Volume 48 Number 9 September 2022

The Celestial Mechanic

The Official Newsletter of the Astronomy Associates of Lawrence

Coming Events

Monthly Meeting
September 25, 2022, 7:00PM
Baker Wetlands Discovery Center

Public Observing
September 25, 2022, 8:00PM
Baker Wetlands Discovery Center

Club Officers

President
Rick Heschmeyer email

AICOR
William Winkler email

NSN Coordinator
Howard Edin email

Faculty Advisor
Dr. Jennifer Delgado email.

Newsletter Editor
Chuck Wehner email

Inside This Issue

Report From the Officers

By Rick Heschmeyer

The new school year has started and our regularly scheduled club meeting and public observing have restarted as well. In August, Rick Heschmeyer talked about this summer's storm-shortened "Symphony in the Flint Hills" event and gave information to anyone interested in volunteering at this event in the future. As future meeting speakers and subjects are confirmed, the events calendar will be updated.

The Telescope Nights at KU will be starting up again this month, on September 8. These events are fun and informative. Please stop by if you can. I will forward the flyer from the Physics & Astronomy Department when I receive it.

Saturn opposition took place on August 14. Jupiter opposition occurs at the end of this month, on Sept. 26, so the season of planets has started! Enjoy the show!

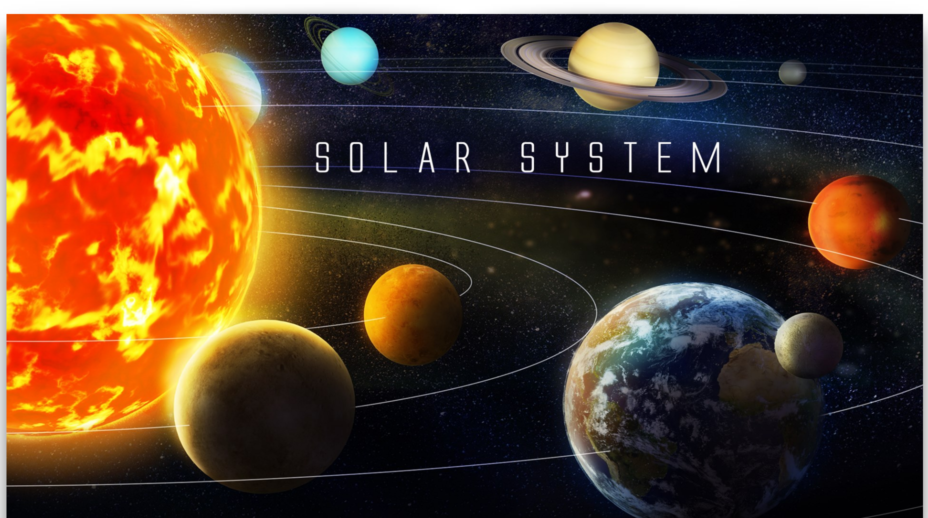
The schedule for meetings for the remainder of 2022 is shown below. All meetings will start at 7:00PM to be followed by observing following the meeting, weather permitting.

Sunday, September 25

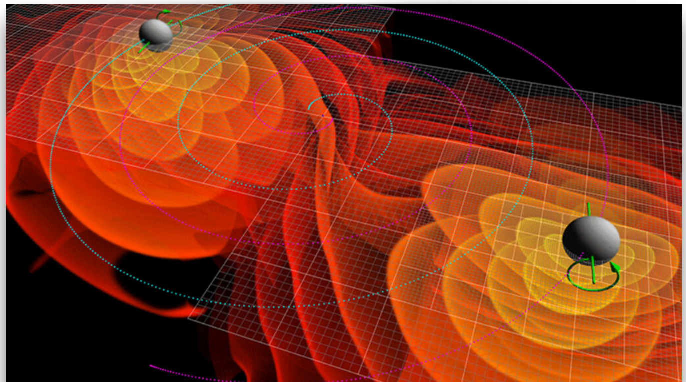
Sunday, October 30

Sunday, December 4

Clear skies to all!



Two black holes merged despite being born far apart in space



A detection of gravitational waves (illustrated) from the merger of two black holes that spin in different directions (green arrows) suggests they were born in very different places. If so, it's the first time that kind of merger has been detected.

By James R. Riordon
SCIENCENEWS, AUGUST 2, 2022

Signals buried deep in data from gravitational wave observatories imply a collision of two black holes that were clearly born in different places.

Almost all the spacetime ripples that experiments like the Laser Interferometer Gravitational-Wave Observatory, or LIGO, see come from collisions among black holes and neutron stars that are probably close family members (*SN: 1/21/21*). They were once pairs of stars born at the same time and in the same place, eventually collapsing to form orbiting black holes or neutron stars in old age.

