Volume 49 Number 8

August 2023

# The Celestial Mechanic

The Official Newsletter of the Astronomy Associates of Lawrence

## Coming Events

**Monthly Meeting**
**August 27, 2023, 7:00PM**
**Baker Wetlands Discovery Center**

**Public Observing**
**August 27, 2023, 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

Summer is almost over, and its time to start our monthly club meetings again. But first a review of our summertime activities. Weather caused three of our four scheduled City Band Concert observing sessions to be cancelled when the concerts were moved indoors. We have been discussing other possible summer activities that the club could undertake in the future. If you have any ideas feel free to share them with us.

With this month's Celestial Mechanic we will be bringing back "The Backyard Observer," a series that ran in the newsletter from 1987 through 1990. Each month will focus on a different constellation and the objects contained therein.  The constellation maps have been upgraded with new maps from the International Astronomical Union. I hope you enjoy these articles.

As I mentioned earlier, our club meetings will start again in August. The fall meeting dates are listed below.

Sunday, August 27

Sunday, September 24

Sunday, October 29

Sunday, December 3

All meetings take place at Baker Wetlands Discovery Center, and start at 7 PM. Public observing will start after the meeting, usually around 8 PM.

Looking forward to another year. Keep looking up.

# A newfound gravitational wave 'hum' may be from the universe's biggest black holes

The timing of pulses from dead stars hints at ripples in spacetime that are light-years long

By Emily Conover

SCIENCENEWS, JUNE 28, 2023

Dead stars called pulsars (illustrated) emit beams of radio waves that sweep past Earth like clockwork. Gravitational waves from supermassive black hole pairs (upper left) are thought to ripple the fabric of spacetime and alter the pulsars' timing.

Beneath the explosions, collisions and other intermittent bangs in the cosmos, scientists suspect a nonstop soundtrack plays, created by ripples in spacetime continually washing through the universe. After more than a decade of searching, scientists may have finally heard that background hum.

Several teams of researchers from around the world reported on June 28 the first clear evidence of these gravitational waves. Unlike previously detected gravitational waves, these new ones have ripples that are staggeringly long — on the scale of light-years. Their likely source: innumerable pairs of gargantuan black holes, which churn the spacetime cauldron as they orbit one another.

If that hunch is correct, the result would provide the first evidence that pairs of monster black holes, with masses billions of times that of the sun, can coalesce into one.

If the gravitational waves are real, and if they truly are a signal of supermassive black hole pairs, "it's miraculous," says astrophysicist Meg Urry of Yale University. "It's extremely interesting, because we have essentially no handle on what the most massive black holes are doing."

Gravitational waves are produced by accelerating, massive objects. As these waves careen through the universe, they rumple the fabric of spacetime upon which reality is embroidered. In 2015, scientists with the Advanced Laser Interferometer Gravitational-Wave Observatory, or LIGO, detected gravitational waves for the first time (*SN: 2/11/16*). Those waves were spawned by mergers of relatively puny black holes, entirely different beasts than the supermassive ones that lurk at the centers of galaxies (*SN: 2/11/16*).

While LIGO picks up gravitational wave blips that can last mere fractions of a second, orbiting supermassive black holes are expected to pump out waves continually for millions of years, creating ripples that blanket the cosmos with their constant hum. "This is a very different sort of thing, very new sort of thing," says LIGO researcher Daniel Holz, an astrophysicist at the University of Chicago. "That is awesome."

Across the universe, galaxies regularly mingle and merge. As they do, scientists suspected, their supermassive black holes would orbit one another and emit gravitational waves. Many pairs of black holes would be doing this orbital dance at once, in the many merging galaxies scattered throughout the cosmos, all sending their spacetime ripples out into space.

Astronomers used a variety of radio telescopes, including the Effelsberg radio telescope (shown) in Germany, to monitor pulsars in the hunt for gravitational waves.

"The Earth is just randomly bumping around on this sea of gravitational waves," says astrophysicist Maura McLaughlin of West Virginia University in Morgantown and a member of the North American Nanohertz Observatory for Gravitational Waves, or NANOGrav.

Detecting this mishmash of gravitational waves is not easy. The task required scientists to MacGyver the Milky Way, turning the galaxy into a gravitational wave detector by timing the clocklike ticking of dead, spinning remnants of exploded stars called pulsars, which emit beams of radio waves as they twirl. These beams sweep past Earth at regular intervals, like the precise ticks of a clock. Gravitational waves stretching and squeezing the space between the pulsars and Earth cause the pulsars' ticks, observed with a variety of radio telescopes around the world, to come early or late.

