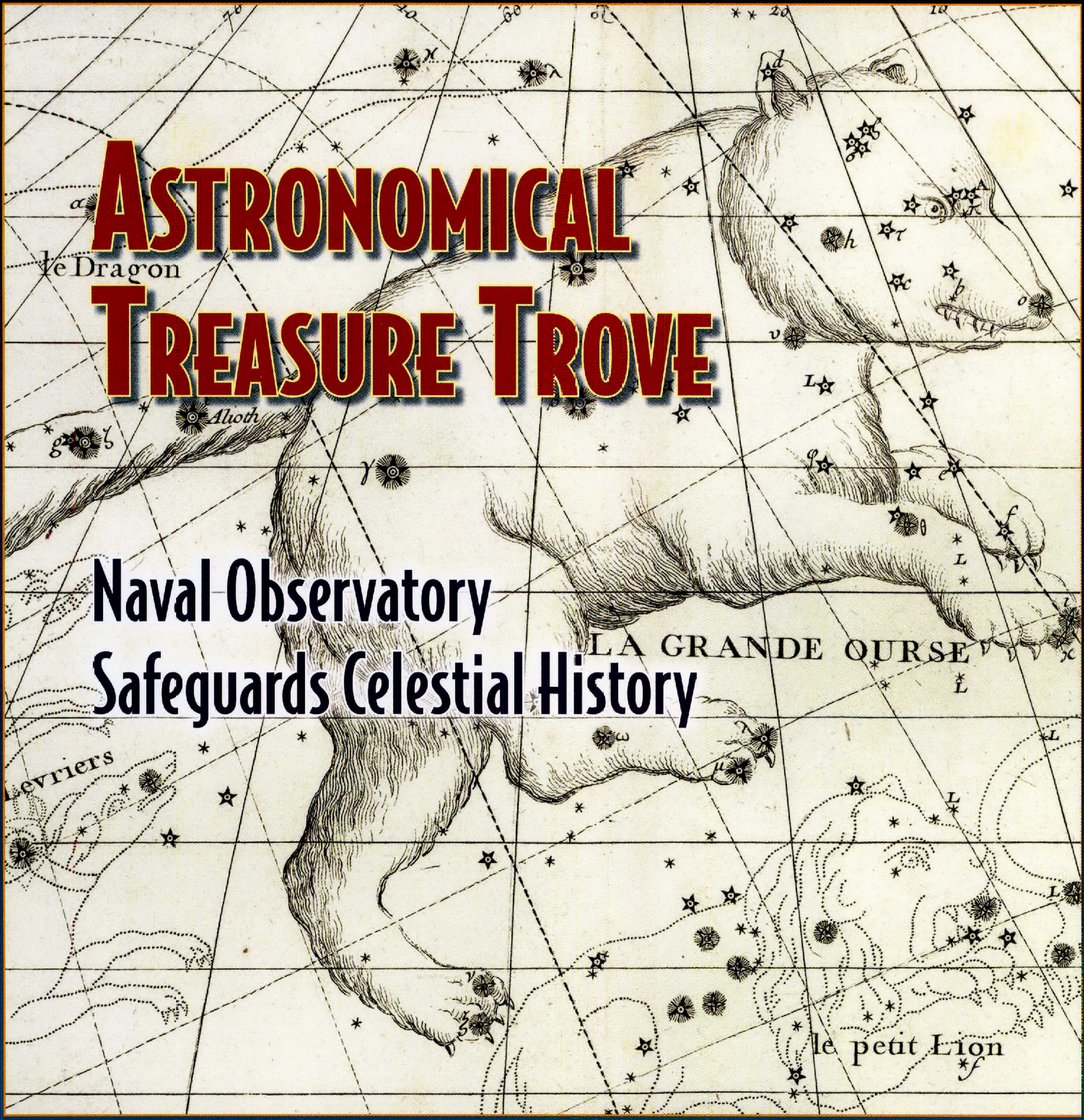
StarDate™

MARCH/APRIL 2009 $5

UNTANGLING A BINARY STAR
Page 4



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StarDate

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Features

Departments

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On The Cover
Ursa Major, the great bear, is seen as 'La Grande Ourse' in the 1795 French edition of British Astronomer Royal John Flamsteed's celestial atlas. For more on historical atlases and other astronomical artifacts, *see page 16.*

This Page
A dying Sun-like star has blown off its outer layers of gas (nitrogen, shown in red; hydrogen, green; and oxygen, blue) to create this beautiful planetary nebula, NGC 2818, spied by Hubble Space Telescope more than 10,000 light-years distant in the southern-hemisphere constellation Pyxis, the compass.

NASA/ESA/HUBBLE HERITAGE TEAM (STScI/AURA)

Coming Up in May/June
The next issue of StarDate *will feature excerpts from new books related to the themes of this year's International Year of Astronomy. And as always, we'll bring you the latest astronomy news, skywatching information, and Merlin's answers to your cosmic questions.*

MERLIN

Dear Merlin,

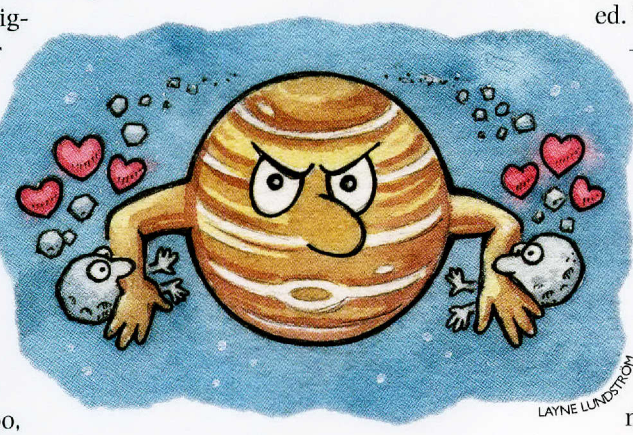
What was the cause of the asteroid belt between Mars and Jupiter?

Brent Davidson
Chatham, Ontario

In a word, Jupiter.

The planets were all born from chunks of rubble that coalesced from the cloud of gas and dust that gave birth to the Sun. The rubble clumped together to form bigger and bigger pieces, eventually creating the planets we see today.

Chunks of rubble between Mars and Jupiter probably tried to come together to form a planet, too, and eventually built up Ceres, which is about 600 miles (900 km) in diameter, plus many other good-sized chunks. But Jupiter didn't allow them to build up any larger bodies. Instead, the giant planet's gravity pushed, pulled, and kicked the asteroids away from each other.



Dear Merlin,

Are the constellations that we see in the night sky part of the Milky Way or are they farther away than they seem?

Bruce Pikas
Cicero, Illinois

Before Merlin answers your question, he will ask one of his own: How do you define "constellation?" Merlin's answer depends on yours.

Most people define a constellation as a connect-the-dots picture of stars, such as the lion of Leo or the teapot of Sagittarius. The stars in those patterns are generally no more than a couple of thousand light-years away, which places them well inside the Milky Way.

Astronomers use a more precise definition, though. In the 1930s, they split the sky into 88 official constellations and drew boundaries for each of them, like borders between states. These constellations incorporate every star and galaxy within their borders, so they extend out to the edge of the observable universe. Under this definition, some of a constellation's objects are inside the Milky Way, while others are far beyond it.

Dear Merlin,

I recently read that both Voyager spacecraft are far from the position they should be. The article said that although scientists can predict the discrepancies, they do not know what force is the cause. Is there any more information about this?

Bill Tandy
Austin

Lots of information, but no conclusions.

In the 1990s, scientists noticed that the Pioneer 10 and 11 spacecraft, which were in the outer reaches of the solar system, seemed to be a little closer to the Sun than expected. The effect was small — a few thousand miles out of billions of miles traveled. Still, the discovery of the "Pioneer anomaly" kicked off a research effort that continues today, as scientists try to determine if it is the result of mundane events or exotic new physics.

The researchers have studied the gravitational effects of the Sun, planets, and moons; the pressure exerted on the craft by the solar wind and solar radiation; maneuvers by the spacecraft, and many other factors.

A couple of years ago, for example, they discovered that heat from the Pioneers' nuclear generators was responsible for at least part of the anomaly. Most scientists expect that continued research will show that the remaining anomaly is the result of gas leaking into space or other effects caused by the spacecraft themselves.

The anomaly is far less pronounced with the Voyagers because they use more thruster firings to keep themselves steady, which makes it more difficult to plot any changes in their expected position.

Dear Merlin,

What are the chances for life in the seas (if there are any) on Jupiter's moon Europa?

Michael Sprufera
Watauga, Texas

A gravitational tug of war between Jupiter and some of its other moons warms Europa's interior, melting some of its mantle of ice. Many scientists say it's likely that this same process creates volcanic vents at the bottom of Earth's ocean, providing an energy source. The vents may spew out a wonderful cocktail laced with organics — the chemistry of life.

So the raw ingredients for life all seem to be there: water, energy, and organic chemistry.

Just because you have eggs, cream, sharp cheddar, and some seasonings, though, doesn't mean you can make a cheese soufflé. Scientists don't know if the ingredients for life always cook themselves up in just the right way to form life itself, or whether the creation of life on Earth was a unique event.

So it's entirely possible that life exists at Europa, but until someone actually drills through the ice and takes a look, any answers are little more than speculation.

Merlin is unable to send personal replies. Answers to many astronomy questions are available through our web site:

stardate.org/resources/faqs

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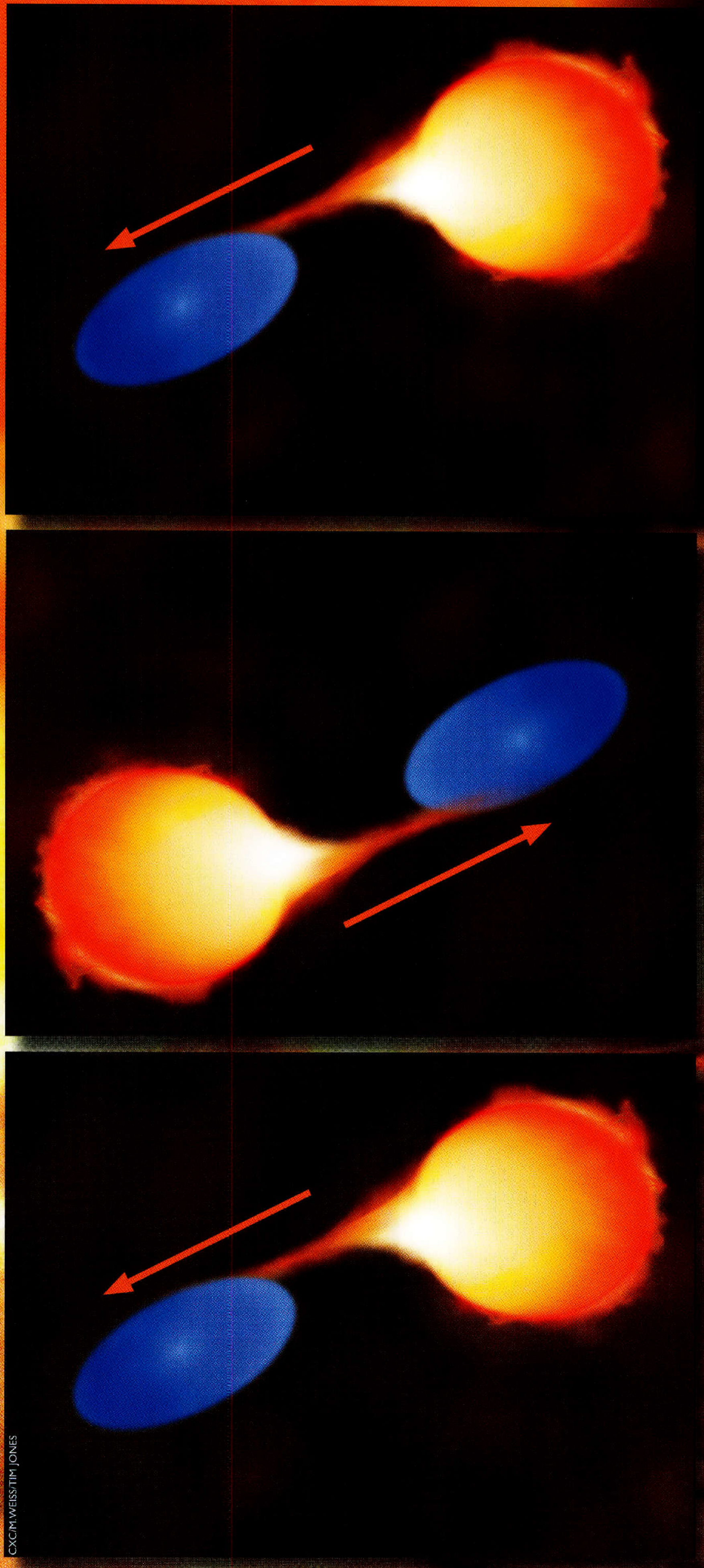