Now, a newly noted marriage of black holes, found in existing data from U.S.–based LIGO and its sister observatory Virgo in Italy, seems to be of an unrelated pair. Evidence for this stems from how they were spinning as they merged into one, researchers report in a paper in press at *Physical Review D*. Black holes that are born in the same place tend to have their spins aligned, like a pair of toy tops spinning on a table, as they orbit each other. But the pair in this case have no correlation between their respective spins and orbits, implying that they were born in different places.

“This is telling us we've finally found a pair of black holes that must come from the non-grow-old-and-die-together channel,” says Seth Olsen, a physicist at Princeton University.

Previous events that have turned up in gravitational wave observations show back holes merging that aren't perfectly aligned, but most are close enough to strongly imply family connections. The new detection, which Olsen and colleagues found by sifting through data that the LIGO-Virgo collaboration released to the public, is different. One of the black holes is effectively spinning upside down.

That can't easily happen unless the two black holes come from separate places. They probably met late in their stellar lives, unlike the black hole littermates that seem to make up the bulk of gravitational wave observations.

In addition to the merger between unrelated black holes, Olsen and his collaborators identified nine other black hole mergers that had slipped through the prior LIGO-Virgo studies (*SN: 8/4/21*).

“This is actually the nice thing about this type of analysis,” says LIGO scientific collaboration spokesperson Patrick Brady, a physicist at the University of Wisconsin–Milwaukee who was not affiliated with the new study. “We deliver the data in a format that can be used by other people and then [they] will have access to try out new techniques.”

To compile so many new signals in data that had already been gone over by other researchers, Olsen's group lowered the analytical bar a little.

“Out of the 10 new ones,” Olsen says, “there are about three of them, statistically, that probably come from noise,” rather than being definitive black hole merger detections. Assuming that the merger of black holes strangers is not among the errant signals, it almost certainly tells a tale of black hole histories distinct from the others seen so far.

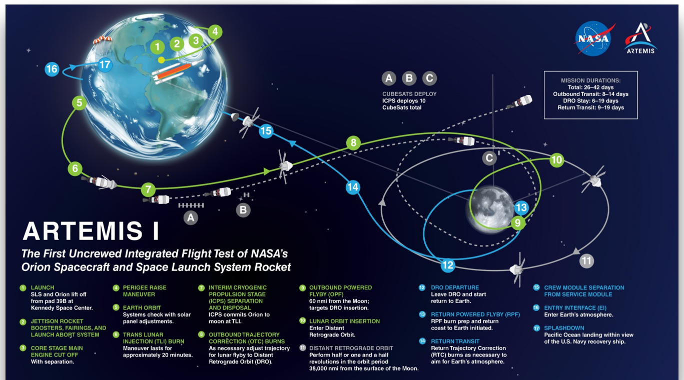
“It would be [extremely] unlikely for this to come from two black holes that have been together for their whole lifespan,” Olsen says. “This must have been a capture. That's cool because we're finally able to start probing that region of the [black hole] population.”

Brady notes that “we don't understand the theory [of black hole mergers] well enough to be able to confidently predict all of these types of things.” But the recent study may point to new and interesting opportunities in gravitational wave astronomy. “Let's follow this clue to see if it really is reflecting something rare,” he says. “Or if not, well, we'll learn other things.”

Artemis 1: A Trip Around the Moon – and Back!

By David Prosper

NIGHT SKY NETWORK, AUGUST 2022



We are returning to the Moon - and beyond! Later this summer, NASA's Artemis 1 mission will launch the first uncrewed flight test of both the Space Launch System (SLS) and Orion spacecraft on a multi-week mission. Orion will journey thousands of miles beyond the Moon, briefly entering a retrograde lunar orbit before heading back to a splashdown on Earth.

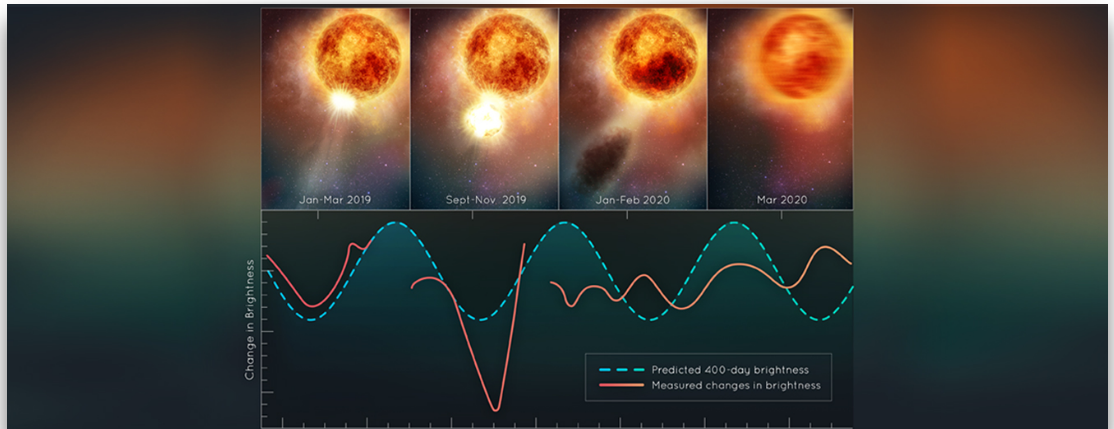
The massive rocket will launch from Launch Complex 39B at the Kennedy Space Center in Florida. The location's technical capabilities, along with its storied history, mark it as a perfect spot to launch our return to the Moon. The complex's first mission was Apollo 10 in 1968, which appropriately also served as a test for a heavy-lift launch vehicle (the Saturn V rocket) and lunar spacecraft: the Apollo Command and Service Modules joined with the Lunar Module. The Apollo 10 mission profile included testing the Lunar Module while in orbit around the Moon before returning to the Earth. In its "Block-1" configuration, Artemis 1's SLS rocket will take off with 8.8 million pounds of maximum thrust, even greater than the 7.6 millions pounds of thrust generated by the legendary Saturn V, making it the most powerful rocket in the world!

