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Eta Carinae

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Gift Shop: Fri.: 5 - 9 pm, Sat.: 3 - 9 pm

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Dusty Mars Rover's Self-Portrait

(NASA/JPL) This self-portrait from NASA's Mars Exploration Rover Opportunity shows dust accumulation on the rover's solar panels as the mission approached its fifth Martian winter. The dust reduces the rover's power supply, and the rover's mobility is limited until the winter is over or wind cleans the panels.

This is a mosaic of images taken by Opportunity's panoramic camera (Pancam) during the 2,111th to 2,814th Martian days, or sols, of the rover's mission (Dec. 21 to Dec. 24, 2011). The downward-looking view omits the mast on which the camera is mounted.

The portrait combines exposures taken through Pancam filters centered on wavelengths of 601 nanometers, 535 nanometers and 482 nanometers. It is presented in approximate true color, the camera team's best estimate of what the scene would look like if humans were there and able to see it with their own eyes.

Opportunity has worked through four Martian southern hemisphere winters since it landed in January 2004 about 14 miles (23 kilometers) northwest of its current location. Closer to the equator than its twin rover, Spirit, Opportunity has not needed to stay on a sun-facing slope during the previous winters. Now, however, Opportunity's solar panels carry a thicker coating of dust, and the team is using a strategy employed for three winters with Spirit: staying on a sun-facing slope. The sun will pass relatively low in the northern sky from the rover's perspective for several months of shortened daylight before and after the southern Mars winter solstice on March 30, 2012. Opportunity is conducting research while located on the north-facing slope of a site called "Greeley Haven."
Delayed Broadcast of a Powerful Stellar Eruption

(NASA/STScI) Astronomers are watching a delayed broadcast of a spectacular outburst from the unstable, behemoth double-star system Eta Carinae, an event initially seen on Earth nearly 170 years ago.

Dubbed the "Great Eruption," the outburst first caught the attention of sky watchers in 1837 and was observed through 1858. But astronomers didn’t have sophisticated science instruments to accurately record the star system’s petulant activity.

Luckily for today’s astronomers, some of the light from the eruption took an indirect path to Earth and is just arriving now, providing an opportunity to analyze the outburst in detail. The wayward light was heading in a different direction, away from our planet, when it bounced off dust clouds lingering far from the turbulent stars and was rerouted to Earth, an effect called a "light echo." Because of its longer path, the light reached Earth 170 years later than the light that arrived directly.

The observations of Eta Carinae’s light echo are providing new insight into the behavior of powerful massive stars on the brink of detonation. The views of the nearby erupting star reveal some unexpected results, which will force astronomers to modify physical models of the outburst.

"When the eruption was seen on Earth 170 years ago, there were no cameras capable of recording the event," explained the study’s leader, Armin Rest of the Space Telescope Science Institute in Baltimore, Md. "Everything astronomers have known to date about Eta Carinae’s outburst is from eyewitness accounts. Modern observations with science instruments were made years after the eruption actually happened. It’s as if nature has left behind a surveillance tape of the event, which we are now just beginning to watch. We can trace it year by year to see how the outburst changed."

The team’s paper appeared Feb. 16 in a letter to the journal Nature.

Located 7,500 light-years from Earth, Eta Carinae is one of the largest and brightest star systems in our Milky Way galaxy. Although the chaotic duo is known for its petulant
outbursts, the Great Eruption was the biggest ever observed. During the 20-year episode, Eta Carinae shed some 20 solar masses and became the second brightest star in the sky. Some of the outflow formed the system’s twin giant lobes. Before the epic event, the stellar pair was 140 times heftier than our Sun.

Because Eta Carinae is relatively nearby, astronomers have used a variety of telescopes, including the Hubble Space Telescope, to document its escapades. The team’s study involved a mix of visible-light and spectroscopic observations from ground-based telescopes.

