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TRACKING BIG BLASTS
Page 20

Summer Bookings

From quarter-an-hour computers to the White House lawn, readings for the Dog Days

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Features

Departments

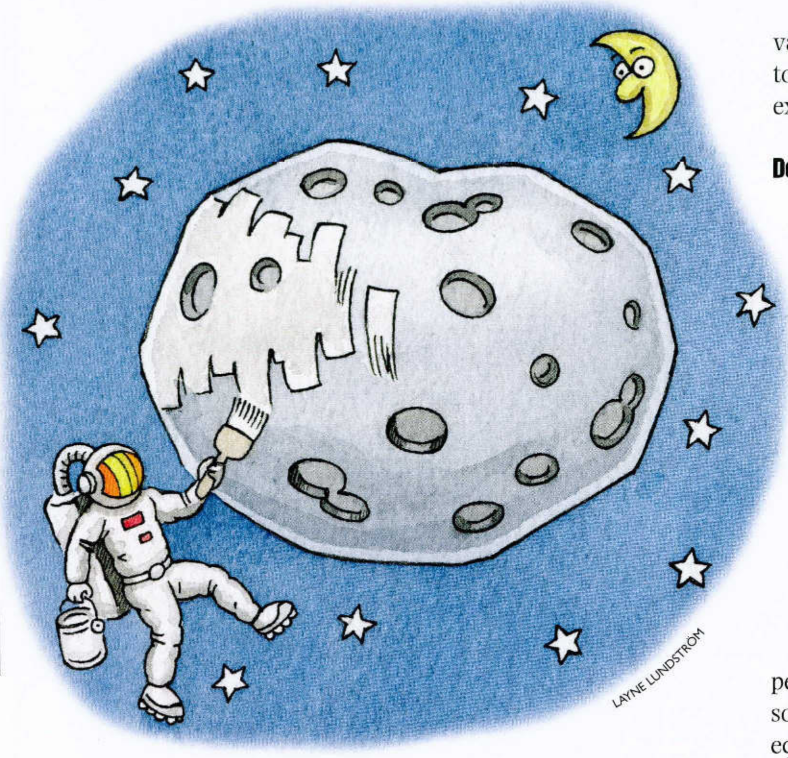
NASA/ESA/M. ROBBERTO, ET AL.

On The Cover
Hubble Space Telescope captured this view of the Orion Nebula, a vast stellar nursery about 1,500 light-years from Earth. The image shows bright newborn stars and billowing clouds of gas and dust, which are giving birth to more stars.

This Page
This artist's impression shows a debris disk from a crushed planetesimal around a binary star, the first detected system containing a dense white dwarf star paired with a brown dwarf, which is not quite massive enough to shine through nuclear fusion.

Coming Up
Our next issue will focus on the Great American Eclipse. On August 21, a total solar eclipse will be visible across a wide swath of the United States, with a partial eclipse in store for the rest of country. We'll tell you how to make the most of it.

Merlin



Dear Merlin,

If one could impart a spin on an Earth-bound asteroid via mounted rockets or some other means, would the gyroscopic effect disrupt its trajectory such that the asteroid would miss Earth?

Daniel Franklin
Los Angeles

That strategem might change the asteroid's course, although not necessarily because of the gyroscopic effect.

An asteroid's surface is mottled and irregular. Some areas are bright while some are dark, for example. As the asteroid rotates, these areas absorb solar energy and re-radiate it back into space at different rates. This process actually imparts a slight thrust, moving the asteroid around a tiny bit. Anything that alters the rotation rate, then, could change the process of absorbing and re-radiating solar energy, which could have a tiny effect on the asteroid's path. It would take a lot more study and experimentation, though, for this to become an effective technique for deflecting asteroids.

It leads, however, to another technique that scientists have pondered: painting large areas of the asteroid's surface. Big patches of white or black could alter the asteroid's interaction with solar energy more dramatically, perhaps deflecting its orbital path enough for the asteroid to miss Earth.

Of course, you could also do something simpler: Strap all the rockets you'd use to change its spin rate to one side of the asteroid and use them to push it to a new course.

One problem with these techniques is that they would require years of lead time to be effective, and Earth won't necessarily have that much warning before an asteroid hits. That's why NASA and other agencies are working hard to find all the potentially hazardous asteroids and plot their orbits far in advance, providing plenty of time to protect the planet from this existential threat.

Dear Merlin,

I just read that a new theory about the Moon says it probably was formed by several celestial bodies hitting Earth, taking chunks that then coalesced to form the Moon. Is there an estimate on the size of Earth before this activity? Just how big was Earth prior to the formation of the Moon?

Kathleen Antol
South Bend, Indiana

The Moon is only about one percent as massive as Earth, so one Earth plus one Moon equals one Earth plus a smidgen — like the difference between a plain ice cream sundae and an ice cream sundae with a cherry on top.

The exact details of how the Moon formed are still debated, but there's pretty good agreement that it was born when one or more bodies rammed into the young Earth. The impact(s) blasted out debris, forming a disk. Some of the material splatted back to Earth, while some clumped together to form larger objects.

Again, the details on this process are still debated. It might have produced more than one moon, with some of the extras escaping from Earth, hitting Earth, or merging with the present-day Moon. Yet the basic point is the same: Present-day Earth is only slightly smaller than the original Earth.

Now, if you will excuse Merlin, he feels the sudden need for an ice cream sundae. With or without the cherry.

Dear Merlin,

From the surface of Earth, the Moon and Sun have the same apparent size, which means that during a solar eclipse the Moon just covers the disk of the Sun but allows us to see the solar corona. Is there any other planet with a moon that has this property?

Jay Beder
Shorewood, Wisconsin

Not a single one.

Earth is the only planet in the solar system with a moon that covers the same angular diameter as the Sun as seen from the planet's surface (or cloudtops, in the case of the giant outer planets). The Sun is about 400 times wider than the Moon is, but it's also about 400 times farther. That astronomical coincidence means that the Moon can exactly cover the solar disk, leaving the corona to shine brilliantly around the Moon.

Merlin hopes that you will get to experience that coincidence yourself on August 21, when a total solar eclipse will be visible across the United States, from Oregon to South Carolina. If you miss it, though, another eclipse will cross the country in 2024, from Texas to Maine.

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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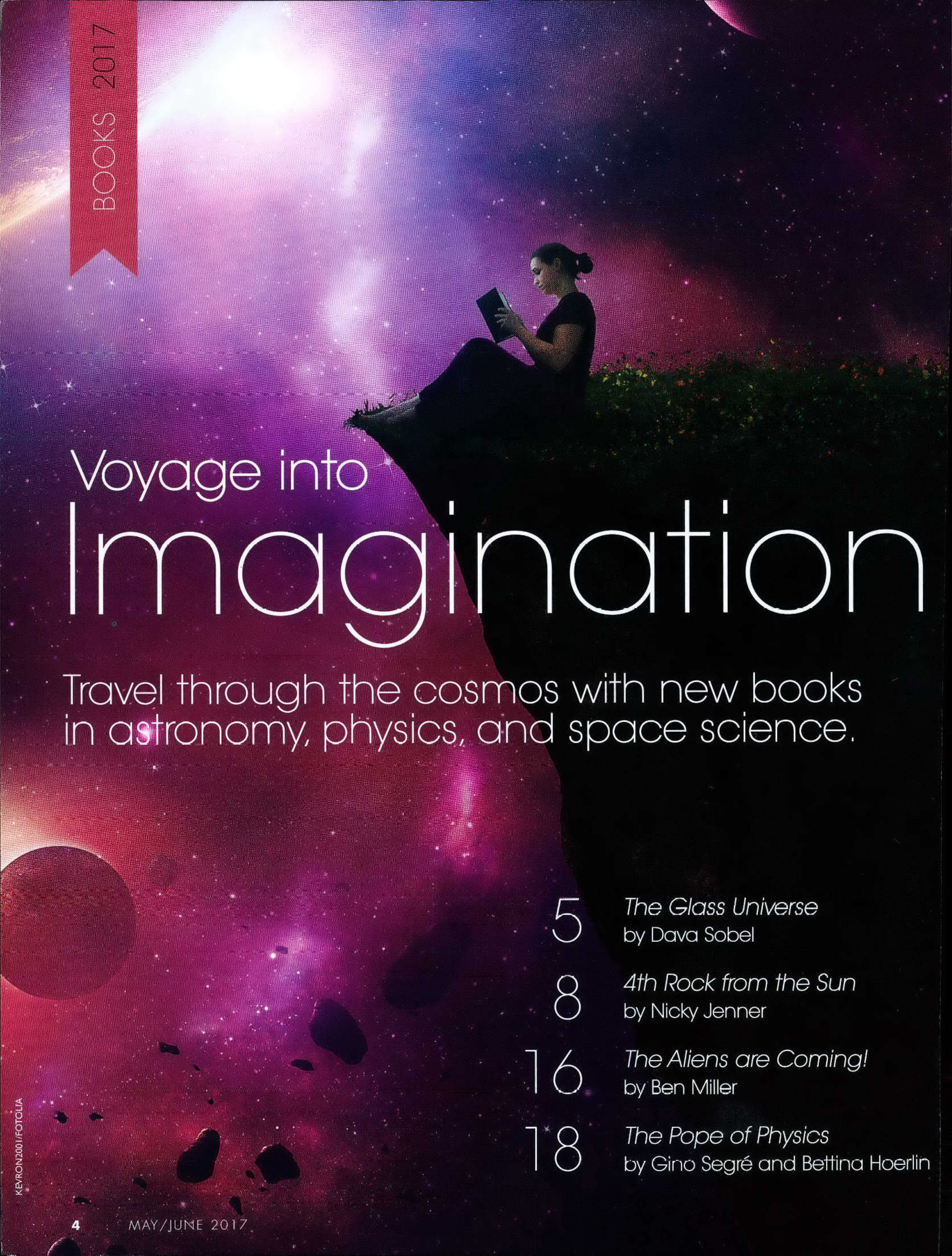

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Voyage into Imagination

Travel through the cosmos with new books in astronomy, physics, and space science.

GLASSY STARE

By analyzing thousands of pictures of the universe, pioneering women 'computers' changed the face of astronomy — for 25 cents per hour

THE SETUP

Astronomy offered few opportunities for women in the 19th century. But the door opened a bit in 1881, when Edward Pickering, director of Harvard College Observatory, hired his maid, Williamina Fleming, to catalog and study the observatory's collection of thousands of glass plates. Many other women soon followed, with Fleming overseeing their work. Over the next few decades, they made extraordinary contributions to astronomy. They developed the stellar classification system that's still used today, for example, and discovered and plotted a type of pulsating star that helped redefine the scale of the universe. Yet as this excerpt shows, these skilled women still faced challenges that their male counterparts did not.

THE EXCERPT

Mina Fleming's star was on the ascendant. In 1899, at Pickering's urging, the Harvard Corporation formally appointed her to a newly created position as curator of astronomical photographs. She thus became, at age forty-two, the first woman ever to hold a title at the observatory, or the college, or the university at large.

At this same time, the turning of the century inspired the Harvard administration to assemble a time capsule of campus life, with photographs, publications, essays, and diaries solicited from students, faculty, and staff. Mrs. Fleming dutifully wrote out her contribution for the "Chest of 1900" over a period of six weeks.