Artemis 1 will serve not only as a test of the SLS and the Orion hardware, but also as a test of the integration of ground systems and support personnel that will ensure the success of this and future Artemis missions. While uncrewed, Artemis- 1 will still have passengers of a sort: two human torso models designed to test radiation levels during the mission, and "Commander Moonikin Campos," a mannequin named by the public. The specialized mannequin will also monitor radiation levels, along with vibration and acceleration data from inside its mission uniform: the Orion Crew Survival Suit, the spacesuit that future Artemis astronauts will wear. The "Moonikin" is named after Arturo Campos, a NASA electrical engineer who played an essential role in bringing Apollo 13's crew back to Earth after a near-fatal disaster in space.

The mission also contains other valuable cargo for its journey around the Moon and back, including CubeSats, several space science badges from the Girl Scouts, and microchips etched with 30,000 names of workers who made the Artemis- 1 mission possible. A total of 10 CubeSats will be deployed from the Orion Stage Adapter, the ring that connects the Orion spacecraft to the SLS, at several segments along the mission's path to the Moon. The power of SLS allows engineers to attach many secondary "ride-along" mission hardware like these CubeSats, whose various missions will study plasma propulsion, radiation effects on microorganisms, solar sails, Earth's radiation environment, space weather, and of course, missions to study the Moon and even the Orion spacecraft and its Interim Cryogenic Propulsion Stage (ICPS)! ☀

HUBBLE SEES RED SUPERGIANT STAR BETELGEUSE SLOWLY RECOVERING AFTER BLOWING ITS TOP

HUBBLESITE, AUGUST 11, 2022



Analyzing data from NASA's Hubble Space Telescope and several other observatories, astronomers have concluded that the bright red supergiant star Betelgeuse quite literally blew its top in 2019, losing a substantial part of its visible surface and producing a gigantic Surface Mass Ejection (SME). This is something never before seen in a normal star's behavior.

Our Sun routinely blows off parts of its tenuous outer atmosphere, the corona, in an event known as a Coronal Mass Ejection (CME). But the Betelgeuse SME blasted off 400 billion times as much mass as a typical CME!

The monster star is still slowly recovering from this catastrophic upheaval. "Betelgeuse continues doing some very unusual things right now; the interior is sort of bouncing," said Andrea Dupree of the Center for Astrophysics | Harvard & Smithsonian in Cambridge, Massachusetts.

These new observations yield clues as to how red stars lose mass late in their lives as their nuclear fusion furnaces burn out, before exploding as supernovae. The amount of mass loss significantly affects their fate. However, Betelgeuse's surprisingly petulant behavior is not evidence the star is about to blow up anytime soon. So the mass-loss event is not necessarily the signal of an imminent explosion.

Dupree is now pulling together all the puzzle pieces of the star's petulant behavior before, after, and during the eruption into a coherent story of a never-before-seen titanic convulsion in an aging star.

This includes new spectroscopic and imaging data from the STELLA robotic observatory , the Fred L. Whipple Observatory's Tillinghast Reflector Echelle Spectrograph (TRES), NASA's Solar Terrestrial Relations Observatory spacecraft (STEREO-A), NASA's Hubble Space Telescope, and the American Association of Variable Star Observers (AAVSO). Dupree emphasizes that the Hubble data was pivotal to helping sort out the mystery.

"We've never before seen a huge mass ejection of the surface of a star. We are left with something going on that we don't completely understand. It's a totally new phenomenon that we can observe directly and resolve surface details with Hubble. We're watching stellar evolution in real time."

The titanic outburst in 2019 was possibly caused by a convective plume, more than a million miles across, bubbling up from deep inside the star. It produced shocks and pulsations that blasted off the chunk of the photosphere leaving the star with a large cool surface area under the dust cloud that was produced by the cooling piece of photosphere. Betelgeuse is now struggling to recover from this injury.

