SPECIAL ISSUE

January 2008

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TOP 10 STORIES 2007




THE YEAR'S HOTTEST STORIES! From testing Einstein's relativity, to brilliant Comet McNaught, an earthlike exoplanet, the first 3-D dark-matter map, and more. p. 28

The colliding Antennae galaxies gleam with new stars. But don't expect fireworks when the Andromeda Galaxy crashes into us.

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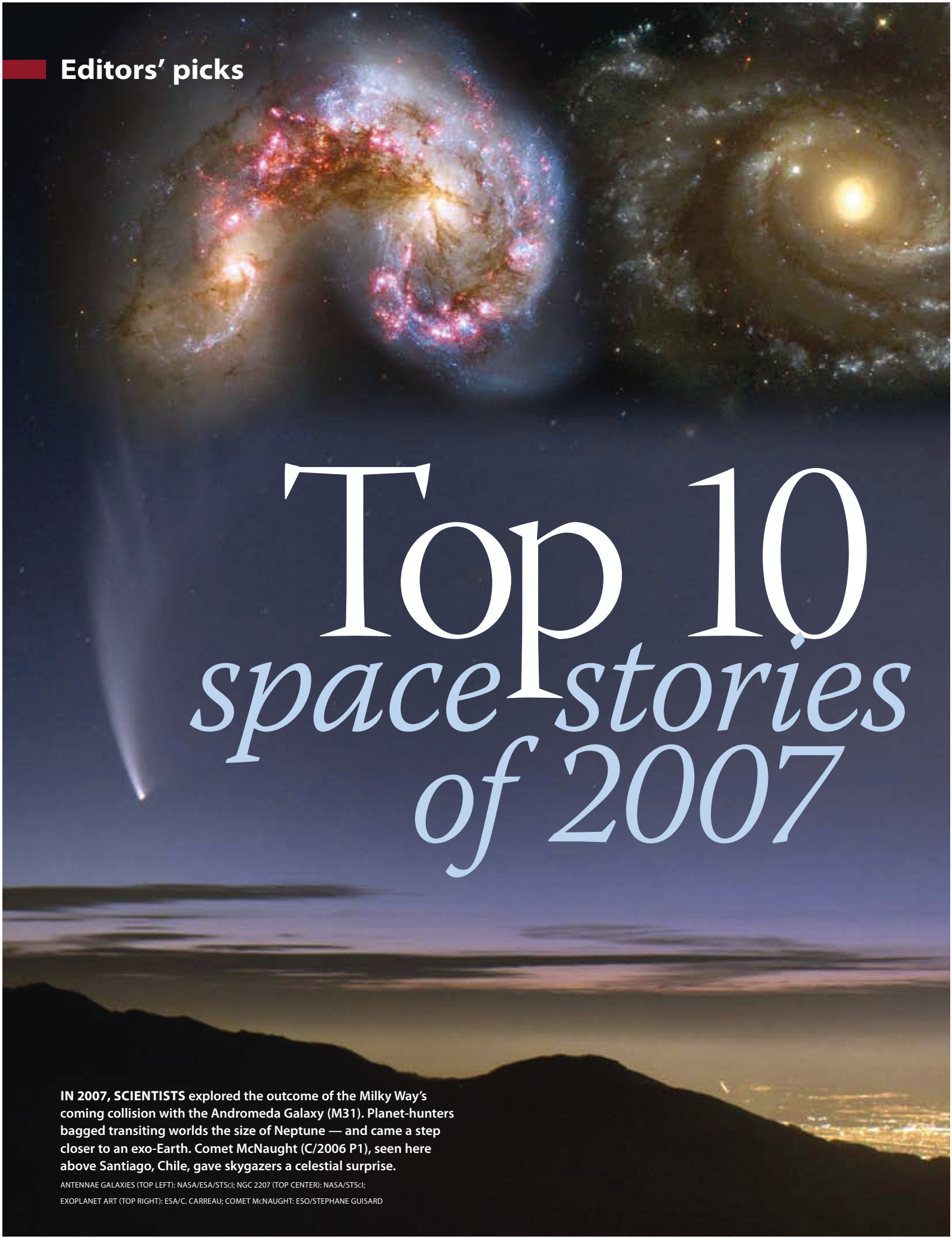
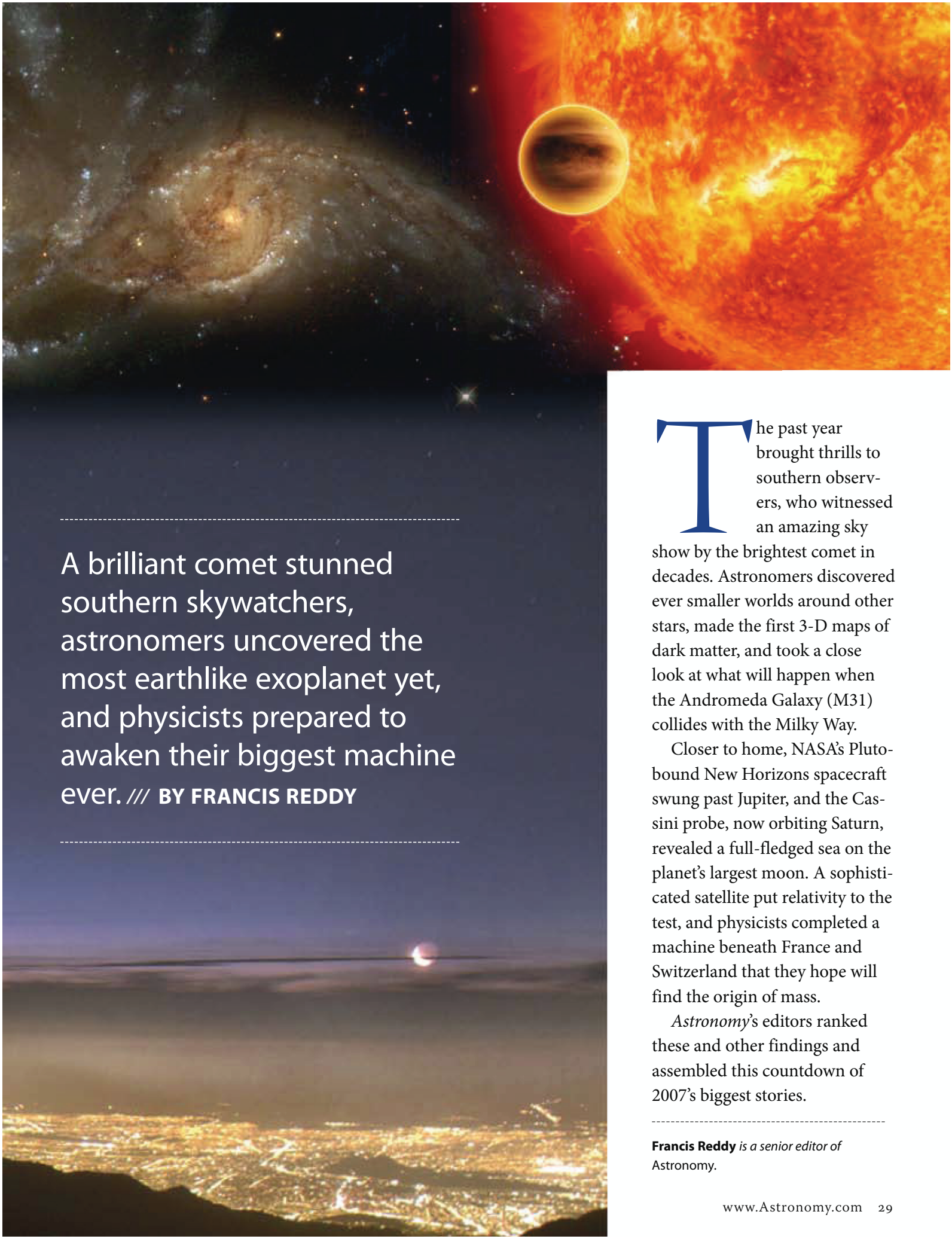


