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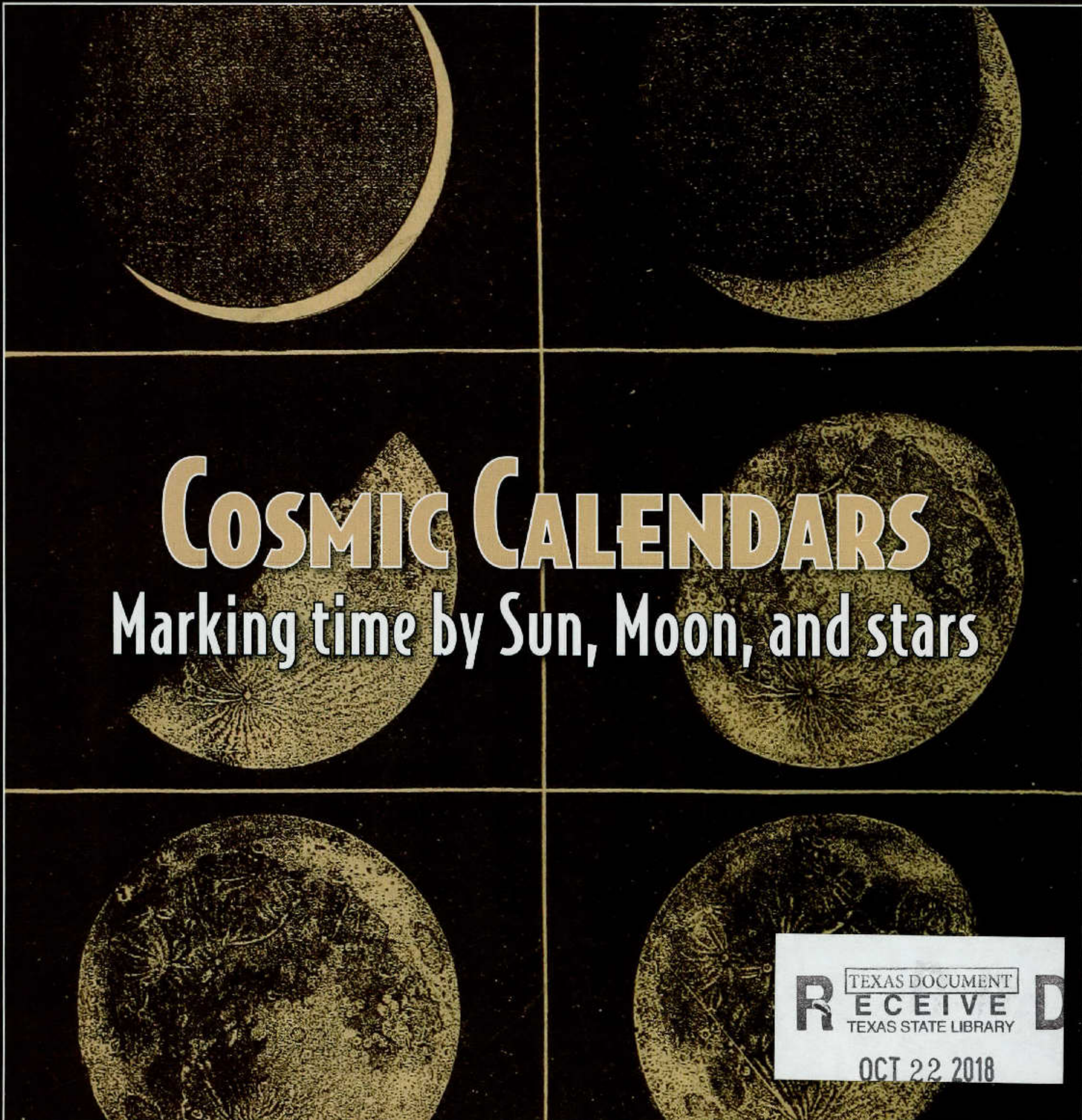
NOVEMBER/DECEMBER 2018 $5

LAST PORT O' CALL
PAGE 16



Cosmic Calendars
Marking time by Sun, Moon, and stars

THE UNIVERSITY OF TEXAS AT AUSTIN McDONALD OBSERVATORY

StarDate™

NOVEMBER/DECEMBER • Vol. 46, No. 6

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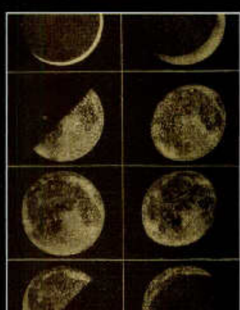


On The Cover
Some calendars, like the Islamic, are based solely on the lunar cycle. For details, see Page 4.

This Page
Hubble Space Telescope recently compiled this image of thousands of galaxies near the Big Dipper. The image shows the galaxies in a combination of wavelengths. Some of the galaxies are as far as 11 billion light-years, which means we see them as they looked when the universe was less than three billion years old.

Coming Up
Our next issue is the 2019 Sky Almanac. We'll bring you a year's worth of skywatching tips, skymaps, anniversaries in astronomy and spaceflight, and more.

MERLIN

Dear Merlin,

Since a year is defined as the time it takes Earth to make one revolution around the Sun, and the precession cycle of Earth's rotational axis is 26,000 years, will the seasons be wrong relative to the calendar in 13,000 years?

Craig Merlic
Los Angeles

Nope, all will be well.

For those readers who are perplexed by the question, a little background:

As Earth rotates on its axis, it wobbles like a spinning gyroscope. It takes 26,000 years to complete a single wobble. During that time, the direction in which Earth's axis aims slowly rotates around the sky, so the stars that mark the north and south celestial poles change as well. In a few thousand years, for example, the star Gamma Cephei will mark the north celestial pole, not Polaris.

As Earth's axis works its way around the sky, so does the Sun — it slowly shifts westward relative to the background of stars. As a result, the Sun's location at the solstices and equinoxes shifts, too. About 4,000 years ago, for example, the Sun appeared in Taurus, near the Pleiades star cluster, at the spring equinox in the northern hemisphere. Today, though, it's about 60 degrees away from that spot, near the western edge of Pisces. That continuous shift is known as the precession of the equinoxes.

The modern calendar, though, is designed to keep the dates aligned with the astronomical solstices and equinoxes. The spring equinox always occurs around March 20, for example, and the winter solstice around December 21 (give or take a day or two). The calendar isn't perfect, though. It drifts by one day every few thousand years. So a few millennia from now, one Leap Day will need to be dropped to keep the seasons and the calendar in sync.

Dear Merlin,

When astronomers use a spectrograph to collect data from a star, is it possible for the data to be "contaminated" by any elements that happen to be between the target and the instrument recording it?

Greg Schulz
Lynd, Minnesota

Not only is it possible, it happens all the time, and it's both a curse and a blessing for astronomers.

As light crosses the universe, it passes through clouds of gas and dust, as well as the smattering of material that suffuses all of space. So when the light from a distant star or galaxy (or even a planet or moon within the solar system) reaches a telescope on Earth, it carries the "fingerprints" of all the material it passed through. It's like a glass in a murder investigation spackled with the fingerprints of dozens of people. The crime lab must eliminate the prints of the innocent, leaving them with those of the killer. In the same way, to best understand their targets, astronomers must eliminate the prints of all the extra material that's in the way, which isn't easy.

On the other hand, astronomers sometimes use distant stars or other objects, such as quasars, as backlights to tell them about all that extra stuff. If they know what the spectrum of that backlight should look like, they can eliminate it from their observations, leaving them with a spectrum of all the foreground material.

Knowing more about what's scattered through space reveals more about the structure of the universe, the formation of the elements, large-scale magnetic fields, and much more.

Dear Merlin,

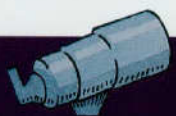
This summer Mars was closer to Earth and much brighter than in many years. At the same time, it was experiencing a planet-wide dust storm. How does that storm affect the brightness of the planet?

Frank Cronin
Austin

Merlin hopes that everyone got a chance to see Mars during the summer. It was quite a spectacle. (Though it's fainter, Mars is still in view in November and December.)

The dust storm, which stirred to life in May and continued for months, had no effect on the Red Planet's brightness or color. The dust in the atmosphere was like the dust that always covers much of the surface of Mars, so there wasn't a big change in the planet's reflectivity.

The storm did change what observers could see through a telescope, though. Most of the planet's features were hidden from view during the height of the storm, making Mars look relatively bland and featureless.



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

stardate.org/astro-guide

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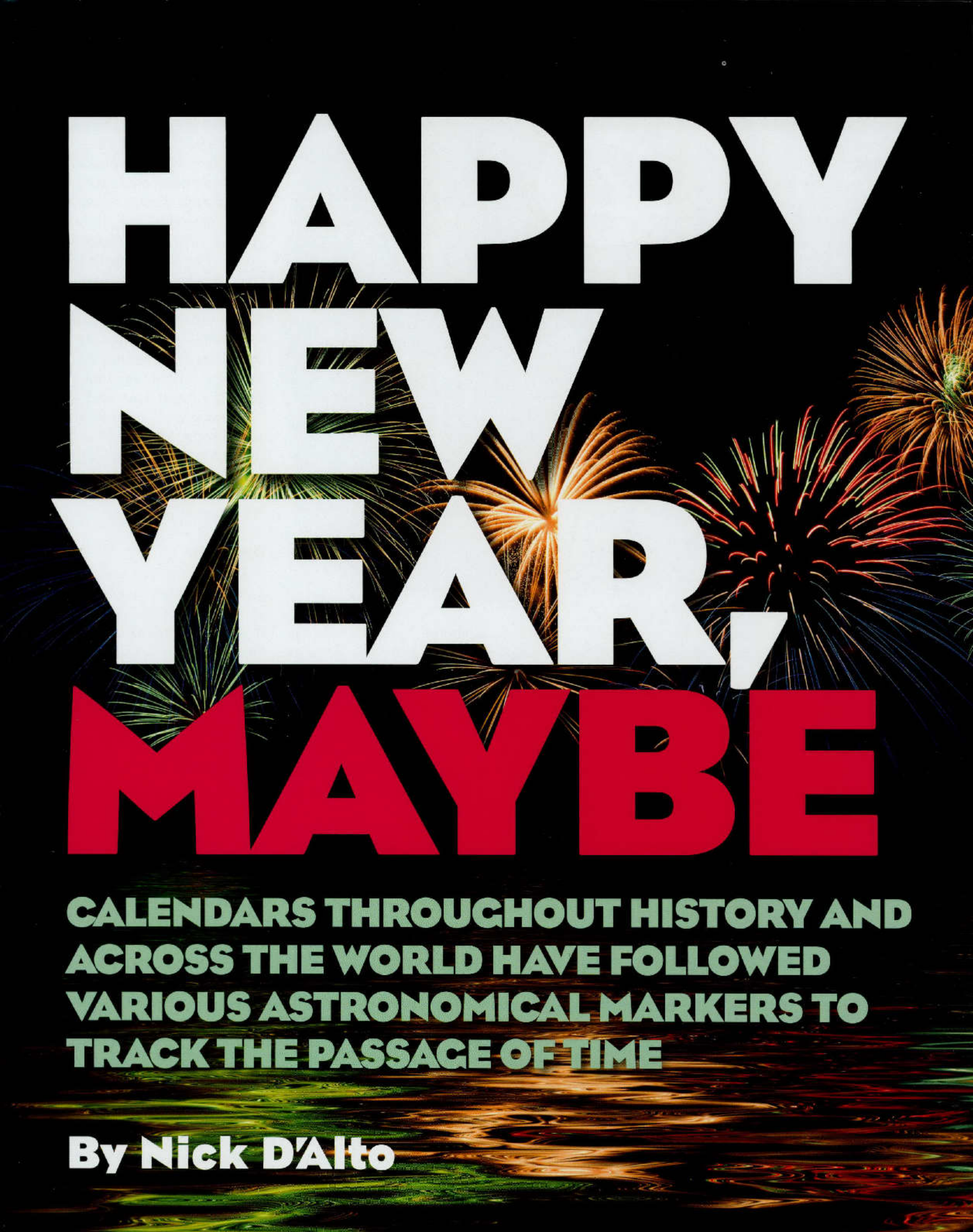