This series of illustrations shows what astronomers now think is going on with the unusual binary star Beta Lyrae. In the first frame, the less-massive component has expanded into a bloated red giant (right), and its outer layers of gas are being siphoned off by its massive but compact companion, buried at the center of a thick disk of swirling gas (left, blue). In the middle frame, the originally dense and compact star (left) has accreted so much mass that it is has now ballooned into a red giant. Its stripped companion (right) is now the one sucking gas away, and has developed its own accretion disk. In the bottom panel, the stars have again switched roles.

CXC/M.WEISS/TIM JONES

P. MARENFELD AND NOAO/AURA/NSF

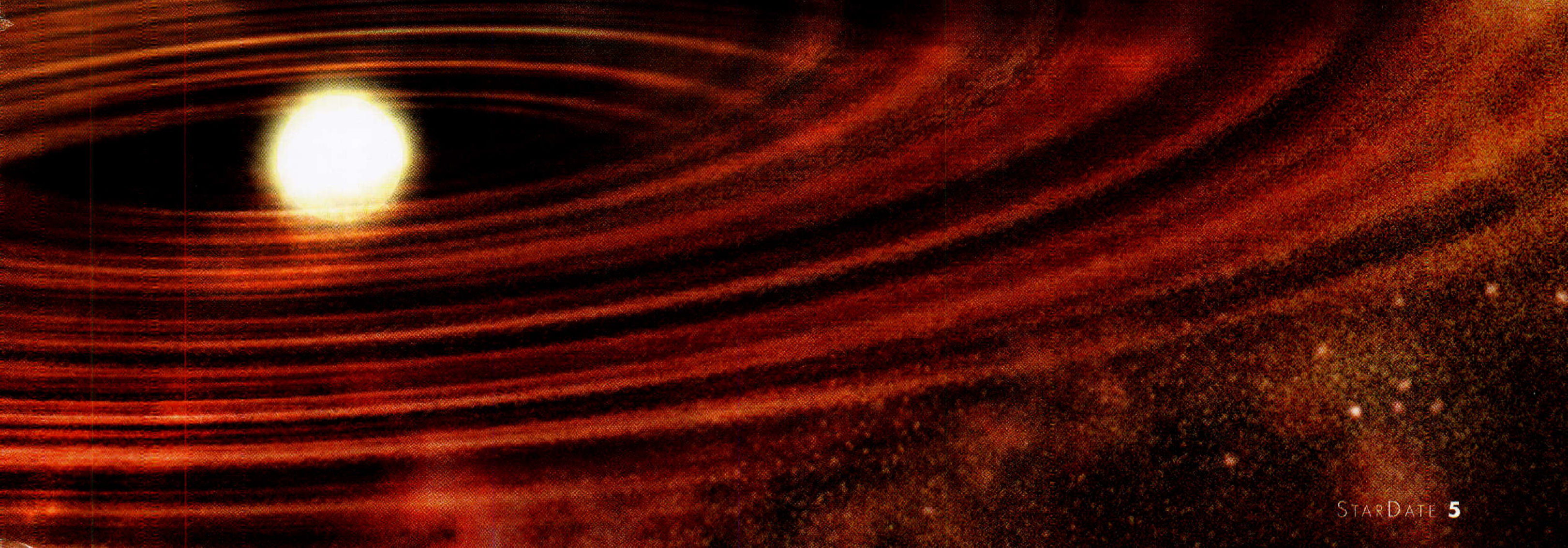
Understanding Beta Lyrae

After more than two centuries of study, a seemingly simple binary star reveals its twisted nature

By Robert Zimmerman

For more than 200 years, astronomers have struggled to explain the nature of a stellar oddball known as Beta Lyrae, the second-brightest star in Lyra, the harp. Every 13 days, the star's brightness waxes and wanes in a constantly changing pattern, first dimming by about 70 percent over a period of three days, then returning to its original brightness only to dim again, this time by about 30 percent. This double pattern has repeated every 13 days since the star's variability was discovered in the late 1700s.

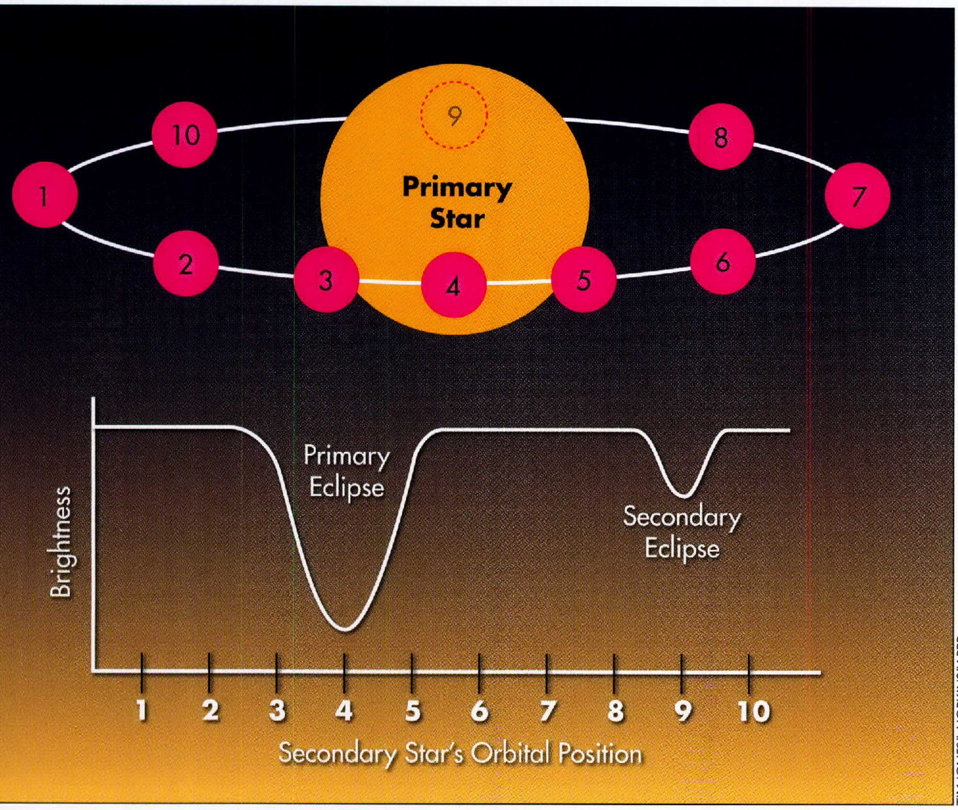
At first glance, the pattern's cause seemed such a simple and obvious thing. Astronomers theorized that Beta Lyrae was made of two stars orbiting each other. As the dimmer star circled behind or in front of its brighter partner, the system's overall light output changed — with the deeper dimming occurring when the fainter star was in front as seen from Earth.



But Beta Lyrae's cycle is *not* simple or obvious. For one thing, the cycle's length has been increasing by about 19 seconds per year for the last few centuries. For another, the smooth nature of the changes fit no eclipse pattern that astronomers could easily understand.

These are not the only mysteries. When scientists took their first really close look at Beta Lyrae in the 1800s, it appeared to be an untidy place, with streams of gas and dust flowing in many directions at various speeds. Even more puzzling, though the system dims significantly during each minimum, the eclipsing star remained completely undetectable.

In the end, the struggle to understand this strange system has helped revolutionize our understanding of stellar evolution and the very nature of stars. And even more exciting, after more than two centuries of study, astronomers finally have a series of images of this binary system, showing the stars as they circle each other, proving that the conclusions from decades of difficult theoretical work to disentangle this baffling system are essentially correct.



If it's dim or distant enough, a binary star system will appear as a single point of light on first glance. Carefully measuring its light output over time can reveal patterns in its brightness (bottom) that indicate recurring eclipses. This diagram represents a typical eclipsing binary star system. The light from Beta Lyrae, however, created a much more complicated pattern that took astronomers centuries to untangle.

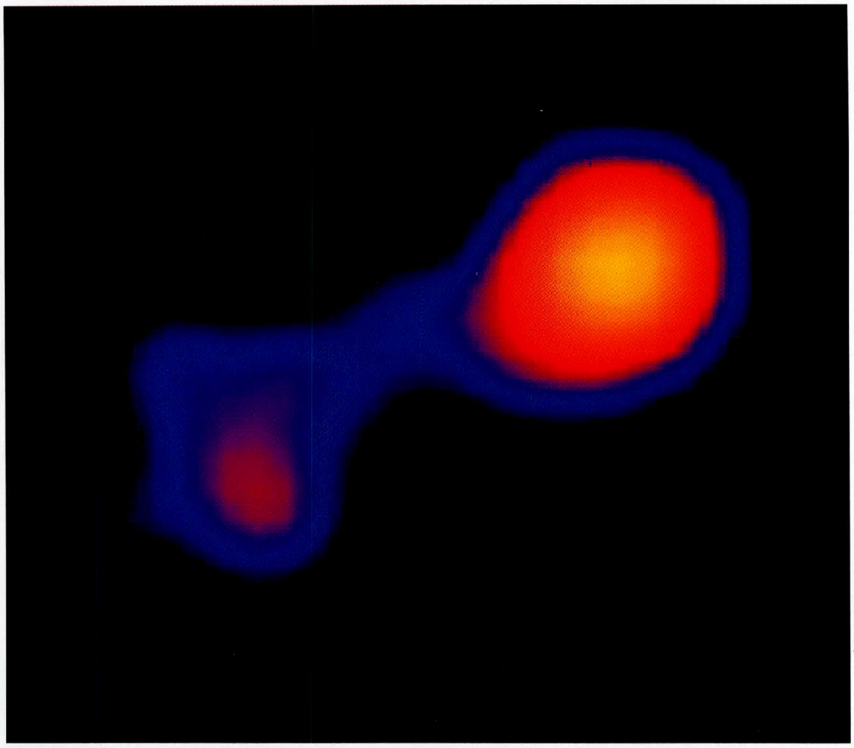
Located about 970 light-years away, Beta Lyrae is probably one of the most studied variable stars in the sky. Though both the Chinese and the Arabs gave the star a name, it wasn't until 1784 that British amateur astronomer John Goodricke first documented the star's light variability. By the late 1850s, astronomers had precisely established both its period (the length of its light cycle) and range (the brightest and dimmest it shines).

Based on the eclipse pattern, astronomers quickly realized that the star was a binary system seen almost edge-on. The system appeared brightest when the two stars were side by side, with the two faint periods occurring when the dimmer star moved either in front of or behind the brighter star.