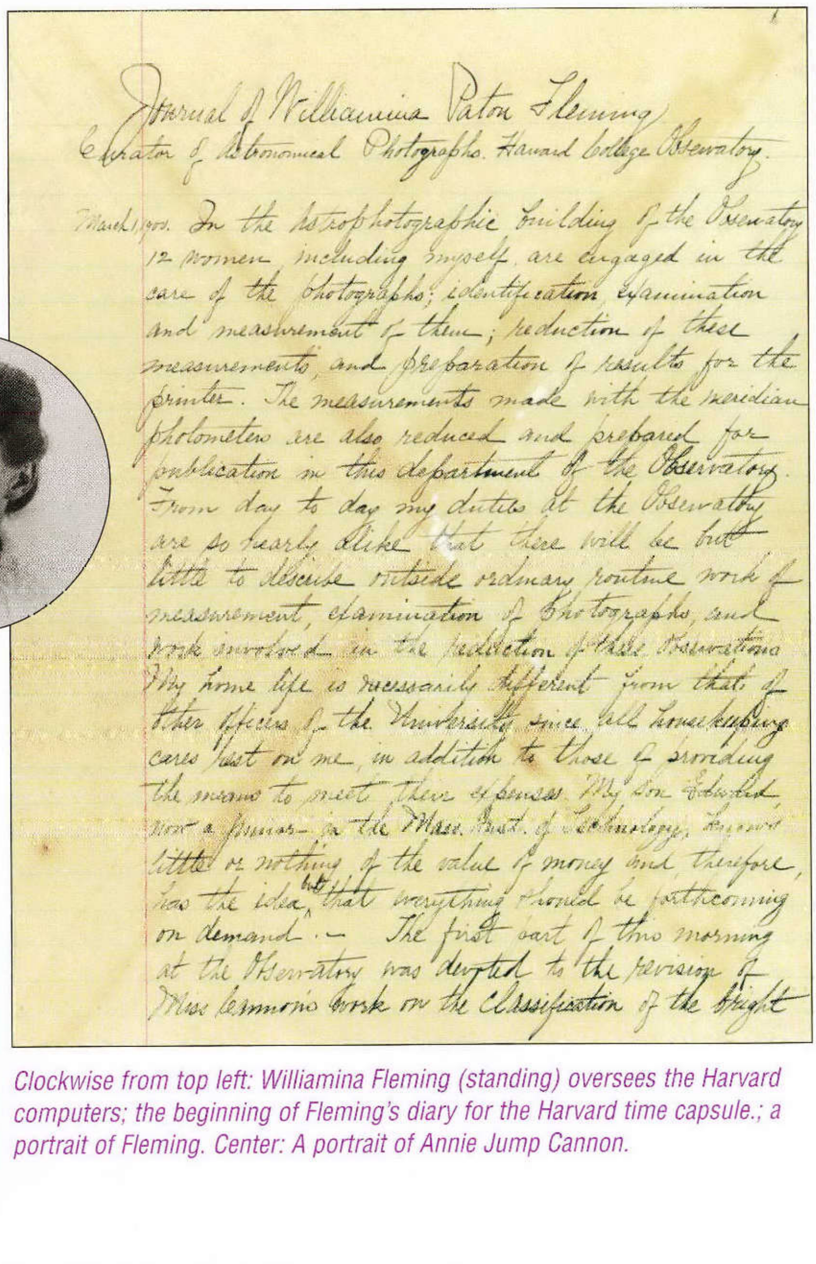
"In the Astrophotographic building of the Observatory," she began March 1, 1900, on a lined yellow notepad, "12 women, including myself, are engaged in the care of the photographs; identification, examination and measurement of them; reduction of these measurements, and preparation of results for the printer." Every day they bent to their examination tasks in pairs, one with a microscope or magnifying glass poised over a glass plate in its frame, and the other holding a logbook propped open on a desktop or in her lap, recording the spoken observations of her partner. A hum of numbers and letters, like conversations in code, pervaded the computing room.

"The measurements made with the meridian photometer," Mrs. Fleming continued, "are also reduced and prepared for publication in this department of the Observatory." Florence Cushman, who had previously worked for a business firm, received the sheaves of magnitude measurements made nightly with photometers in Cambridge and Peru. She and Amy Jackson McKay copied over the visual observers' judgments, calculated the corrections, and checked and rechecked the figures before consigning them to the printer. The rest of the female computing staff, consisting of the sisters Anna and Louisa Winlock (daughters of the previous director) and the ladies who helped them process the data regarding star positions, remained in the west wing of the original observatory, as the Brick Building's limited space could not accommodate everyone.

"From day to day my duties at the Observatory are so nearly alike that there will be but little to describe outside ordinary routine work of measurement, examination of photographs, and work involved in the reduction of these observations." If Mrs. Fleming's days blended in sameness, as she claimed, they bore no resemblance to those of any other invited contributor to the Harvard time capsule. "My home life is necessarily different from that of other officers of the University since all housekeeping cares rest on me, in addition to those of providing the means to meet their expenses." She had to plan and purchase all provisions, plus give instructions to Marie Hegarty, the Irish maid she retained to clean house and cook the evening meal six nights a week. Although Mrs. Fleming was contracted to work seven hours a day at the observatory, she rarely arrived past 9 a.m. or left before six in the evening. "My son Edward, now a junior in the Mass. Inst. of Technology, knows little or nothing of the value of money and therefore, has the idea but that everything should be forthcoming on demand." The frugal Mrs. Fleming minimized her expenses by inviting Annie Cannon to board with her on Upland Road. Miss Cannon proved companionable and came from a good family. Her father, Wilson Lee Cannon, was a bank director and former state senator in Delaware.

"The first part of this morning at the Observatory," Mrs. Fleming reported on March 1, "was devoted to the revision of Miss Cannon's work on the classification of the bright southern stars, which is now in preparation for the printer." Miss Cannon had picked up the knack for classification much faster than Mrs. Fleming expected. Of course, Miss Cannon enjoyed the advantage of college-level instruction in spectroscopy, as well as several years' experience as an assistant physics teacher and observer—opportunities that had been denied Mrs. Fleming. Still, there was no begrudging Miss Cannon the credit due her for making rapid, accurate evaluations of stellar types. She mirrored Miss Maury's ability to characterize individual lines in the hundreds of bright stellar spectra assigned to her, but she did not insist, as Miss Maury had done, on some altogether new scheme of her own devising. Instead Miss Cannon abided by Mrs. Fleming's lettered categories. She had in fact built a bridge between the two Harvard sorting systems by simplifying Miss Maury's double-tiered division and skewing Mrs. Fleming's alphabetical order. Since both those approaches were arbitrary, founded solely on the appearance of the spectra, Miss Cannon was free to assert her own sense of order. After all, astronomers could not yet tie any given traits of stars, such as temperature or age, to the various groupings of spectral lines. What they needed was a consistent classification—a holding pattern for the stars—that would facilitate fruitful future research. Miss Cannon thought it best to move Mrs. Fleming's O stars from the tail end to the top of the list, giving the helium lines precedence over the hydrogen, in the fashion of Miss Maury. B stars likewise ranked ahead of the A in Miss Cannon's appraisal. Beyond those rearrangements, alphabetical order again held sway, except where Miss Cannon conflated certain categories. C, D, E, and a few other class distinctions had fallen away. The resulting order wound up as O, B, A, F, G, K, M. (A wag at Princeton later made the string of letters memorable by the phrase "Oh, Be A Fine Girl, Kiss Me!")

Mrs. Fleming's March 1 journal entry continued with "the classification of the spectra of the faint stars for the Southern Draper Catalogue." This was Mrs. Flem-



Journal of Williamina Paton Fleming
Curator of Astronomical Photographs. Harvard College Observatory.

March 1, 1900. In the Astrophotographic building of the Observatory 12 women including myself are engaged in the care of the photographs; identification, examination and measurement of them; reduction of these measurements, and preparation of results for the printer. The measurements made with the meridian photometer are also reduced and prepared for publication in this department of the Observatory. From day to day my duties at the Observatory are so nearly alike that there will be but little to describe outside ordinary routine work of measurement, examination of photographs, and work involved in the reduction of these observations. My home life is necessarily different from that of other officers of the University since all housekeeping cares rest on me, in addition to those of providing the means to meet these expenses. My son Edward, now a junior in the Mass. Inst. of Technology, knows little or nothing of the value of money and therefore has the idea but that everything should be forthcoming on demand. — The first part of this morning at the Observatory was devoted to the revision of Miss Cannon's work on the Classification of the bright

HARVARD COLLEGE OBSERVATORY (4)

Clockwise from top left: Williamina Fleming (standing) oversees the Harvard computers; the beginning of Fleming's diary for the Harvard time capsule.; a portrait of Fleming. Center: A portrait of Annie Jump Cannon.

ing's own province, though she shared the vast territory with Louisa Wells, Mabel Stevens, Edith Gill, and Evelyn Leland. Whereas, at the beginning of Mrs. Fleming's career, the faint stars of the northern sky had belonged to her alone, the southern sky could not be managed single-handedly. The observing conditions at Arequipa [a Harvard observatory in Peru], for one thing, coaxed many more faint stars out of the dark. On plates made with the Bruce telescope, even ninth-magnitude spectra appeared legible enough for the positions of individual lines to be measured. Moreover, any newfound variable necessitated a search through as many as one hundred previous plates of the same sky area, taken through the decade in Peru, in order to confirm the star's variability. Every year this part of Mrs. Fleming's work grew more laborious, owing to the ever-richer trove of material for comparison. The numerous discoveries that had brought her such pleasure, such acclaim—so many cuttings in her scrapbook—weighed on her now. Even the director admitted that it had become difficult to amass all the required data for one variable star before another turned up.

"The work of measurement is already well advanced," Mrs. Fleming said of the lines in the southern spectra, still on day one in her journal, "and we expect to accomplish much during the coming summer. Professor Bailey's observations with the meridian photometer in South America then came up for examination."

Solon Bailey, now back in Cambridge, was writing out the results of his five-year sojourn at Arequipa. His southern magnitudes, or brightness assessments, focused on the multitude of variable stars in star clusters—the "cluster variables," as he called them. Glass plates he had taken through the Bache, Boyden, and Bruce telescopes revealed some five hundred variables in those stellar agglomerations, and their photographic brightness needed to be rectified with his visual observations. Often he spent the night at the observatory, aiding the director in new observations or supervising one or another of the assistants. ...

"Various other pieces of work" claimed Mrs. Fleming's attention during that first morning of record, and in the afternoon several business matters called her to Boston. Later on, she wrote, "I joined Mrs. S. I. Bailey, Miss Anderson, and my sister Mrs. Mackie at the Castle Square Theatre. The play was 'The Firm of Girdlestone' and we all enjoyed it. Mrs. Bailey tried to persuade me to stop over and dine with her, and spend the night, but my little family needs me at home in the morning. They are apt to be late for breakfast, and consequently for daily duties, when the head of the house is not there to get them going."

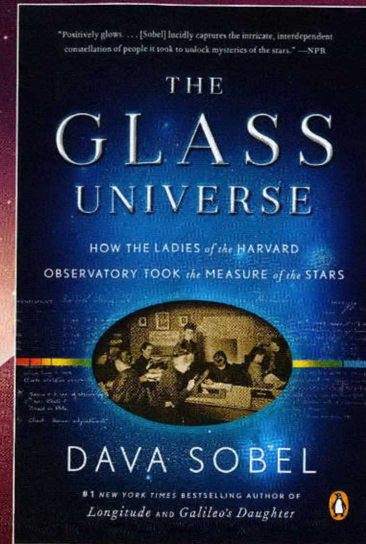
The next day at the observatory, March 2, Mrs. Fleming devoted herself "to miscellaneous odds and ends, and a gathering together of loose strands." These included keeping up with the scientific correspondence and sending out copies of the observatory's latest pamphlet, "Standards of Faint Stellar Magnitudes, No. 2," to all those affiliates, both amateur and professional, who followed the fluctuating brightness of the variable stars. ...

The end of the day afforded Mrs. Fleming a quiet period for reflection. "My small family has deserted me this evening. I am the loadstone left to prevent the house from blowing away. After dinner Miss Cannon found that the clouds had cleared away and the stars were coming out, so she went over to the Observatory to get her observations of the circumpolar variables with the 6 inch telescope. ... Meanwhile I must see the 'Herald' and find out from it, if I can, the condition of the Boers and the British in South Africa. Edward talks of going out there when he finishes his course at the Institute."

Miss Cannon stayed very late at the telescope that night, which bumped the ongoing discussion of her remarks to the next day, March 3, a typical working Saturday at the observatory. Before lunch, Mrs. Fleming found time to examine a few southern spectrum plates. She lamented that supervision of routine procedures left her less and less time for the "particular investigations" that most interested her, or even "to get well settled down for my general classification of faint spectra for the New Draper Catalogue."