To ensure that they were seeing the gravitational waves, rather than uninteresting jitters, the researchers looked for a special type of correlation between different pulsars. Pulsars near one another on the sky should show similar timing shifts, but those that are at right angles to one another should observe opposite shifts: One pulsar's blips come early while the other's come late.

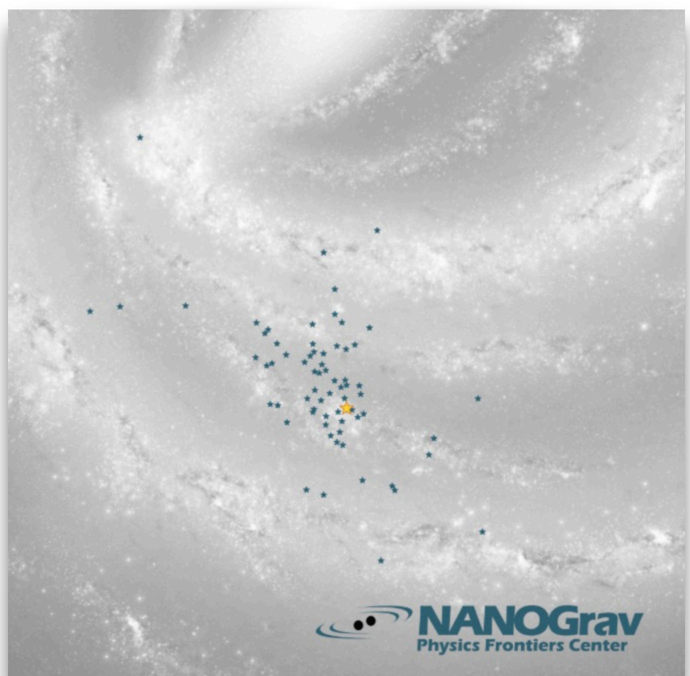
That compelling hallmark has finally been observed, NANOGrav researchers reported June 28 in the *Astrophysical Journal Letters*. "There's nothing in nature that can mimic this," says Chiara Mingarelli, an astrophysicist at Yale University and NANOGrav researcher. "Only gravitational waves can make that." Their result was based on 15 years spent monitoring dozens of pulsars.

"It's really invigorating stuff," says astrophysicist Michael Keith of the University of Manchester in England, a member of the European Pulsar Timing Array, or EPTA.

The EPTA team spent an even longer time staring at pulsars — a quarter of a century. "We were getting to the point where we were starting to think maybe the signal is just so weak, we'll never ever find it," Keith says. But the telltale correlation between pulsars was also evident in the EPTA results, which were reported in a series of papers accepted in *Astronomy and Astrophysics* with researchers from the Indian Pulsar Timing Array.

Some scientists have thought that supermassive black holes in merging galaxies would never draw close enough to coalesce with one another, or to emit gravitational waves like the ones observed. "It's actually been a sore spot for our field for many years," Mingarelli says.

In contrast, the gravitational wave signal seems to be stronger than expected (*SN*: 6/3/23). That suggests, "there are many black holes, they merge happily, and black holes also grow [to large masses] very happily," says astrophysicist Marta Volonteri of Institut d'Astrophysique de Paris, who was not involved with the new research.




Scientists made a gravitational wave detector out of the Milky Way (a section illustrated in gray) by monitoring the timing of signals from dozens of exploded, spinning stars called pulsars (blue stars) as observed from Earth (yellow star).

Future work could reveal more about supermassive black holes and their environs, says astronomer Ryan

Shannon of Swinburne University of Technology in Melbourne, Australia.

“Understanding better the demographics of these supermassive black holes is going to help us understand how galaxies form and evolve,” says Shannon, a researcher on the Parkes Pulsar Timing Array in Australia, which also reported independent results in the *Astrophysical Journal Letters* and in a paper accepted **in** *Publications of the Astronomical Society of Australia*. A shorter-term effort, from the Chinese Pulsar Timing Array, reported its results in *Research in Astronomy and Astrophysics*.

The teams stopped just short of declaring an ironclad detection of the background of gravitational waves, rather presenting their results as strong evidence for the ripples. Taken individually, their results don’t quite meet the most stringent standards for statistical significance set by physicists. In future work, the teams plan to combine their data, in hopes of further solidifying the detection.

And although supermassive black holes are the simplest explanation for the waves’ origins, researchers still can’t rule out a more exotic provenance. For example, the ripples might have arisen from inflation, the period just after the Big Bang when the universe is thought to have expanded incredibly rapidly (*SN: 7/13/12*).