What made the system puzzling, however, was that its brightness changed constantly in a continuous curve of hills and valleys, something that could not easily be explained by this simple eclipse model. When the eclipsing star moves across the face of its companion, the brightness should drop, remain steady while the star completes its transit, then rise again as the eclipse ends. The system's brightness should also become steady during the time the two stars are side by side.

Beta Lyrae's brightness, however, never stopped changing. Instead, it continually waned and waxed. Moreover, long-term observations showed that the cycle was getting longer, by about 19 seconds per year. Even more baffling, the first results from spectroscopy — a new observing tool developed in the late 1800s that breaks a star's light into its component wavelengths — showed a complicated flow of material, with the dimmer eclipsing star having no visible spectrum. It looked as if that star produced no light at all!

Though several astronomers suggested that the variations and spectroscopy might be explained by either a single rotating star covered with bright and dark areas, or a swarm of asteroids that periodically eclipsed the star, almost no one liked these models. The first required that the spots be permanent features



NASA/CXC/SAO/M. KAROVSKA ET AL.

The Chandra X-ray Observatory snapped this photo of binary star Mira, in which a compact white dwarf (Mira B, left) is pulling gas off a much larger red giant (Mira A, right). High-velocity collisions between gas particles around the stars and in the flow of gas between them causes the binary system's X-ray glow.

on the surface of the star, something that could not be explained under any theory of the nature of stars. And the second seemed too convenient and arbitrary. No one could explain how such a swarm of asteroids fit into the system's birth and evolution.

Moreover, neither theory explained the yearly increase in the length of the cycle.

In 1897, astronomer G. W. Myers of the University of Illinois postulated that the light variations and the spectroscopy could only be explained if the two stars — surrounded by a vast cloud of flowing material — were not spherical but somewhat flattened and possibly touching, like a barbell with two misshapen and unequally sized ends. As he wrote, "Although some of the ideas given above may seem a little venturesome, let it be remembered that the peculiar character of the observations of this star leads one to expect an explanation of a somewhat unusual nature."

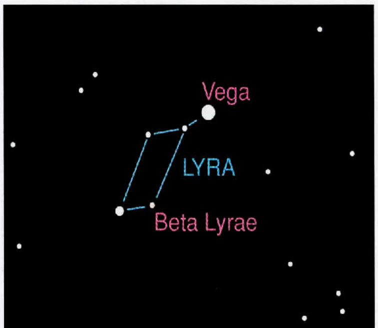
For the first half of the twentieth century, astronomers considered Myers' model the most likely explanation, though they struggled with it. For one thing, it seemed inconceivable that a star far larger than the Sun could be distorted into such a bloated and warped shape. For another, his model still did not provide an explanation for the yearly increase in the 13-day light cycle.

In an attempt to make the data fit then-accepted notions of stellar behavior, astronomers devised theories that required both stars to be incredibly heavy. For example, in 1941 Gerard Kuiper estimated the masses of the two stars at 78 and 52 times the Sun's mass. Though these numbers seemed unrealistically large, they were accepted to make the system fit contemporary theory that dictated dimmer stars must be less massive than brighter stars.

It wasn't until the 1950s and 1960s that astronomers began to abandon these ideas and consider the possibility that the dimmer companion could be the more massive star. At the same time, several astronomers proposed that this invisible object was not merely a star, but a star buried in a large, thick accretion disk — a pancake-shaped cloud of gas spiraling into the star. Moreover, the new models suggested that this disk was growing by sucking matter from the visible star — a transfer of mass that could explain the increase in the length of the system's light cycle.

This idea, that the visible star was losing mass to its invisible companion, revolutionized the field of stellar evolution, which tried to outline the life history of a star from birth to death.

By the middle of the twentieth century, astronomers understood that the initial mass of a star determined how it would evolve and age. Lower-mass stars — stars with masses similar to or less than the Sun's — would burn their hydrogen fuel slowly, taking billions and billions of years to reach their death throes. At the end, they would evolve into red giants, then cast away their outer layer, leaving behind their hot dense cores known as white dwarfs. The white dwarf would slowly cool over the eons, eventually becoming a dark and dead cinder.



Beta Lyrae is visible to the unaided eye near brilliant Vega. In March and April, they rise a few hours after sunset.

TIM JONES

FACT FILE

Names
Beta Lyrae: second-brightest star in Lyra
Sheliak: the lyre

Distance
970 light-years

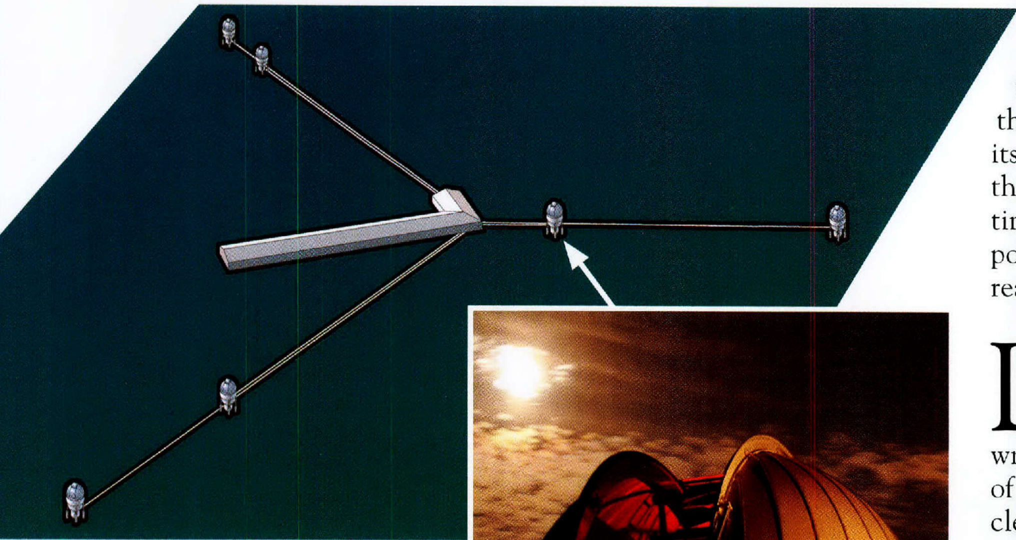
Type
Mass-transfering binary system

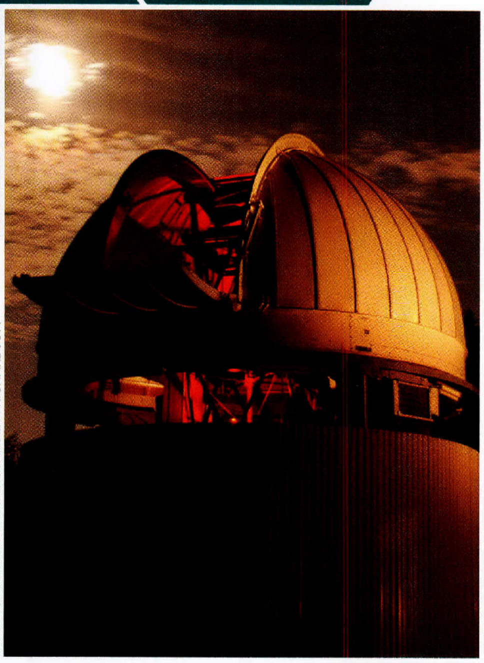
Visual Magnitude
3.5 (visible to the unaided eye under moderately dark skies)

More-massive stars, such as blue supergiants, would have very different lives. They would burn their mass quickly. Not only would their lifespans be short and swift — a few million years — when they finally ran out of fuel they would die spectacularly as violent supernovae.

Since the initial mass of a star determined its type and how it aged, the transfer of gas between Beta Lyrae's two stars meant that their evolution was not linear, and that even though they were binary partners, they could evolve into two different-type stars.

For example, in 1976 Janusz Ziolkowski of Poland's Institute of Astronomy calculated that originally, Beta Lyrae's visible star weighed about 10 solar masses, while the invisible star was about 4 solar masses. Because the visible star was heavier, it aged faster, quickly burning up its hydrogen fuel so that it began to fuse helium instead. When that happened, the star expanded into a red giant, with its outer layers extending out into the gravitational field of the companion star, where they could be grabbed and stripped away.





CHARA/GEORGIA STATE UNIV/CAROLYN RICHARDSON

Top: The wide spacing of the six one-meter telescopes that make up the CHARA array allow the system to operate like a single optical/infrared telescope with a much larger mirror. The high resolution achieved allowed astronomers to resolve Beta Lyrae into its component stars and record their motions. Right: One of the CHARA one-meter telescopes.

Now the invisible star began to grow in mass and burn more fiercely and age more quickly, while also accumulating the accretion disk that today masks its light. After 64,000 years, the two stars traded positions, with the visible star shrinking to 2 solar masses and the invisible companion (together with its accretion disk) growing to 12 solar masses.

Ziolkowski's calculations showed that the now more-massive invisible star would eventually expand into the red-giant stage of evolution. When that happened it would then begin to transfer mass back to the smaller visible star, which would then begin to grow again while also gaining its own accretion disk. Given enough time, the two stars could switch positions several times. In fact, this flip-flop of evolutionary positions might have happened once already.

Despite the ability of this model to explain the data, it remained unclear how correct it was. "What if we are wrong?" asked M.J. Plavec of the University of California in 1983. Without a sharp and clear image of the system, there was no way to know exactly what was going on there.

That changed in 2006 and 2007, when the first high-resolution infrared images of the system were finally taken.

By combining the light from an array of six 1-meter telescopes on Mount Wilson, California, operated by the Center for High Angular Resolution Astronomy (CHARA) of Georgia State University, astronomers could produce images with a resolution equivalent to a single telescope with a mirror a fifth of a mile in diameter. "At this resolution you could read a newspaper at 100 miles," explains the University of Michigan's John Monnier.

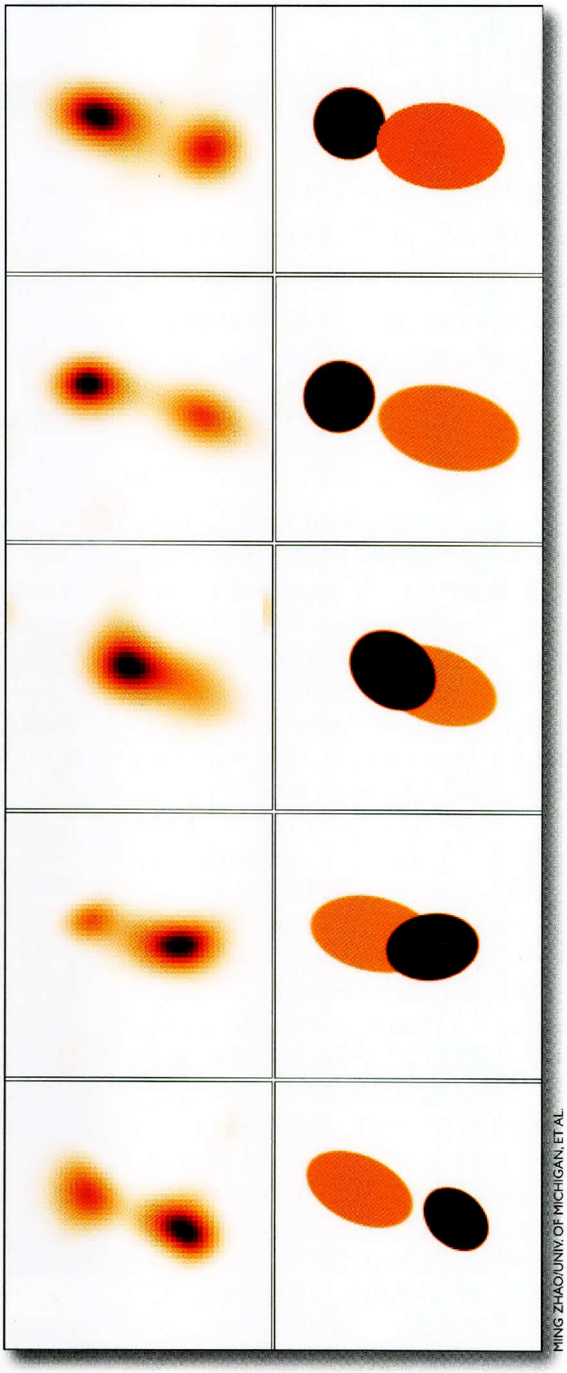
Because there are many ways to combine the light from CHARA's telescopes, other institutions have developed instruments for it. For example, astronomers from the University of Michigan used their Michigan Infrared Combiner (MIRC) instrument to combine the light from four of CHARA's telescopes to produce the array's first images. Their spectacular early results included images of the rapidly rotating and distorted stars Alderamin, Rasalhague, and Altair, all of which appear obviously flattened, with bright and dark areas on their surfaces.