Saturday night guests chez Fleming amused themselves playing "India" (a form of rummy), "jackstraws" (pick-up sticks), and the board games "crokinole" and "cue ring." Sometimes a few friends sang for the rest of the company, but if not, there was plenty of pleasant conversation to go around. Mrs. Fleming prepared fudge and dates stuffed with peanuts to serve to a few guests, or, for a large soiree, creamed oysters with hot cocoa, cakes, and sweets. Cleaning up and winding down afterward with Edward and Miss Cannon, she might not get to bed till well past midnight.

"This is my day of rest and retirement so far as Observatory work is concerned," Mrs. Fleming noted Sunday morning, March 4, "but it brings my only opportunities for investigating the condition of household affairs, and I find the day all too short for them." The linens had to be changed, the family wash gathered for the laundress. "Alas! how matter of fact and different from the Sunday morning duties of other officers of the University."



The Glass Universe

How the Ladies of the Harvard Observatory Took the Measure of the Stars

By Dava Sobel; 2016

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WHIPPING UP TWO MOONS

From capture to a 'big whack,' scientists explore the possible origins of Phobos and Deimos

THE SETUP

Phobos and Deimos, the moons of Mars, are small, lumpy chunks of rock that orbit much closer to Mars than the Moon is to Earth. Planetary scientists have debated the origins of the odd little moons since their discovery in the 19th century. Today, the leading idea says they were born in the same way as the Moon: from a big whack. This excerpt discusses the evolution of these ideas.

THE EXCERPT

Firstly, and perhaps most famously, is the idea that Phobos and Deimos aren't really related to Mars at all — they're actually adopted asteroids that were captured by the planet at some point in its history. Mars may have managed to snag a couple of single nearby objects, pilfered one of the objects in a duo as the pair flew past (this would have had to happen twice, once for Phobos and once for Deimos), or grabbed a single object that later split into two post-capture. The objects captured by Mars could have been from the inner or outer Solar System or from the main asteroid belt — each of these scenarios would result in a different composition for Phobos and Deimos, with a different internal structure and mix of water, organics and minerals.

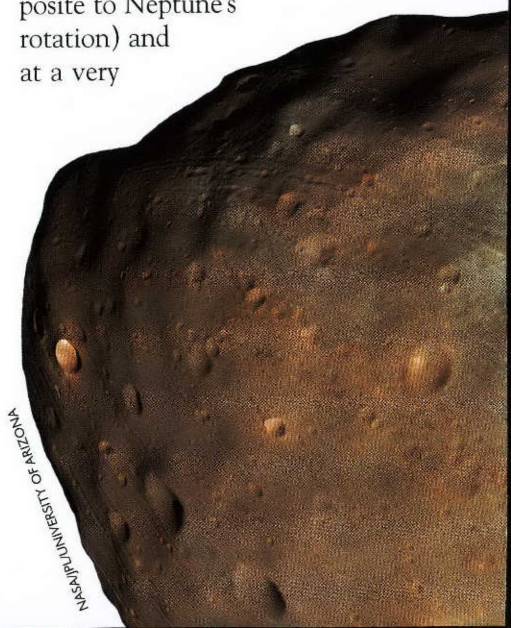
Initially, this looks appealing; the moons' spectra do suggest that both bodies may have similar compositions to asteroids, and Mars does sit close to the asteroid belt. In order to be asteroid-like, the moons must have swept up material that lies far beyond Mars' orbit, implying that they didn't form where they currently live. However, there are a few issues with this, including the fact that capturing an intact object is actually a very, very unlikely event — and for Mars, it would have to have happened not once, but twice.

The behaviour of the moons themselves throws up additional hurdles for this theory. Both have properties that are difficult to reconcile with them being captured asteroids. Both Phobos and Deimos have orbits that are very circular (in fact, almost perfectly circular), prograde (meaning they orbit in the same direction as Mars rotates, anticlockwise, like the vast majority of bodies in the Solar System) and very closely aligned with Mars' equatorial plane.

These orbits are very difficult to explain if we assume the moons to be snagged passers-by. Such bodies would likely be disruptive and travelling on any number of differently aligned orbits. An incoming asteroid could approach from a range of directions and inclinations. In order for the current orbits of Phobos and Deimos to be so well behaved, they must have been altered, reshaped, realigned and circularised over time. This would have required Mars to have a very thick primitive atmosphere — not only to considerably alter the moons' orbits, but so that the planet was capable of removing the excess energy from the passing bodies after it hooked them to slow them down.

Crucially, this thick atmosphere would have had to dissipate rapidly at just the right time in order to avoid either ripping the new moons apart or pulling them down to crash into the surface of Mars. While this is all possible, it requires some precise timings and is therefore unlikely, particularly for Deimos. Phobos is so close to Mars that atmospheric drag could potentially have had this kind of effect, but Deimos exists much further away from Mars. To apply to both moons, Mars' super-thick primitive atmosphere would thus need to have been far-reaching, too.

A good example of the capture mechanism is Triton, Neptune's largest moon, which is a captured dwarf planet from the distant outer Solar System (a body similar to Pluto). However, Triton does not behave as well as Phobos and Deimos do; it orbits Neptune in the 'wrong' direction (retrograde, opposite to Neptune's rotation) and at a very



NASA/JPL/UNIVERSITY OF ARIZONA

high inclination. It likely disrupted the entire Neptunian system when it joined the family, throwing some of Neptune's other moons into disarray and potentially flinging earlier moons out of the system completely.

It's doubtful that Mars could have captured two passing bodies and reshaped their orbits so significantly — scientists dub it anywhere from 'almost impossible' through to 'extremely improbable' and 'unlikely' — but it remains a possibility.

A second idea proposes that the moons simply formed alongside Mars. As Mars grew larger and subsumed material from its surroundings, so did Phobos and Deimos. The two forming moons whirled around their parent planet, eating up material in their path just as Mars did. This would accurately recreate the moons' neat orbits and good behaviour, and could create the suspected rubble.

However, the major problem with this theory is the composition of both Phobos and Deimos — they're both very different to Mars, and if they co-accreted from the same material, they should instead be similar. Additionally, it's not known whether there would have been enough mass available around Mars to form both moons (but it's possible that a nearby collision could have dumped a load of mass into the planet's orbit, flooding the region with new building blocks).

Lastly, it's possible that the Martian system has a great deal in common with our own. While our knowledge of how our moon formed is by no means certain, the leading theory is known as the 'giant impact hypothesis'. This theory proposes that a Mars-sized lump smashed into Earth when it was still forming. This impactor, dubbed 'Theia' (after the mother of Selene, the Greek goddess of the Moon), dealt Earth a destructive blow, sinking deep into the young planet and causing devastation. Material from both Theia and Earth was flung out into space, settling into orbit around Earth. Over time this debris came together and combined to form the Moon. ...

A close-up view of Phobos

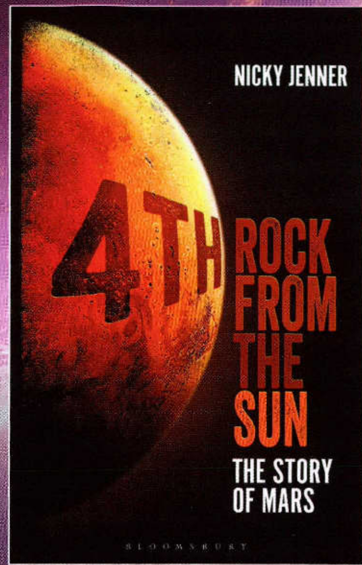
Something similar may have happened with the moons of Mars. Early in Mars' life, a giant Moon-sized body could have violently collided with the planet, shattering into pieces as a result. Material from both the impactor and Mars' early crust would have been thrown out into space to form an orbiting disc, stretching out to beyond the present-day orbit of Deimos. The moons could have then formed within such a disc ... .

There are a few constraintson such an event, including the size of the collision (large), the overall mass contained within the disc (greater than that of Phobos and Deimos combined) and the size of the disc (stretching out to the current orbit of Deimos), but many of the signs look promising. A wide range of impactor orbits could have formed such an accretion disc, but the impactor likely had a mass of around a few per cent of Mars' mass, forming a disc stretching out towards Deimos (a larger disc would have formed moons beyond Deimos, which we don't see). This disc would have contained far more mass than is currently constrained within Phobos and Deimos, and thus would likely have formed a number of large inner satellites that have already spiralled inwards to collide with Mars.

Additionally, there are several different impact basins on Mars that could be related to such a collision, such as the Daedalia, Chryse and Borealis basins, and parts of the northern highlands. Such a collision could explain why Mars' two hemispheres are so disparate, with the southern half sitting much higher in elevation than the northern — much of the material from the northern hemisphere may have been lost to space and used to form Mars' twin sons. ...

According to this model, a forming planet smashed into Mars within the first billion years of its life and threw huge amounts of debris out into orbit around the Red Planet, shattering into pieces as it did so. This ring formed a number of initial — and larger — moons orbiting close to Mars, which dynamically interacted with the remaining dusty, pebbly little building blocks surrounding them and influenced the material there to start clumping together to form the potato-like duo we see accompanying Mars today. These initial moons were eventually dragged inwards to be torn apart and consumed by Mars, and Phobos and Deimos slowly moved and repositioned themselves in space, ending up in their current locations billions of years later. This would explain why the two moons have a different composition to their 'parent' planet, and manages to successfully reproduce the Mars system as we see it today (which is no mean feat).

If things weren't uncertain enough, it's also possible that one of these theories might apply for Phobos and another for Deimos. As with so many things concerning Mars, we are not really certain about anything— to whittle down the list of 'maybes', we simply need to know more.



4th Rock from the Sun

The Story of Mars

By Nicky Jenner; 2017

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Books 2017 continued on page 16

Sky Calendar

by Alan MacRobert

Jupiter dominates May nights, accompanied by Spica, the leading light of Virgo. As the year marches toward summer and the days get longer, stargazing hours of opportunity decrease. In June, look to the east for the Summer Triangle, with its brightest beacon, Vega.

MAY 1 - 15

A long, narrow triangle of three bright points shines on May evenings this year, high in the south to southeast.

The brightest is Jupiter. It far outshines any other starry dot in the evening sky. To the lower left of it, by about a fist-width at arm's length (about 10 degrees), is the faintest of the three points, Spica. Jupiter is creamy white; Spica is an icier shade of bluish white. Can you see the difference?

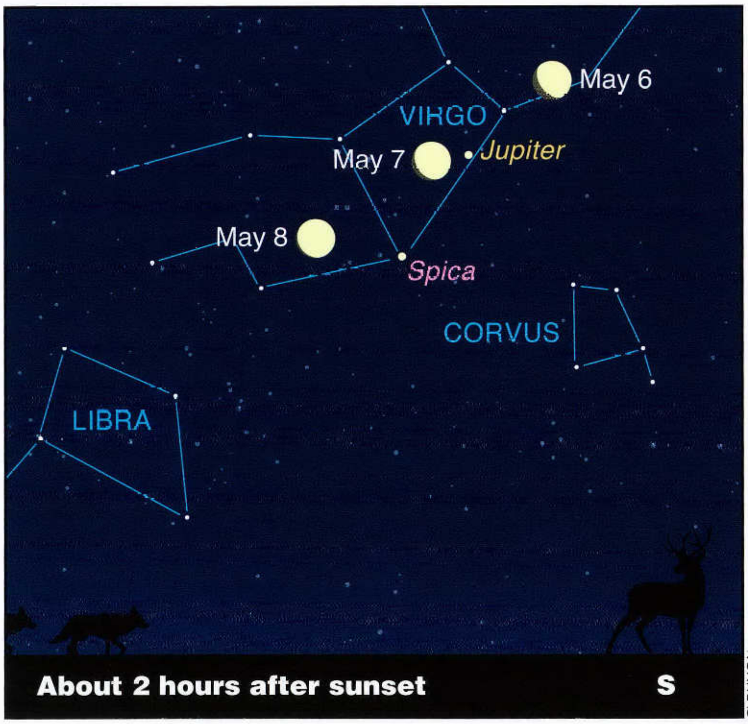
The third is Arcturus, far to the upper left of the other two by about three fists. It's pale golden yellow.