Whatever the source, the future study of these gravitational waves is bound to have ripple effects. ☀

# Saturn’s rings shine in new Webb telescope photo

By Kristen Rogers

CNN, July 4, 2023

Astronomers have discovered surprising details about Saturn’s atmosphere, using a new image captured by NASA’s James Webb Space Telescope.

In the image, Saturn itself appears extremely dark due to the near-total absorption of sunlight by methane gas. The rings, however, remain bright, creating the “unusual appearance” of the planet in this photo, according to NASA.

Saturn’s moons Dione, Enceladus and Tethys dot the left side, while the Cassini division, Encke gap and rings A, B, C and F are shown on the right side. The Cassini division is the largest of the gaps in Saturn’s ring systemThe near-infrared observations of the ringed planet are a first for the highly sensitive telescope, according to NASA — which, at 1.5 million kilometers (nearly 932,000 miles) from Earth, observes the universe with wavelengths of light longer than those of other space telescopes.


The image was taken with Webb’s Near-Infrared Camera, known as NIRCam, as part of a Webb program that involves several exceptionally deep exposures of Saturn, according to NASA. These exposures test Webb’s ability to spot faint moons around the planet and its rings, since any newly discovered moons could help scientists better understand Saturn’s present and past systems.

Unexpectedly, “the large, diffuse structures in the northern hemisphere do not follow the planet’s lines of latitude, so this image is lacking the familiar striped appearance that is typically seen from Saturn’s deeper atmospheric layers,” according to NASA.

Differences in the looks of Saturn’s northern and southern poles are normal, according to NASA, as the northern region experiences summertime while the southern hemisphere is exiting winter darkness. But the darker-than-usual appearance of the northern hemisphere could be from “an unknown seasonal process affecting polar aerosols in particular,” NASA says.

The brightening near the edge of Saturn’s disk might be due to high-altitude methane fluorescence (the process of emitting light after absorbing light) or emissions in the planet’s ionosphere or both. ☀

# Time Appears to Have Run 5 Times Slower in The Early Universe

By Michellel Starr
SCIENCEALERT, JULY 4, 2023

Because of a peculiar effect velocity has on the appearance of the passage of time, our observations make it seem like time ran slower when the Universe was just a baby.

An illustration of a quasar in the early Universe.

At least, that's how it appears to us, at a light travel time of nearly 13 billion years away. This is called time dilation, and astrophysicist Geraint Lewis of the University of Sydney in Australia and statistician Brendon Brewer of the University of Auckland have seen it in the early Universe for the first time by studying the fluctuations of bright galaxies called quasar galaxies during the Cosmic Dawn.

Because of accelerating expansion of the Universe, they have found, we see those fluctuations unfold at a rate five times slower than if they were occurring nearby.

It's the most distant we've ever seen time dilation in action, and it solves several problems. It shows that quasars are consistent with the effect over vast gulfs of space-time, which means not only are they in agreement with the standard model of cosmology, we can take time dilation into account in studies of their behavior.

Something similar should – and does – happen to time, as we've seen in supernova explosions about halfway across the observable Universe.

Time passes normally to us. To someone hanging out near the supernova explosion, time would appear to also pass normally. But because of the relative velocity between the two points, the supernova appears, to us, to occur in slow-motion.

It's been predicted that quasars in the early Universe should show a similar effect, but they are different kinds of objects from supernovae. Quasar galaxies are those that have an actively feeding supermassive black hole in their center. The feeding process produces a great deal of light as the material around the black hole heats up, flickering with turbulence.

"Where supernovae act like a single flash of light, making them easier to study, quasars are more complex, like an ongoing firework display," Lewis says. "What we have done is unravel this firework display, showing that quasars, too, can be used as standard markers of time for the early Universe."

Lewis and Brewer studied a sample of 190 quasars from between 2.45 and 12.17 billion years ago (the Big Bang took place 13.8 billion years ago), with data across a range of wavelengths taken over a time period of two decades. They had around 200 observations for each quasar, allowing detailed reconstructions of their fluctuations.

Previously, scientists had thought that quasar variability did not show the effects of time dilation, but the samples were small, and observed over a much shorter time period.

By dramatically expanding both the number of quasars, and the duration of observations, the two researchers found that they do appear to flicker in slow motion, compared to more recent quasars.