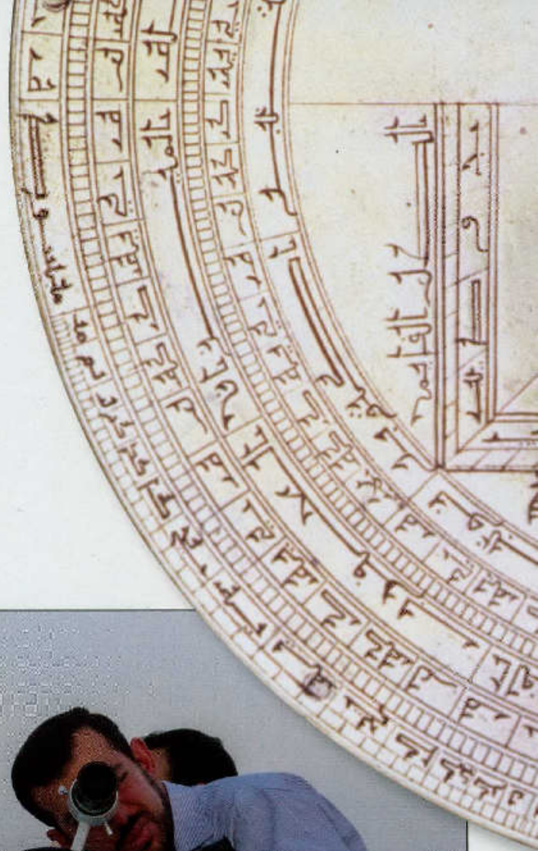
HAPPY NEW YEAR, MAYBE

CALENDARS THROUGHOUT HISTORY AND ACROSS THE WORLD HAVE FOLLOWED VARIOUS ASTRONOMICAL MARKERS TO TRACK THE PASSAGE OF TIME

By Nick D'Alto

LEEKRIS/FOTOLIA

As each December draws to a close, we all get ready to wish each other another "Happy New Year." But in fact, the timing of that celebration depends entirely on your astronomy. For most of us, the year begins on January 1, and measures (at least, in modern times), one complete trip of Earth around the Sun. That's according to the Gregorian calendar. That's not the only way to measure a year, though. Other calendar traditions track the passage of time using different astronomical markers, such as the motions of the Moon, the planets, and stars.



So, which celestial body to follow? Each boasts advantages. The Moon's cycle is conveniently short, and its phases are easy to follow. The stars also cross the night sky dependably; imagining constellations makes this even easier to see. By contrast, the Sun's path across the daytime sky, while harder to follow, also offers signposts to the seasons — ideal for agriculture. Ironically, knowing what's moving and what isn't as you watch the sky hardly matters. As proof of this, some earlier peoples could measure the length of a year with uncanny accuracy, long before anyone realized that Earth orbited the Sun. Precision is what's required to make a good calendar. Whatever celestial markers you choose to follow, you must track them exactly.

Here's the rub: The cycles of Earth, Sun, Moon, and the stars are virtually independent of each other. One Earth day, measured against the stars, requires 23 hours, 56 minutes, 4.1 seconds. Each orbit of the Moon takes just over 29 days, 12 hours, 44 minutes. And a year (depending on how you measure it) takes somewhere between 365.24219 and 365.25964 days. This can make chronicling a year using astronomical means a bit like trying to read a clock where the hour, minute, and second hands never coincide.

The Gregorian calendar, set in place in 1582 by Pope Gregory XIII, offers just one solution to this problem. Other civilizations have devised equally ingenious systems.

MOSTAFAMERAJI

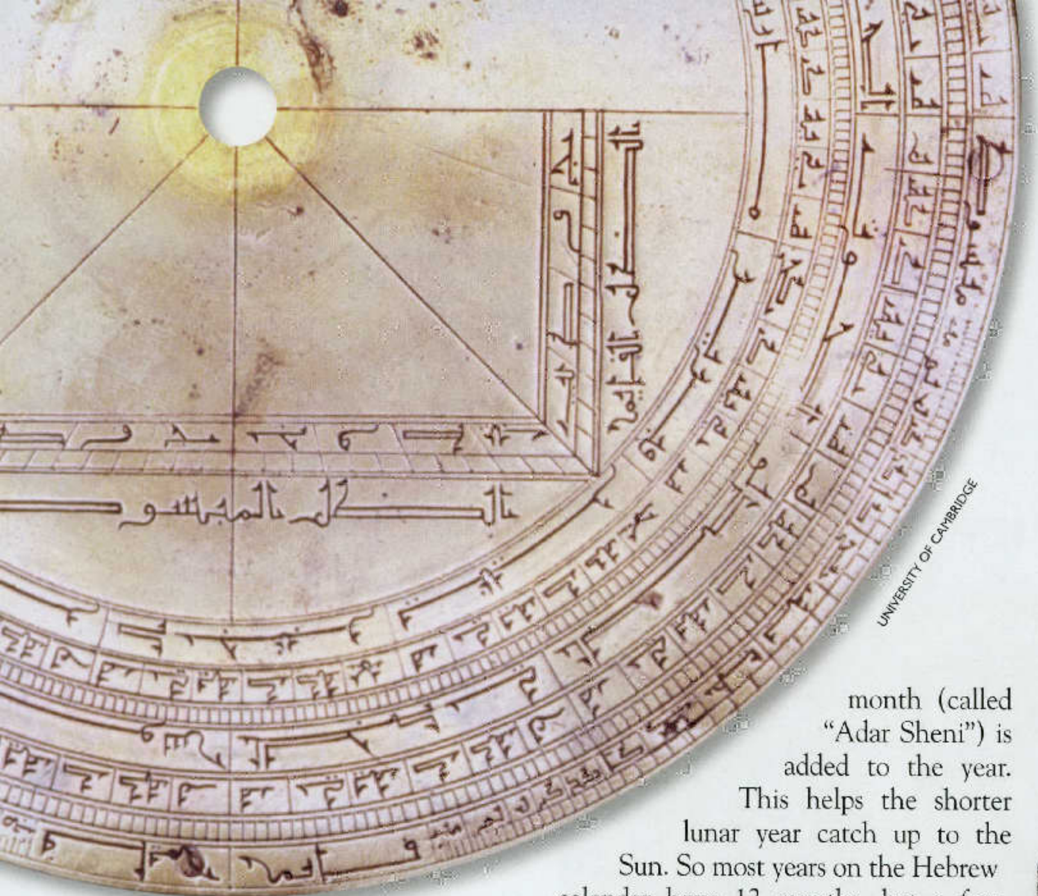
Top: This Islamic astrolabe has calendar scales that can be used to calculate the positions of the Moon and dates of the Hijri, or Islamic lunar calendar. Above: Muslim clerics observe the Moon. The appearance of the crescent Moon marks the beginning of a new month in Hijri.

Hijri, the Islamic calendar, is a pure lunar system, reckoning time using only the phases of the Moon. By Islamic law, each month starts with the sighting, shortly after sunset, of the thin crescent of a new Moon ("Hilal," in Arabic). The new lunar month begins the following day. Each month lasts 29 or 30 days (quite near the Moon's true orbital period). A Hirji year lasts 12 months.

As travel in hot, desert climates often is best by night, a lunar calendar made eminent sense for Islam's first adherents. For the faithful, the Moon's path recalls the travels of the prophet Mohammed. What's most fascinating about Hirji, in astronomical terms, is how this calendar is deliberately detached from the solar cycle. In the Gregorian system, a year is the time for Earth to travel once around the Sun. In Hijri, a year is 12 turns of the Moon.

The first obvious difference is that the Islamic calendar counts shorter years, as 12 lunar months add up to only 354 or 355 days, about 11 days shy of the Gregorian Sun-based year. The result is that each year, dates on the Islamic calendar move backwards that many days. Earth, in effect, has not quite returned to the same point in its orbit during the intervening period. It takes 33 lunar years for the solar and lunar cycles to match up again.

One curious result of this difference is that you are slightly older in Hijri years than Gregorian. (Web-based calculators will even convert your age for you.) A more important note is how this calendar system governs the religious year. For example, while the faithful always mark Ramadan (the month of fasting) in the ninth month of their year, the holiday falls on successively earlier dates of the Gregorian calendar. This means that over subsequent years, the holiday is celebrat-



UNIVERSITY OF CAMBRIDGE

ed in every season in turn.

By contrast, the traditional Hebrew calendar is luni-solar — it uses both the Moon and the Sun. The Hebrew calendar's months are lunar, but its years are solar. Just like in Hijri, the sighting of an emerging crescent Moon begins each month. Ordinarily, 12 lunar months ("Shodashim" in Hebrew) make one year (Shanah).

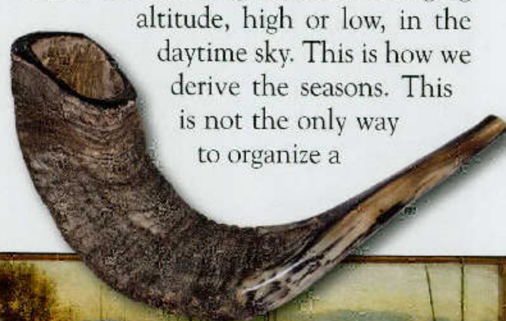
However, Hebrew harvest festivals, such as Sukkot, must remain aligned with the seasons. Periodically, an extra month (called "Adar Sheni") is added to the year. This helps the shorter lunar year catch up to the Sun. So most years on the Hebrew calendar have 12 months, but a few have 13. The general term for this practice is intercalation, and many calendars use it. It is similar to the Gregorian use of leap years, but with more intricate timing: In the Hebrew calendar, the addition must be made seven times over 19 years.

This ratio, called the Metonic Cycle, has its roots in stargazing. It so happens that 235 lunar months (the time for the Moon to complete all its phases) almost exactly equals 19 solar years. This has been known since the Babylonians (though one shudders to imagine how anyone first noticed it). By modern calculation, the difference is only about two hours.

Arranging the Hebrew calendar around this subtle astronomy keeps its holidays always fixed to the lunar cycle. Passover, for example, always begins on a full Moon. The system also nudges the entire Hebrew calendar forward, so it keeps pace with the orbiting Earth.

The Chinese calendar is also luni-solar, and uses a similar intercalary system. It adds a second celestial twist, though: An extra month is added whenever 13 new Moons would otherwise occur in a single year.