Weighing roughly several times as much as our Moon, the fractured piece of photosphere sped off into space and cooled to form a dust cloud that blocked light from the star as seen by Earth observers. The dimming, which began in late 2019 and lasted for a few months, was easily noticeable even by backyard observers watching the star change brightness. One of the brightest stars in the sky, Betelgeuse is easily found in the right shoulder of the constellation Orion.

Even more fantastic, the supergiant's 400-day pulsation rate is now gone, perhaps at least temporarily. For almost 200 years astronomers have measured this rhythm as evident in changes in Betelgeuse's brightness variations and surface motions. Its disruption attests to the ferocity of the blowout.

The star's interior convection cells, which drive the regular pulsation may be sloshing around like an imbalanced washing machine tub, Dupree suggests. TRES and Hubble spectra imply that the outer layers may be back to normal, but the surface is still bouncing like a plate of gelatin dessert as the photosphere rebuilds itself.

Though our Sun has coronal mass ejections that blow off small pieces of the outer atmosphere, astronomers have never witnessed such a large amount of a star's visible surface get blasted into space. Therefore, surface mass ejections and coronal mass ejections may be different events.

Betelgeuse is now so huge now that if it replaced the Sun at the center of our solar system, its outer surface would extend past the orbit of Jupiter. Dupree used Hubble to resolve hot spots on the star's surface in 1996. This was the first direct image of a star other than the Sun.

NASA's Webb Space Telescope may be able to detect the ejected material in infrared light as it continues moving away from the star. ☀

Astronomers confirm star wreck as source of extreme cosmic particles

SCIENCENEWS, AUGUST 11, 2022

Fermi has shown that the shock waves of exploded stars boost particles to speeds comparable to that of light. Called cosmic rays, these particles mostly take the form of protons, but can include atomic nuclei and electrons. Because they all carry an electric charge, their paths become scrambled as they whisk through our galaxy's magnetic field. Since we can no longer tell which direction they originated from, this masks their birthplace. But when these particles collide with interstellar gas near the supernova remnant, they produce a tell-tale glow in gamma rays -- the highest-energy light there is.

"Theorists think the highest-energy cosmic ray protons in the Milky Way reach a million billion electron volts, or PeV energies," said Ke Fang, an assistant professor of physics at the University of Wisconsin, Madison. "The precise nature of their sources, which we call PeVatrons, has been difficult to pin down."

Trapped by chaotic magnetic fields, the particles repeatedly cross the supernova's shock wave, gaining speed and energy with each passage. Eventually, the remnant can no longer hold them, and they zip off into interstellar space.

Boosted to some 10 times the energy mustered by the world's most powerful particle accelerator, the Large Hadron Collider, PeV protons are on the cusp of escaping our galaxy altogether.

Astronomers have identified a few suspected PeVatrons, including one at the center of our galaxy. Naturally, supernova remnants top the list of candidates. Yet out of about 300 known remnants, only a few have been found to emit gamma rays with sufficiently high energies.

One particular star wreck has commanded a lot of attention from gamma-ray astronomers. Called G106.3+2.7, it's a comet-shaped cloud located about 2,600 light-years away in the constellation Cepheus. A bright pulsar caps the northern end of the supernova remnant, and astronomers think both objects formed in the same explosion.

Fermi's Large Area Telescope, its primary instrument, detected billion-electron-volt (GeV) gamma rays from within the remnant's extended tail. (For comparison, visible light's energy measures between about 2 and 3 electron volts.) The Very Energetic Radiation Imaging Telescope Array System (VERITAS) at the Fred Lawrence Whipple Observatory in southern Arizona recorded even higher-energy gamma rays from the same region. And both the High-Altitude Water Cherenkov Gamma-Ray Observatory in Mexico and the Tibet AS-Gamma Experiment in China have detected photons with energies of 100 trillion electron volts (TeV) from the area probed by Fermi and VERITAS.

"This object has been a source of considerable interest for a while now, but to crown it as a PeVatron, we have to prove it's accelerating protons," explained co-author Henrike Fleischhack at the Catholic University of America in Washington and NASA's

Goddard Space Flight Center in Greenbelt, Maryland. "The catch is that electrons accelerated to a few hundred TeV can produce the same emission. Now, with the help of 12 years of Fermi data, we think we've made the case that G106.3+2.7 is indeed a PeVatron."

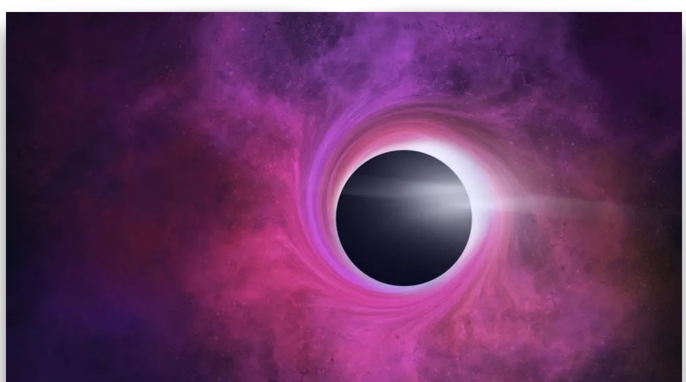
A paper detailing the findings, led by Fang, was published Aug. 10 in the journal *Physical Review Letters.*

The pulsar, J2229+6114, emits its own gamma rays in a lighthouse-like beacon as it spins, and this glow dominates the region to energies of a few GeV. Most of this emission occurs in the first half of the pulsar's rotation. The team effectively turned off the pulsar by analyzing only gamma rays arriving from the latter part of the cycle. Below 10 GeV, there is no significant emission from the remnant's tail.