Top 10 *space stories of 2007*

IN 2007, SCIENTISTS explored the outcome of the Milky Way's coming collision with the Andromeda Galaxy (M31). Planet-hunters bagged transiting worlds the size of Neptune — and came a step closer to an exo-Earth. Comet McNaught (C/2006 P1), seen here above Santiago, Chile, gave skygazers a celestial surprise.

ANTENNAE GALAXIES (TOP LEFT): NASA/ESA/STScI; NGC 2207 (TOP CENTER): NASA/STScI; EXOPLANET ART (TOP RIGHT): ESA/C. CARREAU; COMET McNAUGHT: ESO/STEPHANE GUISARD



A brilliant comet stunned southern skywatchers, astronomers uncovered the most earthlike exoplanet yet, and physicists prepared to awaken their biggest machine ever. /// **BY FRANCIS REDDY**

The past year brought thrills to southern observers, who witnessed an amazing sky show by the brightest comet in decades. Astronomers discovered ever smaller worlds around other stars, made the first 3-D maps of dark matter, and took a close look at what will happen when the Andromeda Galaxy (M31) collides with the Milky Way.

Closer to home, NASA's Pluto-bound New Horizons spacecraft swung past Jupiter, and the Cassini probe, now orbiting Saturn, revealed a full-fledged sea on the planet's largest moon. A sophisticated satellite put relativity to the test, and physicists completed a machine beneath France and Switzerland that they hope will find the origin of mass.

Astronomy's editors ranked these and other findings and assembled this countdown of 2007's biggest stories.

Francis Reddy *is a senior editor of* Astronomy.

THE COMET shone in daylight January 14 following its closest approach to the Sun. ROB RATKOWSKI

10 Nights of the comet

Comet McNaught, the brightest comet in 42 years, took everyone by surprise. On August 7, 2006, Scottish astronomer Robert McNaught at Australia's Siding Spring Observatory imaged the 17th-magnitude comet using the 0.5-meter Uppsala Schmidt Telescope. Officially cataloged as C/2006 P1, Comet McNaught gave no hint its brief visit would be the least bit noteworthy.

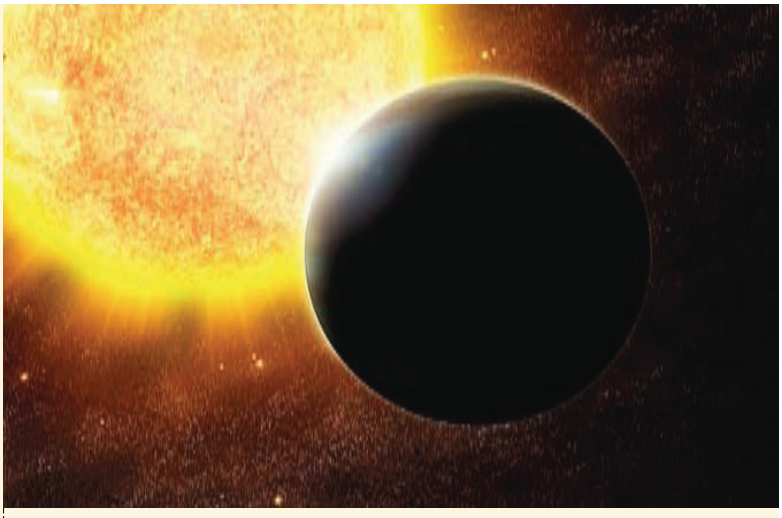
As 2007 opened and the comet neared the Sun, it brightened rapidly and put on a nice show for skywatchers in the Northern Hemisphere. By January 11, McNaught had reached magnitude –3, outshining every star and planet except Venus. Despite the comet's low altitude and the presence of bright twilight, people who just happened to be outside after sunset noticed it readily.

And it got better. On January 12, McNaught passed 15.9 million miles (25.5 million kilometers) from the Sun — less than half Mercury's distance. The next day, the comet's brightness peaked at magnitude –6, far outshining Venus. Observers who shielded the Sun from their eyes could pick out McNaught in broad daylight. The last comet so bright was 1965's Ikeya-Seki.

After swinging around the Sun, McNaught became an evening sight for Southern Hemisphere observers. By January 17, as the comet rose out of twilight, a spectacular dust tail appeared. Particles ejected by the comet's icy nucleus in the months, weeks, and days before it rounded the Sun formed a broad, striated fan at least 35° long. Even after the comet disappeared from view for northern observers, parts of this enormous tail remained visible as faint, eerie bands.

The comet faded rapidly, but remained a naked-eye sight into February. By chance, the U.S. and European Ulysses probe flew almost directly behind McNaught as the month opened. The craft spent a record 5 days sampling tail gases 160 million miles (257 million km) from the comet's icy nucleus.