The observations mark the first time astronomers have used spectroscopy to analyze a light echo from a star undergoing powerful recurring eruptions, though they have measured this unique phenomenon around exploding stars called supernovae. Spectroscopy captures a star’s “fingerprints,” providing details about its behavior, including the temperature and speed of the ejected material.

The delayed broadcast is giving astronomers a unique look at the outburst and turning up some surprises. The turbulent star system does not behave like other stars of its class. Eta Carinae is a member of a stellar class called Luminous Blue Variables, large, extremely bright stars that are prone to periodic outbursts. The temperature of the outflow from Eta Carinae’s central region, for example, is about 8,500° F, which is much cooler than that of other erupting stars. "This star really seems to be an oddball," Rest said. "Now we have to go back to the models and see what has to change to actually produce what we are measuring."

Rest’s team first spotted the light echo while comparing visible-light observations he took of the stellar duo in 2010 and 2011 with the U.S. National Optical Astronomy Observatory’s Blanco 4-meter telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile. He obtained another set of CTIO observations taken in 2003 by astronomer Nathan Smith of the University of Arizona in Tucson, which helped him piece together the whole 20-year outburst.

The images revealed light that seemed to dart through and illuminate a canyon of dust surrounding the doomed star system. "I was jumping up and down when I saw the light echo," said Rest, who has studied light echoes from powerful supernova blasts. "I didn’t expect to see Eta Carinae’s light echo because the eruption was so much fainter than a supernova explosion. We knew it probably wasn’t material moving through space. To see something this close move across space would take decades of observations. We, however, saw the movement over a year’s time. That’s why we thought it was probably a light echo."

Although the light in the images appears to move over time, it’s really an optical illusion. Each flash of light is reaching Earth at a different time, like a person’s voice echoing off the walls of a canyon.

The team followed up its study with spectroscopic observations, using the Carnegie Institution of Washington’s Magellan and du Pont telescopes at Las Campanas Observatory in Chile. That study helped the astronomers decode the light, revealing the outflow’s speed and temperature. The observations showed that ejected material was moving at roughly 445,000 miles an hour, which matches predictions.

Rest’s group monitored changes in the intensity of the light echo using the Las Cumbres Observatory Global Telescope Network’s Faulkes Telescope South in Siding Spring, Australia. The team then compared those measurements with a plot astronomers in the 1800s made of the light brightening and dimming over the course of the 20-year eruption. The new measurements matched the signature of the 1843 peak in brightness.

The team will continue to follow Eta Carinae because light from the outburst is still streaming to Earth. "We should see brightening again in six months from another increase in light that was seen in 1844," Rest said. "We hope to capture light from the outburst coming from different directions so that we can get a complete picture of the eruption."
Relic from a Shredded Galaxy

(NASA/STScI) Astronomers using NASA’s Hubble Space Telescope may have found evidence for a cluster of young, blue stars encircling one of the first intermediate-mass black holes ever discovered. Astronomers believe the black hole may once have been at the core of a now-disintegrated unseen dwarf galaxy. The discovery of the black hole and the possible star cluster has important implications for understanding the evolution of supermassive black holes and galaxies.

Astronomers know how massive stars collapse to form black holes but it is not clear how supermassive black holes, which weigh billions of times the mass of our Sun, form in the cores of galaxies. One idea is that supermassive black holes may build up through the merger of smaller black holes.

Sean Farrell of the Sydney Institute for Astronomy in Australia discovered a middleweight black hole in 2009 using the European Space Agency’s XMM-Newton X-ray space telescope. Known as HLX-1 (Hyper-Luminous X-ray source 1), the black hole has an estimated weight of about 20,000 solar masses. It lies towards the edge of the galaxy ESO 243-49, 290 million light-years from Earth.

Farrell then observed HLX-1 simultaneously with NASA’s Swift observatory in X-ray and Hubble in near-infrared, optical, and ultraviolet wavelengths. The intensity and the color of the light may indicate the presence of a young, massive cluster of blue stars, 250 light-years across, encircling the black hole. Hubble can't resolve the stars individually because the suspected cluster is too far away. The brightness and color is consistent with other clusters of stars seen in other galaxies, but some of the light may be coming from the gaseous disk around the black hole.