The distant planet Jupiter moves slowly against the starry background, so the triangle changes shape just a little from week to week. But keep watch on it this summer. Jupiter will move slightly away from Spica, then back toward it, widening and then narrowing the triangle's short side. By early September, the triangle will narrow into a long straight line, as Jupiter and Spica come closest together, in conjunction.

On May 7 and 8, the waxing gibbous Moon shines near Jupiter, then Spica.

Turning to the west, the great Arch of Spring is settling downward in twilight and early darkness. The top of the Arch consists of Pollux and Castor, the heads of Gemini. They're nearly horizontal and about three finger-widths apart.

Look to their lower left for Procyon, at one end of the Arch. Look to the other end, farther to their lower right in the northwest, for Menkalinan (Beta Aurigae) and brilliant Capella (Alpha Aurigae).



About 2 hours after sunset S

CJ DUNCAN

The Arch of Spring is the last, departing section of the much bigger Winter Hexagon.

Summery Vega is rising in the northeast, matching Capella in brightness.

MAY 16 - 31

Now that the Moon is gone from the evening sky, look below Castor and Pollux in the west just after dark for the full stick figures of the Gemini twins. You'll need a sky without much light pollution to make out all their stars easily. Whenever the twins are in the west, they stand upright, holding hands. When they're in the east (such as evenings in December), they lie on their sides holding hands.

In the southeast, Arcturus has now moved a little higher. Sometimes it's called the "spring star." Look a whopping 60 degrees to its lower left — six fists at arm's length — for bright Vega, the "summer star."

A third of the way down that line, you'll find fainter Alphecca, the one modestly bright jewel of the little semicircular constellation Corona Borealis, the northern crown. It's a subtly lovely thing in a dark sky.

Dawn begins *very* early in the morning now, what with the summer solstice only a month away. The first hint of sky-brightening in the east comes sometime around 4 a.m. (Daylight Time), depending on your location. An hour later, all but the brightest stars have disappeared into the oncoming blue. But you can't miss Venus lording it over the dawn as the Morning Star in the east. It's currently at its brightest.

Look far to the lower left of Venus in the last two weeks of May for smaller, lower Mercury. It's a good 20 to 25 degrees from Venus during this period: about 2 to 2½ fists at arm's length. Binoculars will help you find Mercury as dawn grows bright.

JUNE 1 - 15

By nightfall, quite late in the evening now, serious signs of summer are making themselves known in the east.

Vega is the brightest star here, shining well up in the east-northeast. It's the top star of the big Summer Triangle. Look for the fainter specks of its little constellation, Lyra, dangling below it.

Deneb lies to the lower left of Vega by two fists or a little more, in Cygnus, the swan. Look a greater distance to Vega's lower right for Altair, in Aquila, the eagle. Altair is the last and lowest of the Summer Triangle stars to rise (for us at mid-northern latitudes).

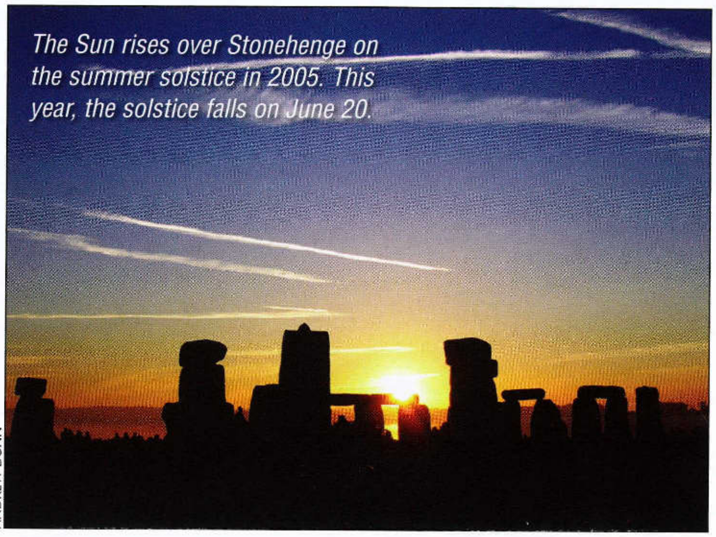
Turn around to the right to look low in the southeast. There's the orange-red supergiant Antares with the other, whiter stars of upper Scorpius around it and to its upper right. On June 7, the bright Moon shines above them.

Look to the left or lower left of Antares, by about a fist and a half, for Saturn. It glows with a steadier light. The Moon poses near Saturn on June 9.

These summer tableaux will

rise higher as the night advances and as the season advances. If you don't know the starry correlation between time of night and time of year, learn it: *One month later* in the year is the same as *two hours later* in the night, when it comes to star and constellation positions.

Meanwhile, almost overhead to the north-northwest, the Big Dipper has swung around to start its long descent, bowl down.



The Sun rises over Stonehenge on the summer solstice in 2005. This year, the solstice falls on June 20.

ANDREW DUNN

Follow the arc of the dipper's handle up and around to the left for about a dipper-length, and you'll land back at Arcturus, high above Jupiter. The Big Dipper and Arcturus share an ancient mythological connection. The dipper is the brightest part of Ursa Major, the great bear, and the name Arcturus is from the Greek for "bear driver." As the bear eternally stalks around the north celestial pole, Arcturus always follows behind it.

JUNE 16 - 30

Jupiter has now moved over to the southwest as the stars come out. It's still the brightest point in the evening sky, with Spica sparkling 11 degrees to its left.

Look much closer to Jupiter, on the opposite side from Spica, for fainter Gamma Virginis. This star, also known as Porrima, is a tight double star for telescopes. Its telescopic appearance at high power is sometimes likened to a pair of headlights in the far dark.

Look well below Spica and Jupiter for the four-star sail-shape of Corvus, the crow. The top left star of the sail is Delta Corvi, a much wider double star for amateur telescopes than Gamma Virginis.

Don't wait too late or Corvus will set. It's a spring evening constellation, and spring officially ends on June 20, the summer solstice.

That is the shortest night of the year. It's still called Midsummer's Night from centuries ago, when the solstice was considered the apex of summer rather than summer's beginning.

How short a night is Midsummer's Night? That depends on your latitude. At Miami, you still get more than seven hours of solid darkness, counting from the end of twilight to the vey beginning of dawn. At New York or Denver, make that only five hours. If you're as far north as Vancouver, there's no true dark at all around the solstice; evening twilight doesn't quite end before dawn sets in. And at the Arctic Circle, the Sun doesn't set at all that day.

Of course, if you're in the southern hemisphere, the opposite is true. This is the longest night, the official beginning of winter. If you're south of the Antarctic Circle, the Sun doesn't rise.

Assuming darkness happens where you are, look to the east after the end of the fadeout. The Summer Triangle has risen higher than it was a couple weeks ago. Vega is still on top. If your sky is moonless and really properly dark — far from light-polluted population centers — you'll see that Vega floats just above the frothy star-foam of the vast Milky Way, which is rising to span the entire eastern sky.

Deneb, still to Vega's lower left, is right in the Milky Way's centerline. Deneb forms the head of the big Northern Cross, which is lying on its side with its long end running to the right (beneath Vega) through one of the Milky Way's richest star clouds.

And you can tell you've found Altair, still far to the lower right of Vega, because of its third-magnitude attendant star Tarazed, now glimmering above it and a bit to the left.

Follow the Milky Way far to the left of the Summer Triangle, and you'll see that it passes through W-shaped Cassiopeia low in the north-northeast.

Follow it far the other way, and you'll see that it slides down below steady-glowing Saturn, now more easily visible in the south-southeast with the coming of summer.

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

Meteor Watch

The Shower

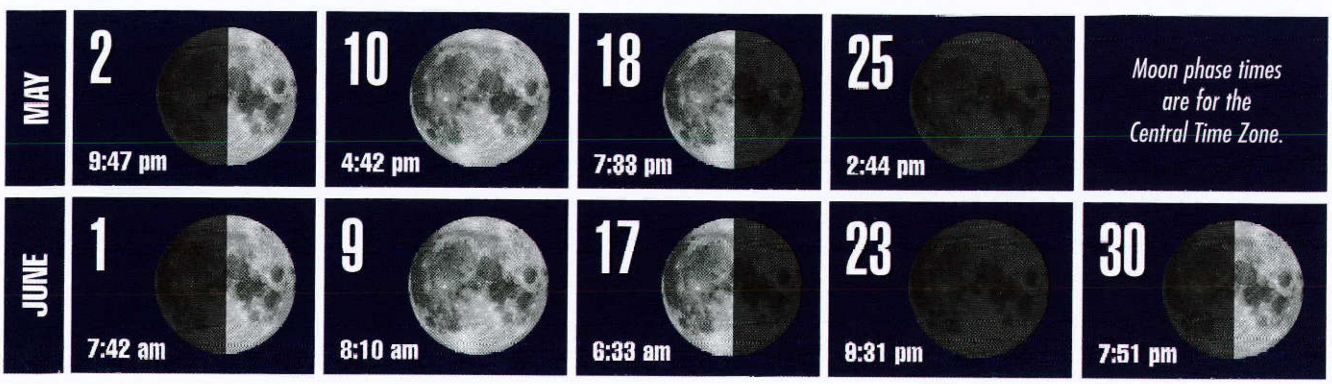
Eta Aquarids

Peak

Night of May 5

Notes

The Eta Aquarids are a modest shower for skywatchers in the northern hemisphere, with maximum rates of about a dozen meteors per hour. The bright gibbous Moon doesn't set until a couple of hours before sunrise, though, so its light will overpower all but the brightest meteors.



MAY

How to use these charts:

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

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

NORTH

EAST

WEST

SOUTH

MAGNITUDES

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

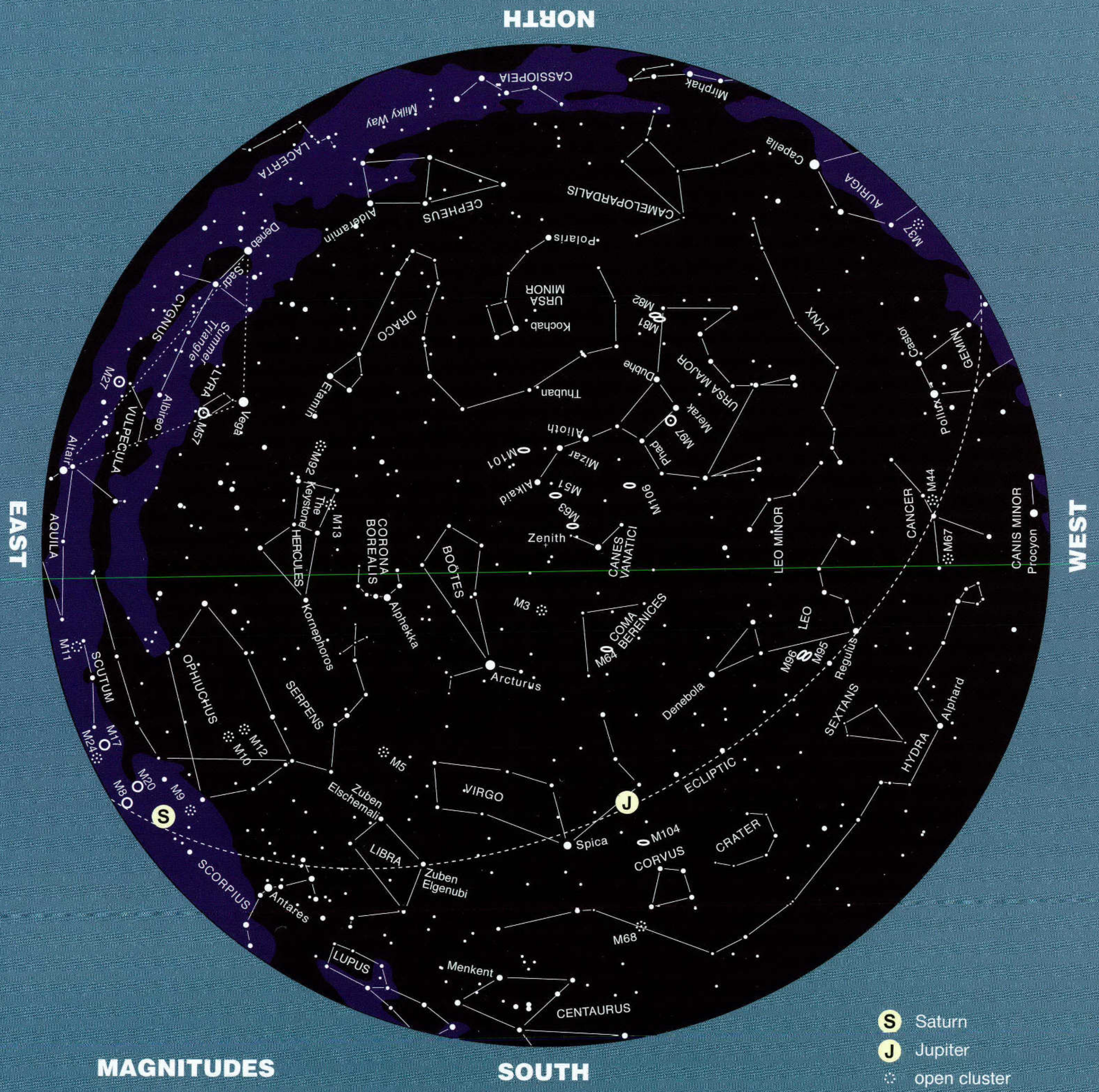
- J Jupiter
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