"Earlier studies led people to question whether quasars are truly cosmological objects, or even if the idea of expanding space is correct," Lewis says. "With these new data and analysis, however, we've been able to find the elusive tick of the quasars and they behave just as Einstein's relativity predicts." ☀

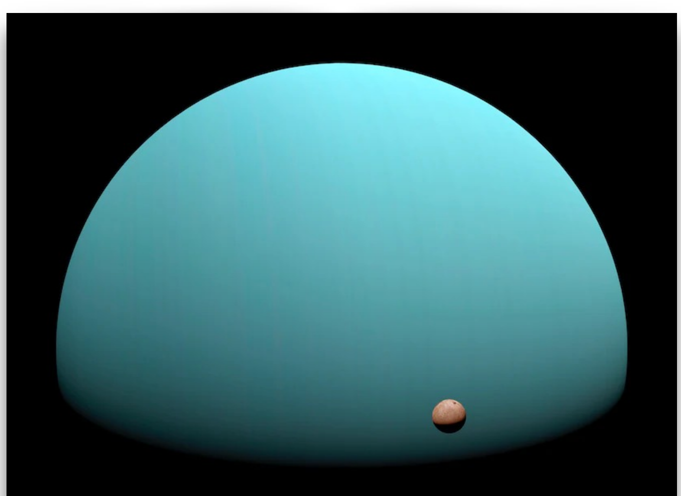
Astrophysicist Geraint Lewis of the University of Sydney in Australia.

# Probing Uranus Could Help NASA Indirectly Find Planet Nine

By Kiona Smith

Inverse, July 14, 2023

If there's a planet hiding in our outer Solar System, its gravitational pull on spacecraft passing through the outer Solar System could give it away.



If NASA ever probes Uranus, it just might find Planet 9; that's not a terrible joke, just an actual research idea from a team of physicists. NASA **wants to probe Uranus**, and the agency has been kicking around ideas for a mission, tentatively named the Uranus Orbiter and Probe, to do exactly that.

On its way to Uranus, the mission could also help settle the debate about whether there's a ninth planet somewhere beyond Pluto. According to recent computer simulations by University of Zurich physicist **Jozef Bucko** and his colleagues, measuring tiny changes in the spacecraft's flight path might reveal the gravitational pull of a hidden planet and tell astronomers where to look.

### LOOKING FOR PLANET 9 ON THE WAY TO URANUS

Astronomers have spent years debating whether there's a giant planet orbiting somewhere in the outer reaches of our Solar System, far beyond Pluto. One of the best arguments for Planet 9's existence is the weird way a handful of small icy objects in the Kuiper Belt seem to cluster into similar long, tilted orbits, as if something much bigger was influencing all of them. Some astronomers, especially Caltech planetary scientists Mike Brown and Konstantin Batygin, argue that the "something" is a planet a little smaller than Neptune and 20 times farther from the Sun: **Planet 9**.

Bucko and his colleagues used computer simulations to model how the gravitational pull of planets in the outer Solar System would affect the course of NASA's proposed Uranus Orbiter and Probe mission during the long cruise from Jupiter to Uranus. We're talking about very tiny changes, adding up to about 12 miles over the course of ten years and more than a billion miles of travel.

But Bucko and his colleagues figured out how to unravel the subtle pull of distant Planet 9 from the competing tugs coming from Jupiter, Saturn, Neptune, and Uranus. The result suggests that keeping a close eye on the probe's position could help narrow down Planet 9's mass and the direction to it — assuming it's out there somewhere.

In the event NASA actually decides to probe Uranus, Bucko and his colleagues say the mission could also discover lots of things that have nothing to do with Uranus. Radio-ranging data from the spacecraft could reveal the passing of extremely low-frequency gravitational waves or help physicists measure how much dark matter is in our Solar System.

**HOW IT WORKS**

When spacecraft are on their way to distant locations, they radio home every day. Engineers use the Doppler shift of those radio messages to measure how fast the ship is moving away from Earth, and they can be extremely precise; New Horizons' team managed to measure the spacecraft's velocity to within a millimeter per second. Bucko and his colleagues simulated what radio-ranging data would like over the course of the Uranus probe's 9-year cruise between Jupiter and Uranus (if there was, in fact, a whole planet lurking somewhere beyond Neptune's orbit).

The researchers discovered that it would be possible to figure out what part of that movement was thanks to Planet 9 — or at least, what part wasn't thanks to the subtle pull of Jupiter, Saturn, Neptune, and Uranus, and of course the Sun. Bucko and his colleagues' simulation only included the Sun and the four planets (that we know of) in the outer Solar System.

In real life, engineers would need to account not only for those five heavyweights, but also for the gravitational "noise" of dwarf planets like Pluto, large moons like Triton, and smaller objects in the Kuiper Belt. That means the math is more complicated, but the principle is the same.