"Before this latest discovery we suspected that intermediate-mass black holes could exist, but now we understand where they may have come from," Farrell said. "The fact that there seems to be a very young cluster of stars indicates that the intermediate-mass black hole may have originated as the central black hole in a very-low-mass dwarf galaxy. The dwarf galaxy might then have been swallowed by the more massive galaxy, just as happens in our Milky Way."

From the signature of the X-rays, Farrell's team knew there would be some blue light emitted from the high temperature of the hot gas in the disk swirling around the black hole. They couldn't account for the red light coming from the disk. It would have to be produced by a much cooler gas, and they concluded this would most likely come from stars. The
next step was to build a model that added the glow from a population of stars. These models favor the presence of a young massive cluster of stars encircling the black hole, but this interpretation is not unique, so more observations are needed. In particular, the studies led by Roberto Soria of the Australian International Centre for Radio Astronomy Research, using data from Hubble and the ground-based Very Large Telescope, show variations in the brightness of the light that a star cluster couldn’t cause. This indicates that irradiation of the disk itself might be the dominant source of visible light, rather than a massive star cluster.

"What we can definitely say with our Hubble data is that we require both emission from an accretion disk and emission from a stellar population to explain the colors we see," said Farrell.

Such young clusters of stars are commonly found inside galaxies like the host galaxy, but not outside the flattened starry disk, as found with HLX-1. One possible scenario is that the HLX-1 black hole was the central black hole in a dwarf galaxy. The larger host galaxy may then have captured the dwarf. In this conjecture, most of the dwarf’s stars would have been stripped away through the collision between the galaxies. At the same time, new young stars would have formed in the encounter. The interaction that compressed the gas around the black hole would then have also triggered star formation.

Farrell theorizes that the possible star cluster may be less than 200 million years old. This means that the bulk of the stars formed following the dwarf’s collision with the larger galaxy. The age of the stars tells how long ago the two galaxies crashed into each other.

Farrell proposed for more observations this year. The new findings are published in the February 15 issue of The Astrophysical Journal. Soria and his colleagues have published their alternative conclusions in the January 17 online issue of the Monthly Notices of the Royal Astronomical Society.

**Hubble Reveals a New Class of Extrasolar Planet**

(NASA/STScI) Observations by NASA’s Hubble Space Telescope have come up with a new class of planet, a water-world enshrouded by a thick, steamy atmosphere. It’s smaller than Uranus but larger than Earth.

Zachory Berta of the Harvard-Smithsonian Center for Astrophysics (CfA) and colleagues made the observations of the planet GJ1214b. "GJ1214b is like no planet we know of," Berta said. "A huge fraction of its mass is made up of water."

The ground-based MEarth Project, led by CfA’s David Charbonneau, discovered GJ1214b in 2009. This super-Earth is about 2.7 times Earth’s diameter and weighs almost seven times as much. It orbits a red-dwarf star every 38 hours at a distance of 1.3 million miles, giving it an estimated temperature of 450°F.

In 2010, CfA scientist Jacob Bean and colleagues reported that they had measured the atmosphere of GJ1214b, finding it likely that it was composed mainly of water. However, their observations could also be explained by
the presence of a planet-enshrouding haze in GJ1214b’s atmosphere.

Berta and his co-authors used Hubble’s Wide Field Camera 3 (WFC3) to study GJ1214b when it crossed in front of its host star. During such a transit, the star’s light is filtered through the planet’s atmosphere, giving clues to the mix of gases.

"We’re using Hubble to measure the infrared color of sunset on this world," Berta explained.

Hazes are more transparent to infrared light than to visible light, so the Hubble observations help tell the difference between a steamy and a hazy atmosphere.

They found the spectrum of GJ1214b to be featureless over a wide range of wavelengths, or colors. The atmospheric model most consistent with the Hubble data is a dense atmosphere of water vapor.