The Gregorian calendar is based largely on observing the Sun's changing altitude, high or low, in the daytime sky. This is how we derive the seasons. This is not the only way to organize a



NATIONAL MUSEUM, WARSAW; ZACHI EVENOR

This late-19th-century painting by Aleksander Gierymski shows Hasidic Jews offering prayers and symbolically casting sins into flowing water, a ritual called tashlikh, on Rosh Hashanah, the Jewish New Year. Inset: Traditionally, the shofar, a ceremonial horn, is blown to celebrate Rosh Hashanah.

WHAT IS A YEAR?

Modern astronomy offers several subtly different measures. The tropical year, also called the solar year, is the time required to complete one cycle of the seasons. This could be measured from one spring equinox to the next.

The sidereal year is the time for Earth to finish one complete orbit as measured against the fixed stars. The solar and sidereal years are not exactly the same, owing to the precession of the equinoxes (the gradual change in Earth's axial tilt). The sidereal year, at least at present, is about 20 minutes longer.

Compared to these, it is worth noting that the ancient Persian calendar, still widely used in Iran and Afghanistan, boasts an accuracy rivaling the best efforts of modern astronomy. It is a solar calendar like the Gregorian, but uses direct astronomical observation (not a leap-year formula) to reset the year. Each year begins on the midnight closest to the spring equinox, preferably measured at exactly 52.5 degrees east longitude (the Iran Standard Time meridian). By this method, this 1,400-year-old calendar will drift less than one day in 3,000 years. **ND**

Sun-based calendar, though. Some calendars are based on the recognition that the Sun is also a star, like the others in the night sky.

This is the guiding principle behind Malayalam, one of the traditional calendars used in India. This calendar is solar-sidereal. Its dates are based on the Sun's apparent path against the fixed stars, known as the ecliptic. Months in the Indian system are named for the constellations through which the Sun appears to pass. So the calendar begins in the month of Chingam (the western constellation Leo, in mid-August), and ends on Karkadakam (Cancer), 12 months later. Indian calendars (there are many variations) also attach great significance to what they call sankranti, the moment when one month passes into the next.

Of course, the Sun's path against the nighttime stars cannot be observed directly (except during an eclipse). Instead, dates in the Indian calendar are inferred, by noting which bright stars are visible on the horizon just before the Sun rises or after it sets. To astronomers, these times are known as the heliacal rising and setting of those stars, after Helios, the Greek god of the Sun.

Once you have selected your celestial markers, as a calendar-maker, you must next decide how directly or indirectly you will follow them. For example, the modern Gregorian calendar is termed a calculated system. Its months simply approximate the Moon's actual cycle, and its year is a standard length, with leap years added according to a formula. By contrast, calendars such as Hijri are still based on direct celestial observation. Thus a new month — or a new year — can begin only when a new crescent Moon is actually observed in the night sky.

This requirement raises a number of issues. The visibility of the Moon depends on local atmospheric conditions, as well

PATRICK KWAN


ALEXANDER SYNAPTIC

Chinese New Year celebrations incorporate colorful traditions, like hanging lanterns (below, seen in Kota Kinabalu, Malaysia) and dragon dancers (left, in New York City's Chinatown).

WHEN DOES A NEW YEAR BEGIN?

Recognizing that the night sky moves in cycles that repeat periodically was one of the great discoveries of Neolithic times. It inspired the idea of a calendar. But deciding at what point these cycles repeat is another issue. It's like finding the beginning of a circle. Which astronomical event is important enough to mark the start of the year? Throughout history, that decision has varied widely.

You might wait for a particularly bright star or star cluster to rise. For example, native Hawaiians mark the beginning of the new year by observing the rising of Makali'i (the Pleiades cluster). This falls in February on the Gregorian calendar. The inhabitants on Kodiak Island in the Arctic herald the new year using the Pleiades, too, though for them, it isn't observable until six months later. The Havasupai tribe, native to Arizona's Grand Canyon, use the stars of Corona Borealis. They become visible over the canyon's sheer cliffs in mid-November.

Other calendars wait for multiple astronomical markers to coincide. Rosh Hashanah (Hebrew for "the head of the year") begins each Jewish year on the first new Moon after the fall equinox. This is in the Hebrew month of Tishrei (late September). Chinese New Year occurs on the second new Moon after the winter solstice (late January).

Astronomically, the Gregorian calendar's new year lands close to Earth's closest approach to the Sun (perihelion), between January 2 and 5. In truth, the calendar makers did not know that. Still, the reason for the Gregorian January 1 start to the year does relate to stargazing. The original Roman calendar began in March, and contained just 10 months (October, November, and December then being months eight, nine, and ten, explaining their names). Adding Ianuarius (January) and Februarius (February) plumped the Roman year to 355 days. But it still failed to track the seasons, requiring a clumsy variety of adjustments.

It fell to Julius Caesar to enact decisive calendar reform. After consulting the Greek astronomer Sosigenes, Caesar abolished the old system, instituting instead the now-familiar 365-day year, with leap years. However, to enact this, the year 45 BC on the new Julian calendar had to run for 445 days. This moved the date for New Year's Day from March 25 to January 1, where it stayed.

Originally named for two-headed Janus (the god who looks both forward and back), this month seemed an especially auspicious one to start the year. It was also politically expedient, as high-level Romans traditionally took office on January 1. Later, during the Renaissance, Caesar's reforms were improved a second time (again, to better get the calendar to agree with the sky). This produced the modern Gregorian calendar. **ND**

as the position of the Moon relative to Earth and the Sun. This means that months in the Islamic calendar occasionally begin on different days in different locales, sometimes requiring diplomacy to iron things out. Likewise, months can vary in length from one year to the next. One curious result of this is that it is not practical to print Hijri calendars in advance. Keeping such a calendar literally is astronomy.

In the past, the Hebrew calendar worked this way, too. Temple observers sighted the Moon, and then blew the shofar (ceremonial horn) to herald each month. Today, though, the Hebrew calendar is calculated using mathematics called the Molad. It alternates 29- and 30-day months to closely approximate the Moon's cycle of phases.

In many ways, the different calendars reflect different societies' cultural experiences of the night sky. For example, in the Islamic calendar, important holidays such as Eid al-Fitr (which ends Ramadan), are likewise ushered in by direct observation of the Moon. In modern times, that can mean congregants gathering in good sighting locations, some peering through telescopes, perhaps while consulting modern astronomical tables to improve their chances, then communicating their observations via smartphone, posting them online for millions to follow.

This makes each important date on the calendar a kind of shared, global astronomical event resembling the kind of fanfare often experienced around an eclipse. There is even a "crowdsourcing" of sorts, as protocol requires that two reliable witnesses attest to a sighting before it is confirmed.

Similarly, in the Hebrew calendar, rabbis chant a prayer called the kiddush levanah to sanctify the new Moon. The prayer is traditionally written out in large letters, the better to be read outdoors by moonlight.

Different cultures' choices of calendar often reveal how they see the sky. For example, at the Arctic Circle, where the conventional day and night disappear, the Inuit must depend on the stars. For them, the appearance of stars in Orion's shoulder mark the long winter. When Sirius, hanging low on the horizon, turns reddish in color (an atmospheric effect), it indicates the coldest nights. A world away, as many as nine climate-based events define the Australian seasons. The rising of the Pleiades marks the beginning of aboriginal Nyinng (the cold season), while Piscis Australis heralds the coming of the rains.

Our calendars make us all astronomers. Even in the Gregorian system, virtually all our timekeeping words descend from stargazing, from month (which is Germanic for Moon) to calendar (from the Latin calare, to call out the first new Moon of the year). Truly, the calendars we keep preserve fascinating glimpses into astronomy, which touches every day of our lives.

Nick D'Alto is a science writer and engineer in Bellmore, New York.

RESOURCES

INTERNET

Gregorian Calendar
galileo.rice.edu/chron/gregorian.html

Islamic Calendar
timeanddate.com/calendar/islamic-calendar.html

Hebrew Calendar
hebcal.com

Chinese Calendar
sacu.org/chinesecalendar.html

Calendar Converter
fourmilab.ch/documents/calendar/

SKY CALENDAR

by Alan MacRobert

Mars and Saturn shine overhead in November, and Taurus, the bull, charges through the autumn sky. Its fiery orange eye, Aldebaran, rises at sunset and shines high above at midnight. The tiny Pleiades cluster shines nearby. In December, lonely Fomalhaut, the "autumn star," shines in the south after dark, below Mars. Month's end brings a rare joint appearance of dim Mercury and bright Jupiter in our evening skies.

NOVEMBER 1 - 15

Mars and Saturn, both glowing on the warm-colored side of white, are the two bright planets of evening.

Mars catches the eye high in the south around nightfall. It's quite bright, at about magnitude -0.5; in fact, it's the brightest point on the southern side of the sky. Yet Mars is now an unimpressive thing compared to when it was eight times this bright (at magnitude -2.8) when it was passing closest to Earth in the middle of the summer.

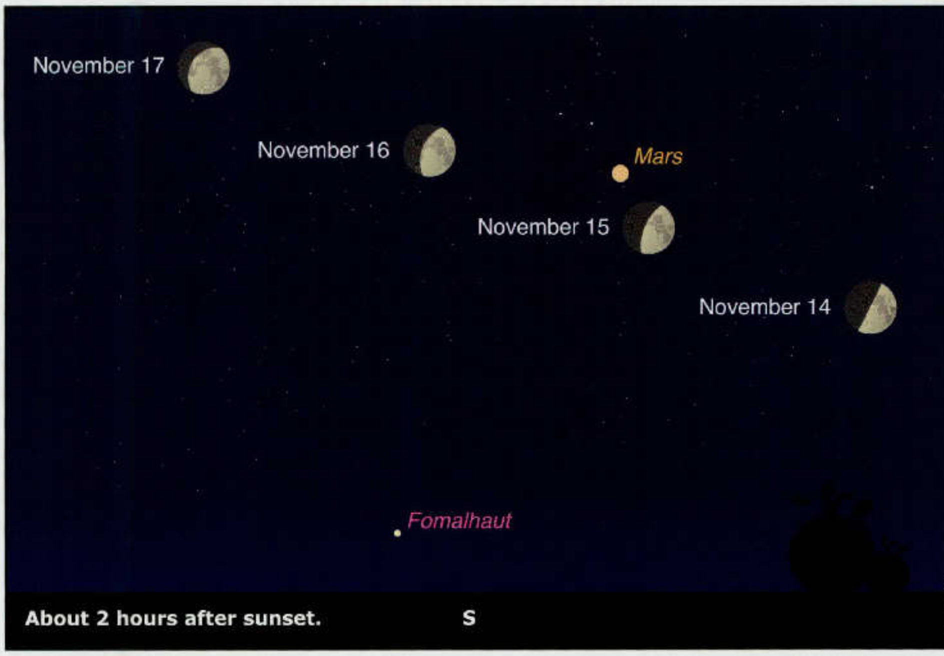
Look about 20 degrees to the lower left from Mars (about two fists at arm's length) for lonely Fomalhaut, "the autumn star," at magnitude 1.2. Catch the first-quarter Moon shining just under Mars on the evening of November 15.

Saturn, meanwhile, is descending in the southwest after displaying itself through many months of warm-weather evenings. It's still fairly easy to spot in late twilight and just after dark.

