet, with weakly collimated outflows, in recent millennia.

"A spinning black hole is like a rocket on the launch pad," said Biny Sebastian, a co-author from the University of Manitoba in Winnipeg, Canada. "Once material gets close enough, it's like someone has fueled the rocket and hit the 'launch' button."

This means that in the future, if the properties of the matter and the magnetic field strength close to the black hole change, part of the enormous energy of the black hole's spin could drive more powerful outflows. This source material could come from gas or from the remnants of a star torn apart by the black hole's gravity if that star wanders too close to Sgr A*.

"Jets powered and collimated by a galaxy's spinning central black hole can profoundly affect the gas supply for an entire galaxy, which affects how quickly and even whether stars can form," said co-author Megan Donahue from Michigan State University. "The 'Fermi bubbles' seen in X-rays and gamma rays around our Milky Way's black hole show the black hole was probably active in the past. Measuring the spin of our black hole is an important test of this scenario."

Fermi bubbles refer to structures that emit gamma rays above and below the black hole that researchers have theorized resulted from prior massive outflows.

The researchers used the outflow method to determine the spin of Sgr A*. Daly's approach incorporates consideration of the relationship between the spin of the black hole and its mass, the properties of the matter near the black hole and the outflow properties. The collimated outflow produces the radio waves, while the disk of gas surrounding the black hole emits X-rays. The researchers combined observational data from Chandra and the VLA with an independent estimate of the black hole's mass from other telescopes to inform the outflow method and determine the black hole's spin.

"We have a special view of Sgr A* because it is the nearest supermassive black hole to us," said co-author Anan Lu from McGill University in Montreal, Canada. "Although it's quiet right now, our work shows that in the future it will give an incredibly powerful kick to surrounding matter. That might happen in a thousand or a million years, or it could happen in our lifetimes."

In addition to those mentioned above, co-authors include Christopher O'Dea, University of Manitoba, and Daryl Haggard, McGill University.

NASA's Marshall Space Flight Center manages the Chandra program. The Smithsonian Astrophysical Observatory's Chandra X-ray Center controls science operations from Cambridge, Massachusetts, and flight operations from Burlington, Massachusetts.

# *Schedule of Coming Events*

| Date | Event |
|---|---|
| **1 March Friday Night 7:30 PM** | **Monthly General Meeting**<br>**Topic:** Interplanetary Navigation for Dummies<br>**Speaker:** TBD |
| **3 March Saturday Evening** | **In-Town Observing Session at Christmas Tree Cove**<br>Located at the west end of Palos Verdes Peninsula at the intersection of Via Neve and Paseo Del Mar. Reached from PV West, turn on Via Anacapa then turn left on Via Sola and left again on Via Neve. |
| **4 March Monday Night 7:30 PM** | **Monthly Planning Meeting**<br>See directions on Page 4. |
| **10 March** | **New Moon** |
| **10 February** | **Out-of-Town Observing Session**<br>Contact Ken Munson for a location. |
| **16 March** | **First Quarter Moon** |
| **24 March** | **Full Moon** |
| **24 March** | **Mercury at Greatest Eastern Elongation** |
| **24 March** | **Penumbral Lunar Eclipse**<br>As viewed from the LA area, the Moon will enter the Earth's penumbral shadow at about 9:55 PM and will exit the shadow at about 2:32 AM |
| **1 April** | **Last Quarter Moon** |

# South Bay Astronomical Society

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***Next General Meeting at El Camino College Planetarium***

***Friday, March 1st 7:30 PM***

**"Interplanetary Navigation for Dummies"**

**Ken Munson**

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**South Bay Astronomical Society**
**P.O. Box 1244**
**Redondo Beach, CA 90278**