"The Hubble measurements really tip the balance in favor of a steamy atmosphere," Berta said.

Since the planet’s mass and size are known, astronomers can calculate the density, of only about 2 grams per cubic centimeter. Water has a density of 1 gram per cubic centimeter, while Earth’s average density is 5.5 grams per cubic centimeter. This suggests that GJ1214b has much more water than Earth does, and much less rock.

As a result, the internal structure of GJ1214b would be an extraordinarily different world than our world.

"The high temperatures and high pressures would form exotic materials like "hot ice" or ‘superfluid water,’ substances that are completely alien to our everyday experience," Berta said.

Theorists expect that GJ1214b formed farther out from its star, where water ice was plentiful, and migrated inward early in the system’s history. In the process, it would have passed through the star’s habitable zone, where surface temperatures would be similar to Earth’s. How long it lingered there is unknown.

GJ1214b is located in the direction of the constellation Ophiuchus, and just 40 light-years from Earth. Therefore, it’s a prime candidate for study by the planned James Webb Space Telescope.

A paper reporting these results has been accepted for publication in The Astrophysical Journal and is available online. 

Dark Matter Core Defies Explanation in Hubble Image

(NASA/STScI) It was the result no one wanted to believe. Astronomers observed what appeared to be a clump of dark matter left behind during a bizarre wreck between massive clusters of galaxies.

The dark matter collected into a "dark core" containing far fewer galaxies than would be expected if the dark matter and galaxies hung together. Most of the galaxies apparently have sailed far away from the collision. This result could present a challenge to basic theories of dark matter, which predict that galaxies should be anchored to the invisible substance, even during the shock of a collision.

The initial observations, made in 2007, were so unusual that astronomers shrugged them off as unreal, due to poor data. However, new results from NASA’s Hubble Space Telescope confirm that dark matter and galaxies parted ways in the gigantic merging galaxy cluster called Abell 520, located 2.4 billion light-years away.

Now, astronomers are left with the challenge
of trying to explain dark matter’s seemingly oddball behavior in this cluster.

"This result is a puzzle," said astronomer James Jee of the University of California, Davis, leader of the Hubble study. "Dark matter is not behaving as predicted, and it's not obviously clear what is going on. Theories of galaxy formation and dark matter must explain what we are seeing."

A paper reporting the team’s results has been accepted for publication in The Astrophysical Journal and is available online.

First detected about 80 years ago, dark matter is thought to be the gravitational "glue" that holds galaxies together. The mysterious invisible substance is not made of the same kind of matter that makes up stars, planets, and people. Astronomers know little about dark matter, yet it accounts for most of the universe's mass.

They have deduced dark matter's existence by observing its ghostly gravitational influence on normal matter. It’s like hearing the music but not seeing the band.

One way to study dark matter is by analyzing smashups between galaxy clusters, the largest structures in the universe. When galaxy clusters collide, astronomers expect galaxies to tag along with the dark matter, like a dog on a leash. Clouds of intergalactic gas, however, plow into one another, slow down, and lag behind the impact.

That theory was supported by visible-light and X-ray observations of a colossal collision between two galaxy clusters called the Bullet Cluster. The galactic grouping has become a textbook example of how dark matter should behave.

But studies of Abell 520 showed that dark matter’s behavior may not be so simple. The original observations found that the system's core was rich in dark matter and hot gas but contained no luminous galaxies, which normally would be seen in the same location as the dark matter. NASA’s Chandra X-ray Observatory detected the hot gas. Astronomers used the Canada-France-Hawaii and Subaru telescopes atop Mauna Kea to infer the location of dark matter by measuring how the mysterious substance bends light from more distant background galaxies, an effect called gravitational lensing.

The astronomers then turned Hubble’s Wide Field Planetary Camera 2 to help bail them out of this cosmic conundrum. Instead, to their chagrin, the Hubble observations helped confirm the earlier findings. Astronomers used Hubble to map the dark matter in the cluster of trying to explain dark matter’s seemingly oddball behavior in this cluster.