In 2006 and 2007, the MIRC team aimed its instrument at Beta Lyrae six different times, covering about half of the system's orbit, and was rewarded with some especially dazzling near-infrared images.

Not only did these pictures actually resolve both the star and the accretion disk as they circled each other, they showed that, as predicted by Myers more than 100 years earlier, the star was significantly elongated, almost like an oozing teardrop. Moreover, the data have allowed scientists to better pin down the specifics of the system. The visible star appears to weigh about 3 solar masses and circles an invisible star plus disk that weighs about 13 solar masses — both very close to the most recent predicted values.

The infrared images also showed subtle differences from theory. For example, the accretion disk of the invisible star appeared puffier and less flat than expected. "We also see that the disk is asymmetric," notes Michigan's Ming Zhao, which means that it is not evenly spread out. "Previous models had assumed a symmetric disk geometry."

When Beta Lyrae becomes visible to CHARA again this summer and fall, the astronomers hope to do further observations — this time in higher resolution and in optical wavelengths using the University of Sydney's Precision Astronomical Visible Observations instrument. "We hope then to resolve the individual components more, getting more detail about them," Zhou explains.


MING ZHAO/UNIV. OF MICHIGAN, ET AL.

This table shows both CHARA images of Beta Lyrae (left) and computer models (right) for the system from July 3 to July 12, 2007. In the CHARA images, the star that's losing mass has a dark center, and the bridge of gas flowing between the two stars is visible. Viewed in sequence, the images and models show how the 'donor' star passed in front of its companion over the nine-day period.

Until the 20th century, most stars were assumed to be like the Sun: round and stable with a distinct surface. The few known exceptions where stars fluctuated in brightness included pulsating variable stars and the much rarer binaries in which two stars of unequal brightness eclipsed each other.

Beta Lyrae and its mysterious 13-day light cycle, however, added another strange star to the then-short list of misbehavers. When astronomers began to study Beta Lyrae closely in the late nineteenth century, they found that none of their simple assumptions worked. The more they looked into it, the messier, fuzzier, and more confusing the star seemed to be.

Beta Lyrae is one of the handful of stars that proved early on that most stars are not like the Sun. Today, astronomers know that stars can be unkempt things — weird multi-star systems surrounded by complex nebulae and winds, each star distorted and bloated like burning superhot clouds — and very rarely simple spheres shining with dependable light.

Robert Zimmerman is the author of several books on space history, his latest being The Universe in a Mirror: The Saga of the Hubble Space Telescope and the Visionaries Who Built It.

RESOURCES

INTERNET

CHARA
www.chara.gsu.edu/CHARA

StarDate: Beyond the Solar System
stardate.org/resources/btss/stars

Stars
www.astro.uiuc.edu/~kaler/sow/sowlist.html

Beta Lyrae
en.wikipedia.org/wiki/Beta_Lyrae

SKY CALENDAR

by Alan MacRobert

Heading into spring, two planets put in impressive appearances — Venus and Saturn. Winter constellations have a last hurrah as the hunter Orion strides across the sky with his two dogs, carrying their brilliant dog stars with them. And spring constellations Virgo, Leo, and Corona Borealis charge into view.

MARCH 1 - 15

Brilliant Venus, the "evening star" of winter 2009, is rapidly sinking in the west during twilight now that winter is nearing its end. But don't be fooled. If you have any optical aid to bring to bear, this is when Venus really gets interesting.

Even binoculars, steadily braced or mounted, will show that Venus is becoming a brilliant little crescent. The planet is swinging close to Earth in its faster orbit around the Sun, so it's growing larger in apparent diameter even as it turns its night side toward us and the crescent thins. Keep watch on its changing aspect each clear dusk.

Venus isn't the only planet of evening. As twilight fades, Saturn glows low in the east, and it climbs higher after dark. It's next to the dim hind foot of the constellation Leo, as the starry stick-figure lion is often drawn.

Don't confuse Saturn with Regulus, the lion's forefoot, to the upper right of Saturn by about two fist-widths at arm's length. Saturn and Regulus are nearly the same brightness.

If you look at Saturn with a magnification of 30 times or more, you will see that its rings have turned nearly edge-on to our line of sight.

Looking deeper into space, Sirius, the brightest star in the sky, shines at its highest in the south right after dark in early March. Sirius is 8.6 light-years from Earth, compared to 3 light-minutes for Venus and 70 light-minutes for Saturn. In fact, Sirius is the first thing beyond Saturn that you can easily see with the naked eye from our latitudes — even though it's 65,000 times farther, a mighty a big jump.

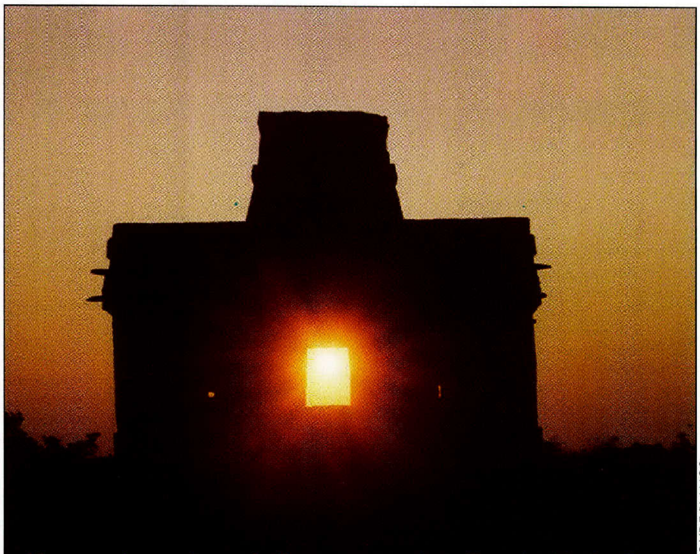
Orion stands to the upper right of Sirius. In early evening, Procyon — another near stellar neighbor at a distance of 11 light-years — shines a similar distance above Sirius, and a bit to the left. Sirius, Procyon, and fire-colored Betelgeuse in Orion's shoulder form the Winter Triangle: big, bright, and equilateral.

As always, Orion's Belt in his middle points one way to Sirius and the other way toward Aldebaran, more or less. Aldebaran is a close match in color to Betelgeuse. The former is an orange-red giant 65 light-years distant; Betelgeuse is an orange-red supergiant about 650 light-years away.

MARCH 16 - 31

Venus keeps getting lower and harder to see in the west after sunset, but it keeps getting more interesting in firmly mounted binoculars or a telescope. The best views of it using optical aid actually come *before* sunset, when it's still moderately high in a blue sky. The crescent is turning eerily thin now while still enlarging in size.

Late March offers a special Venus-watching challenge that comes only every eight years. When the planet passes through *inferior conjunction*, its closest to our line of sight to the Sun, it will be fully 8 degrees off to the Sun's north side. Such a wide miss of the Sun means that, for a couple of days around March 25, those of us living at north temperate latitudes will get a rare chance to spot Venus at both dusk *and* dawn.



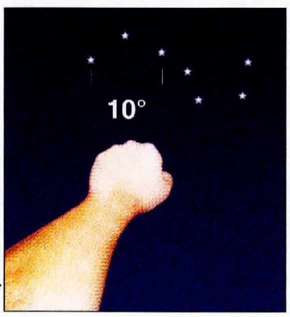
JUAN CARLOS ALCAIDE BLANCO

Many ancient cultures built structures that aligned with the Sun on important celestial dates. Here, the Sun shines through windows of a Mayan temple at Dzibilchaltun on the vernal equinox.

Look for Venus barely above the west horizon about 10 minutes after sunset, and barely above the east horizon about 10 minutes before sunrise. Scan for it with binoculars, and if you pick it up, see if you can then make it out with your unaided eyes. This will be an unusual accomplishment to add to your skywatching logbook.

You can find your local sunset and sunrise times in your local daily newspaper or by using a customizable

THE BASICS



TIM JONES

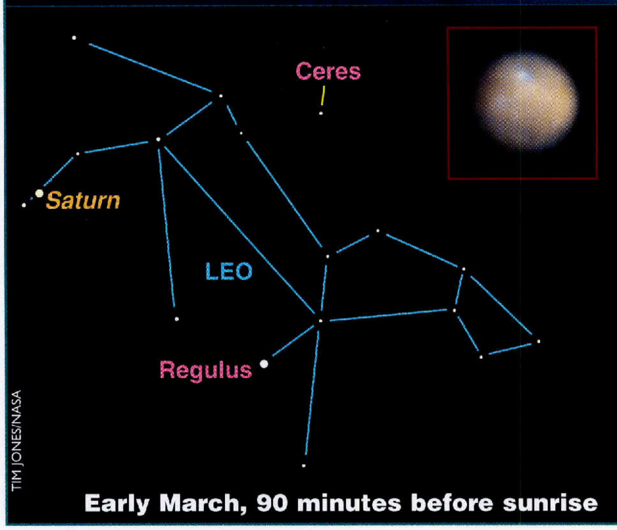
One way to measure the distances between objects in the night sky is to use your hand held out at arm's length. The width of one finger is about two degrees. (By comparison, the Moon spans about one-half degree.) A clinched fist spans about 10 degrees, while a spread palm stretches 20 degrees from pinkie to thumb.

online almanac, like the one at StarDate Online (*stardate.org/nightsky/riseset*).

If you're outdoors earlier in the dawn when the sky is still fairly dark, you'll get a preview of the evening sky as it will appear next July. Jupiter will be glowing very low in the east-southeast. Fiery Antares will be at its greatest height in the south, and Vega will be nearing the zenith when you face east.

After dark in late March, you'll find that Saturn (and Regulus to its upper right) are getting higher in the east. Orion is still high in the southwest, but he is tilting downward toward his annual springtime exit. Accordingly, Orion's Belt is turning horizontal — its springtime orientation — which means that bright Sirius to its left, and pale orange Aldebaran to its right, are shining at fairly similar altitudes above the horizon for the first time. Both Sirius and Aldebaran are roughly two fists at arm's length from Orion's Belt.

Binocular Vision



Early March, 90 minutes before sunrise

Ceres

With a diameter of about 600 miles (1,000 km), Ceres is the largest asteroid orbiting in the main belt between Mars and Jupiter. A few years ago, Ceres was re-classified as a "dwarf planet," along with Pluto and several other solar system bodies massive enough to be spherical, but too small to be major planets. In early March, Ceres is brightest for the year, at magnitude 6.9. Look for it due west about 90 minutes before sunrise, to the right of Leo, about 25 degrees above the horizon. Saturn glows to the lion's left. Through binoculars, Ceres simply looks like a star. But you can watch it sink lower each day as March progresses, moving against the background stars like a planet.