Look to the left of Saturn for the four-star handle of the Sagittarius teapot. The waxing crescent Moon pairs up with Saturn on November 11.

And that's it for bright planets throughout the hours of darkness.

Look northeast during evening, and there's Capella: low at first, higher as night grows late. When Capella is low in the northeast, you'll always find Cassiopeia standing on end high above it (as seen from mid-northern latitudes). Sparkly Perseus is just to the right of the space between them. The blank area between them and to the left is occupied by big, dim Camelopardalis, the giraffe — a "modern" constellation, invented by the sky mapper Petrus Plancius in 1613 to fill an otherwise unassigned piece of territory on the celestial sphere. None of its stars is brighter than 4th magnitude.



NOVEMBER 16 - 30

Saturn lingers in view low in the southwest in late twilight. But each week, finding it requires a little more effort and a lower open view to the southwest.

As the stars come out, look for Saturn far below Altair, the brightest star high in the southwest. You can always tell Altair by its little sidekick Gamma Aquilae, also known as Tarazed; they're about a finger width at arm's length apart. Look to Altair's other side, just a little farther away, for a second, fainter sidekick: Beta Aquilae, or Alshain. They're magnitudes 2.7 and 3.7, respectively.

Altair is the second-brightest star of the Summer Triangle. The brightest is Vega, three or four fists to its right. Deneb is the dimmest, high above Vega and not far west of the zenith. How to remember the brightness order of the Summer Triangle stars? Think "vivid Vega, dim Deneb, average Altair."

Of course, Altair is average only compared to those other two. It's a first-magnitude star in its own right (magnitude 0.8 to be exact) and the third-brightest star now shining in early evening. The two beating it are Vega and Capella (shining rather low in the northeast). Both of these are close to magnitude 0.

But that's not counting Mars! The Red Planet shines highest in the south as twilight becomes night. It burns at magnitude -0.3 on November 16 and fades to 0 by month's end, as Earth continues pulling farther ahead of it in our faster orbit around the Sun.

Venus, the brightest planet of all, has leapt up out of the sunrise to shine before and during dawn. Spot it then in the southeast. It's currently having a tryst with Spica, a first-magnitude star, but less than 1 percent as bright. Their separation widens from 1.4 degrees (about a finger width), on the morning of November 16, to 6 degrees at the end of the month. Look early; Spica disappears into the brightening sky long before Venus does.

And if you're out that early, take a good look around. You're getting a preview of the evening stars of spring. Arcturus shines about three fists (30 degrees) to Venus' upper left. In the southwest, Orion is slumping downward in his early-spring orientation, with his three-star belt almost horizontal. Orion's Belt points left to brilliant Sirius in Canis Major (the big dog is now walking almost horizontally). The belt points to the right, toward orange Aldebaran, and, farther on, the Pleiades. And high in the northeast, the Big Dipper is dumping its springtime showers all out of season.

DECEMBER 1 - 15

How long can you keep Saturn in view, low in the southwest in the afterglow of the December sunset? Probably long enough to catch it with the thin crescent Moon on December 8 and 9 (to the upper left of the Moon on the 8th, lower right of it on the 9th). But how soon after that will it be lost from view?

Mars, on the other hand, lingers in the south after dusk through the passing weeks. That's because Mars is traveling eastward against the background stars almost as fast as the stars turn seasonally westward. Mars will stay in the same general area of your evening sky long into the coming winter as it continues to shrink and fade.

In the first half of December, look straight down south from Mars by about 20 degrees (two fists) and you're at Fomalhaut.

Look well below Fomalhaut for the stars of the far-southern constellation Grus, the crane, rarely noticed by us northerners. Use binoculars, or your unaided eyes in a very dark sky, to look to the lower right of Fomalhaut by 15 degrees (about a fist and a half at arm's length, or a little more than two binocular fields) for 3rd-magnitude Gamma Gruis. It's the first of a dim diagonal line of stars running from there to the lower left by a fist and a half. This line forms the crane's head and long neck.

Meteor Watch

The Shower
Leonids
Named for the constellation Leo, the lion, which rises in the wee hours of the morning. Its most prominent star, Regulus, stands at the bottom of a pattern of stars that looks like a backward question mark.

Peak
Night of November 17

Notes
The Moon sets by around 2 a.m., providing plenty of hours for watching the shower.

The Shower
Geminids
Named for Gemini, the twins. This shower can produce some especially bright meteors, although its peak viewing time is shorter than that of many other showers.

Peak
Night of December 13

Notes
The Moon sets in late evening, so it won't interfere with the best meteor-viewing hours.

You'll know you've got the right line if your binoculars show that two of the stars on the way down it are both equal double stars, aligned more or less with the line itself. The first pair is Mu^1 and Mu^2 Gruis, both 5th magnitude. The second, lower-left pair is Delta^1 and Delta^2 Gruis, both 4th magnitude. Both pairs are one-third degree wide — a couple of interesting and out-of-the-way trophies.

In the early dawns of December, Venus illuminates the southeastern sky. And by December 10, you should have no trouble spotting little Mercury about 23 degrees to Venus' lower left.

DECEMBER 16 - 31

The Great Square of Pegasus has been a landmark of autumn evenings. In early to mid-evening now, the Great Square floats high in the south if you live at the latitudes of the northern U.S. or Canada. If you live in the southern U.S., the Great Square passes almost straight overhead. Look for a square bigger than your fist at arm's length, formed by stars of only moderate brightness (2nd magnitude).

The Great Square makes a fine starting point for locating other sights. For instance:

Extending left from the Great square's top left corner (as you face south) is the big, long Andromeda line of three 2nd-magnitude stars, counting the Square's corner itself.

If you have a dark sky, make a right-angle turn upward at the middle of these three stars. Go up by a little less than the distance each of the three are apart. Two fainter stars guide your way. Near the second of these is a dim, elongated little cloud of grayness: the Andromeda galaxy. At 2.5 million light-years away, it's the farthest thing most people can see with their unaided eyes. Binoculars reveal it more easily.

Follow the western (right-hand) side of the Great Square far down toward the south, by three and a half times its own length. This brings you to Fomalhaut.

Follow the eastern (left) side of the Great Square a slightly lesser distance down south and you'll be near Diphda, or Beta Ceti, one of the few bright stars of enormous Cetus, the whale.

Three morning planets beckon you out of bed in early dawn. Venus blazes as the Morning Star high in the southeast. About 25 degrees to Venus' lower left, Mercury and Jupiter compete to be the first to catch your eye. On the morning of December 16, Mercury is still 5 degrees above Jupiter. They pass each other, 1 degree apart, on December 21 and 22 (Jupiter is the brighter of the two). Thereafter, it's no contest: Jupiter climbs higher each morning while Mercury sinks.

Jupiter is heading for Venus as we see them projected on our morning sky. They will pass each other on January 22, just a little more than 2 degrees apart.

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

NOVEMBER

How to use these charts:

1. Determine the direction you are facing.
2. Turn the chart until that direction is at the bottom.

October 20 — 11 p.m.
November 5 — 10 p.m.
November 20 — 8 p.m.*

* Daylight Saving Time ends November 4.

MAGNITUDES

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

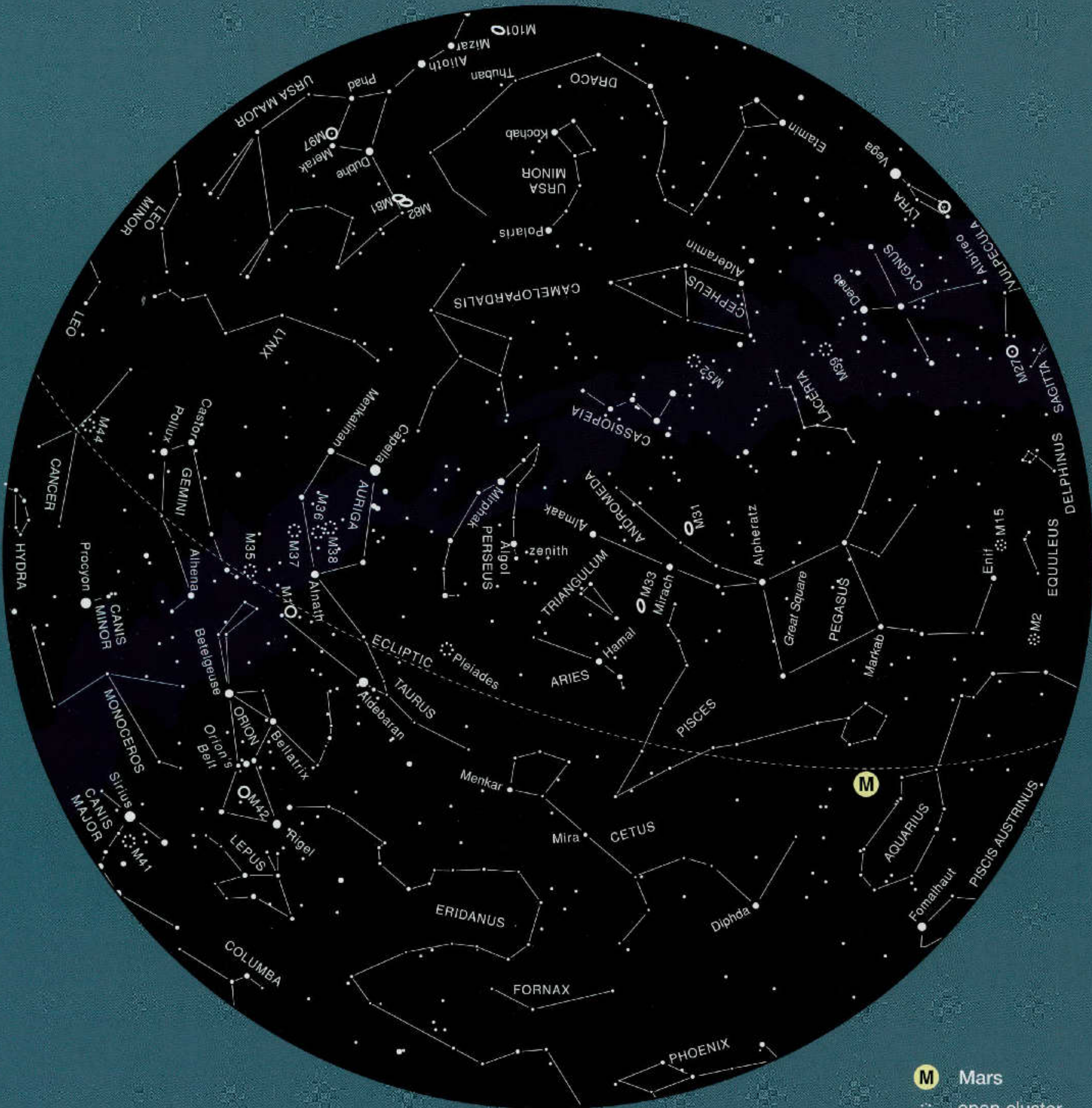
- M Mars
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

DECEMBER

How to use these charts:

1. Determine the direction you are facing.
2. Turn the chart until that direction is at the bottom.

November 20	**11 p.m.**
December 5	**10 p.m.**
December 20	**9 p.m.**



MAGNITUDES

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

- M Mars
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

Picturing a Trip to Space

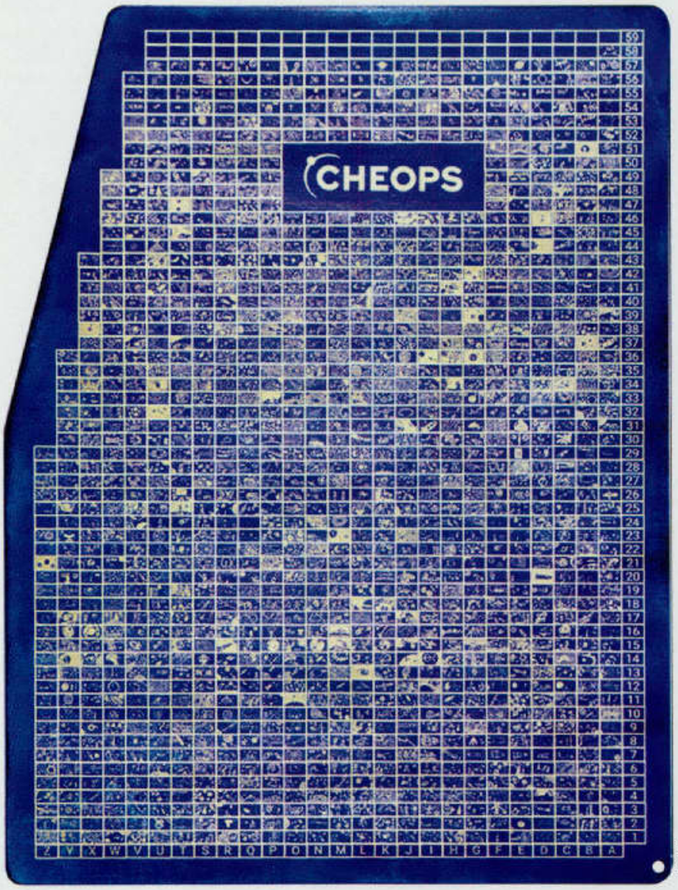
Almost every spacecraft that's designed to explore the universe carries a few trinkets from home. A Mars rover has a DVD packed with Mars-themed novels, while New Horizons, which is headed for a second encounter in the Kuiper Belt (see page 16), carries a postage stamp and some of the ashes of Clyde Tombaugh, who discovered Pluto.

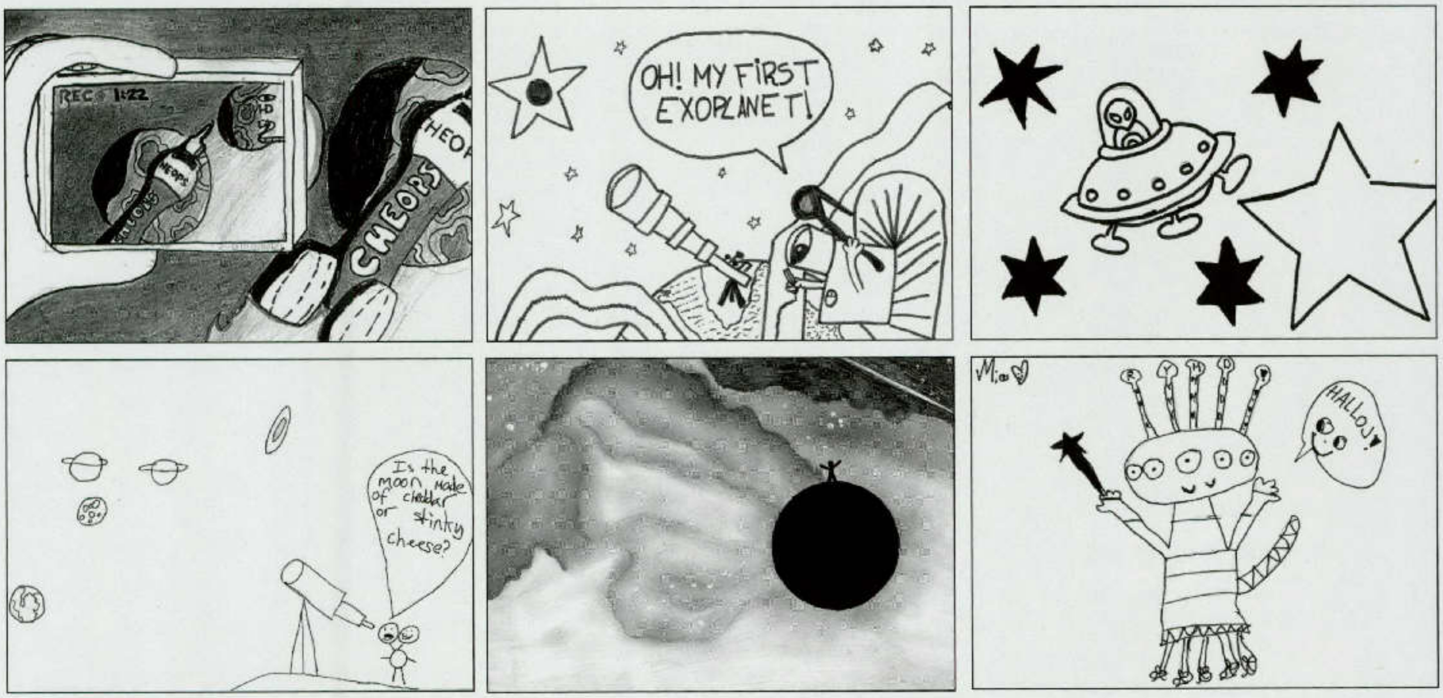
A European craft designed to study exoplanets will tote miniaturized versions of about 2,700 drawings made by children ages 8 to 14. The drawings, which were done in black and white, were etched on two metal plaques, which were installed on the spacecraft this summer.

CHEOPS, which is scheduled for launch early next year, will study star systems with known exoplanets. Its observations, when combined with ground-based work, will help scientists characterize the planets as rocky worlds, gas giants, ice giants, or perhaps even water worlds.

The drawings were selected from thousands of entries submitted for a contest in 2015. Each drawing was shrunk by a factor of a thousand before being etched on the plaques.

sci.esa.int/cheops





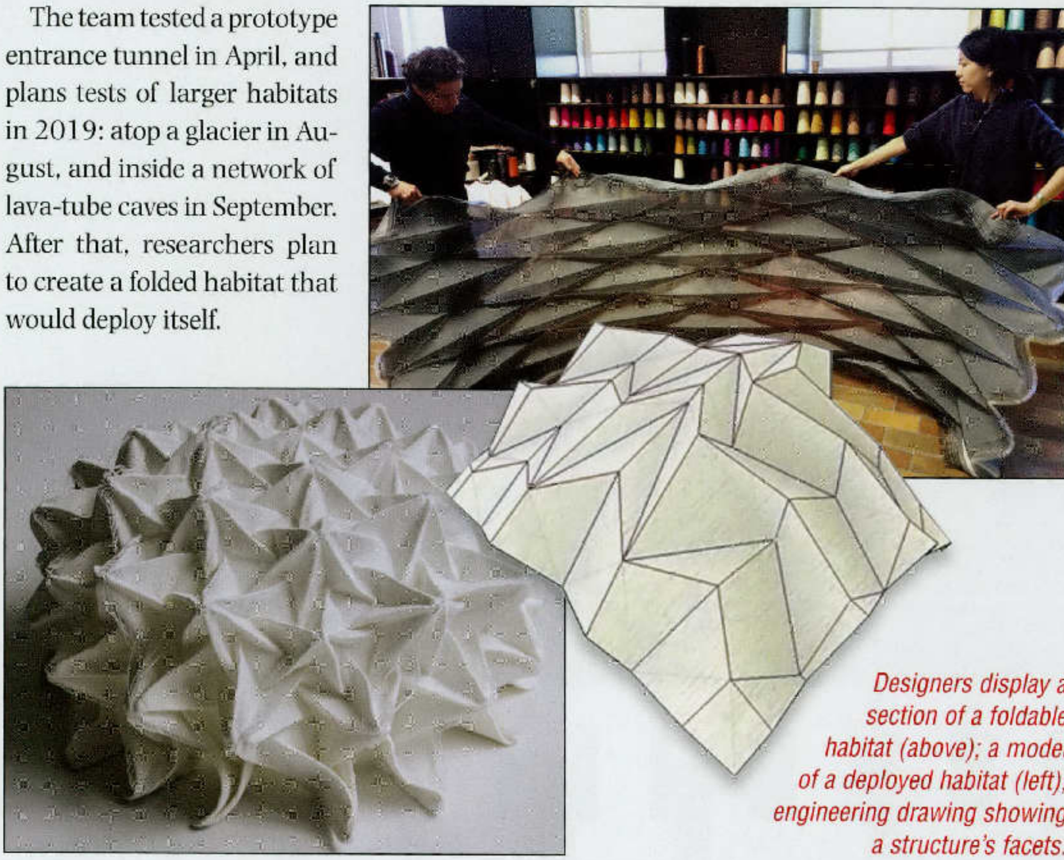
One of the two art-engraved plaques aboard CHEOPS (top right); several of its artworks.

Folding the Tent for a Long Trip

Art and science sometimes overlap in odd ways. A project in Europe, for example, is combining the art of origami with the science of living on the Moon and Mars to create foldable habitats.

Scientists at several European space and research centers are working with a design studio to produce the structures. The researchers say origami habitats can be made of tough but light textiles that are easy to transport and assemble. Their faceted design can provide protection from micrometeorites, and "smart" textiles with embedded solar cells can follow the Sun during the day to provide maximum solar power.

The team tested a prototype entrance tunnel in April, and plans tests of larger habitats in 2019: atop a glacier in August, and inside a network of lava-tube caves in September. After that, researchers plan to create a folded habitat that would deploy itself.



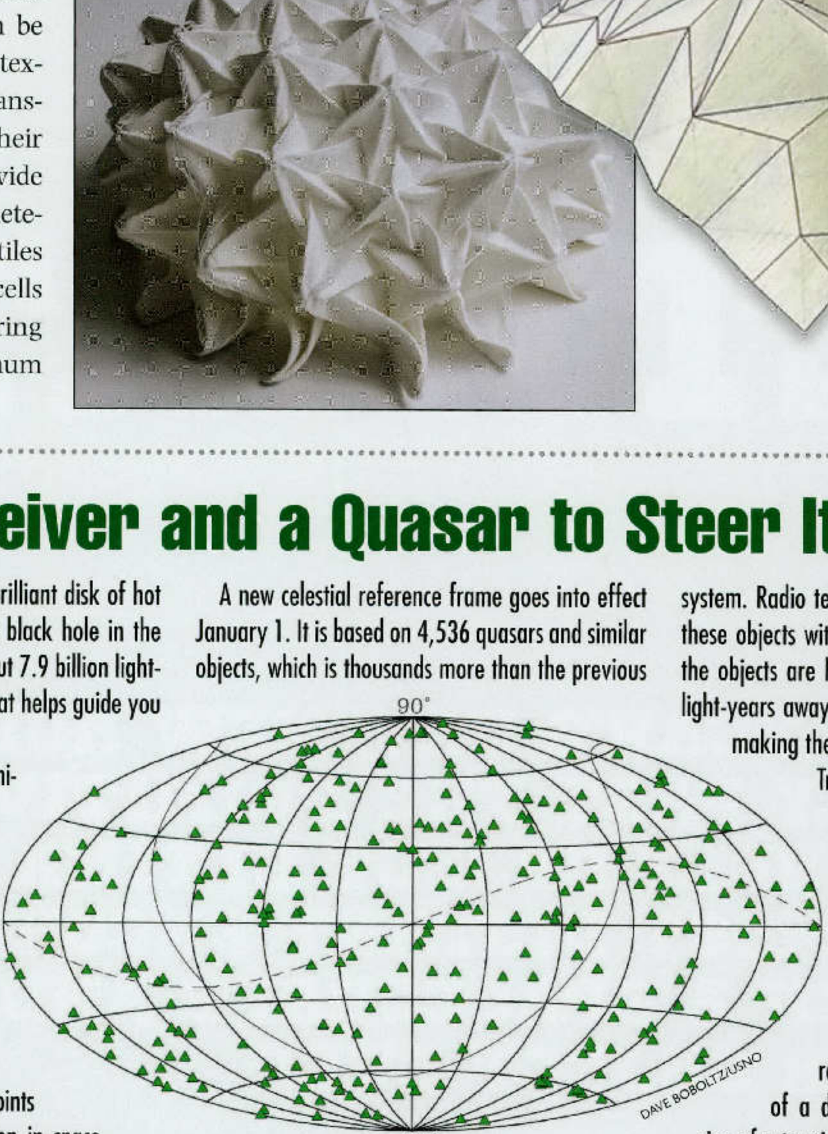
Designers display a section of a foldable habitat (above); a model of a deployed habitat (left); engineering drawing showing a structure's facets.