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through the gravitational lensing technique.

"Observations like those of Abell 520 are humbling in the sense that in spite of all the leaps and bounds in our understanding, every now and then, we are stopped cold," explained Arif Babul of the University of Victoria in British Columbia, the team’s senior theorist.

Is Abell 520 an oddball, or is the prevailing picture of dark matter flawed? Jee thinks it’s too soon to tell.

"We know of maybe six examples of high-speed galaxy cluster collisions where the dark matter has been mapped," Jee said. "But the Bullet Cluster and Abell 520 are the two that show the clearest evidence of recent mergers, and they are inconsistent with each other. No single theory explains the different behavior of dark matter in those two collisions. We need more examples."

The team has proposed a half-dozen explanations for the findings, but each is unsettling for astronomers. "It’s pick your poison," said team member Andisheh Mahdavi of San Francisco State University in California, who led the original Abell 520 observations in 2007. One possible explanation for the discrepancy is that Abell 520 was a more complicated interaction than the Bullet Cluster encounter. Abell 520 may have formed from a collision between three galaxy clusters, instead of just two colliding systems in the case of the Bullet Cluster.

Another scenario is that some dark matter may be what astronomers call "sticky." Like two snowballs smashing together, normal matter slams into each other during a collision and slows down. But dark matter blobs are thought to pass through each other during an encounter without slowing down. This scenario proposes that some dark matter interacts with itself and stays behind when galaxy clusters collide.

A third possibility is that the core contained many galaxies, but they were too dim to be seen, even by Hubble. Those galaxies would have to have formed dramatically fewer stars than other normal galaxies. Armed with the Hubble data, the group hopes to create a computer simulation to try to reconstruct the collision, hoping that it yields some answers to dark matter’s weird behavior. "

Citizen Scientists Reveal a Bubbly Milky Way

(NASA/SSC) A team of volunteers has pored over observations from NASA’s Spitzer Space Telescope and discovered more than 5,000 "bubbles" in the disk of our Milky Way galaxy. Young, hot stars blow these bubbles into surrounding gas and dust, indicating areas of brand new star formation.

Upwards of 35,000 "citizen scientists" sifted through the Spitzer infrared data as part of the online Milky Way Project to find these telltale bubbles. The volunteers have turned up 10 times as many bubbles as previous surveys so far.

"These findings make us suspect that the Milky
Way is a much more active star-forming galaxy than previously thought," said Eli Bressert, an astrophysics doctoral student at the European Southern Observatory, based in Germany, and the University of Exeter, England, and co-author of a paper submitted to the Monthly Notices of the Royal Astronomical Society.

"The Milky Way’s disk is like champagne with bubbles all over the place," he said.

Computer programs struggle at identifying the cosmic bubbles. But human eyes and minds do an excellent job of noticing the wispy arcs of partially broken rings and the circles-within-circles of overlapping bubbles. The Milky Way Project taps into the "wisdom of crowds" by requiring that at least five users flag a potential bubble before its inclusion in the new catalog. Volunteers mark any candidate bubbles in the infrared Spitzer images with a sophisticated drawing tool before proceeding to scour another image.

"The Milky Way Project is an attempt to take the vast and beautiful data from Spitzer and make extracting the information a fun, online, public endeavor," said Robert Simpson, a postdoctoral researcher in astronomy at Oxford University, England, principal investigator of the Milky Way Project and lead author of the paper.

The data come from the Spitzer Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) and Multiband Imaging Photometer for Spitzer Galactic (MIPSGAL) surveys. These datasets cover a narrow, wide strip of the sky measuring 130 degrees wide and just two degrees tall. From a stargazer’s perspective, a two-degree strip is about the width of your index finger.
held at arm's length, and your arms opened to the sky span about 130°. The surveys peer through the Milky Way's disk and right into the galaxy's heart.

The bubbles tagged by the volunteers vary in size and shape, both with distance and due to local gas cloud variations. The results will help astronomers better identify star formation across the galaxy. One topic under investigation is triggered star formation, in which the bubble-blowing birth of massive stars compresses nearby gas that then collapses to create further fresh stars.