According to Bucko and his colleagues in their recent paper, "Planet 9's gravitational field will produce an almost constant acceleration throughout the mission," which is "a very clear signature of unique distant objects." And the effects of Planet 9's gravity should get stronger as the Uranus probe flies farther from the Sun, so those changes over time will also be a good sign that it's really Planet 9 pulling on the spacecraft. That should be the best evidence yet for the hypothetical planet's existence (if it does, in fact, exist).

**NEXT STEP, PICTURES OF PLANET 9?**

Radio ranging data from a spacecraft on its way to Uranus should help astronomers estimate Planet 9's mass, but the really exciting prospect is that astronomers should be able to pinpoint a patch of sky two degrees wide and two degrees tall and say "Planet 9 is somewhere in out here, specifically."

That could tell astronomers where to look for the distant planet. Because it's so far from the Sun, Planet 9 probably doesn't reflect much light, so it's going to be a difficult target for even the most sensitive telescopes; narrowing down the search area could be a tremendous help.

Assuming Brown and Batygin's computer simulations are correct about how large and how far away Planet 9 might be, astronomers should be able to photograph it within the next decade or so. But don't expect anything like JWST's recent images of Jupiter. The first images of Planet 9 will probably be just a few faint pixels. ☀

# Strange two-faced dying star 'Janus' baffles scientists in cosmic oddity

By Monisha Ravisetti

SPACE.COM, JULY 20, 2023

"I was completely blown away by what I saw."


The looping lines here represent magnetic fields around Janus. Potentially, these fields may express an uneven distribution of strength.

While routinely scanning the sky for the burnt-out remnants of dying stars, scientists stumbled upon a strange cosmic signal. After running a few more tests, they were stunned.

One of their observed stellar corpses, a white dwarf star more than 1,000 light-years from Earth that spins once every 15 minutes, had a peculiar appearance. Its orb-like surface possessed two different elements on either of its sides, weirdly divided like a basketball sliced down the middle. On one face, the researchers identified traces of hydrogen — on the other, helium. Though the split may not be exactly 50-50, the breakup the researchers saw was apparent enough to leave them scratching their heads.

"This was a completely serendipitous discovery," astrophysicist Ilaria Caiazzo, a postdoctoral scholar at the California Institute of Technology and member of the discovery team, told Space.com via email. "I was completely blown away by what I saw, and so is any astronomer to whom I show the data."

The researchers even nicknamed the strange object "Janus," after the two-faced Roman god of transition. Of course, Janus also has a more scientific name: ZTF J203349.8+322901.1. Scientists studied the star with a wide range of equipment ranging from spectrometers to powerful laboratories such as its namesake, the Zwicky Transient Facility in San Diego, California.

It is true that both hydrogen and helium are characteristic of white dwarf compositions because these objects are thought to go through a sort of evolutionary phase where their heavier elements, like helium, sink toward the bottom and their lighter elements, like hydrogen, float toward the top. Caizzo notes, however, that such a transitional phase had been heavily theorized in the past but wasn't physically proven yet.

Nevertheless, the researchers say their discovery marks the first time the two elements have been seen present on a white dwarf with such a stark separation.

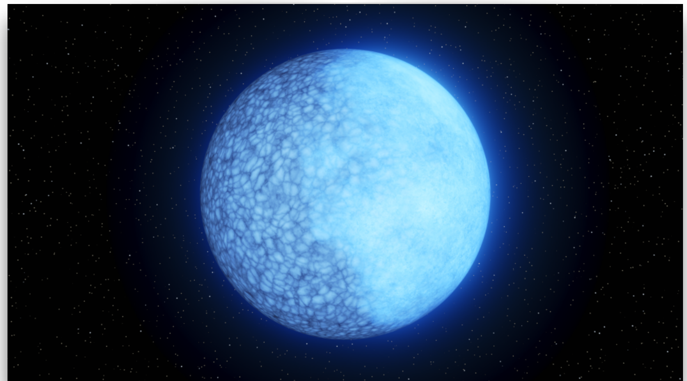
"In my search with ZTF, I was looking for rapidly rotating and highly magnetized white dwarfs that might be the remnants of double-white dwarf mergers -- and I found many candidates," Caiazzo said. "However, when I looked at the spectrum of Janus I immediately understood that this was something different."

To help uncover Janus' unconventional story, Caiazzo and fellow researchers did come up with a couple of explanations. Both theories, in essence, have two important aspects.

First off, it's possible Janus was caught during that aforementioned convection phase, but during a time when the elements started to mix together — a process some white dwarfs may experience when they reach a certain temperature. Janus happens to be around that temperature. But second, and perhaps key in solving the mystery, is that Janus might have asymmetric magnetic fields.