Above this energy, the pulsar's interference is negligible and the additional source becomes readily apparent. The team's detailed analysis overwhelmingly favors PeV protons as the particles driving this gamma-ray emission.

"So far, G106.3+2.7 is unique, but it may turn out to be the brightest member of a new population of supernova remnants that emit gamma rays reaching TeV energies," Fang notes. "More of them may be revealed through future observations by Fermi and very-high-energy gamma-ray observatories.” ☀

Black hole 'superradiance' phenomenon may aid quest for dark matter



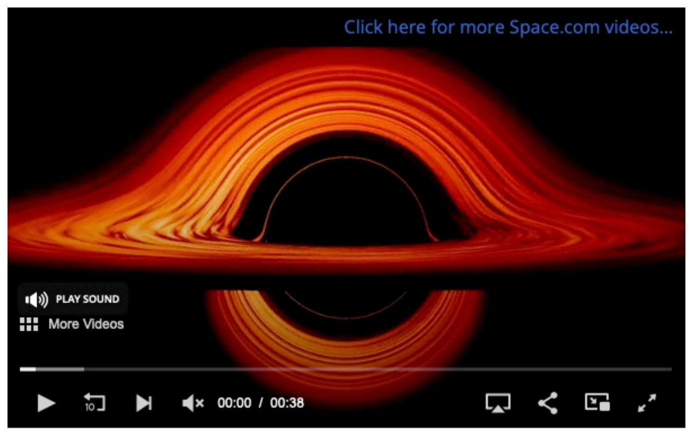
By Paul Sutter

SPACE.COM, AUGUST 16, 2022

New research challenges what we thought we knew about what happens around black holes.

We're used to thinking of black holes as the ultimate vacuums, capable of sucking in everything around them and refusing to let anything out again. That includes light, hence the "black" in their names. But over the past 50 years, physicists have realized that black holes affect their environments in interesting, complicated ways. One of those ways leads to a process called superradiance, in which a black hole boosts any nearby light into intense levels of energy.

For superradiance to work, the black hole has to spin. That's not a problem, as black holes are born from the deaths of massive stars, and those stars are already spinning. As black holes spin, they literally drag on space-time around them, creating a region around the event horizon — the point beyond which nothing can escape — known as the ergosphere. Inside the ergosphere, it's impossible to stay still. If you were to fall into a black hole, before you reached the event horizon, you would be pulled into its orbit, even if you tried really hard to stay still.



Click here for video.

The spinning effect of the ergosphere gets stronger the closer you get to the black hole, and this is what creates the superradiance effect. Some photons — fundamental units of light — passing close to the black hole get trapped in the ergosphere, and as they get closer to the event horizon, they whip around the black hole faster and faster. With every loop, they gain more and more energy. Some of those photons fall to their doom, crossing the event horizon, never to be seen again. But some scatter off of other photons and escape, and are boosted to incredibly high energies in the process.

The superradiance process is unstable. Over incredibly long timescales, enough photons can get boosted to high enough energies that the entire surroundings of the black hole turn into a giant "bomb," with the trapped photons blasting away in a single gigantic burst. But this process happens slowly enough that we haven't seen it play out in the universe yet.

Superradiance can extend beyond photons; it can happen to any kind of boson, including all the force carriers of nature and the Higgs boson — and also, maybe, dark matter.

Dark matter is the dominant form of matter in the universe, making up over 80% of all the mass of every galaxy and cluster. Astronomers have troves of circumstantial evidence for the existence of dark matter but have yet to pin down its identity.

Dark photons

One possibility is that dark matter is a new kind of ultralight particle that shares a lot of characteristics with bosons but does not interact with all the normal particles in the universe. These "dark photons" would be incredibly light yet absolutely flood the cosmos. But because they would not interact with normal matter, they would be exceedingly difficult to observe directly.

That is, unless they collect around black holes. Superradiance can operate on dark photons just as well as it does on normal photons. When dark photons collect around black holes, they can get trapped and boosted to high energies, where they might transform into other particles (or even just normal photons).

For decades, physicists have been studying this strange phenomenon, especially because the superradiance process offers an avenue for potential direct observations of dark matter if it is made of some superlight boson. (If the dark matter bosons are too heavy, they will not collect around black holes in the same way, and the superradiance trick wouldn't work anymore.)