"The Milky Way Project has shown that nearly a third of the bubbles are part of 'hierarchies,' where smaller bubbles are found on or near the rims of larger bubbles," said Matthew Povich, a National Science Foundation Astronomy and Astrophysics Postdoctoral Fellow at Penn State, University Park, and co-author of the paper. "This suggests new generations of star formation are being spawned by the expanding bubbles."

Variations in the distribution pattern of the bubbles intriguingly hint at structure in the Milky Way. For example, a rise in the number of bubbles around a gap at one end of the survey could correlate with a spiral arm. Perhaps the biggest surprise is a drop-off in the bubble census on either side of the galactic center. "We would expect star formation to be peaking in the galactic center because that's where most of the dense gas is," said Bressert. "This project is bringing us way more questions than answers."

In addition, the Milky Way Project users have pinpointed many other phenomena, such as star clusters and dark nebulae, as well as gaseous "green knots" and "fuzzy red objects." Meanwhile, the work with the bubbles continues, with each drawing helping to refine and improve the catalog.

For those interested in counting bubbles and contributing to the Milky Way Project, visit the following link: http://www.milkywayproject.org. To learn of other citizen science-based efforts, check out the Zooniverse: https://www.zooniverse.org.

Other authors of the paper include Sarah Kendrew of the Max Planck Institute, Heidelberg, Germany; Chris Lintott and Arfon Smith, also of the University of Oxford and the Adler Planetarium in Chicago, Ill.; Kim Arvidsson, also of the Adler Planetarium; Grace Wolf-Chase, also of the Adler Planetarium and the University of Chicago; Reid Sherman, also of the University of Chicago; Claudia Cyganowski of the Harvard-Smithsonian Center for Astronomy, Cambridge, Mass. and a National Science Foundation Astronomy and Astrophysics Postdoctoral Fellow; Sarah Maddison of Swinburne University, Hawthorn, Australia; and Kevin Schawinski of Yale University, New Haven, Conn. and an Einstein Fellow.
Month in History

May

1: Boulder Dam completed, 1935
1: Supernova discovered from China in 1006.
1: In 1949, Gerard Kuiper discovered a moon of Neptune he named Nereid.
4: In 1988, the Pepcon rocket fuel plant in Henderson, NV, exploded, rattling Las Vegas with a Richter 3.5 shock wave.
5: The launch of Mercury 3 with a Redstone rocket in 1961. The Freedom 7 capsule carried Alan Shepard, on a suborbital trip into space that lasted about 15 minutes.
8: The Spanish explorer Hernando de Soto was the first European to navigate through the Mississippi Delta to discover the Mississippi River in 1541 near the present site of Memphis.
8: The first color, transatlantic television transmission was accomplished with the Telstar 2 satellite in 1963.
9: Admiral Richard Byrd became the first person to complete an aerial crossing of the North Pole in 1926. He made the round trip flight from Spitzbergen Island in a three-engined Fokker aircraft.
10: On this date in 1869 from Promontory Summit northwest of Ogden, Utah, a single telegraphed word, “done,” signaled to the nation the completion of the first transcontinental railroad.
11: Albert Einstein’s General Theory of Relativity was presented for the first time in Germany in 1916.
14: In 1908, Wilbur Wright flew with the first airplane passenger, Charles Furnas, in North Carolina. Furnas was the Wright brothers’ mechanic.
14: The Skylab 1 mission put the first US space station in orbit in 1973. Damage to the solar panels and thermal shield during launch delayed the occupation of the station. Skylab was launched with a Saturn V rocket similar to that used in the Apollo moon missions.
17: The English astronomer Joseph Lockyer, who discovered helium in the spectrum of the sun in 1868 (27 years before it was found on the earth), was born on this date in 1836.
20: The Portuguese navigator Vasco da Gama was the first to demonstrate a sea route to India around the southern tip of Africa in 1498.
22: Apollo 10 lunar module descends to 50,000 feet above the lunar surface in 1969.
25: President John F. Kennedy, in 1961, declared the national goal of landing a man on the moon and returning him safely to earth before the end of the decade.
29: One aspect of Einstein’s General Theory of Relativity was tested during a British solar eclipse expedition in 1919. The gravitational field of the sun was demonstrated to bend starlight passing near the sun as predicted.