A GPS Receiver and a Quasar to Steer It By

The quasar 1308+326 is a brilliant disk of hot gas around a supermassive black hole in the heart of a galaxy that's about 7.9 billion light-years away. It's also a beacon that helps guide you to the corner store.

That's because quasars and similar objects form a network of fixed reference points in space, like mile markers on a highway. Scientists use those reference points to help establish reference points on Earth. Global Positioning Satellites use the network of ground-based points to determine their precise location in space, which, in turn, allows them to help phones and other GPS receivers plot their location on Earth.

A new celestial reference frame goes into effect January 1. It is based on 4,536 quasars and similar objects, which is thousands more than the previous system. Radio telescopes measure the positions of these objects with extreme accuracy. And because the objects are hundreds of millions to billions of light-years away, they don't move across the sky, making them a steady reference grid.



A map of the sky shows some of the objects used in the new celestial reference system.

Tracking stations will use the new grid to measure the positions of spacecraft scattered through the solar system. And astronomers will use it to point their telescopes and determine the locations of stars and other objects with an accuracy of a hundredth of a millionth of a degree — the equivalent of the size of a tennis ball at the distance of the Moon, according to the International Astronomical Union, which adopted the new system in September.

NASA/JHUAPL/SWRI/STEVE GRIBBEN

ULTIMATE ENCOUNTER

ON NEW YEAR'S DAY, NEW HORIZONS WILL FLY PAST THE PRIMITIVE KUIPER BELT OBJECT ULTIMA THULE, IN THE MOST DISTANT ENCOUNTER BETWEEN A SPACECRAFT AND ANOTHER OBJECT EVER

BY REBECCA JOHNSON

Left: An artist's impression shows New Horizons at Ultima Thule, depicted as a binary object with a moon. Observations from Earth point to this configuration as a possibility. Below: This overlay of five Hubble Space Telescope images from June 24, 2014, records the discovery of Kuiper Belt object 2014 MU69, later nicknamed 'Ultima Thule.'

New Horizons' 2015 triumph at Pluto completed its primary mission. The small spacecraft brought that distant world, and its moons, to us in detailed, colorful images. More than just a bright dot in grainy photos, today we know Pluto as a cratered, dusty beige world sporting a rusty red heart. Now New Horizons is set to bring us the most distant spacecraft encounter yet, with a small, primitive object so far from Earth that it can't be studied by the largest ground-based telescopes: Ultima Thule.

Mission planners always hoped that after a successful Pluto encounter, New Horizons would continue to operate in the Kuiper Belt, the solar system's third zone after the realms of the inner and outer planets. They have been planning for the spacecraft's extended mission through this region of millions of small bodies since the beginning.

"The search for a target to fly by in the extended mission actually began even before we launched," says Cathy Olkin, New Horizons Deputy Project Scientist at the Southwest Research Institute in Boulder, Colorado. "Back in 2004, we had a search that was taken by some large ground-based telescopes searching for a target."

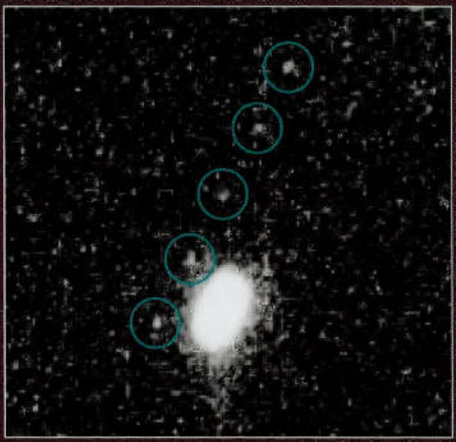
That search was in vain, though. "We certainly didn't find anything," Olkin says.

New Horizons launched toward its primary target on January 9, 2006.

For several years, mission planners continued to search for an extended mission target. "In 2011, 2012, we still weren't finding anything," Olkin says, though the team was employing some of the world's largest telescopes, including the 8.2-meter Subaru Telescope in Hawaii.

"We realized 'we really need to ramp this up a little bit,'" Olkin remembers. The New Horizons team requested a target search with Hubble Space Telescope.

That successful search turned up three potential targets that would be within New Horizon's reach after it passed by Pluto. Further investigation narrowed the list to a winner: a Kuiper Belt object orbiting the Sun a billion miles beyond Pluto, with the uninspiring moniker 2014 MU69. The object was discovered during Hubble observations in 2014 by Marc Buie of the Southwest Research Institute, a member of the New Horizons team.



Once chosen as New Horizons' extended mission target, the team set up a public contest to choose a nickname for 2014 MU69. Team member Mark Showalter of the SETI Institute ran the contest. Interested parties submitted more than 100,000 entries, and the team chose a handful of finalists. NASA picked the winning name, Olkin explains: Ultima Thule.

In Medieval literature and mapmaking, Thule was a mythical, far northern island. Ultima Thule means "beyond Thule" — in effect, "beyond the known world," Olkin says: A fitting destination for the farthest spacecraft encounter ever.

Having identified the extended mission target, the team scrambled to learn as much about Ultima Thule as possible before the encounter. Armed with some information ahead of time, they would be able to make the most of the short-lived opportunity as the craft whipped past.

But how to study this object so faint that it can be seen only by Hubble Space Telescope? Rather than study light from the target itself, they would take advantage of the times when its orbit around the Sun saw it passing in front of a distant star — an event called a stellar occultation.

To predict when any such events would happen, the team needed to know the positions of Ultima Thule and any nearby stars in the future. They used Hubble observations to characterize Ultima Thule's orbit around the Sun. For star positions, they used a recent star map from Gaia, the European spacecraft that has created the most accurate catalog of stars in the Milky Way to date.

Combining information from Hubble and Gaia, the New Horizons team determined that Ultima Thule would pass in front of four different stars prior to the spacecraft's arrival there. Three of these occultation events would take place in summer 2017, with the fourth happening in August 2018.

Occultations are like solar eclipses: You have to be at the right place at the right time to observe them. Once the occultations were predicted, the team coordinated a massive effort to get telescopes and people to the remote locales where the occultations would be visible.

In 2017, two of the occultations meant trekking to remote regions of Argentina; the third would be visible only over the

Observers Paul Maley and Ted Blank of the International Occultation Timing Association watch Ultima Thule pass in front of a star, in July 2017, from South Africa's Karoo desert. The Milky Way is in view overhead. Inset: The shadow of Ultima Thule is depicted crossing the field of view of five telescopes that viewed the occultation from Argentina. The red circles show Ultima Thule's likely double-lobed or binary nature.

NASA/JHUAPL/SwRI/THROOP/A PARKER

Pacific Ocean. The 2018 occultation would be visible from Senegal and Colombia.

Getting to the sites was no easy task. In Argentina, 60 observers set up two dozen telescopes in remote sites while battling high winds and frigid temperatures. The team had cooperation from the local governments, which closed roads to keep headlights from interfering with the observations.

The third 2017 occultation called for a special tool. Since the occultation was visible only over the Pacific Ocean, SOFIA — an infrared telescope mounted in a Boeing 747 jetliner — flew out from Christchurch, New Zealand, to study the event.

The 2018 occultation was once again over land. Fifty researchers went to Senegal and Colombia to observe the event, again receiving support from local governments and U.S. embassies.

"Gathering occultation data is an incredibly difficult task," said Marc Buie, who led the effort to study the occultations. "We literally are at a limit of what we can detect with Hubble and the amount of computer processing needed to resolve the data is staggering."

But their efforts paid off in a wealth of data that has helped the New Horizons team plan the upcoming encounter between spacecraft and target.

The team determined that Ultima Thule is about 20 miles (30 km) wide, and hinted at different possibilities for its shape. It could be two objects orbiting each other (a binary Kuiper Belt object), or two objects orbiting each other while touching (a contact binary), or it could be a single object. Last but not least, Ultima Thule might have a moon.

Beyond matters of size and shape, studies of the occultations allowed the team "to place limits on what sort of environment might be around Ultima," Cathy Olkin says. Their results showed that there is no thick ring around Ultima Thule, as has been seen around other Kuiper Belt objects, such as Haumea.

Finally, the occultation results helped the team determine how close they would like to fly by Ultima Thule: 2,175 miles (3,500 km).

While these observations continued from Earth over the last few years, New Horizons cruised toward Ultima Thule at more than 30,000 miles per hour. On August 16, the spacecraft got close enough to take its own first image of the tiny world, four months ahead of their New Year's rendezvous.

From 100 million miles out, the spacecraft's Long Range Reconnaissance Imager (LORRI) snapped a series of 48 images that team members stacked together. The combined image allowed them to distinguish the dim blip of Ultima Thule against a field dense with background stars, precisely where they had predicted it would be.

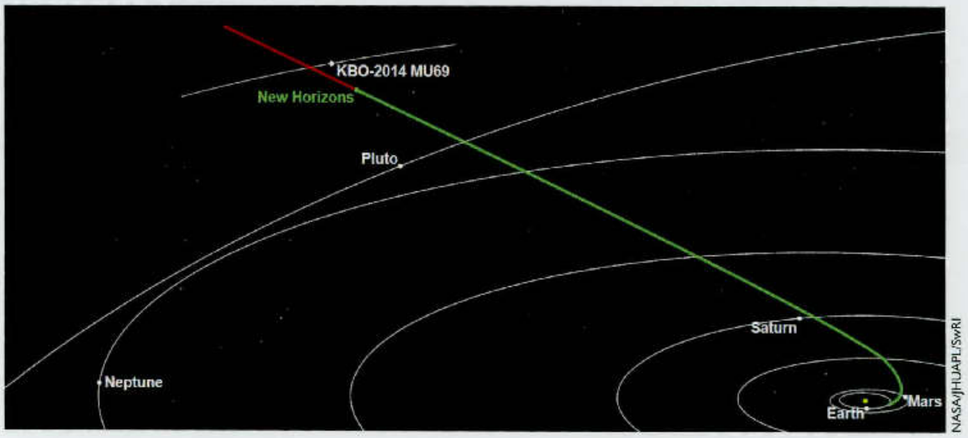
The spacecraft will continue to take images of Ultima Thule as it approaches. The team will use these images for navigation, and make corrections to the craft's trajectory if necessary.