Indeed, astronomers have used actual observations of black holes to put limits on the number of dark photons in the universe. We have yet to observe superradiance around black holes, which means that dark photons may not exist. But a new research paper published to the preprint database arXiv

Most work on dark matter assumes it's made of a single new kind of particle. But there's no reason the world of dark matter can't be as complex and as rich as the world of normal matter. In contrast to previous work, the new research assumes the existence of two different "species" of dark matter: one that's similar to dark photons (a boson) and another that's similar to a new particle (like a dark matter version of an electron).

challenges those results, saying the situation can be much more complex.

The researchers found that the interactions between the different kinds of dark matter can mess up the superradiance process, thus preventing the dark photons from getting a boost and blasting off. Instead, as they whip around the black hole, they might keep hitting the other species of dark matter particle, sapping their energy in the process.

This means we can't take the observed limits at face value. Just because astronomers haven't seen superradiance doesn't necessarily indicate that dark photons don't exist. Instead, it might mean the physics of dark matter is much more complicated than we thought. ☀

BARBARA MIKULSKI DONATES SPACE COLLECTION TO SPACE TELESCOPE SCIENCE INSTITUTE IN BALTIMORE

HubbleSite, August 9, 2022

The Space Telescope Science Institute (STScI) in Baltimore, Maryland, is thrilled to announce that retired U.S. Senator Barbara A. Mikulski is donating her space memorabilia collection to STScI. The collection includes framed astronomical images, photos, illustrations, and models. Also included in the collection are signed presentation plaques from the crews of two of the Hubble Space Telescope's servicing missions thanking Senator Mikulski for her support.

Senator Mikulski, the longest-serving woman in U.S. Congressional history, was one of Hubble's biggest cheerleaders and a staunch supporter of the space telescope and STScI. As a Senator, she advocated for Hubble and for the next-generation space telescope, now named the James Webb Space Telescope. When the last scheduled Hubble servicing mission was canceled in 2004, Mikulski helped lead the cause to reinstate the Hubble repair visit. That servicing mission’s repairs were pivotal in keeping Hubble functioning today. She is also wrapping up her tenure as a Johns Hopkins professor of public policy and an advisor to the university's president this spring semester.

"I'm so pleased that the Space Telescope Science Institute here on the Johns Hopkins campus will be the new home of my space collection," said Mikulski. "During my time in Congress, I had the honor of helping all the exceptional men and women who made our space program the best in the world, and the epicenter for astronomy and astrophysics has been Baltimore's own Space Telescope Science Institute."

She continued, "From the scientists who teach us about dark matter and the origins of the universe, to the creative graphics artists who connect Hubble's breathtaking images to the world's classrooms, to all the valuable support staff who keep the operations running non-stop – they've all made the Institute the world-class facility it is today. I feel like I've been part of this talented team all these years, so the Home of Hubble and now Mission Control for Webb seems like the ideal place to permanently share my space memories and memorabilia."

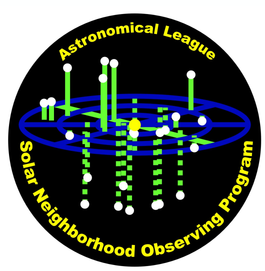
The Space Telescope Science Institute honored Senator Mikulski in 2012 by naming the world's largest astronomical data archives after her. Called the Barbara A. Mikulski Archive for Space Telescopes, or MAST, the huge database contains astronomical observations from several NASA space astronomy missions, including Hubble, as well as some ground-based observatories. Mikulski received another honor in 2012 when a distant, exploding star observed by Hubble was named Supernova Mikulski.

"We are gratified and honored to house Senator Mikulski's space memorabilia collection here at the Space Telescope Science Institute, where service and science are essential elements of our mission to help humanity explore the universe with advanced space telescopes and her namesake data archive," said STScI director Kenneth Sembach. "We cherish her continued relationship with the Institute and our staff. Her unparalleled efforts to advance astronomical research and her legacy of accomplishment embodied in this collection serve as an inspiration and a reminder to all who see it that anything is possible when we work together and reach for the stars.”

The items donated by Senator Mikulski will be displayed in the lobby and library of the Muller Building on the Johns Hopkins University Homewood campus. ☀

ASTRONOMICAL LEAGUE

2 NEW AL Observing Programs!



The Solar Neighborhood Observing Program

This program is designed to educte the participants about the stars that are the sun's nearest neighbors. National Observing Program Director Marie Lott will initially be the SNOP's coordinator: https://www.astroleague.org/content/solar-neighborhood-observing-program