APRIL 1 - 15

Orion and his attendant panoply of winter stars and constellations are dropping fast in the west now, as sunsets come later and later. Meanwhile, spring constellations are rising into seasonal view in the east just as rapidly.

The Big Dipper, for instance, is already high in the northeast after dark, and tipping over to dump spring showers. The dipper's handle curves around to point in an arc toward Arcturus, the brilliant "spring star," shining lower due east. Blue-white Spica is still lower in the southeast, not quite a match for Arcturus in brightness. Look high to Spica's upper right for Saturn and Regulus in Leo.

To the right of Spica, by about one and a half fists, look for the four-star constellation of Corvus, the crow. Like all the eastern-sky star patterns, it rises higher later in the night. To my mind Corvus ranks as one of the most conspicuous constellations that most people have never heard of. Its stars are not very bright but they're compact, forming an eye-catching quadrilateral about the size of your extended fist.

Meteor Watch

The Shower

Lyrids

Named for the constellation Lyra, the harp, which is notable for its brightest star, Vega, the third-brightest nighttime star visible from most of North America.

Peak

Night of April 21/22

Notes

The Moon is a waning crescent, so it doesn't rise until the wee hours of the morning, and its feeble light should not interfere with the show.

Arcturus, too, has a small but distinctive constellation posing fairly nearby. Look to Arcturus' left, and slightly lower, by a little more than the distance Corvus is to Spica's right. Corona Borealis, the semicircular northern crown, glimmers there. This group, however, is a good deal dimmer than Corvus, with only one moderately bright star. To see the whole little tiara you need a pretty dark sky.

APRIL 16 - 30

Late April is when the Big and Little Dog Stars line up vertically while twilight is fading and the stars are coming out. The Big Dog Star is Sirius, now sparkling fairly low in the southwest. The Little Dog Star is Procyon, shining nearly three fists at arm's length above it.

For the second half of April this year, we get an unusually good look at elusive little Mercury in evening twilight. Look for it glittering above the west-northwest horizon about an hour after sunset. It's far below brilliant Capella, more or less (depending on the latitude where you live). At the end of April, Mercury passes closely to the left of the Pleiades; bring binoculars. The waxing crescent Moon joins Mercury and the Pleiades on April 26.

If life gets you up and outdoors before dawn, maybe you've been following Venus since its inferior conjunction. Only slowly is it gaining better morning visibility. Look for it very low due east as dawn brightens. Don't confuse it with not-quite-as-bright Jupiter higher in the southeast.

The waning crescent Moon hangs with Jupiter on the morning of April 19, with Neptune invisibly faint in their background. Then on the 22nd the Moon pairs up very closely with Venus. Binoculars on that date should reveal faint little Mars down below them. Invisibly faint in the background this time is Uranus, although it is fairly easy to spot with binoculars.

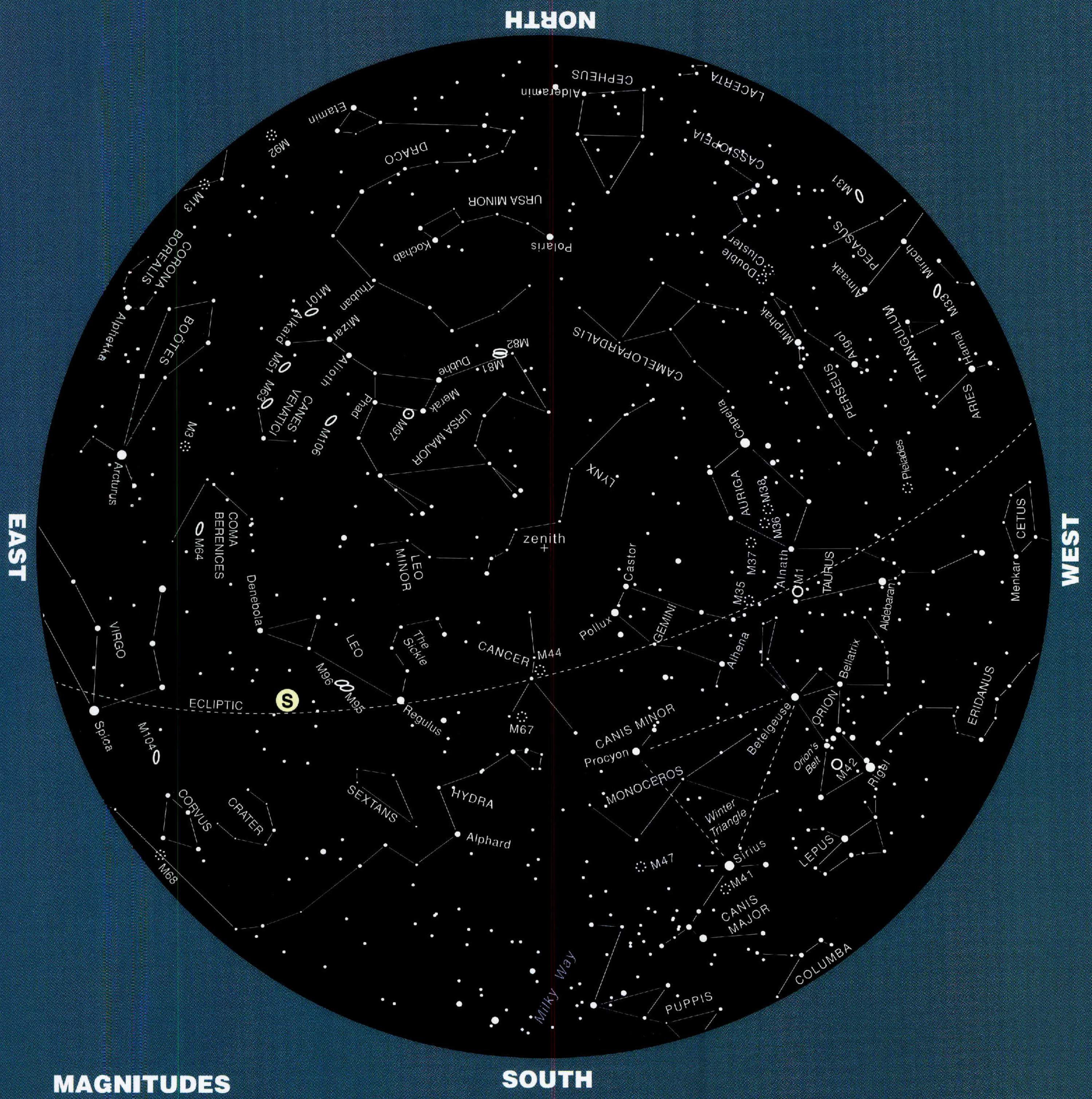
Add Saturn in the southeast after dark, and that accounts for all eight planets. (We did leave out Earth, but just look down and there it is). If you insist on calling Pluto the ninth planet, it's high in the south at dawn, in the northwestern corner of Sagittarius. But it's 250 times fainter than even Neptune.

Alan MacRobert is a senior editor of Sky & Telescope *magazine.*

MARCH

How to use these charts:
1. Determine the direction you are facing.
2. Turn the chart until that direction is at the bottom.

February 20	**11 p.m.**
March 5	**10 p.m.**
March 20	**9 p.m.**



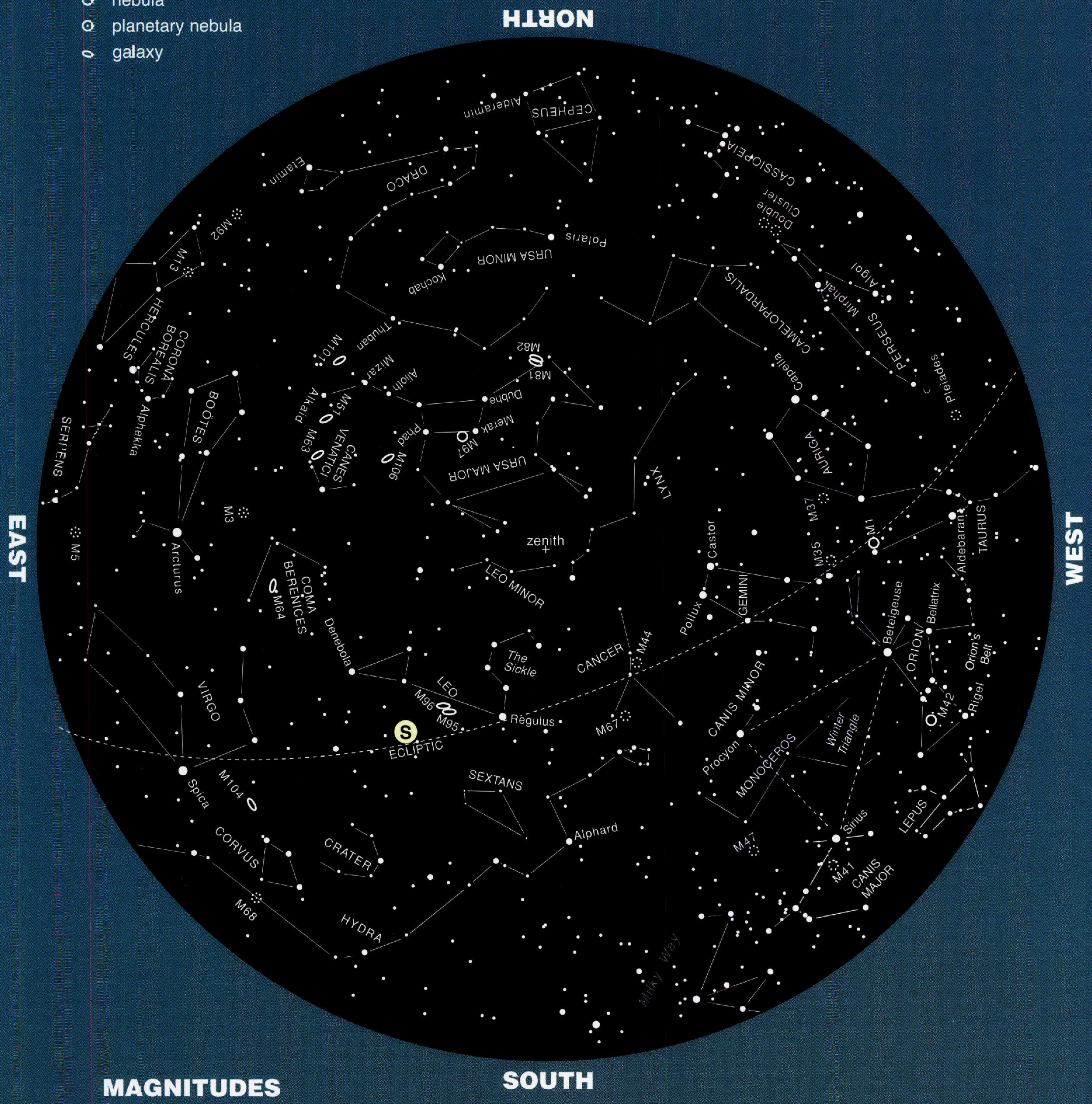
MAGNITUDES
- 0 and brighter
- 1
- 2
- 3
- 4 and fainter

Charts produced with Voyager II software.

APRIL

March 20	**11 p.m.**
April 5	**10 p.m.**
April 20	**9 p.m.**

- S Saturn
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy



MAGNITUDES

- 0 and brighter
- 1
- 2
- 3
- 4 and fainter

Sky Highlights

by Damond Benningfield

March

Moon phase times are for the Central Time Zone.