Simply put, this means one side of the white dwarf may have stronger fields than the other side. And, magnetic fields are likely key in deciding how much helium or hydrogen a white dwarf has on its surface.

In the same vein, Caiazzo also suggests the fields could lead to lower gas pressures in Janus' atmosphere and therefore a hydrogen "ocean" in the area with stronger fields.



An artist's illustration of the two-faced white dwarf star, Janus.

Going forward, the researchers hope they'll identify more stars like Janus with future ZTF surveys. With enough of these two-faced star corpse subjects, maybe a pattern will reveal itself.

"As we have indications that Janus could be the most striking example of a whole class of transitioning white dwarfs," Caiazzo said, "this discovery could help shed light on the physical mechanisms underpinning the spectral evolution of white dwarfs."

Even farther down the line, Janus could ultimately impact our understanding of atmospheric physics in general. "The fact that there is such a strong separation between the two elements over the surface," Caiazzo said, "as well as the fact that such structure has been stable for at least several years challenges our understanding of white dwarf atmospheres." ☀

# THE BACKYARD OBSERVER

by Rick Heschmeyer

Look directly overhead this month and you will see the constellation LYRA, the lyre or harp. It is an easy constellation to identify, in part due to its unique shape, a parallelogram with a triangle at one corner, but also because of the bright star Vega. Vega is one third of the asterism "The Summer Triangle", along with Altair in Aquila and Deneb in Cygnus. There are several objects in Lyra worth looking at if you have binoculars or a small telescope.

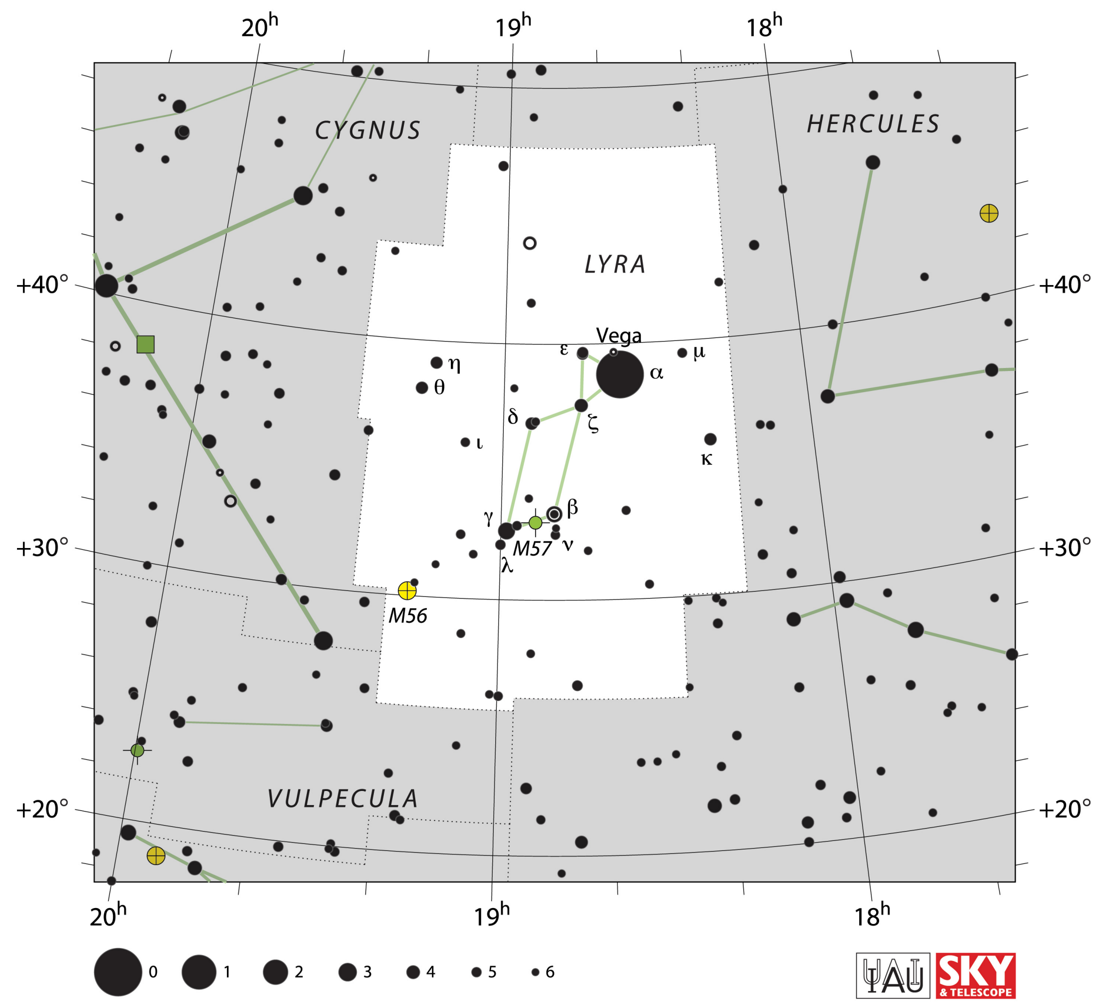
**ALPHA LYRAE:** Commonly known as Vega, it is the brightest star in the constellation with an apparent magnitude of +0.03, making it the fifth brightest star in the night sky. It is in the direction of Vega that our Sun and Solar System is travelling, at a speed of 19 km/sec. Located about 25 light years away, Vega was the first star ever photographed in 1850.