"There are two plans for arrival at Ultima," Olkin says. "One where we fly close to 3,000 kilometers from the object … and another where we're flying more like 10,000 kilometers from it."

The team prefers the closer option, she said, "But if we feel like there's a hazard in the area, we can fall back to the farther position, maybe two weeks out. We have a couple of opportunities for trajectory corrections maneuvers."

The team is looking for potential hazards as New Horizons approaches its target — small objects that could damage the spacecraft. "We don't expect to see any," Olkin says, "it's really just being a good shepherd of the resources, and making sure that we make the most out of the encounter."

Assuming the closer path is taken, New Horizons will fly three times closer to Ultima Thule than it did Pluto, giving an even more detailed look at



Ultima Thule, here labeled with its scientific name, KBO-2014 MU69, lies about a billion miles beyond Pluto. This graphic shows the position of New Horizons in December 2017, when it made a course correction.

the Kuiper Belt object's surface.

Arrival at Ultima is scheduled for just after midnight Eastern Time on New Years' Day. According to Olkin, the encounter will occur 43 astronomical units from the Sun, which is about 4 billion miles (an astronomical unit, or AU, is the average Earth-Sun distance of about 93 million miles.)

Planetary scientists are keen to study Ultima Thule because they expect it to be unchanged since the formation of the solar system about 4.5 billion years ago. They expect it to be the most primitive solar system relic ever studied.

There are many things she's looking forward to learning from the encounter, Olkin says, but, "I guess I'm most interested in seeing what the surface of a cold, classical Kuiper Belt object looks like. This is a very primitive object. It's not like it's had encounters with giant planets and been flung from the inner solar system to the outer solar system.

"It likely formed in the outer solar system. … We haven't seen anything like that before. Pluto's in the outer solar system, but, of course, it suffered a giant impact that caused the Pluto-Charon binary to be formed. So it's a little bit of a different beast. It's going to be really interesting to see what this cold, classical object looks like."

Planetary scientist Bonnie Buratti agrees. "The question is, 'What does Ultima Thule look like?'" she says. "The shape [indicated] from the occultations looks like it's bifurcated in some way. Is it just elongated, or is it two planetesimals stuck together?"

Buratti is a co-investigator on New Horizons, and the manager of the Planetary Sciences section at NASA's Jet Propulsion Laboratory. She also is U.S. project scientist for Rosetta, the European mission to comet 67/P Churyumov-Gerasimenko. That comet is a Kuiper Belt object that had been flung inward into the realm of the major planets.

"One of the biggest discoveries we made from that mission was that it looks like this primitive object [67/P], and it's really not as primitive as Ultima Thule is going to be … is two planetesimals stuck together. It kind of shows the process of planets being formed."

One of the things that makes Ultima Thule an interesting target is that "it's a size we've never seen before," Buratti says.

She explains that Ultima Thule is smaller than Kuiper Belt objects that have been studied up close so far, like Pluto, its largest moon Charon, and some large moons of the outer planets that are thought to be captured Kuiper Belt objects. These include Saturn's outermost moon, Phoebe, which Buratti studied as part of the Cassini mission team, as well as Neptune's large moon Triton.

Though it's smaller than these, Ultima Thule is larger than the comet studied by Rosetta. "67/P, which is a Jupiter-family comet, which comes from the Kuiper Belt, is small, about the size of Manhattan," Buratti says.

"So Ultima Thule has a size range that we've never looked at before. … It should be interesting to see what a little planet looks like in its formative years."

In addition to being the farthest spacecraft encounter, "this is the first truly primitive object we are going to see," Buratti says. "It's been out in the Kuiper Belt, out in the cold reaches of space. And if it's processed at all, we're going to have to figure out how that happened," she said, referring to any geological activity that might be discovered on Ultima Thule. "It's always been cold, it's never come into the Sun to have any outgassing. So if we see something like that, we have to figure out why."

All of the instruments on board New Horizons will scrutinize Ultima Thule and its environment, Olkin says. In addition to the long-range camera LORRI, the craft's main camera, Ralph, will take images of Ultima Thule's surface. The Alice instrument will look at the body's chemical composition. SWAP and PEPSSI, two instruments that study energetic particles from the solar wind and planetary atmospheres, will study the space environment around Ultima Thule. Finally, the Student Dust Counter will look to see if there is an increased density of dust in the tiny body's environs.

After the encounter, NASA and the New Horizons team will choose a formal name for Ultima Thule to propose to the International Astronomical Union, the official body that ratifies astronomical names. The name will be based on what they learn about the distant world from the flyby.

New Horizons is expected to continue its journey through the Kuiper Belt after its run-in with Ultima Thule. It has enough power to continue operating through the mid 2030s, but probably not enough to make any additional changes in direction.

Rebecca Johnson is editor of StarDate *magazine.*

Resources

Internet

New Horizons
pluto.jhuapl.edu

NASA New Horizons
nasa.gov/mission_pages_newhorizons/main

Kuiper Belt
ess.ucla.edu/~jewitt/kb.html

Books

Chasing New Horizons: Inside the Epic First Mission to Pluto, by Alan Stern and David Grinspoon, 2018

Exploring the Kuiper Belt and the Trans-Neptunian Region, by Joan Kloster, 2015

by Damond Benningfield and Rebecca Johnson

Ready for Touchdowns

The InSight spacecraft will take the most thrilling ride in the solar system on November 26. It will hit the Martian atmosphere at about 14,000 miles per hour. And if everything works the way it's supposed to, it will gently touch down on the surface just six minutes later.

Another solar-system explorer, OSIRIS-REx, is scheduled to enter orbit around an asteroid just a few days later, while a Japanese craft, Hayabusa-2, continues operations around another asteroid.

InSight is scheduled to land on a smooth, featureless plain. It carries cameras to view the landscape as well as instruments to monitor the weather. Its main mission, though, is to study the Martian interior. It will use a seismometer to record marsquakes and a heat probe to measure temperatures below the surface. Those observations should tell planetary scientists more about how Mars is put together, which should give them a better understanding of the formation and evolution of all the solar system's rocky inner planets.

OSIRIS-REx will rendezvous with 101955 Bennu on December 3 and settle in for a long cruise with the asteroid, which measures about 1,650 feet (500 meters) in diameter. During its first month of operations, the craft will skim close to Bennu's poles and equator, allowing scientists to accurately measure the asteroid's shape and mass.

OSIRIS-REx is scheduled to scoop a small sample from Bennu's surface in July 2020 and return it to Earth three years later. The sample and the craft's other observations will reveal details about the birth of the planets, which were assembled from objects similar to the asteroid.

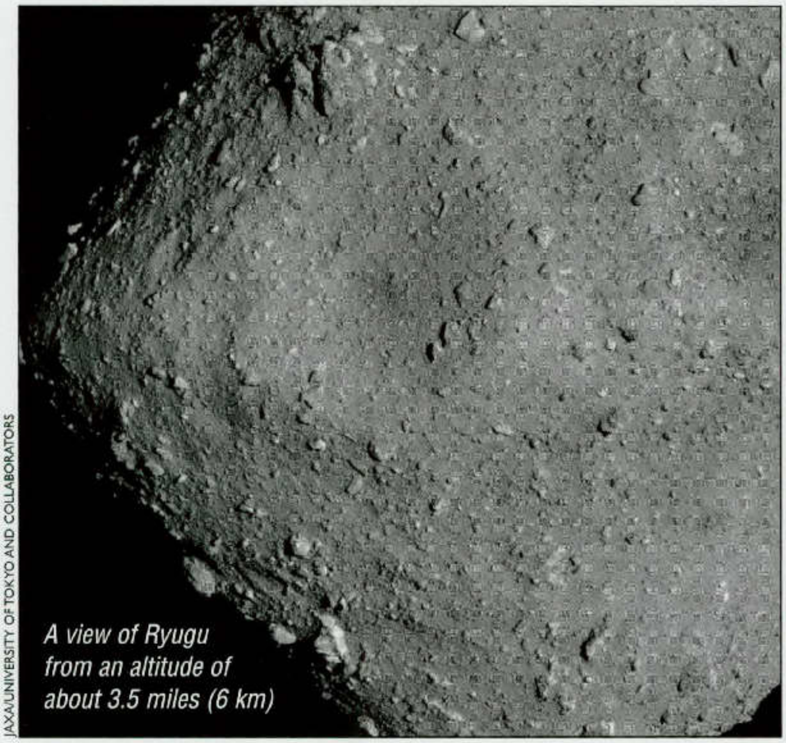
Bennu was chosen as the mission's target because it belongs to a rare class of asteroids that contain large amounts of water and carbon, suggesting they also contain organic compounds — the basic chemical building blocks of life. Bennu also occasionally passes as little as 200,000 miles from Earth, making it a relatively easy target to reach. And scientists say it could hit Earth in the late 22nd century, so studying it today could help future generations decide how to deflect it.

Hayabusa-2 is studying 162173 Ryugu, which also comes close to Earth. The asteroid is about a half-mile (0.9 km) in diameter.

The spacecraft arrived at Ryugu in June and has been studying the asteroid from different altitudes. Scientists evaluated those observations to select landing sites for small rovers, which touched down in late September, and for gathering samples of surface material. Three rovers will hop across the surface, while a fourth will tumble. The rovers are equipped with cameras and instruments for measuring Ryugu's composition.

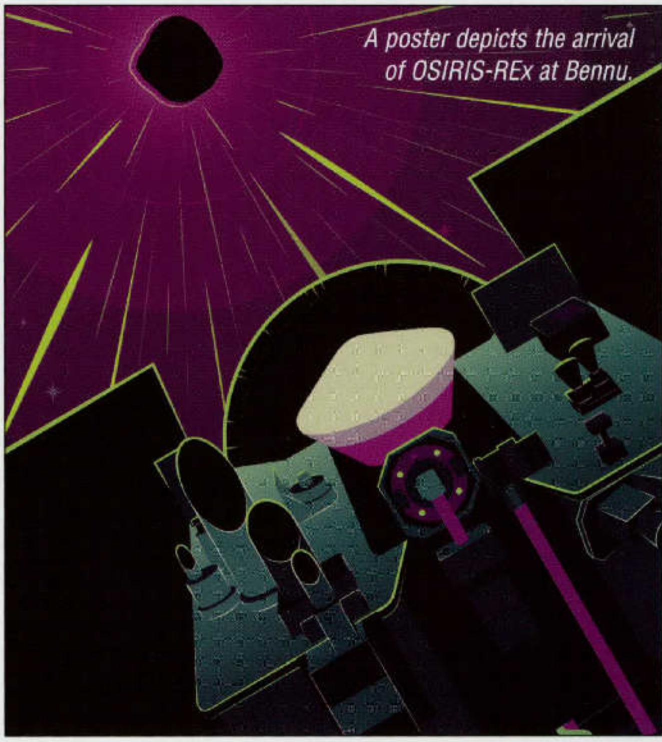
The main spacecraft will touch down on the asteroid twice to gather samples. The first will be a quick grab-and-go attempt. For the second, the craft will deploy a device to blast out a small crater. Hayabusa-2 then will alight near the crater to try to grab material blasted out of the asteroid's interior. That sample should be unaffected by the asteroid's exposure to radiation and impacts by micrometeorites, so it should preserve a record of the asteroid's formation.