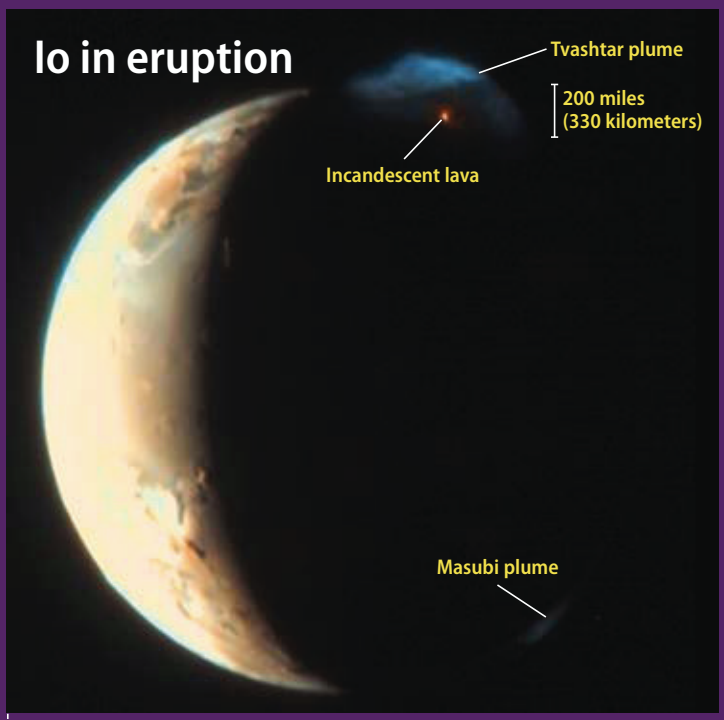
After McNaught, skygazers can only wonder when the next brilliant comet will surprise us.



ASTRONOMERS discovered the first transiting ice giant, illustrated here, orbiting the red dwarf GJ 436. The planet is about a third more massive than Neptune. ESO

9 Zeroing in on exo-Neptunes

In 2007, astronomers' tally of planets found around other stars crested 250. Exciting new finds included the smallest-known transiting exoplanet and the first Neptune-mass world found in a star's



NEW HORIZONS captured Jupiter's volcanic moon Io as no spacecraft has done. The bright orange glow of hot lava punctuates an enormous blue plume from the volcano Tvashtar. Eruption plumes from other volcanoes arc above the moon's dark limb. The spacecraft captured this image 19 hours after its February 28, 2007, closest approach, 1.4 million miles (2.3 million km) from Io. JHUAPL/SwRI

habitable zone. The surface of a planet in a star's habitable zone can retain liquid water for long periods — a minimum requirement for the development of life as we know it, say scientists.

In April, Michael Gillon at Liege University, Belgium, led a team that observed the first passage of an ice-giant planet in front of its star. Every 2.6 days, a Neptune-sized world transits the red dwarf GJ 436, 30 light-years from Earth.

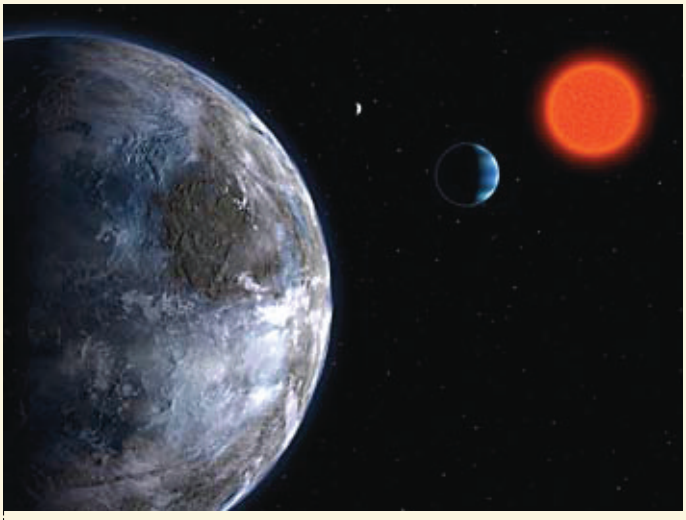
The transits allowed Gillon and his colleagues to pin down the planet's mass at 22.4 Earths, or about a third more massive than Neptune. They also let scientists compute the planet's density — twice that of water. This led planet-hunter Geoff Marcy of the University of California, Berkeley, to describe GJ 436b as a "hybrid super-Earth/Neptune." High-temperature water maintained in solid form by pressure may surround the planet's rocky core.