JUNE

How to use these charts:

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

May 20	**11 p.m.**
June 5	**10 p.m.**
June 20	**9 p.m.**



MAGNITUDES

- 0 and brighter
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- S Saturn
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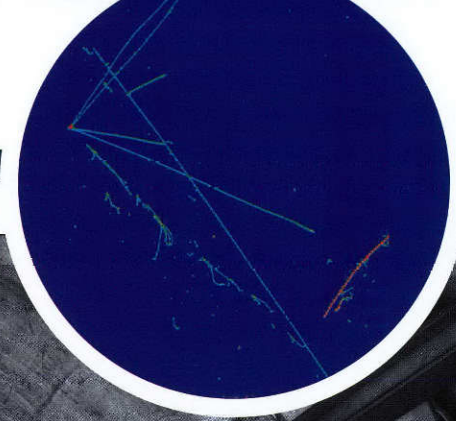
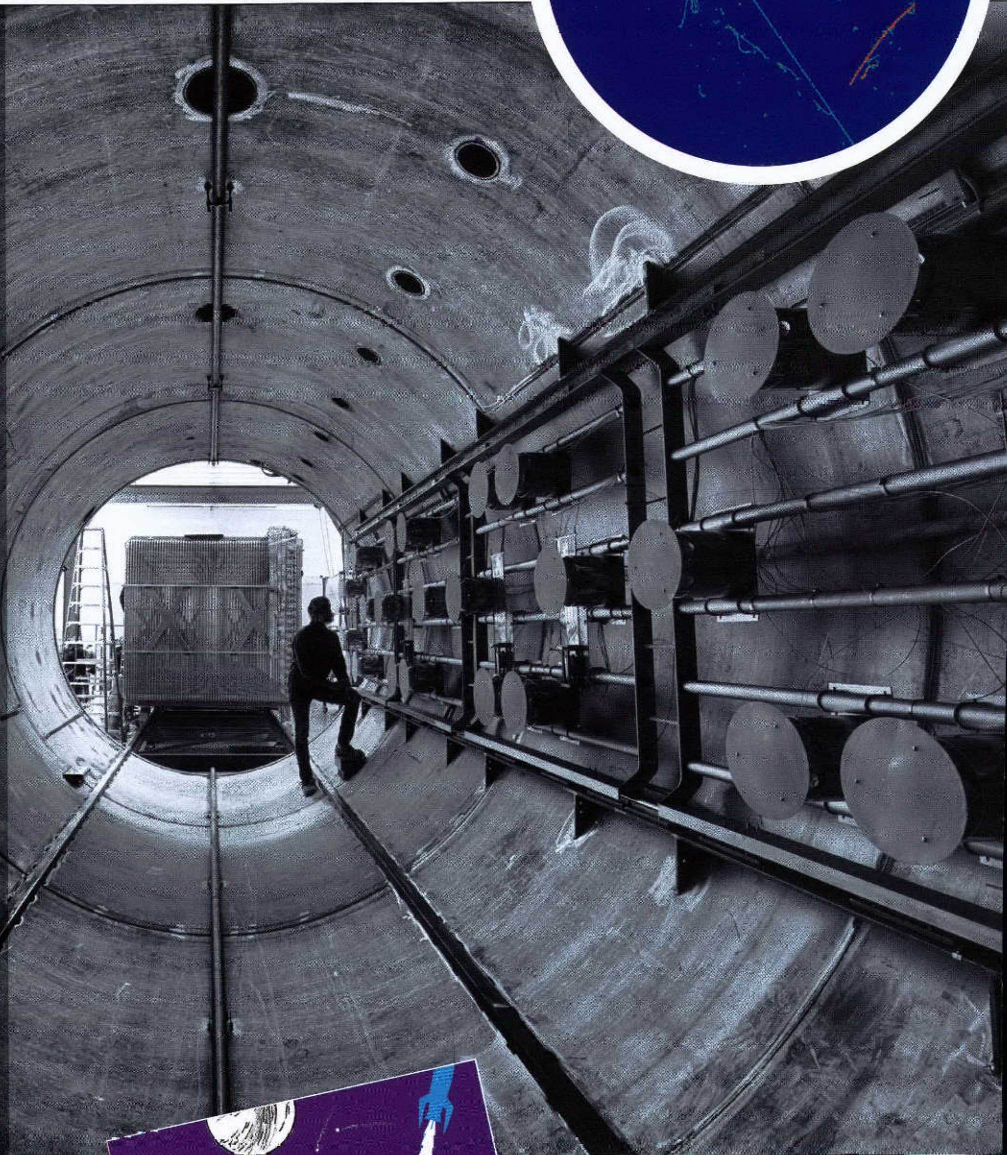




Tracking Neutrinos by Phone

Neutrino scientists have created a new free app for both Apple and Android smartphones called "VENu." Users play a game to catch neutrinos, those tiny, almost massless particles that are flowing through Earth —and our bodies! — at all times, mostly undetected.

The app comes from the MicroBooNE neutrino experiment, a 100-ton neutrino detector at Fermilab, the particle accelerator lab outside Chicago. The $19 million project uses a chamber filled with liquid argon that tracks the particles created when a neutrino collides with an argon atom in the detector.

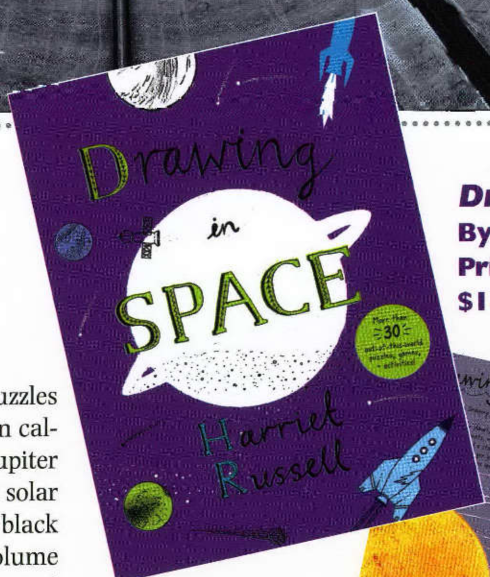
Users of the VENu app try to catch neutrinos while dealing with interference from cosmic rays, just like the real experiment. In addition to the game, the app contains a section where users can learn more about the science of neutrinos, cosmic rays, and the MicroBooNE experiment.

venu.physics.ox.ac.uk

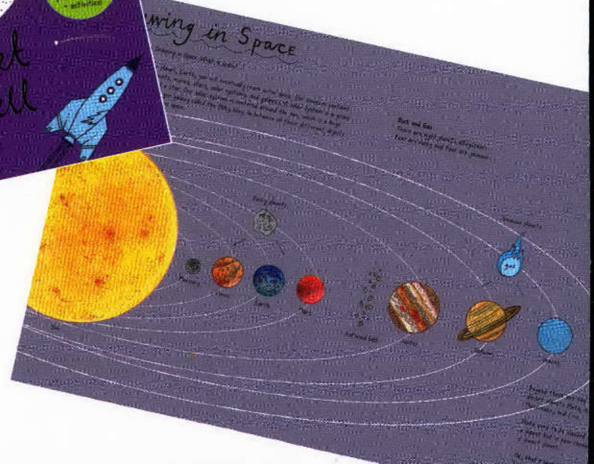
A technician inside the MicroBooNE tank at Fermilab. Inset: A neutrino event recorded by MicroBooNE.

FNAL/DOE (2)

Mazes, Puzzles, and Games, Oh My!



Drawing in Space
By Harriet Russell
Princeton Architectural Press
$18.95



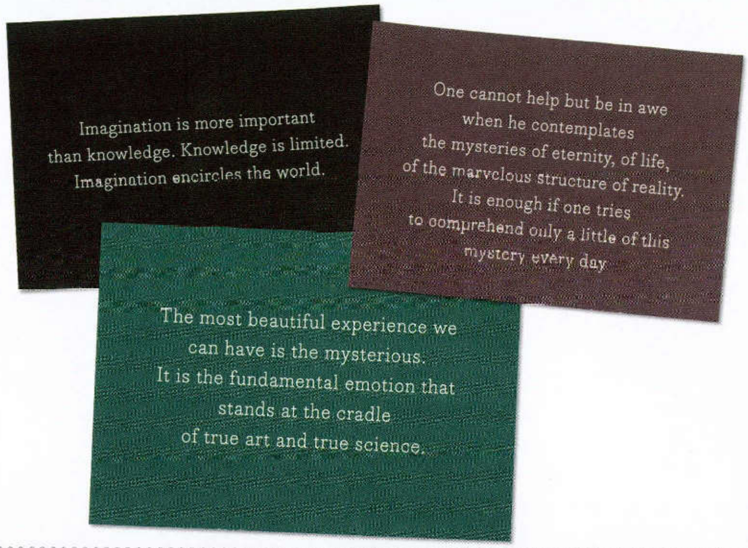
Drawing in Space is the latest children's activity book from British children's author and illustrator Harriet Russell. Designed for kids ages five to eight, it presents facts and figures about the planets, stars, black holes, and more through dozens of activities like word searches, connect-the-dots, mazes, and other puzzles and games. Readers can calculate their age in Jupiter years, create their own solar system, and navigate a black hole. The 64-page volume is full of Russell's whimsical illustrations of the cosmos. It is a follow-up to her previous children's activity book, *Drawing in the Sea.*