4 Venus is stationary against the background stars, so the "evening star" moves neither east nor west for a while.

8-10 The Moon sweeps past the star Regulus and the planet Saturn. They are in the east as night falls. The Moon is above them on the night of the 8th, between them on the 9th (with Regulus above the Moon, Saturn below), and below them on the 10th. Saturn is at opposition on the 8th, so it lines up opposite the Sun in our sky. It rises around sunset, is visible all night, and is brightest for the year.

12 Spica, the brightest star of Virgo, is a little to the lower left of the Moon as they climb into view in the southeast by around 10 p.m. The Moon will move closer to Spica as they scoot across the south during the night.

17 Antares, the brightest star of Scorpius, stands a little to the right of the Moon at first light this morning.

20 The vernal equinox occurs at 6:44 a.m. CDT, marking the beginning of spring in the northern hemisphere.

Su	M	T	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

22-23 The Moon and Jupiter team up in the dawn sky. Jupiter, which looks like a brilliant star, is to the lower left of the Moon on the morning of the 22nd, but to its right on the 23rd.

24 Mars is just below the Moon early this morning, quite low in the southeast about 30-40 minutes before sunrise. You probably will need binoculars to spot Mars.

27 Venus passes between Earth and the Sun. It will return to view as the "morning star" in a few days.

April

5 Regulus, the brightest star of Leo, stands a little to the left or upper left of the Moon at nightfall. The planet Saturn is below them.

6 Saturn, which looks like a bright golden star, aligns quite close to the Moon this evening, with Regulus above them.

12 Antares, the brightest star of Scorpius, huddles close to the Moon tonight. It is close to the Moon's lower left as they rise after midnight, and even closer at first light. As seen from Hawaii, the Moon will briefly cover up Antares on the morning of the 13th.

Su	M	T	W	Th	F	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

18 The brilliant planet Jupiter stands a little to the lower left of the Moon at first light. They are low in the southeast.

21 The Lyrid meteor shower is at its best tonight.

22 The Moon, Venus, and Mars congregate low in the east at first light. The Moon will pass across the face of Venus, briefly hiding the planet from view.

26 The Moon, the Pleiades, and the planet Mercury align low in the west-northwest as night falls. The Pleiades star cluster is a little below the Moon, with Mercury about the same distance below the Pleiades. Mercury looks like a fairly bright star. Binoculars will enhance the view.

by Damond Benningfield

Expanding Cosmic Horizons

Hans Lippershey didn't set out to change the universe. Instead, the Dutch lensmaker saw a business opportunity. But a device that Lippershey began making in 1608 soon expanded humankind's view of the universe and our knowledge of our place in it.

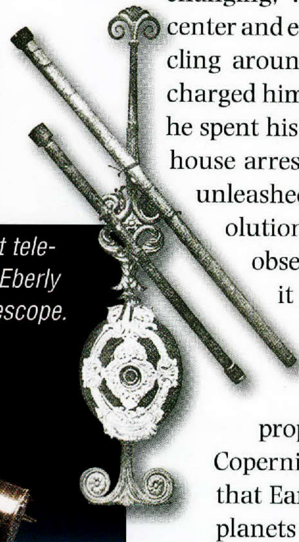
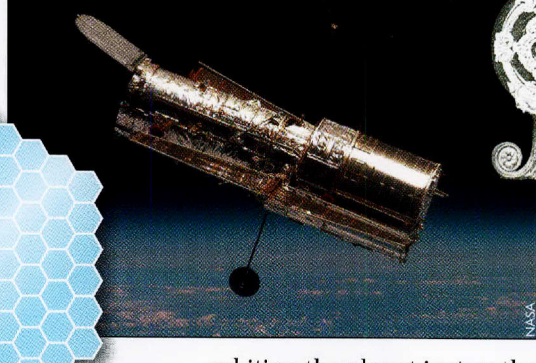
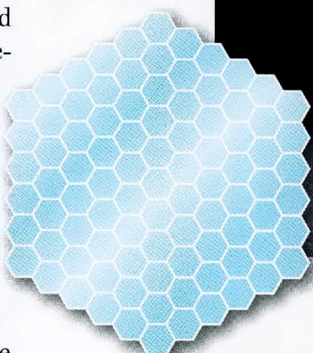
Legend says that sometime in 1608, two children entered Lippershey's shop in Middelburg, the capital of Zeeland in the Netherlands. The children picked up two lenses and held one in front of the other, producing a magnified image of the weathervane atop a nearby church. Lippershey was astounded. He encased two lenses in a small lead tube and offered his new "looker" to the government.

Lippershey's looker was a refracting telescope, which uses lenses to gather and focus light. In the original design, the lens at the front of the telescope was curved outward at both front and back, while the lens at the eyepiece was curved inward. The first lens "bent" parallel light rays, bringing them together at a specific point behind the lens. The second lens magnified the view. Working together, the lenses made distant objects look larger and closer.

By early 1609, the telescope was a must-have item for the rich and educated across western Europe. France's ambassador to the Netherlands presented one to the French king, and telescopes of up to about three-power magnification were sold in Paris, Venice, and other centers of commerce and learning.

Galileo Galilei, a mathematics professor at the University of Padua, near Venice, heard rumors of the remarkable new device. When the rumors were confirmed, Galileo built one himself, and earned a lifetime appointment and a fat salary by demonstrating it to local leaders.

Galileo earned his reputation as one of the giants of scientific thought, though, by turning his telescopes toward the sky.

Telescopes then and now: Galileo's first telescope (right), the mirror of the Hobby-Eberly Telescope (left), and Hubble Space Telescope.

NASA

When Galileo looked at the Moon, for example, he saw a rugged surface marred by mountains, an amazing number of bowl-shaped craters, and other features. And as the Moon changed phases, and the dividing line between night and day swept across the landscape, he could see the shadows of the mountains and craters.

In the hazy, glowing band of the Milky Way, Galileo saw thousands of individual stars, along with clusters of many stars scattered across the sky.

Perhaps his most remarkable discoveries came when he viewed the other planets, which look to the unaided eye like bright stars. Galileo saw four tiny "stars" arrayed near Jupiter, for example. As he watched them night after night, they remained near Jupiter but changed configuration. Galileo decided that they must be moons of Jupiter, orbiting the planet just as the Moon orbits Earth.

And when he watched Venus, he saw that it went through a series of phases, just as the Moon does. At the time, the leading model of the solar system placed Earth at the center, with the Sun, Moon, and planets all orbiting our planet. Venus was thought to circle between Earth and the Sun. Galileo's discovery, however, showed that Venus must circle the Sun instead of Earth. As with a crescent Moon, when Venus forms a crescent the planet is roughly between Earth and the Sun, so only a sliver of the daylight side faces our way. And a nearly full Venus must align "behind" the Sun as seen from Earth, allowing us to see almost the entire sunlit side.

Galileo's observations challenged the belief that the universe was perfect and unchanging, with Earth at the center and everything else circling around it. The Church charged him with heresy, and he spent his final years under house arrest. Yet Galileo had unleashed a scientific revolution. With Galileo's observations to back it up, the world soon accepted a new model of the solar system, proposed by Nicolaus Copernicus, which held that Earth and the other planets orbited the Sun.

As with Lippershey's invention, today's telescopes are wonders of technology as well as science. Giant reflecting telescopes, which use mirrors instead of lenses to collect starlight, have mirrors that cover as much area as an apartment. Others are sensitive to radio waves, heat, or other types of energy. And others have escaped Earth's obscuring atmosphere to view the heavens from space.

Yet all are continuing the same basic work as Galileo's telescope four centuries ago: expanding human horizons.

Adapted from Galileo to Gamma Cephei, *telescopes.stardate.org*.

SALLY BOSKEN

James M. Gilliss (above) established the U.S. Naval Observatory's library. The engraving of Orion on this page is from the library's 1661 edition of Johannes Bayer's star atlas Uranometria. *The library also holds a 1603 first edition of* Uranometria *— the first true star atlas. Woodcuts from the 1482* Poeticon Astronomicon, *the library's oldest book, are shown opposite.*

USNO JAMES M. GILLISS LIBRARY (5)

Keeping Astronomical History Alive

From European Salons to the Moons of Mars, Naval Observatory Library Preserves Celestial Treasures

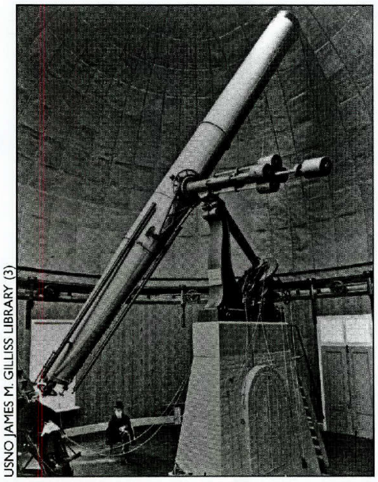
By Margaret Buranen

The United States Naval Observatory in Washington, D.C., creates sophisticated star charts and serves as the official source of time for the Department of Defense and a standard of time for the United States ("Astronomy in Service to the Nation," *StarDate*, September/October 2006). But it also preserves the astronomical history of the United States and the world. Its James M. Gilliss Library holds a treasure of books, charts, globes, and instruments.

It all began with an unusual shopping trip. When the Observatory was carved from the Navy's Depot of Charts and Instruments in 1842, Navy Secretary Abel P. Upshur sent Lt. James Melville Gilliss to Europe to buy instruments and books. A self-taught astronomer at a time when there was not even one fixed observatory in the country, Gilliss had to use his knowledge to buy wisely: Congress had appropriated only $25,000 for the Observatory's building and contents.

Remarkably, he managed to purchase 700 volumes of English, French, Latin, and German scientific works, many of them rare first editions. He received gifts of 200 more volumes from foreign observatories. These purchases and gifts became the foundation of one of the world's leading astronomical libraries. In 1996, the library was renamed in honor of Gilliss, who also served as Superintendent of the Observatory during the Civil War.

Below, constellation maps from the Gilliss Library's 1795 French edition of John Flamsteed's celestial atlas. The Observatory's Great Equatorial Telescope is shown at right.



USNO/JAMES M. GILLISS LIBRARY (3)

In the more than 150 years since Gilliss' European shopping spree, the Observatory's library has continued to collect not only books, but historical artifacts and instruments as well. Today, it has one of the most complete collections of astronomical literature in the world. The collection includes more than 600 books and pamphlets printed before 1800. Many are first editions or rare copies.

The library's oldest book is an elementary work on astronomy called *Poeticon Astronomicon*, printed in 1482 by Erhard Ratdoldt, one of the most important Venetian printers of the late fifteenth century. Its text is attributed to the Roman scholar Casius Julius Hyginus (46 BC-AD 17). This copy of the second edition (but the first illustrated one) contains woodcuts of the constellations commissioned by Ratdoldt. Printed in black and bound in vellum, this book's spine carries a gold-stamped leather label.

The library also holds a first edition *Uranometria*, Johannes Bayer's revolutionary work with beautifully detailed engravings of the constellations by Alexander Mair, printed in Augsburg in 1603. But *Uranometria* is not just a catalog of pretty pictures — it is the first true star atlas, and set the standard for those that followed.

The work contains 51 separate star charts, showing the positions and magnitudes of 1,706 stars in 60 constellations. These include the 48 constellations created in antiquity, and a separate southern-hemisphere map showing a dozen constellations created by Dutch navigators.

Bayer created his star maps for *Uranometria* using the star positions published in 1602 by Tycho Brahe. A grid printed on each star chart in *Uranometria* allows the user to pinpoint a star's location to within less than one degree on the sky.

Bayer also conceived the method, widely used today, of designating the brighter stars in each constellation with Greek or Latin letters, generally in order of decreasing brightness.

The Gilliss Library also holds a 1725 edition of British Astronomer Royal John Flamsteed's *Historia Coelistis*. George Vertue's engravings of constellations are beautifully drawn and were later reproduced in other works.