Hayabusa-2 is scheduled to depart the asteroid in December 2019 and deliver its samples to Earth the following year. **DB**



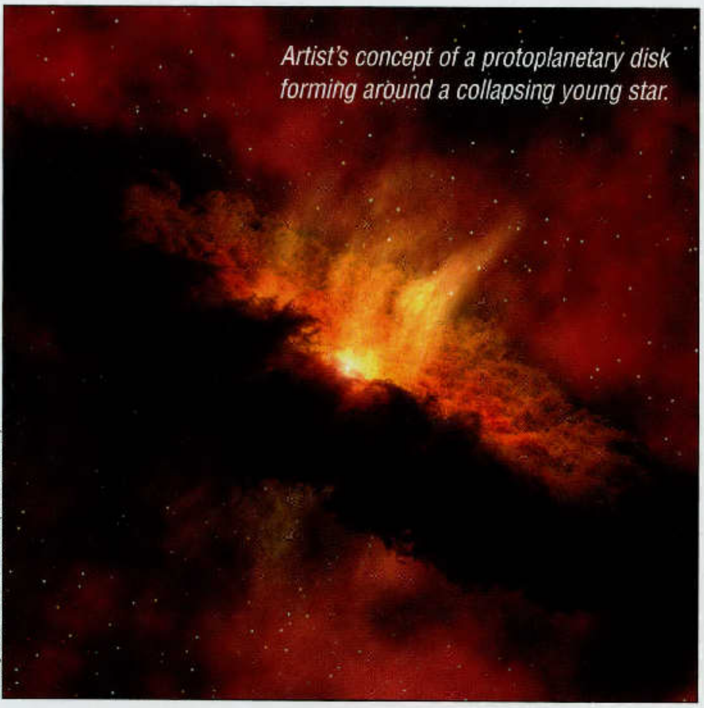
JAXA/UNIVERSITY OF TOKYO AND COLLABORATORS

A view of Ryugu from an altitude of about 3.5 miles (6 km)



NASA/GSFC/UNIV. ARIZONA/LOCKHEED MARTIN

A poster depicts the arrival of OSIRIS-REx at Bennu.



Artist's concept of a protoplanetary disk forming around a collapsing young star.

NASA/JPL-CALTECH/R. HUNT (SSC/CALTECH)

Stellar Close Call May Have Shaped our Solar System

New research from astronomers at the Max Planck Institute for Radio Astronomy in Bonn, Germany, shows that a passing star may have shaped the outer reaches of our solar system.

The Sun formed from a collapsing cloud of gas and dust, and the planets from a disk that took shape around the proto-Sun as it collapsed. This proto-planetary disk produced the major and minor planets, asteroids, and comets that we see today.

However, research has found that the total mass of the bodies orbiting the Sun beyond Neptune is much less than expected. What's more, the orbits of most of those bodies are tilted at extreme angles to the plane in which the major planets lie. Various theories exist to explain these puzzles, none are yet proven.

Susanne Pfalzner led a team testing the theory that these effects resulted from a close encounter between the Sun and another star billions of years ago. Such events are rare now, but may have been more common in the Sun's earliest days, as Sun-like stars are usually born in large, densely packed groups.

Pfalzner's team ran thousands of computer simulations to study what happens when a star passes by a young Sun. They found that if a star with the Sun's mass, or even half that, passed by at around three times Neptune's distance, it would cause the characteristics of the outer solar system seen today.

"The beauty of this model lies in its simplicity," Pfalzner said. While the team stressed that the idea is not proven, "the strength of the flyby hypothesis lies in the explanation of several outer-solar system features by one single mechanism." Her team showed that in addition to outer solar system masses and orbits, a stellar close encounter also could explain the masses of Neptune and Uranus, and how the Kuiper Belt came to have two separate populations of objects. **RJ**

Juno Looks Deep into Jupiter

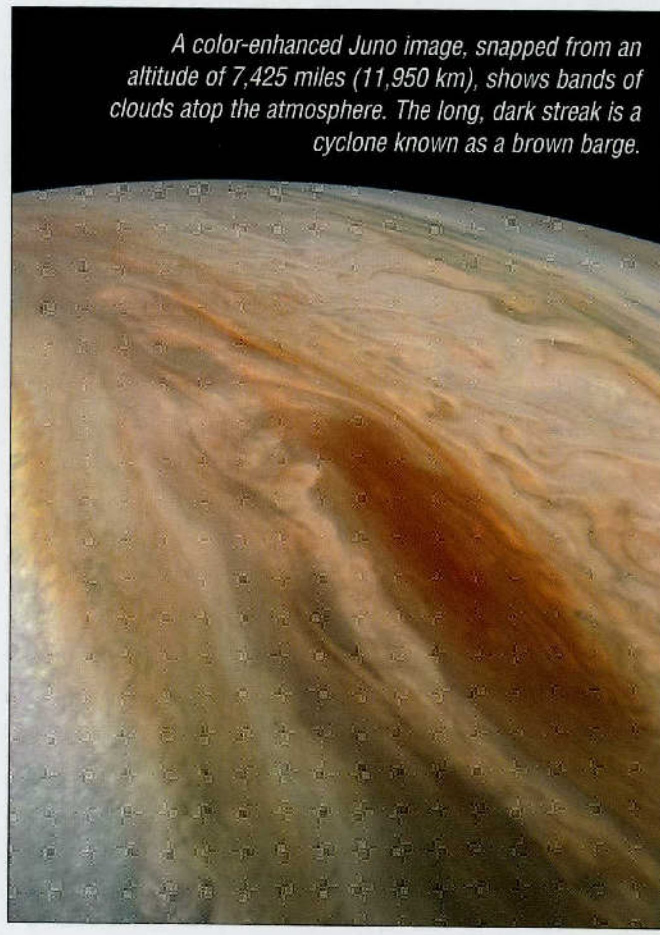
The main mission of the Juno spacecraft, which has been orbiting Jupiter since July 2016, is to probe the giant planet's interior. And recent results suggest it's getting the job done.

A study by researchers in the United States and Denmark, for example, found some oddities in Jupiter's magnetic field. The field is generated deep inside the planet, with current ideas suggesting it's produced by the motions in a layer of metallic hydrogen that surrounds the core. Those motions generate electric currents which in turn create the magnetic field.

As on Earth, the field acts like a bar magnet, with lines of magnetic force emerging from the northern hemisphere and returning to the southern hemisphere. But Juno's measurements show that some of the lines of force return to a spot at Jupiter's equator, effectively giving the solar system's largest planet a third magnetic pole.

In addition, a component of the magnetic field that's not associated with the bar-magnet effect is concentrated almost entirely in the northern hemisphere.

The researchers say the odd readings could mean that Jupiter's core is larger and more fluid than expected, like a large blob of taffy. The readings also could mean that all or part of Jupiter's magnetic field is generated by the motions of multiple layers of hydrogen at different depths inside the planet.



A color-enhanced Juno image, snapped from an altitude of 7,425 miles (11,950 km), shows bands of clouds atop the atmosphere. The long, dark streak is a cyclone known as a brown barge.

NASA/JPL/SwRI/MSSS/KEVIN M. GILL

NASA/CXC/INAF/A. WOLTER ET AL/STScI

Black Hole Ring

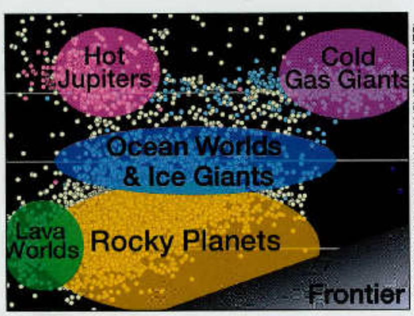
A phalanx of black holes or neutron stars surrounds the ring galaxy AM 0644-741, which is about 300 million light-years from Earth. Another galaxy plunged through it in the distant past, altering its structure and triggering the birth of millions of new stars, which outline the oval ring. Some of those stars have exploded, leaving behind black holes or neutron stars that are pulling in some of the gas and dust around them. That makes them shine brightly in X-rays, which are seen as bright pink spots along the blue ring. The image, which combines visible and X-ray wavelengths observed by two space telescopes, also shows a supermassive black hole growing in the galaxy's nucleus, which is the bright region just inside the top of the ring.

Empty Tanks End Mission

Kepler is out of gas.

The most prolific exoplanet hunter to date has exhausted its fuel supply, leaving it unable to lock on to its stellar targets and ending its mission.

The small space telescope was launched in 2009. It discovered planets in other star systems as they passed in front of their parent stars, briefly reducing the stars' brightness.



NASA/ARC/NATALIE BATALHA/WENDY STENZEL

Kepler's observations have shown several types of planets, from rocky worlds like Earth to giants bigger than Jupiter.

During Kepler's initial mission, it stared continuously at 150,000 target stars in a single region of the northern sky. Near the end of that mission, the spacecraft's primary pointing system failed.

Engineers then worked out an alternative pointing technique that allowed it to aim at different parts of the sky for about 80 days at a time. That mission, known as K2, was expected to end when Kepler used the last of its propellants in late September or October.

The original and K2 missions discovered more than 2,650 confirmed exoplanets, with a similar number of candidates awaiting confirmation. Kepler also gathered data on variable stars and other objects, which astronomers will study for many years to come.

No-Go for Stellar Fireworks

A fireworks show in the constellation Cygnus, expected around 2022, has been cancelled. Astronomers have discovered that the source of the proposed light show isn't what it first seemed.

In early 2017, astronomer Lawrence Molnar of Calvin College in Michigan reported that the members of a binary system in Cygnus, known as KIC 9832227, were spiraling closer together (*StarDate*, March/April 2017). The stars are so close together that they already touch each other, forming a contact binary. Based on the timing of their mutual orbit, and observations of another contact binary a few years earlier, Molnar and his team projected that the two stars would merge around 2022. The merger would produce a brilliant outburst known as a red nova.

The prediction was based on observations made by Molnar's team and others in 1999 and 2007-2016. In September, though, a team led by Quentin Socia of San Diego State University nixed the idea of a pending merger.

Socia and his colleagues found that there was a typo in the published 1999 observations. They also found that a 2003 observation didn't fit the timing found in later years. The team concluded that the two stars won't merge.

In a press release, Molnar agreed. "There have been a few other papers that have tried to poke at our project, and we've been able to poke back criticisms that just don't fly," he said. "But this one does fly, and I think they have a good point." **DB**

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Hot young stars light up clouds of gas and dust in the Carina Nebula, one of the largest stellar nurseries in the Milky Way galaxy. The nebula is about 7,500 light-years away, in the southern constellation Carina, the keel, and spans about 300 light-years. Light from the hottest stars causes gas in the nebula to glow. Radiation and winds from the hot stars squeeze surrounding clouds, causing them to collapse and give birth to new stars. The hot stars also erode the surfaces of some of the dark clouds, robbing them of the material needed to make even more stars.