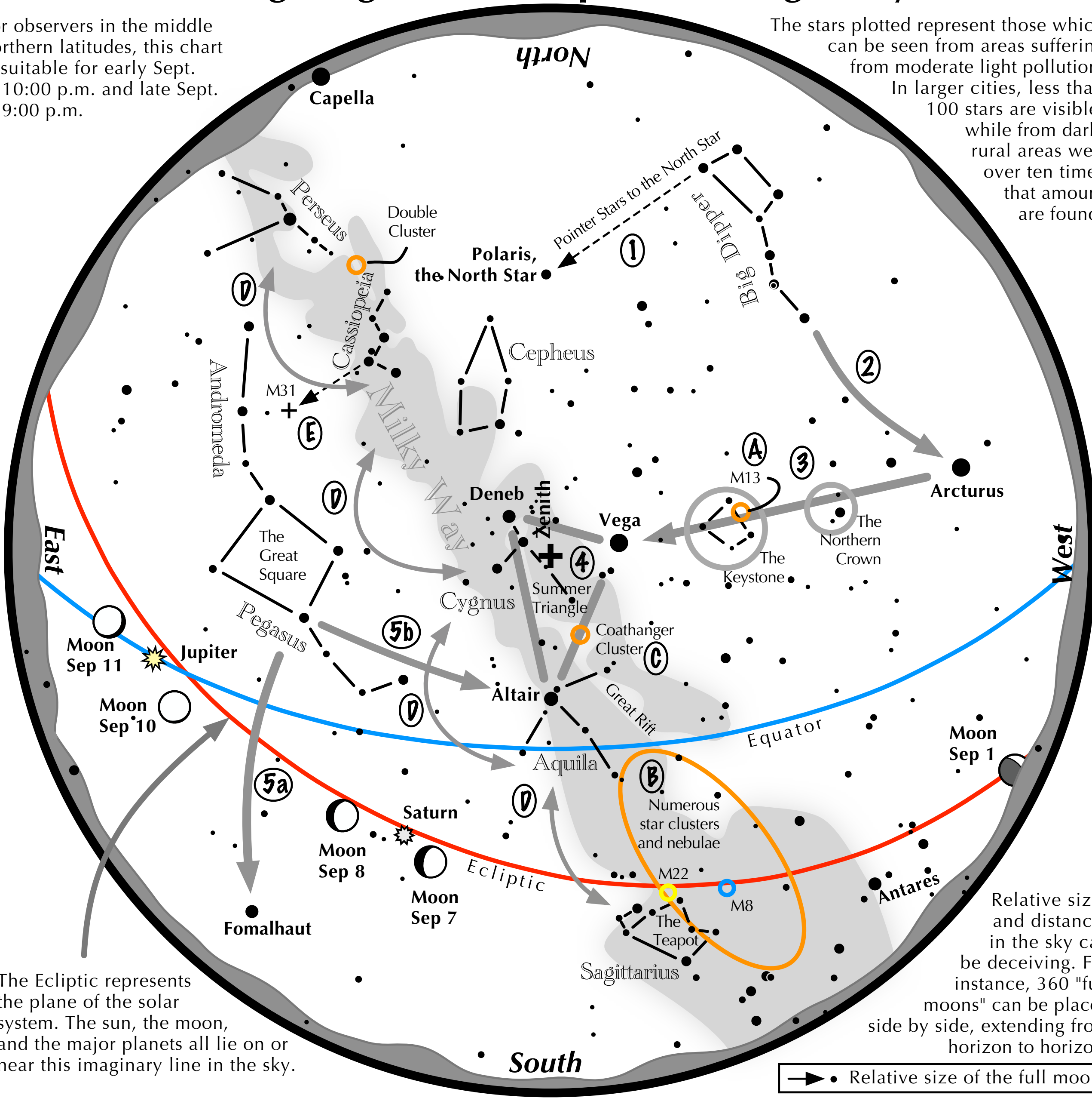
Bennett Observing Program

This is a program of deep space wonders that is a southern sky equivalent of the Messier Observing Program. National Observing Program Director Al Lamperti will initially be the BOP's coordinator. The program is a complete Observing Program of its own comprising 107 objects, and it will be the southern sky alternative to the Messier OP requirement for the Master Observer Award: https://www.astroleague.org/content/bennett-observing-program

Navigating the mid September Night Sky

For observers in the middle northern latitudes, this chart is suitable for early Sept. at 10:00 p.m. and late Sept. at 9:00 p.m.

The stars plotted represent those which can be seen from areas suffering from moderate light pollution. In larger cities, less than 100 stars are visible, while from dark, rural areas well over ten times that amount are found.



The Ecliptic represents the plane of the solar system. The sun, the moon, and the major planets all lie on or near this imaginary line in the sky.

Relative sizes and distances in the sky can be deceiving. For instance, 360 "full moons" can be placed side by side, extending from horizon to horizon.

Relative size of the full moon.