In addition to its books, the library maintains historical artifacts related to the Observatory's history. One contains the record of an important event in the understanding of our solar system: the discovery of Mars' moons Phobos and Deimos, made at the Observatory in 1877 by Asaph Hall. His tan leather observing book, a bit scuffed with age, is government issue, but "very attractive government issue," says Observatory librarian Sally Bosken.

All Naval Observatory astronomers recorded what they saw each night in these books. This one covers the nights of August 5 to September 24, 1877. In it, Hall wrote in pencil, adding mathematical calculations in ink later, Bosken thinks.

Sometimes the only notation is "cloudy," and a reader senses the astronomer's disappointment on those nights. Fog from the nearby Potomac River and bad weather kept Hall from confirming what he thought might be a moon of Mars. But on August 16, 1877, he saw the moon again — and his assistant confirmed the sighting.

Hall wrote, "while waiting and watching for the outer moon, the inner one was discovered. The observations of the 17th and 18th put beyond doubt the character of these objects …"

Hall received both the French Arago gold medal and Britain's Royal Astronomical Society gold medal for these discoveries. His descendants donated both medals to the Obser-

USNO JAMES M. GILLISS LIBRARY

vatory, and they are on display in the library. The library also maintains Asaph Hall's desk, made by a Connecticut ancestor. It holds the chronometer used by the astronomer's son, Asaph Hall Jr., an astronomer who worked at the Observatory at various times from 1882 to 1929.

Perhaps most significant of all the Hall artifacts is the document showing his 1864 commission into the U.S. Navy Corps of Professors of Mathematics, signed by President Abraham Lincoln. This rank was used for Naval Observatory astronomers and professors at the U.S. Naval Academy. In this 200th anniversary of Lincoln's birth, the library is displaying a facsimile of the document.

SALLY BOSKEN

The books and artifacts held in the Gilliss Library are kept company by some well-worn but well-made astronomical instruments. The Observatory's 26-inch refracting telescope, the Great Equatorial, that Hall used is now the oldest large refractor still in continuous use. In Hall's day, it was the most powerful telescope in the world. It was built for the Observatory in 1873 for $40,000 by Alvan Clark and Sons in Cambridge, Massachusetts. In those shaky economic times just after the Civil War, Clark specified that he must be paid in gold. Concerned about depleting so much gold from the national treasury, Congress voted an appropriation of four annual payments of $10,000 in gold.

In addition to its monumental telescope, the Observatory preserves its original official clock. Built by Heinrich Johannes Kessels of Altona, Germany, this classical pendulum clock, which is about six feet tall, was purchased by the Observatory soon after its founding. It was the standard sidereal (star time) clock, the reference that was synchronized to the astronomical observations made at the Observatory.

To keep the clock aligned with these observations, its pendulum swing was adjusted by adding or removing tiny weights to a brass cup which was attached to the pendulum. Adding 100 grams increased the clock's rate by 9.7 seconds per day. Newer technology put the Kessels clock out of practical use by the early 1900s.

While the Gilliss Library's rare books and documents are kept in a temperature- and humidity-controlled vault to protect them, they are not inaccessible. Each month, Bosken arranges a new exhibit connecting items in the collection to current events. The books "are meant to be used, read, looked at," Bosken says.

The Observatory also provides digital versions online. Beautiful images from their various celestial atlases are available for downloading (see Resources sidebar).

To visit the Observatory, plan carefully and be flexible. Because the Observatory is a federal installation, and the grounds include the residence of the Vice President, tours may be cancelled on short notice. Generally, however, the Observatory offers tours twice per month, on Monday nights. Reservations are required. Tours include a presentation on the Observatory's mission and history, an overview of its timekeeping responsibilities, and an astronomer-hosted star party with the 12-inch Alvan Clark refracting telescope.

This is freelance writer Margaret Buranen's first article for StarDate.

Asaph Hall (left) was commissioned into the Navy's Corps of Professors of Mathematics by President Abraham Lincoln in 1864. The astronomer used the Naval Observatory's Great Equatorial Telescope to discover Mars' moons in 1877.

RESOURCES

INTERNET

James M. Gillis Library
www.usno.navy.mil/USNO/library

Historical Artwork Collection
aa.usno.navy.mil/library/artwork/artwork.html

Astronomy Libraries
eso.org/sci/libraries/astrolib.html

ARTICLES

"Astronomy in Service to the Nation" by Rebecca Johnson, *StarDate*, September/October 2006.

by Damond Benningfield

From Planets to the Big Bang

Satellites will look for Earth-like worlds, probe chemistry of starbirth, map first structure in the universe

The roster of known planets outside our own solar system is about to get a lot longer. The Kepler spacecraft, which is scheduled for launch in early March, will spend three and a half years staring at more than 100,000 stars for evidence of planets like Earth.

"Kepler's main goal is to find the first evidence for Earth-size planets around nearby stars," says Alan Boss, a physicist at the Carnegie Institution and a Kepler mission scientist. "By looking at these hundred thousand stars, we'll have a very good idea of how many such planets exist."

Kepler is the first of three astronomy satellites scheduled for launch in March and April. The others, Herschel and Planck, are European missions that will share a ride to space around April 12. Herschel is an infrared mission that will study the birth of stars and planets and peer into the hearts of some of the earliest galaxies. Planck will map the afterglow of the Big Bang in greater detail than any previous mission.

Kepler is basically a sensitive light meter attached to a one-meter (39-inch) telescope. It will monitor stars that are between 600 and 3,000 light-years away in Lyra and Cygnus.

If a planet orbits one of the stars, and if the system is aligned properly with Earth, then the planet will periodically pass in front of the star, blocking a tiny bit of its light. Astronomers have already used this technique, called the transit method, to discover several giant planets orbiting other stars. Kepler, however, will be sensitive enough to detect planets as small as Earth in orbits similar to Earth's orbit around the Sun. Such an orbit would place the planet in the star's habitable zone, which is the distance at which the temperature is just right for liquid water.

Each transit will last for only a few hours, though, with a year or so between transits. Astronomers want to see three transits to confirm that a system contains a planet. The transits will allow astronomers to estimate the planet's mass and surface temperature as well as the distance from its parent star.

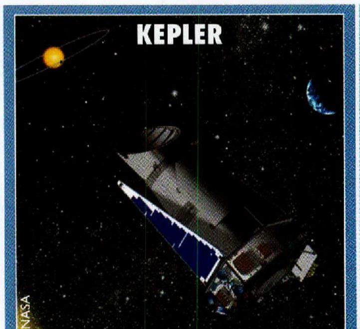
Scientists with the Herschel mission are interested in the chemistry of the clouds of gas and dust that give birth to planets and stars.

Herschel "will allow us to look inside star-forming clouds, planet-forming clouds, and decipher what's going on with the chemistry and therefore the physics," says George Helou, director of the NASA Herschel Science Center. "It's not too much of a stretch of the imagination to expect that maybe we'll discover complex molecules, possibly pre-biotic molecules — the kinds of things we know can grow in interstellar space, but that we haven't been able to see and analyze."

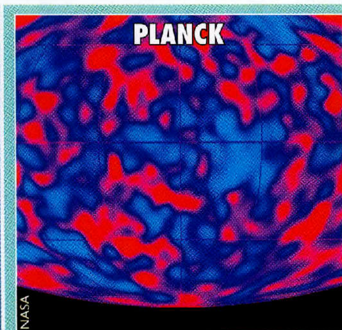
At a diameter of 3.5 meters (140 inches), Herschel's telescope will have the largest mirror ever launched into space. Its instruments, cooled by liquid helium, will be sensitive to light at infrared and submillimeter wavelengths, which are blocked by Earth's atmosphere. The instruments will allow Herschel to see through clouds of dust and gas that are giving birth to new stars and planets and to look at how stars were born in some of the first galaxies in the universe.

Planck, which will ride the same Ariane rocket as Herschel, will map the afterglow of the Big Bang in unprecedented detail. Previous satellites discovered tiny variations in the temperature of the afterglow, known as the cosmic microwave background. The variations indicate that the early universe was slightly lumpy, allowing matter to clump together to form the first stars and galaxies.

Planck will see finer details in this lumpiness, providing a more complete look at the formation of the first structure in the universe. Its observations may also provide new clues about the nature of dark matter and dark energy.

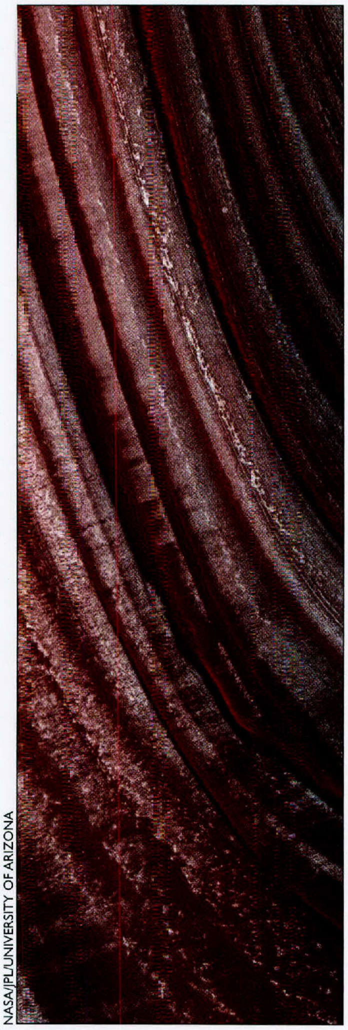


Mission
Look for Earth-like planets in the habitable zones of Sun-like stars
Launch
March 5
Telescope
1 meter; optical
Length of Mission
3.5 years



Mission
Look for structure in the 'afterglow' of the Big Bang
Launch
April 10
Telescope
1.5 meters; microwave
Length of Mission
3 years

Mission
Study the chemistry of star and planet formation and cores of distant galaxies
Launch
April 10
Telescope
3.5 meters; infrared and submillimeter
Length of Mission
1.5 years



NASA/JPL/UNIVERSITY OF ARIZONA

Ice coats layers of sand and rock near Mars' north pole in this image from Mars Reconnaissance Orbiter. As ice evaporates during summer, methane gas may erupt into the atmosphere.

Mars Burps

Ground-based telescopes have sniffed out evidence of life on Mars, although not necessarily biological life. Instead, the observations may show that Mars retains some *geological* life.

The evidence consists of several outbursts of methane, which is the main ingredient of natural gas. Using two telescopes at Mauna Kea, Hawaii, a research team detected the chemical signature of the gas in the planet's atmosphere.

On Earth, most methane is related to biological activity, from the decay of dead plants to the digestive processes of humans and cattle. Methane is also a byproduct of some geological processes involving iron oxide. Since Mars gets its orange color from iron oxide, the compound is abundant at and below the surface.

Reactions with sunlight and other chemical compounds destroy methane in the Martian atmosphere, so any methane that is present must have been released recently.

The research team detected several outbursts of methane, which must have come from underground — either from bacteria living in warm, wet chambers below the surface, or from volcanoes that retain some of their heat. Many volcanoes cover the surface of Mars, yet there is little evidence of recent eruptions.

Each outburst was recorded during summer in the planet's northern hemisphere. Team members speculate that the methane may erupt from chambers that had been sealed by thick layers of winter ice.

Another research team reported evidence of methane on Mars three years ago. Those observations found smaller amounts of methane, however. The more-recent study detected up to 20,000 tons of methane in a single outburst.

NASA's Mars Science Laboratory, which is scheduled to arrive at Mars in 2012, will carry instruments that can analyze the atmospheric methane in more detail, perhaps revealing whether the gas is produced by living organisms or geological processes on a not-quite-dead planet.