**EPSILON LYRAE:** One of the most famous multiple stars in the night sky. In fact, the two major components, Epsilon 1 and Epsilon 2, can be seen with only the slightest optical aid. Most interestingly, both stars are double stars in their own right as viewed through a telescope, leading to the system's nickname of "The Double-Double".

There are two deep sky objects in Lyra that were catalogued by the French astronomy Charles Messier in the late eighteen century.

**MESSIER 57:** Known as "The Ring Nebula", this object is a fine example of a planetary nebula. Not related to planets at all, the name refers to the similarity to planets in early telescopes. Planetary nebulae are the gaseous remains of stars that sloughed off material from their atmospheres during their Red Giant phase, leaving behind a White Dwarf. Ous Sun will suffer a similar fate in 5 billion years or so. M57 can be seen as a star-like object in binoculars, but needs a telescope to discern the smoke ring nature of the nebula.

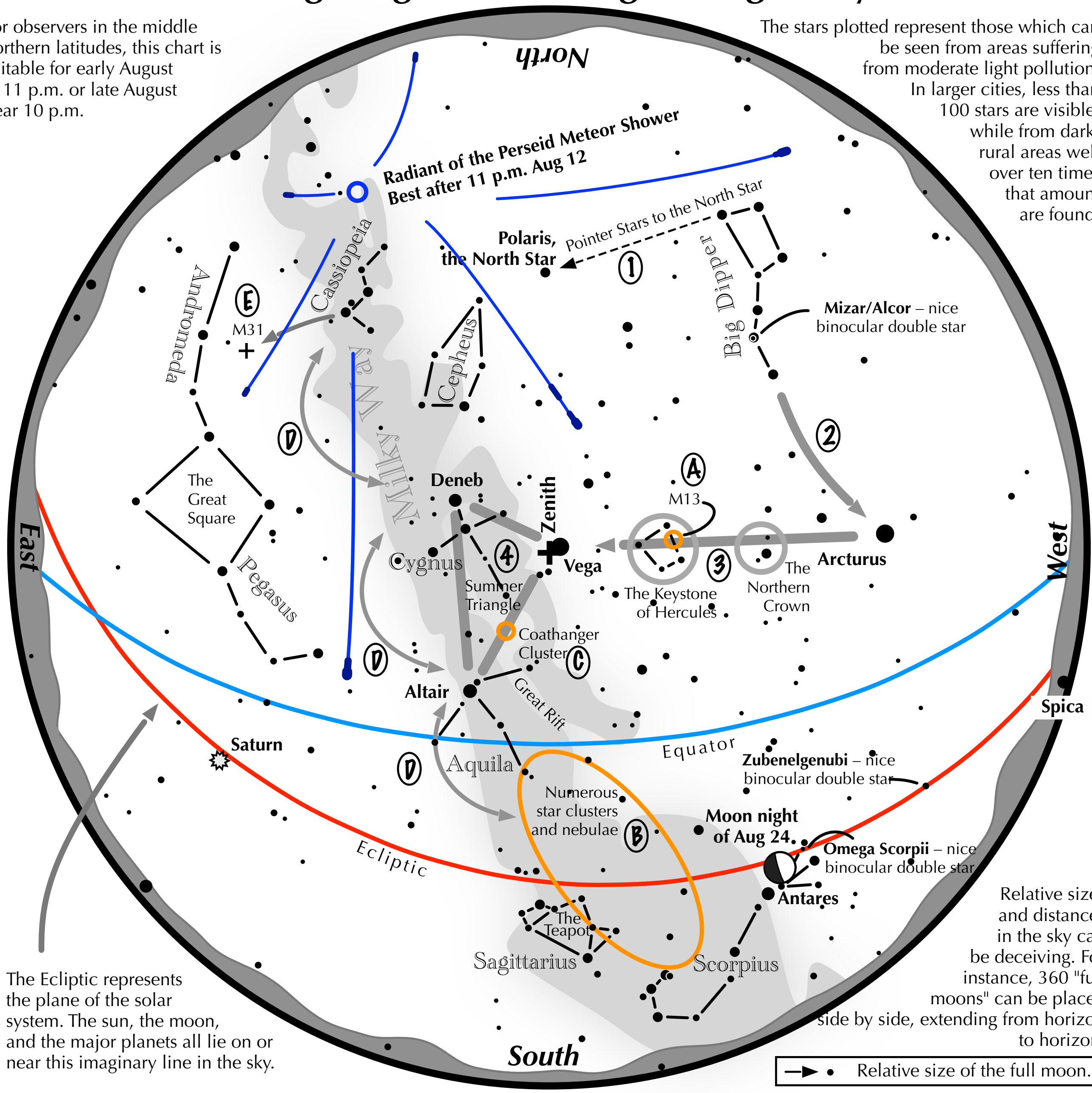
**MESIIER 56:** This object is a globular cluster, a compact group of thousands of gravitationally bound stars located in the outer fringes of our galaxy. With binoculars, from a dark location, M56 looks like a small hazy spot. A scope of 6 inches or better is needed to resolve any of the cluster's stars.