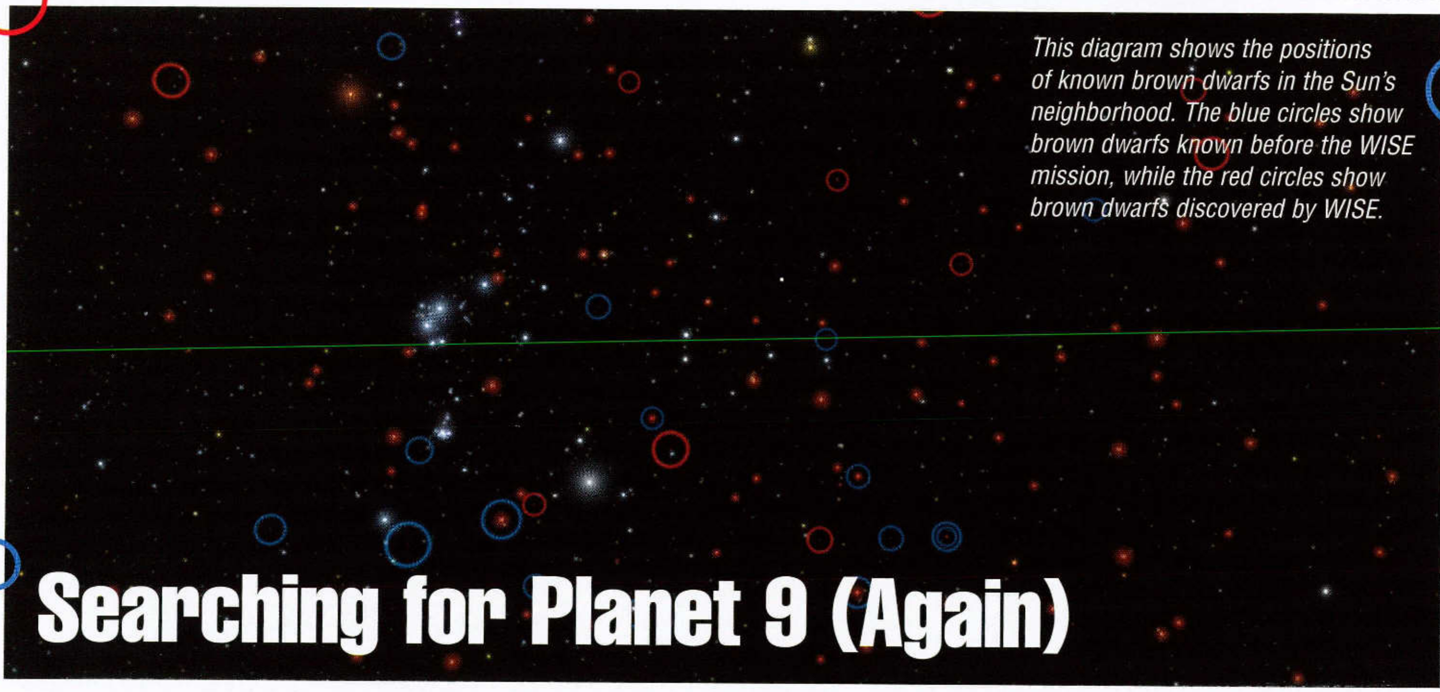
by Damond Benningfield and Rebecca Johnson

Notable Einsteinisms

For those who remember the genteel craft of writing notes, or who would like to discover it, Princeton Architectural Press has published a set of notecards that feature quotes from Albert Einstein. The set includes four quotes, with envelopes that show Einstein's equations or images of the cosmos. The new set is part of a collection of cards that features quotes from such notables as Emily Dickinson and Henry Thoreau.

12 notecards and envelopes, $14.95
www.papress.com





This diagram shows the positions of known brown dwarfs in the Sun's neighborhood. The blue circles show brown dwarfs known before the WISE mission, while the red circles show brown dwarfs discovered by WISE.

NASA/JPL/CALTECH

Searching for Planet 9 (Again)

It took Clyde Tombaugh almost a year of searching to discover the original Planet 9, known today as Pluto. He photographed patches of the sky at intervals of a few nights, then compared the pictures to see if any point of light in them moved against the background of stars.

A present-day team of astronomers is using a similar technique to search for a new Planet 9, but unlike Tombaugh, who did the job alone, the current team has help from a few friends: more than 25,000 volunteers who are examining millions of possible targets through an online project known as Backyard Worlds: Planet 9.

The motions of several objects in the Kuiper Belt, a band of chunks of ice and rock beyond the orbit of Neptune, suggest that a ninth planet could lurk billions of miles from the Sun. The planet could show up in a catalog of infrared images snapped by WISE (Wide-field Infrared Survey Explorer).

A team led by Marc Kuchner of NASA's Goddard Space Flight Center posted many of those images online for review by volunteers from the general public, who look for moving objects in short videos that consist of several images of the same region of sky. If they find any, they tag the images for review by professionals.

The project also could reveal the presence of dwarf planets in the Kuiper Belt, and brown dwarfs near the solar system. Brown dwarfs are heavier than planets, but not massive enough to ignite nuclear fusion and shine as stars. They radiate most of their feeble energy at infrared wavelengths, which makes them good targets for WISE.

The batch of images went online in February, with more scheduled for release throughout the year.

www.zooniverse.org/projects/marckuchner/backyard-worlds-planet-9

THE ALIEN AMBASSADOR

How would the world respond to contact from an alien civilization? The United Nations has some ideas

THE SETUP

In his new book *The Aliens Are Coming!*, physicist-actor-comedian Ben Miller gives a smart, funny overview of the state of alien affairs on Earth today. Along the way, Miller looks into how scientists estimate the numbers of intelligent civilizations in our galaxy and what clues could signify habitability in the scores of planets found outside our solar system, and takes a skeptical look at decades of claims of UFO encounters. In this excerpt, he visits the UN's Vienna office to talk with that agency's top space scientist, whom some reporters have dubbed 'the Alien Ambassador.'

THE EXCERPT

There is something oddly futuristic about the United Nations. Though the squat Arrivals building of its Vienna offices bears more than a passing resemblance to my low-rise 1970s primary school, the enormous courtyard I step out into is unfeasibly impressive. Everything about the place should seem dated: the mountains of grey concrete; the jet fountains that strafe an enormous shallow circular pool; the towering Cold War-style flagpoles; but instead the overall effect is of vertiginous progress. The trappings may all be mid-twentieth century, but the very existence of a super league of sovereign nations, united in the common interest of mankind, still seems like pure science fiction.

And it's this unique position in the world of human affairs that interests me today, because it's been widely reported in the British press that thanks to the recent discoveries of Earthlike planets by the Kepler Space Telescope—and the possibility that they might harbor intelligent life that we can make radio contact with—the UN is appointing a spokesperson for the human race. The "Ambassador for Earth" has been named by no less a newspaper than the UK's *Sunday Times* as one Dr. Mazlan Othman of the United Nations Office for Outer Space Affairs (ONOOSA), and I have an appointment to meet her for lunch.

Yet as I mount the stairs to Dr. Othman's office, the strong scientific imperative for my visit suddenly evaporates. This is the opposite of "l'esprit d'escalier," a phrase nonexistent in French but which we English take to mean the inspiration which strikes as soon as an encounter is over and we are heading down the stairs on our way home. The more floors I climb, the drier my mouth gets and the sweatier my brow becomes, until all confidence in my mission has completely drained away.

In the world of extraterrestrial intelligence, this discomfort is commonplace, and is known simply as "the giggle factor." For some reason, when talking about the very real, scientifically sound possibility of communicating with aliens, everyone gets the urge to laugh. And here, where national flags flutter at the top of impossibly tall flagpoles, and where international diplomats negotiate the gravest of choices while pursuing the loftiest of ambitions, what on Earth do I think I'm doing asking the UN's head space executive about flying saucers?

It doesn't help that Dr. Othman has an extremely impressive CV. Malaysian by birth and an astrophysicist by training, in the early noughties she spearheaded the Malaysian space program, ANGKASA, and built a space observatory on the island of Langkawi, launched a remote-sensing satellite, *RazakSAT*, in the world's first near-equatorial Low Earth Orbit, and oversaw the launch of the first Malaysian astronaut to the International Space Station in 2007. Since then, she has served as Director of ONOOSA, and was appointed Deputy Director-General of the United Nations Vienna Office in 2009.

I needn't have worried. Once I have sweated and spluttered my way past her secretary in a manner even Hugh Grant would think was exaggerating, Dr. Othman greets me warmly, blaming the layout of the UN rather than my terrible sense of direction, and is disarmingly relaxed and informal. She leads me through to her office, a bright and breezy affair with a spectacular view across the Danube toward the Old City. Her desk sits in the far corner, half obscured by a jungle of luscious potted plants and, to my right, a sideboard displays glittering scale models of satellites and space stations.

We sit, and I do my best to try and convince her that I am not a crazy person, that I know my stuff about science, and that, while I think the evidence for UFOs is feeble, I am very interested in the possibility that there is intelligent, communicable life on other planets. I state my belief that biology is as universal as chemistry and physics, and the recent discoveries of the Kepler Space Telescope have shown us plenty of places where that biology might get a chance to do its thing. In short, I do everything I can to try and reassure her that I am an emotionally well-balanced, scientifically literate individual with a passion for astrobiology. And, in doing so, I am pretty sure I come across as a crazy person.

When I finally pause for breath, I see that the Director of the United Nations Office for Outer Space Affairs has a twinkle in her eye. "Come on," she says. "Say it. You want to talk about aliens." …

The Restaurant at the Beginning of the Universe

As we walk to lunch Mazlan tells me how the media came to refer to her as the Alien Ambassador. "I was due to give a talk at a Royal Society conference about extraterrestrial life. I was going to say that if we do receive signals, the United Nations is the best way to coordinate a response." …

"So there's nothing in it?" I ask. She smiles, and we continue our walk. "A journalist called after the story first broke. She asked me, 'Are you the alien ambassador?' I said, 'I have to deny it. But it sounds pretty cool.'"

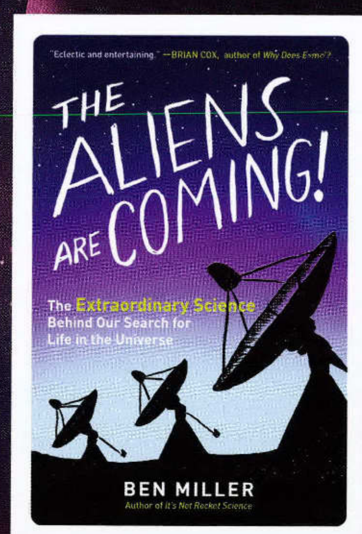
When it comes to messaging aliens, of course, the UN has got form. … [I]t's Secretary-General Kurt Waldheim's voice that opens *Voyager's* Golden Record, and I think I know an audition speech when I hear one. The way things are going, very soon the people of Earth are going to need someone to speak on their behalf. Isn't this the role the UN was born to play? Someone must have thought this through. If the aliens call, surely somewhere among all those reports and resolutions there has to be a protocol? Dr. Othman laughs. "Here at the UN, we simply serve. We don't create protocols unless we are mandated to by our member states."

Suddenly it hits me. There's only one thing worse than the aliens talking to the UN, and that's them talking to just about anyone else. After all, we kind of know how this goes. In 1996, when American scientists in Antarctica thought they had found fossilized bacteria in a Mars meteorite, the first the rest of the world knew about it was when President Clinton announced it on TV. We need to keep politicians out of it; they'll just hog all the glory. The last thing any of us wants to see is a humanoid alien on the White House lawn, hand in hand with Donald Trump.

It's time to put Dr. Othman on the spot. What if an alien ship lands tomorrow? I wince, expecting her to tell me not to be so silly. To my great surprise, she hardly breaks stride.

"It depends where they land. If they land in Mali, they will be the provenance of Mali."

"Really? But what about the UN?"



The Aliens Are Coming!
The Extraordinary Science Behind Our Search for Life in the Universe
By Ben Miller; 2016

"If the government of Mali requested that we became involved, we would get involved."

"And if they did make that request?"

"Then we would need to get it verified. We could help assemble a team of scientists, and assist in obtaining visas, but that could take a couple of months."

"But SETI have a protocol, don't they, for what happens if a ship lands?"

"There's a SETI protocol, sure. But it has never been adopted [by the UN]. There has never even been a debate." …

Follow the Methane

Mazlan Othman and I have finished our lunch. In fact, we've been talking so long that the waitresses are wondering whether to offer us another meal. We've somehow got on to the topic of what a highly evolved species might look like, and whether they would even be interested in the physical universe at all. As Mazlan puts it, why go to the trouble of building a spaceship to visit new worlds when you can just build virtual ones? That's one answer to the Fermi Paradox: The aliens aren't here because they are playing nine-dimensional *Tetris*.