Give a Star

A popular service of The CSN Planetarium lets you dedicate a star to a loved one. For a donation of $35, we will provide an attractive certificate that proclaims your dedication of the star of your choice to any other person. The certificate will have a chart of the constellation containing the star and complete information about the star. A donation of $100 will give you an exclusive dedication. Call 651-4138 or 651-4505 for further information.
All times are Pacific Daylight Time. Rise and set times are for the astronomical horizon at Las Vegas or Reno as noted.

### The Moon

**Mercury.** Mercury is visible in the morning sky at the beginning of the month. Greatest western elongation (27°) occurred on April 18. By mid-month, it will be too close in direction to the sun to be seen. Superior conjunction on the far side of the Sun is on May 27.

**Venus.** Venus, in Taurus, appears in the southwestern sky setting shortly after the sun. By the end of the month, it will be too close in direction to the sun to be seen with inferior conjunction between the earth and sun occurring on June 5 with a transit.

**Mars.** Mars, in Leo, is high in the south at sunset. Look for the first quarter moon about 7° below Mars on the evening of May 28.

**Jupiter.** Jupiter, in Taurus, is too close in direction to the sun to be seen. Jupiter will reach conjunction with the sun on May 13.

**Saturn.** Saturn, in Virgo, is in the east after sunset. Opposition occurred on April 15. The waxing gibbous moon will be to its right on the evenings of May 3 and 30.

**Uranus.** Uranus, in Pisces, is rising in the east shortly before the sun. The waning crescent moon will be above Uranus on the morning of the 16th.

**Neptune.** Neptune, in Aquarius, is rising in the east several hours before the Sun. Look for the waning crescent moon to rise to the left of Neptune on the morning of May 14.

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### Dwarf Planets

<table>
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<tr>
<th>Planet</th>
<th>Constellation</th>
<th>Transit</th>
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<tbody>
<tr>
<td>Pluto</td>
<td>Sagittarius</td>
<td>3:45 am (35°)</td>
</tr>
<tr>
<td>Ceres</td>
<td>Aries</td>
<td>11:59 pm (65°)</td>
</tr>
<tr>
<td>Eris</td>
<td>Cetus</td>
<td>10:47 pm (50°)</td>
</tr>
<tr>
<td>MakeMake</td>
<td>Coma Berenices</td>
<td>9:42 pm (82°)</td>
</tr>
<tr>
<td>Haumea</td>
<td>Boötes</td>
<td>10:53 am (73°)</td>
</tr>
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</table>

All Dwarf Planets require a telescope. Ceres is visible through most amateur telescopes. Pluto usually requires a telescope of at least 12” diameter. Dwarf planets beyond the orbit of Neptune can also be referred to as Plutoids. Eris ("EE-ris"), MakeMake (mah-keh-mah-keh) and Haumea, like most Plutoids, require a professional sized telescope. Transit times and altitudes (from Las Vegas) are when the object is at its highest in the southern sky. Each will appear slightly lower in the sky from Reno. ❄️

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### The Planets

**Mercury.** Mercury is visible in the morning sky at the beginning of the month. Greatest western elongation (27°) occurred on April 18. By mid-month, it will be too close in direction to the sun to be seen. Superior conjunction on the far side of the Sun is on May 27.

**Venus.** Venus, in Taurus, appears in the southwestern sky setting shortly after the sun. By the end of the month, it will be too close in direction to the sun to be seen with inferior conjunction between the earth and sun occurring on June 5 with a transit.

**Mars.** Mars, in Leo, is high in the south at sunset. Look for the first quarter moon about 7° below Mars on the evening of May 28.