# Navigating the mid August Night Sky

For observers in the middle northern latitudes, this chart is suitable for early August at 11 p.m. or late August near 10 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.

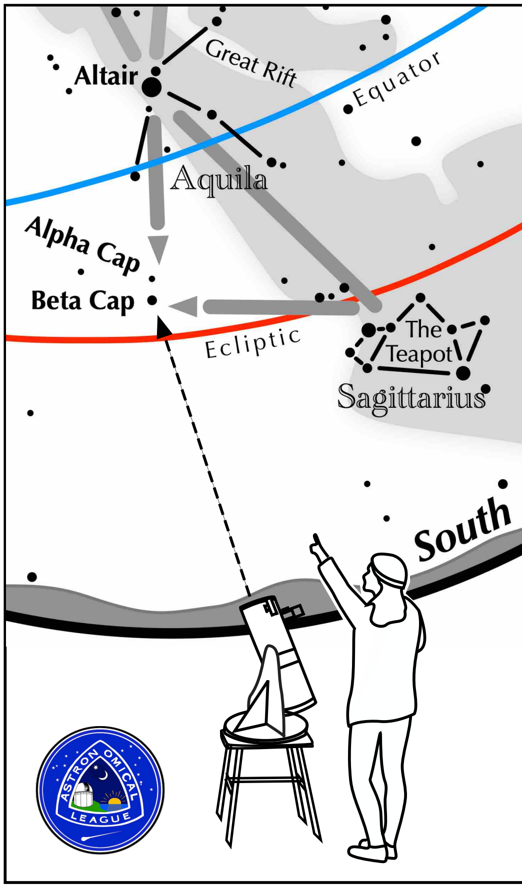
**Navigating the mid August night sky: Simply start with what you know or with what you can easily find.**

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 June evening sky.
3. To the northeast of Arcturus shines another star of the same brightness, 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. High in the East lies the summer triangle stars of Vega, Altair, and Deneb.

**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.

# ASTRONOMICAL LEAGUE Double Star Activity



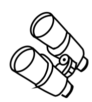

## Other Suns: Beta Capricorni

### How to find Beta Capricorni on an August evening

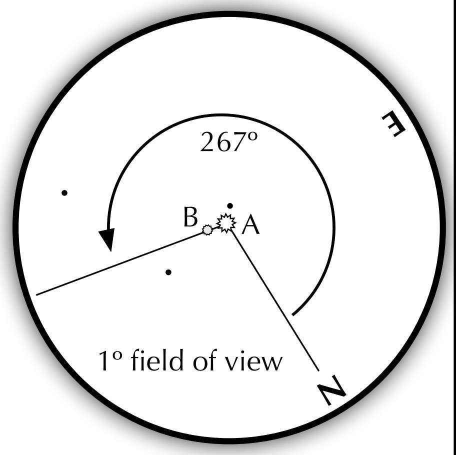
Find bright Altair, the southeastern member of the Summer Triangle. Then locate the "Teapot" asterism of Sagittarius. Use them to form a right triangle with Beta Capricorni being the right angle vertex.

Suggested magnification: >10x
Suggested aperture: >2 inches

**Beta Capricorni**
A-B separation: 207 sec
A magnitude: 3.2
B magnitude: 6.1
Position Angle: 267°
A & B colors:
orange, white



**Good binocular object!**




## 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.