The dream of SETI is to receive an extraterrestrial message that we can understand and respond to. But would it ever really be possible to communicate with species much more evolved than our own? "You and I need this," says Mazlan, knocking on the tabletop. "We rely on the physical world for our existence. When I no longer have need of the material world, what am I? Maybe the purest form that a being can take is energy."

I start to worry that someone might overhear us and call security. Isn't she worried that this kind of loose talk is somehow, you know, unprofessional? "I think it's a missed opportunity when people don't want to talk about aliens. I want to hear what people believe. If it engages people, draws them in, then what have you got to lose? Because then we can ask ourselves, 'what's true?' And then the discussion becomes meaningful."

GENIUS IN TRAINING

Enrico Fermi possessed one of the twentieth century's greatest minds, but in the 1920s he was a struggling young physicist from a scientific backwater

THE SETUP

In their new biography *The Pope of Physics: Enrico Fermi and the Birth of the Atomic Age*, Gino Segré and Bettina Hoerlin trace the Nobel Prize-winning Italian physicist's route from rural Italy, to various parts of Europe, and eventually his emigration to America. Both an experimentalist and a theorist — a rare combination — Fermi worked on everything from the Manhattan Project to cosmic rays to early computers. This excerpt chronicles his efforts to make his way into the circles of the exciting work being done in the new quantum physics of the 1920s, an era when Italy was not known as a physics powerhouse.

THE EXCERPT

After four years at the Scuola Normale, Fermi received a magna cum laude doctorate in physics in July 1922. The oral defense of his thesis was anticlimactic; some of the eleven examiners in black academic robes and square hats were repressing yawns. None of them shook hands with him or offered congratulations, as was the custom. For them, his presentation was too erudite.

Afterward, Fermi returned to Rome. In spite of his brilliance, he had no obvious prospect for employment. Lacking a mentor, he found himself stymied. A very real danger loomed that university-based Italian physicists would not recognize his contributions to the nascent field of theoretical physics, and that mathematicians would not regard him as one of their own. Who, then, would be his advocate?

The prescribed path for entering academic life in Italy was first a position as assistant to a professor and then a *libera docenza*, the qualifying title for being a teacher. After sufficient time passed, one entered a competition for a professorship. This meant presenting your publications to a panel of five professors chosen by the Ministry of Education, since universities were state institutions. The professors would make the appointment after scrutinizing the merits of all candidates.

Given the system, appointments often involved favoritism. In addition, even if lucky enough to become a professor, one initially was almost always assigned to a minor university. After a few years, one might be able to transfer to a major center such as Turin, Bologna, or Padua and eventually maybe even to Rome.

Fermi was lucky; an influential patron recognized his astonishing talent. Moreover, this man, Orso Mario Corbino, was connected politically as well as being extraordinarily astute. ... In 1920 he became a Senator of the Kingdom, a lifetime selection made by the king, and in 1921 he was named minister of public education. ...

These notable appointments, political and administrative, coexisted with the retention of [Corbino's] physics professorship.

More than any other senior physicist in Italy, Corbino was aware of the extraordinary advances taking place in quantum physics and was distressed to see that nobody in Italy participated in them. Serendipitously, Fermi appeared in Corbino's office, unsure of how much time the illustrious senator would have for a new university graduate. This shrewd judge of talent detected the young man's promise and saw him as the answer to his dream of Italy as a serious contributor to modern physics.

Thus began a close relationship that would last until Corbino's early death from a heart attack in 1937. During these fifteen years, the older man would advise Fermi on both professional and personal matters while constantly smoothing the way for the growing and increasingly successful research group Fermi led. Though not a participant, Corbino took pride in the group's achievements and made sure he was aware of their progress on almost a daily basis.

But the first thing Corbino did for Fermi was to ensure for him a stay in a great research center in northern Europe. Sensing that his young protégé needed to be challenged, Corbino wanted Fermi to meet others who might be his equals. The Ministry of Public Education offered a yearly scholarship for study outside Italy to a recent university graduate in the sciences. Not surprisingly, the selection committee that included Corbino unanimously chose Fermi as its 1923 recipient.

Germany, then the world leader in science, was Fermi's destination in January of that year. Language difficulties were not a problem, for his grasp of German was excellent—though still more at a reading rather than conversational level. He even had written his childhood friend Persico an occasional letter in German, signing off as Heinrich Fermi.

Two schools of theoretical physics had emerged in Germany as training grounds for young physicists during the early 1920s, both concentrating on atomic physics. They were where Fermi was most likely to find his peers. One was in Göttingen. Its university had been a world center of mathematics for over a century, and now, with Max Born at the helm, it was also a world center of theoretical physics. Arnold Sommerfeld, whose *Atombau und Spektralinien* was the bible for atomic phenomena, had made Munich the second mecca.

Fermi decided to use his scholarship in Göttingen. Curiously enough, his stay there was neither especially happy nor productive. Although Fermi was not treated badly during his eight months in Göttingen, there is no indication of his having been perceived as especially promising or of his having formed any connection with Werner Heisenberg, his contemporary and a rising star there.

Fermi was surely made conscious of the low esteem in which German physicists held physics research in Italy. According to a close colleague, Fermi had felt the Germans "were very conscious of their capacity, of their preparation, of their ability. All others were coming to learn from them. And it was true. But they tried to make a point of this, to stress the point." This bothered the proud young man.

The lonely twenty-two-year-old Fermi wrote Persico with some irony about Göttingen, including a comical sketch of the German perception of atomic scattering and a portrait of a prototypical Göttingen woman physicist. Both were uncomplimentary. He assured Persico that given the woman's looks, there was no danger of his being summoned as best man for a wedding.

Both the foci and the ethos of Göttingen physics were unappealing to Fermi. He always pursued a physical picture rather than the mathematical formalism prevalent in Göttingen. In this respect, it's interesting to compare Fermi to three other budding theoretical physics geniuses who were his contemporaries. Unlike Fermi's, the talent of those three was immediately recognized in Göttingen. In addition to Heisenberg (b. 1901), there were Wolfgang Pauli (b. 1900) and Paul Dirac (b. 1902).

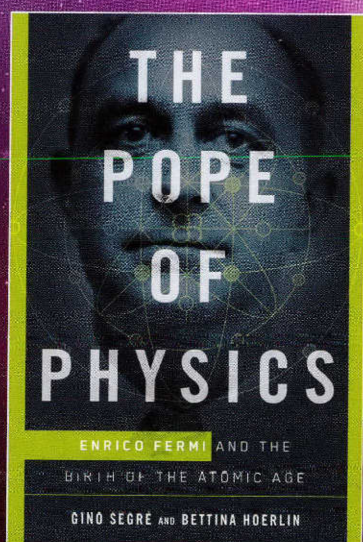
By 1930, all four prodigies had done Nobel Prize-caliber work, were established professors, and were attracting younger physicists from around the world to their respective centers in Leipzig, Zurich, Cambridge, and of course Rome. The four often worked on similar problems, and sometimes even on the same ones, but in markedly dissimilar ways. Each had a characteristic style, a reflection of his personal strengths and predilections. It may seem strange that style plays such an important role in theoretical physics, since science's results are often portrayed in an impersonal manner. But human passions and special abilities shape its achievements as much as they do in other endeavors.

Pauli and Heisenberg had been Sommerfeld's students together in Munich and in successive years were assistants of Born's in Göttingen. Dirac had been educated at Cambridge, hardly the physics backwater that Italy was. Unlike the other three, Fermi was self-taught. In addition, Fermi considered himself an experimentalist as well as a theorist, combining action with concepts.

The three others, in contrast to Fermi, were exclusively grounded in theory. Dirac wanted mathematical elegance and beauty to be his guide. He was known for his quirkiness, often brusquely answering questions with "Yes" or "No" or "That is not a question." Heisenberg almost failed his doctorate exam because he enraged the committee's experimental physicist by being unable to explain how a storage battery worked. As for Pauli, he prided himself on the so-called Pauli Effect, which said that a key piece of machinery would always break when he entered the room.

One cannot imagine any of these stories being told about Fermi. He operated easily in both the theoretical and experimental spheres. Years later, when asked how he had entered the experimental field, he laughed and said, "I could never learn to stay in bed late enough in the morning to be a theoretical physicist."

While effectively bridging experiment and theory, Fermi also had his limits. He would not make the intellectual leaps that Heisenberg became known for or formulate one of Dirac's aesthetic mathematical marvels. Nor was he as famously critical as Pauli. But nobody could grasp all the interconnected aspects of a problem and reach a conclusion the way he could, nobody was able to significantly probe as many areas of physics as he was, and nobody could estimate orders of magnitude of physical phenomena as surely and as quickly as he could.

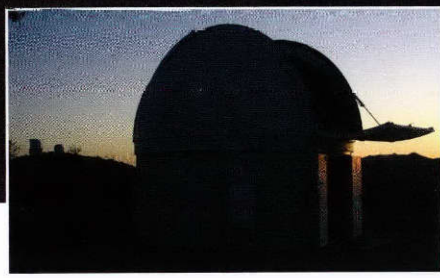


The Pope of Physics
Enrico Fermi and the Birth of the Atomic Age
By Gino Segrè and Bettina Hoerlin; 2016

by Damond Benningfield and Rebecca Johnson

ESA/HUBBLE/NASA

The supernova project will learn about stars like SBW1, which is likely to end its life as a supernova, perhaps within years. The star is blowing big bubbles of gas, much like the star that became Supernova 1987A. Inset: the Las Cumbres telescope at McDonald Observatory.



DLPETRY/WIKIPEDIA

Spying on Exploding Stars

New initiative will track hundreds of supernovae

A project that begins in May will allow astronomers to compile extensive dossiers on hundreds of supernovae, providing a better picture of how these stars work, how they interact with their surroundings, and how they seed the cosmos with chemical elements. "The bottom line is, we hope to get a much greater understanding of the stars that become supernovae," says Andrew Howell, leader of the Global Supernova Project (GSP), a collaboration of about 150 astronomers and 30 telescopes around the world.

A supernova is the catastrophic explosion of a star, either a massive star that can no longer produce nuclear reactions in its core, or a small stellar corpse that stole gas from a companion star, triggering a runaway thermonuclear explosion. Massive stars may leave behind a neutron star or a black hole remnant, while the smaller stars are completely destroyed.

Supernovae are of special interest because they create and distribute many of the chemical elements, which can be incorporated into new stars, planets, and perhaps living organisms. "Carl Sagan said that we are all starstuff, but I say we're also supernova stuff," says Howell, an astronomer with the Las Cumbres Observatory and University of California, Santa Barbara. Supernovae also influence the formation of other stars and serve as markers that allow astronomers to measure the distances to other galaxies. "Understanding supernovae improves our knowledge of many areas of astrophysics," Howell says.

GSP will use the Las Cumbres Telescope network, which consists of 18 telescopes of 0.4, 1, and 2 meters (16, 40, and 80 inches) distributed around the world (including a one-meter instrument at McDonald Observatory). Another dozen or so telescopes, on the ground and in space, also will join the project. "We have so many telescopes, with so much time, we can do things other people can't," says Howell. "We can look at many supernovae at once, for example. It's always dark somewhere, so we can see a supernova within minutes of its discovery, and get observations every few hours."

Early discovery and continuous observations are important because a supernova changes quickly. The first hours and days after an explosion reveal details about the exploding star, such as its composition and its structure. But the chemical signatures from some expelled materials fade quickly, and the radioactive decay of some elements soon overwhelms the light from the supernova debris.

GSP isn't designed to discover new supernovae, but to study them in detail. It will rely on other telescopes, such as the Swift X-ray satellite, to notify it of new discoveries. Project scientists will then signal the network to begin studying a new supernova. Howell expects it to scrutinize about 600 stars during its three-year run.

This is a follow-up to the Las Cumbres Observatory Supernova Key Project, which began in May 2014 and ended in April. That project, which included fewer telescopes and astronomers, followed more than 400 supernovae, Howell says.