It's a Desert Out There: Brown-Dwarf Searches Come Up Empty

When astronomers discovered the first brown dwarf a decade ago, they expected it to be the tip of the iceberg, with many more discoveries to follow. Instead, though, they have found that another terrestrial analogy is more appropriate: a desert. Several searches have turned up only a handful of the "failed stars" in our own stellar neighborhood.

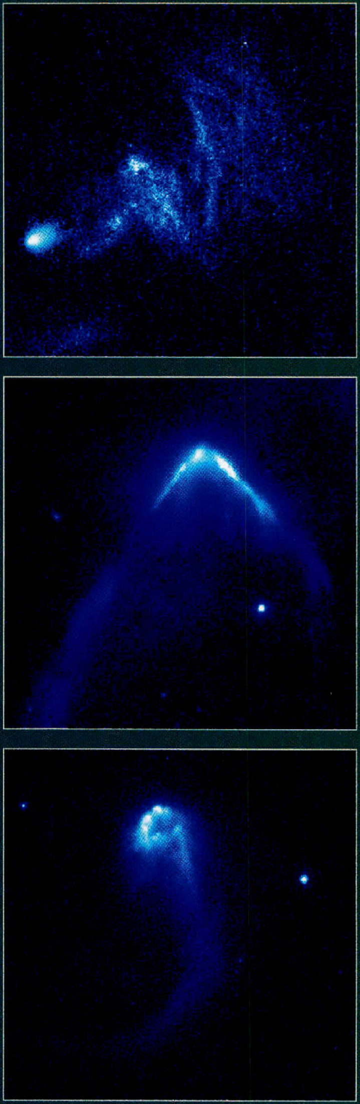
"It looks like brown dwarfs are running out of places to hide," said Georgia State University astronomer Sergio Dietrich at the American Astronomical Society conference in January.

Brown dwarfs are more massive than planets, but not massive enough to ignite nuclear fusion and shine as stars. A brown dwarf's gravity squeezes it tightly, however, heating it and causing it to glow a dull red in optical wavelengths, and to produce copious amounts of infrared energy.

Dietrich and his colleagues used an infrared detector aboard Hubble Space Telescope to scan 233 red-dwarf stars for evidence of brown-dwarf companions. Red dwarfs are the smallest class of true stars, and account for about 70 percent of all the stars in our region of the galaxy. The search revealed four new red dwarfs but only two brown dwarfs, both of which were in a single binary system.

"The brown-dwarf desert clearly extends to red dwarfs, not just Sun-like stars," Dietrich said. "There must be something intrinsic to brown dwarfs that limits their formation."

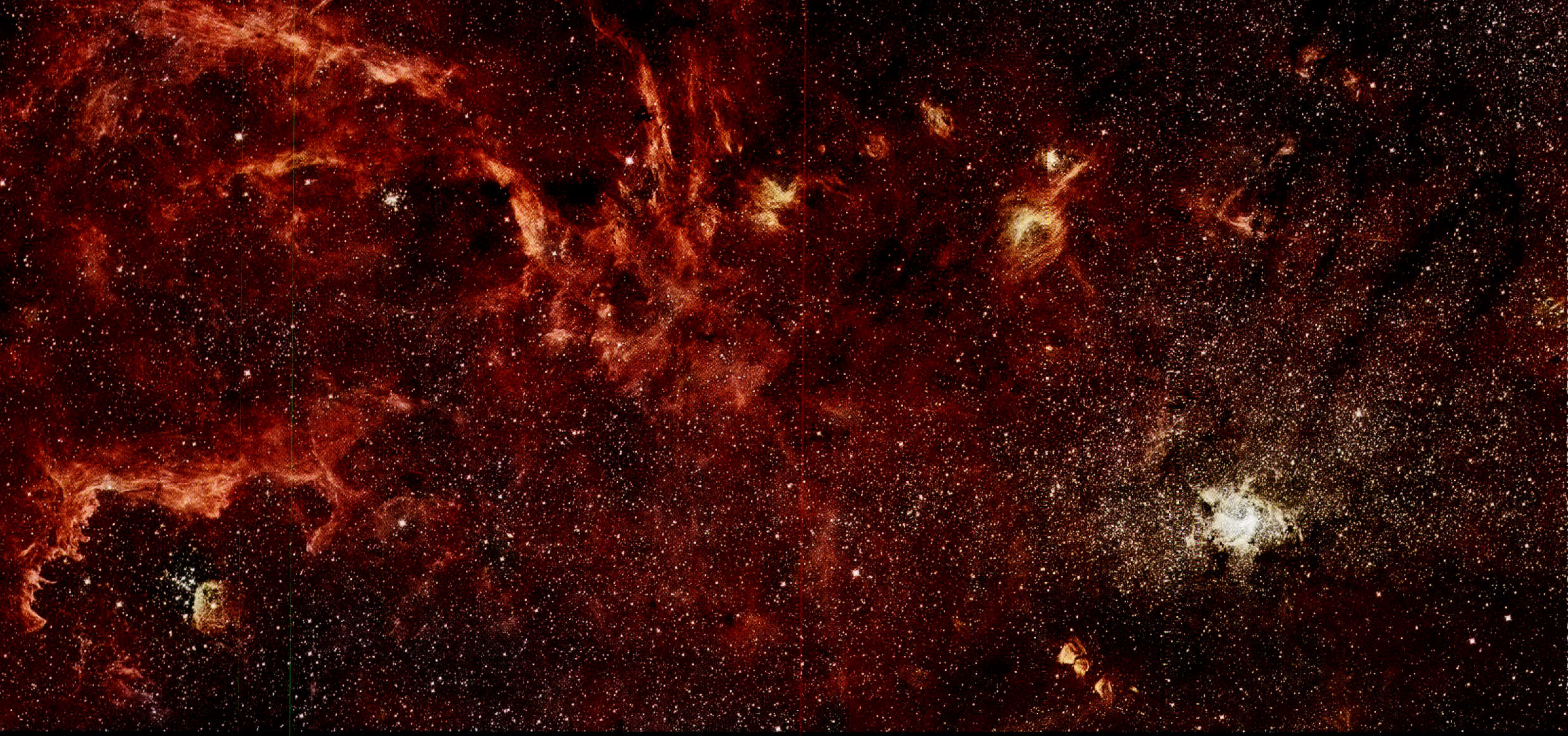
The total population of known brown dwarfs within 32.6 light-years of Earth is just 12, compared to 350 stars and 11 extrasolar planets.



NASA/ESA/R. SAHAI (JPL)

Stellar Firing Range

Like bullets fired from a high-powered rifle, these stars may have been fired away from their birthplaces by gravitational encounters or other mechanisms. Hubble Space Telescope recently caught 14 of these high-speed stars, which are leaving 'wakes' behind them as they plow through gas clouds at speeds of up to 100,000 miles per hour. Depending on the distances to the stars, the wakes may be up to one trillion miles long — about 10,000 times the distance from Earth to the Sun. The stars are only a few million years old, and they may have been ejected from the clusters where they were born by gravitational interactions with other stars.



NASA/ESA/Q.D. WANG (UNIV. MASS. AMHERST)/JPL/S. STOLOVY (SSC/CALTECH) (2)

The Milky Way's Busy Hub

Billowing clouds of gas, dark fingers of cold dust, and thousands of hot young stars populate the core of the Milky Way galaxy in this new infrared view from the Hubble and Spitzer space telescopes. Recent observations detected 600,000 newly formed stars in the galaxy's center. A supermassive black hole, which is far too small to see, sits at the lower right of the image, embedded in the bright 'swirl' of stars. The galaxy's center is 27,000 light-years from Earth.

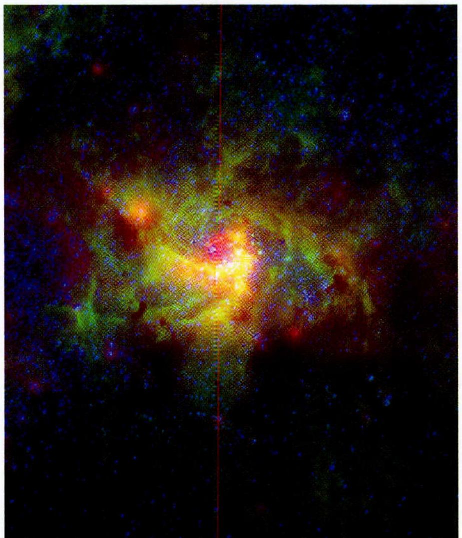
Stellar Infants Survive Tough Neighborhood

The region around a supermassive black hole is a bad neighborhood for stars. The black hole's gravity pulls apart stars that pass too close and rips potential star-forming clouds of gas and dust to shreds.

Even so, a team of astronomers says it has found at least two infant stars orbiting close to the supermassive black hole at the center of the Milky Way galaxy. The stars probably were born quite close to the black hole, in the middle of the bad neighborhood.

A team led by Elizabeth Humphreys of the Harvard-Smithsonian Center for Astrophysics studied the environment around the black hole with the Very Large Array, a group of 27 radio antennas in New Mexico.

"Near the supermassive black hole, chaos reigns," Humphreys said during a briefing at the American Astronomical Society conference in January. The black hole's gravity pulls apart nearby gas clouds, leaving strands of gas that cannot coalesce to form a star. "Yet many stars are observed near the black hole," she said.



An infrared view shows a swirl of stars and gas around the supermassive black hole at the center of the Milky Way. This is a more detailed view of the swirl of stars at lower right corner of the image at top.

The stars either formed near the black hole or formed farther out and snuggled closer to the black hole as they aged.

Humphreys and her colleagues looked for "water masers" within a few light-years of the black hole, which is about three million times as massive as the Sun. The masers are water-rich clouds of gas that amplify background radio signals, and can be associated with newly forming stars or with the extended outer layers of old stars.

The team found two masers associated with infant "protostars." One of them is about 7 light-years from the black hole, while the other is about 10 light-years away. Combined with an earlier discovery, that provides a sample of three stars that are so young that they must have formed where they are seen today, near the black hole.

"We believe that the only explanation ... is that we have indeed discovered protostars right at the heart of the Milky Way," Humphreys said.

One of the newly found protostars resides inside a broad disk of gas and dust around the black hole. The disk may be thicker and clumpier than astronomers had thought, Humphreys says. Thicker clouds would have enough gravity to collapse under their own weight to form new stars, even against the black hole's considerable tug. **DB**

Spend Your Spring Break with Us!

McDonald Observatory has a beefed-up schedule of guided tours, live telescope views of the Sun, and star parties scheduled for March. And in April, we're welcoming everyone to our free Open House.

MARTIN HARRIS

March 14-21*

Guided Tours

10:30 a.m., noon, and 1:30, 3, and 4:30 p.m. daily

Solar Viewings

11 a.m. and 12:30, 2, 3:30, and 5 p.m. daily

(No 5 p.m. solar viewings on Sunday and Thursday)

Twilight Program and Star Parties

Twilight programs will be offered at 6:15, 6:55, and 7:35 p.m. on March 14, 16, 17, 18, 20, and 21. Star parties start at 9 p.m.

** Additional dates may be added; check web site for details.*

Open House
April 4, 2-10 p.m.

Come visit McDonald Observatory's Open House to enjoy special programs, speakers and more. Free admission.

For more information
mcdonaldobservatory.org/visitors
toll-free 877-984-7827

Dozens of hot young stars show off in this view of NGC 2264, a star cluster in Monoceros, the unicorn. The stars were born from a vast cloud of gas and dust. Ultraviolet light from the hot stars makes the remaining gas shine like the inside of a neon bulb, surrounding the stars with a pink glow. A finger of cold, dark gas, known as the Cone Nebula, juts up from the bottom of the image. The picture, which was snapped at the European Southern Observatory in Chile, spans about 25 light-years.

ESO