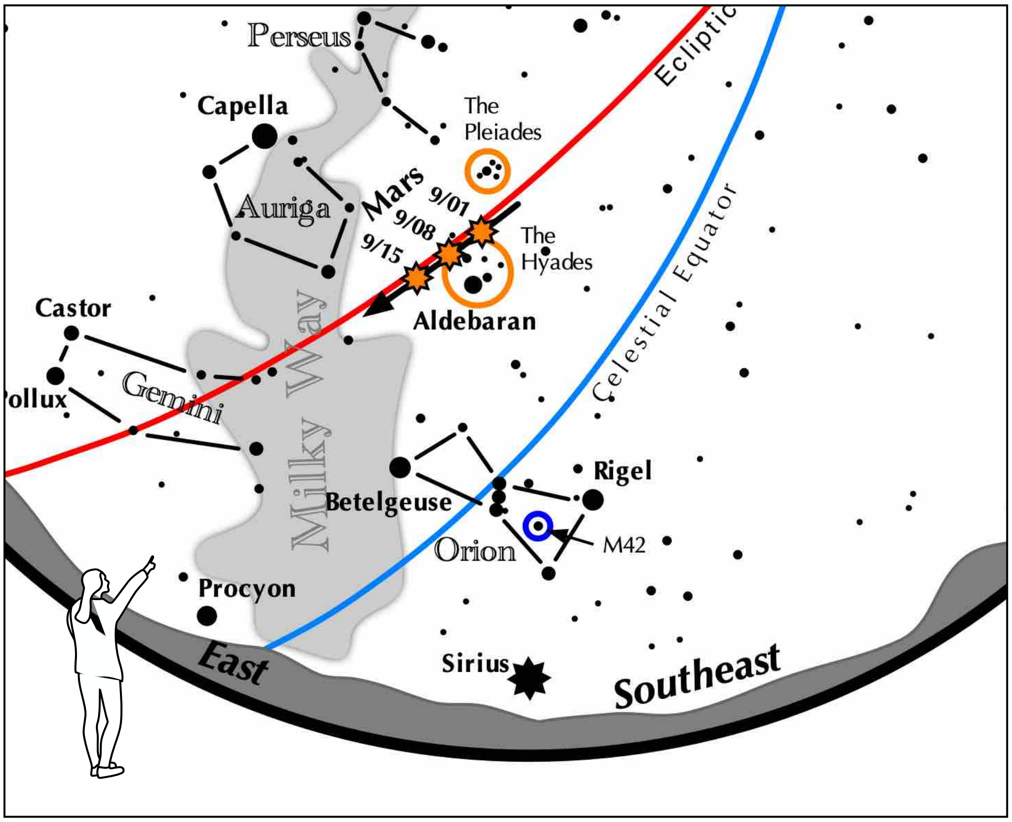
Navigating the mid September night sky: Simply start with what you know or with what you can easily find.

1. Extend a line north from the two stars at the tip of the Big Dipper's bowl. It passes by Polaris, the North Star.
2. Follow the arc of the Dipper's handle. It intersects Arcturus, the brightest star in the September evening sky.
3. Nearly overhead shines a star of similar brightness as Arcturus, Vega. Draw a line from Arcturus to Vega. It first meets "The Northern Crown," then the "Keystone of Hercules." A dark sky is needed to see these two dim stellar configurations.
4. The stars of the summer triangle, Vega, Altair, and Deneb, shine overhead.
5. The westernmost two stars of the Great Square, which lies high in the east, point south to Fomalhaut. The southernmost two stars point west to Altair.

Binocular Highlights

A: On the western side of the Keystone glows the Great Hercules Cluster.
B: Between the bright stars Antares and Altair, hides an area containing many star clusters and nebulae.
C: 40% of the way between Altair and Vega, twinkles the "Coathanger," a group of stars outlining a coathanger.
D: Sweep along the Milky Way for an astounding number of faint glows and dark bays, including the Great Rift.
E: The three westernmost stars of Cassiopeia's "W" point south to M31, the Andromeda Galaxy, a "fuzzy" oval.

If you can see only one celestial event in the morning this September, see this one.



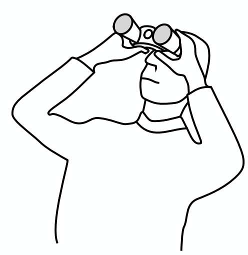
Mars Slides Between the Pleiades and the Hyades

On the first few mornings of September, look high in the east–southeast 90 minutes before sunrise.

• Bright, red Mars brightly shines to the upper right of Orion.

• From September 1 through September 8, the Red Planet slides between the Pleiades and Hyades star clusters.

• Compare Mars' hue and brightness with those of nearby Aldebaran.



About Astronomy Associates

The club is open to all people interested in sharing their love for astronomy. Monthly meetings are typically on the last Sunday of each month and often feature guest speakers, presentations by club members, and a chance to exchange amateur astronomy tips. These meetings and the public observing sessions that follow are scheduled at the Baker Wetlands Discovery Center, south of Lawrence. All events and meetings are free and open to the public. Periodic star parties are scheduled as well.

Because of the flexibility of the schedule due to holidays and alternate events, it is always best to check the Web site for the exact Sundays when events are scheduled.

Copies of the Celestial Mechanic can also be found on the web at newsletter.
Annual Dues for the club are: $12 for regular members; $6 for students Membership forms can be accessed at the club website form.