The combination of the two projects will yield an extensive database that astronomers can mine for details on the exploding stars. "When I was a graduate student, finding any supernova was a big deal," Howell says. "Now, we can start to ask questions about how they work. Are supernovae in low-mass galaxies different from those in high-mass galaxies? What about those in elliptical versus spiral galaxies? And we'll discover new types of supernovae — things that are one in a few hundred, we'll start to see those. And I'm very sure we'll find a lot more surprises."

DB

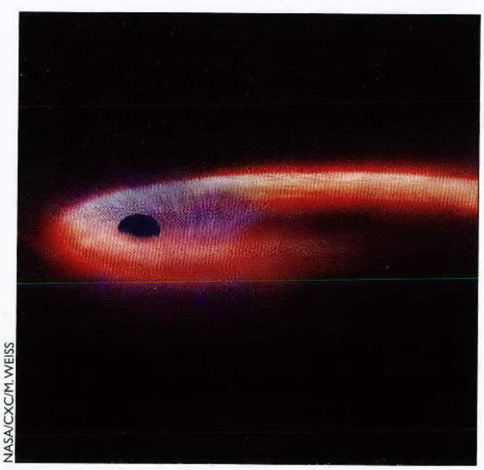
Colliding Galaxies Shred Stars

If a star ventures too close to the black hole at the center of its galactic home, it can be ripped apart by gravitational forces. Astronomers call this a tidal disruption event, or TDE. Until recently, TDEs were considered to be quite rare, happening only once every 10,000 or 100,000 years in a galaxy. A new study found that these events happen 100 times more frequently.

A group of astronomers at the University of Sheffield was studying a small sample of galaxies that are undergoing collisions. Comparing studies of 15 colliding galaxies from 2005 to studies of the same galaxies in 2015, they turned up evidence of a TDE in a galaxy during that decade.

"Our surprising findings show that the rate of TDEs dramatically increases when galaxies collide," said James Mullaney, co-author of the study. "This is likely due to the fact that the collisions lead to large numbers of stars being forced close to the central supermassive black holes in the two galaxies as they merge together."

The study's leader, Clive Tadhunter, predicts that this means violent events are in store for our galaxy in the future. "We expect that TDE events will become common in our own Milky Way galaxy when it eventually merges with the neighboring Andromeda galaxy in about five billion years," he said. "Looking towards the center of the Milky Way at the time of the merger, we'd see a flare approximately every 10 to 100 years. The flares would be visible to the naked eye and appear much brighter than any other star or planet in the night sky." **RJ**

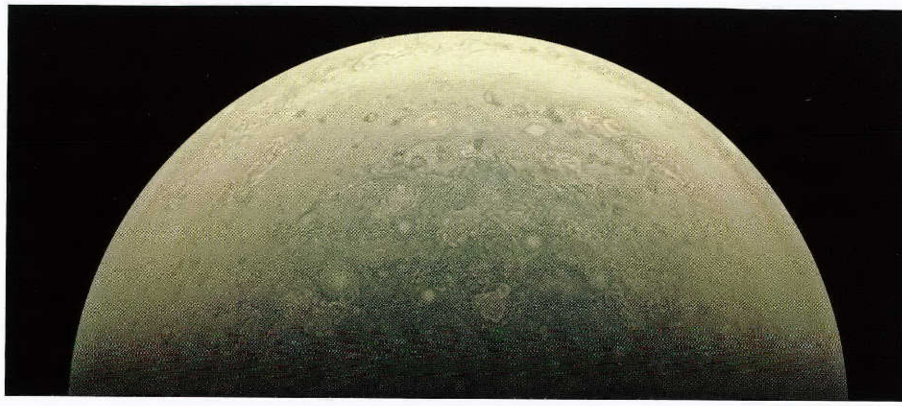


NASA/CXC/M.WEISS

Artist's concept of a star being shredded by a black hole

Staying Away

Juno, NASA's latest mission to Jupiter, won't dip closer to the giant planet as planned because of a problem with its main rocket engine. Juno, which arrived at Jupiter in July, is orbiting the planet once every 53 days, measuring its magnetic and gravitational fields to probe its interior. It's also snapping pictures of the planet during each of its closest approaches, showing details in its atmosphere (below: storms swirl through the atmosphere). Juno was scheduled to drop to a 14-day orbit late last year, but balky valves forced a postponement of the planned engine firing. In February, mission managers decided to abandon any further attempts to fire the engine, leaving Juno in the higher orbit. The lower orbit was designed to provide more precise measurements of the planet, giving planetary scientists a better look at Jupiter's interior structure and composition. Juno's primary mission will end in July 2018.



NASA/SWRI/MSSS/DON DAVIS

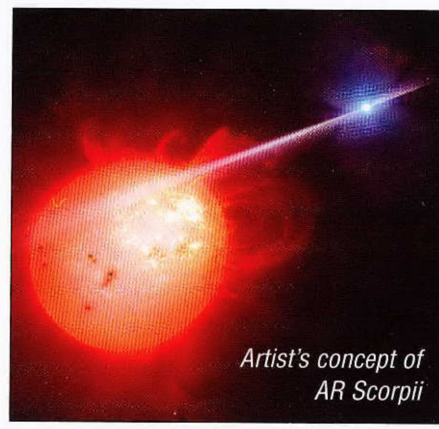
Astronomers Bag Exotic Quarry

An exotic new kind of star, theorized for decades, has been found: a white dwarf pulsar. White dwarfs are the leftover cores of mid-sized stars that have blown off their atmospheres into space. No longer undergoing nuclear fusion, they spend the rest of their lives cooling down.

Pulsars are completely different. They are neutron stars that are the remains of massive stars that exploded as supernovae. They are superdense, spinning stars that are giving off beams of light as they rotate, like a lighthouse.

A white dwarf pulsar is a white dwarf that gives off a beam of radiation like a traditional pulsar.

A group of astronomers, including Tom Marsh and Boris Gansicke of the University of Warwick and David Buckley of the South African Astronomical Observatory, has identified the first white dwarf pulsar as part of a binary star 380 light-years away called AR Scorpii. The white dwarf pulsar's partner is a cool red dwarf star.



Artist's concept of AR Scorpii

M. GARLICK/UNIVERSITY OF WARWICK/ESA/HUBBLE

"AR Sco is like a gigantic dynamo: a magnet, size of the Earth, with a field that is about 10,000 times stronger than any field we can produce in a laboratory, and it is rotating every two minutes," Gansicke said. "This generates an enormous electric current in the companion star, which then produces the variations in the light we detect."

The two stars are separated by a million miles (1.6 million km), about four times the Earth-Moon distance. They orbit each other every 3.6 hours. **RJ**

Aeolis Mons rises from the floor of Gale Crater in this mosaic of Curiosity rover images.

Sculpting a Martian Mountain

An old line says that a good sculptor starts with a block of marble and simply chips away everything that doesn't look like the intended subject. The winds of Mars appear to have followed that same rule. They started with a sediment-filled crater, then blew away everything that didn't look like a mountain, leaving a peak that's more than three miles high.

The Curiosity rover is ascending the flanks of that mountain, known as Aeolis Mons or Mount Sharp, which is at the center of Gale Crater. Curiosity is studying the mountain's rock layers to reveal details about Martian climate history.

Observations by both Curiosity and Mars orbiters suggest that rivers and streams filled the crater with sediments, which later were topped by wind-driven sand and dust. These layers eventually formed a thick bed of rock.

A recent study by two geologists at The University of Texas at Austin reported that since then, though, winds have been scouring sediments from inside the crater. Winds in the thin Martian atmosphere are weak, but they've been working on the excavation project for more than three billion years, the researchers say. The winds have sculpted the central mountain peak and scoured a deep moat around it.

That analysis says that a north wind was responsible for most of the work. It carved Aeolis Mons into a streamlined shape, prevented dunes from forming on the mountain's northern flank, and deposited dark sediments across thousands of square miles south of Gale Crater, the geologists say.

In recent times, however, the mountain itself has changed the crater's wind patterns, creating a more swirling pattern. Today, the winds sculpt and move sand dunes on the crater floor while continuing to bring shape to the mountain. **DB**

Water, Organics, and Volcanoes Jazz Up Ceres

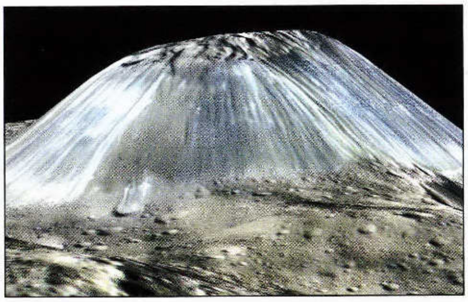
Water may have bubbled to the surface of Ceres, the largest member of the asteroid belt, as recently as four million years ago. A bed of organic material rings one of its craters. And volcanoes may have belched ice in the distant past, forming mountains that were miles high.

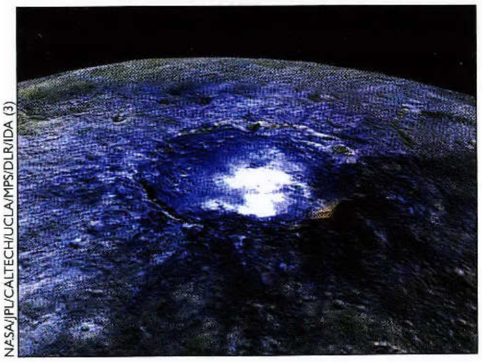
Those are among the recent discoveries of the Dawn mission, which has been orbiting Ceres since 2015. The craft was recently maneuvered to a new orbit to give it a different viewing angle on Ceres, which, at almost 600 miles in diameter, is the solar system's largest dwarf planet.

Ceres' most dramatic feature is a set of bright white spots at the bottom of Occator Crater. Dawn's instruments determined that the spots are made of salts. They likely were deposited about four million years ago, when a slurry of water, ice, and minerals percolated to the surface through cracks in the crater's floor. The water and ice quickly vaporized, leaving the minerals behind.

Dawn also detected organic materials in and around another crater. The organics, which are some of the most basic chemical building blocks of life, appear redder than the surrounding landscape in enhanced-color images of Ceres. The organics could have erupted from inside Ceres, or they could have been deposited by an impacting comet or asteroid.

Mission scientists also reported that simulations show that ice-belching volcanoes, known as cryovolcanoes, may once have been common on Ceres. Its tallest mountain, Ahuna Mons, which is 2.5 miles high, is likely made of a mixture of ice and rock. Simulations show that many such mountains could have formed over Ceres' long history. Because they are made of ice, however, they could have spread out like lumps of melting butter, eventually disappearing from sight. **DB**





NASA/JPL/CALTECH/UCLA/MPS/DLR/IDA (3)

From top: Ahuma Mons, a mountain of ice, towers above the landscape in this computer-generated view based on Dawn images. The elevation has been exaggerated by a factor of two. Organic material shines red in this enhanced-color view of Ernutet Crater, which is about 32 miles (52 km) in diameter. A false-color image compiled from Dawn images shows the bright deposits at the bottom of Occator Crater. The crater is about 60 miles (100 km) wide.

Summer Under the Stars

This summer, visit McDonald Observatory for an experience you'll never forget! We have both daytime and evening programs, as well as a gift shop and café.

During the day, enjoy safe live views of the Sun in our theater and guided tours of our large telescopes. On Tuesday, Friday, and Saturday evenings, take in amazing sights through the telescopes at our popular Star Parties, attend a constellation tour under dark night skies in our amphitheater, and more. Reservations are highly recommended; some programs sell out far in advance.

For more information, or to make reservations:

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Dark streamers of dust and bright stellar nurseries highlight this image of NGC 1055, a spiral galaxy in the constellation Cetus, the whale or sea monster. Bright red knots are regions where gas and dust clouds are collapsing to form new stars. The galaxy's disk, which we view edge-on, is slightly warped, indicating that another galaxy has passed close to NGC 1055. That interaction has pulled some of the dark dust lanes away from the plane of the galaxy.