**Jupiter.** Jupiter, in Taurus, is too close in direction to the sun to be seen. Jupiter will reach conjunction with the sun on May 13.

**Saturn.** Saturn, in Virgo, is in the east after sunset. Opposition occurred on April 15. The waxing gibbous moon will be to its right on the evenings of May 3 and 30.

**Uranus.** Uranus, in Pisces, is rising in the east shortly before the sun. The waning crescent moon will be above Uranus on the morning of the 16th.

**Neptune.** Neptune, in Aquarius, is rising in the east several hours before the Sun. Look for the waning crescent moon to rise to the left of Neptune on the morning of May 14.

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### The Moon

Each day the moon rises about one hour later than the day before. The New Moon (not visible) is in the direction of the sun and rises and sets with the sun. The first quarter moon rises at about noon and sets near midnight. The full moon is opposite the sun in the sky and rises at sunset and sets at sunrise. The last quarter moon rises near midnight and sets near noon. Perigee is when the moon is closest to the earth and apogee is when it is farthest. The distance varies by ±6% from the average.

- **First quarter:** Apr. 29, 2:57 am pdt
- **Full Moon:** May 5, 8:35 pm
- **Last quarter:** May 12, 2:47 pm
- **New Moon:** May 20, 4:47 pm
- **First quarter:** May 28, 1:16 pm
- **Perigee:** May 5, 8:34 pm pdt
- **Apogee:** May 19, 9:14 am
- **Perigee:** Jun. 3, 6:21 am

There will be an annular eclipse on the Sun visible in North America along a line that passes just north of Reno, Nevada, and St. George, Utah. It will occur on May 20 and be in progress as the Sun sets. ❄️
The Sun
Las Vegas

<table>
<thead>
<tr>
<th>Date</th>
<th>Sunrise</th>
<th>Sunset</th>
<th>Day</th>
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The Sun
Reno

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Meteor Shower

On the night of May 4/5, the Eta Aquarid meteor shower will reach its peak. At its peak, this shower typically produces about 10-15 meteors per hour. This is not a particularly rich shower. The nearly full moon will not interfere with observing this shower as it is in the sky all night. Adding sporadic meteors that are not part of the shower, the typical observer can usually expect about 20 meteors per hour during this shower.

Shower meteors are caused by particles entering the earth's atmosphere on paths parallel to each other. While these meteors can be seen anywhere in the sky, their paths trace back to a common direction making them appear to radiate outward from this "vanishing point."

Sporadic meteors are the random meteors that occur all of the time. They can be seen anywhere in the sky traveling any direction. On the average, about 10 sporadic meteors can be seen each hour on any night of the year.

The particles from this shower are associated with Comet Halley. They follow the same path as the comet and are thought to be material ejected from the comet. As seen in the sky, the meteors seem to radiate outward from a point near the star Eta Aquarii, giving the name to the shower.

In the Fall, the Orionid shower is caused by the same stream as the earth crosses it again in five months.

The best conditions for observing meteors are found by traveling away from the city where the sky is dark. More meteors are seen after midnight when you are on the leading side of the earth as it travels around the sun.

When possible, observe meteors at times when the moon is below the horizon. The moon provides additional light in the sky that can impede meteor viewing.

This year, the best viewing period will be well after midnight as the radiant point rises a short while before the beginning of astronomical twilight a little after 3 am.

Astronomical twilight is when the sun is 18° below the horizon. There is no significant dawn visible. Nautical twilight is when the sun is 12° below the horizon and dawn is visible in the east, but the brighter stars are still easily seen. In early May, this occurs a little before 5 am. Civil twilight occurs when the sun is 6° below the horizon (about 5:15 am) and no stars are easily visible. Civil twilight is bright enough to preclude artificial lighting.

While meteors can be seen anywhere in the sky during the shower, the meteors are more easily viewed near the overhead point. With this shower, the greatest numbers are likely to be viewed in the early morning hours before dawn when the radiant point for the shower is high in the southern sky.
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