Planets around another red dwarf made headlines, too. In 2005, a team of Swiss, French, and Portuguese astronomers discovered a 15-Earth-mass planet around Gliese 581, 20.5 light-years away from Earth in Libra. In April 2007, the same team announced two additional lower-mass planets orbit the star.

The smaller of the two new worlds, 5-Earth-mass Gl 581c, orbits the star every 13 days — and lies within its habitable zone. That's important because if Gl 581c is a rocky, earthlike world instead of a Neptune-type ice giant, pools of liquid water could exist on its surface.

A month later, a study led by Werner von Bloh at the Potsdam Institute for Climate Impact Research in Germany demonstrated Gl 581c's orbit carries the planet too close to the star for any surface water to remain liquid.

But the scientists found the orbit of 8-Earth-mass Gl 581d actually straddles the habitable zone's outer edge. "Despite the adverse conditions on this planet, at least some primitive forms of life may be able to exist on its surface," the team concluded.



THREE PLANETS orbit the red-dwarf Gliese 581. The system, shown in this artist's conception, includes the first Neptune-like ice-giant found within a star's habitable zone. ESO

8 New Horizons encounters Jupiter

On February 28, 2007, NASA's New Horizons spacecraft flew by Jupiter. The probe captured the most detailed images of the giant planet and its moons in 4 years.

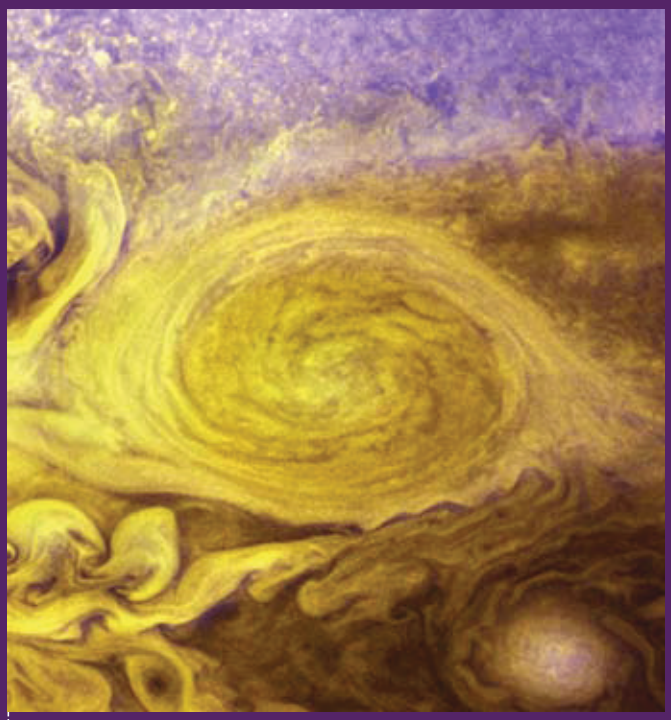
"From the first close-up look at the Little Red Spot storm, to the best views ever of Jupiter's rings, to sequences of a volcanic eruption on the jovian moon Io, we've seen some amazing things," says Hal Weaver, a mission scientist at Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.

"The data are better and richer than we ever expected," says lead researcher Alan Stern at NASA Headquarters in Washington.

New Horizons caught Io's Tvashtar volcano launching a spectacular 200-mile-high (330 kilometers) umbrella-shaped cloud. The probe's high-resolution cameras mapped Jupiter's four big moons — Io, Europa, Ganymede, and Callisto — in unprecedented detail.

After passing the planet, the spacecraft sped nearly 100 million miles (160 million km) along Jupiter's magnetotail, an ionized-gas structure the solar wind sweeps behind the planet. Measurements revealed unexpected structure and organization in this previously uncharted environment.

By the end of June, the spacecraft had beamed back enough Jupiter data to fill a DVD. But this isn't its main mission. Designed to provide the first close-up look at Pluto and its moons, New Horizons needed a 9,000-mph (14,400 km/h) speed boost from Jupiter in order to reach its target by July 2015.



JUPITER'S NEWEST RED SPOT is the second-largest storm on Jupiter. Roughly 70 percent of Earth's size, the storm began turning red in late 2005. This false-color portrait from NASA's New Horizons probe shows details as fine as 9 miles (15 km) across. That's about 10 times the resolution of the Hubble Space Telescope. JHUAPL/SwRI

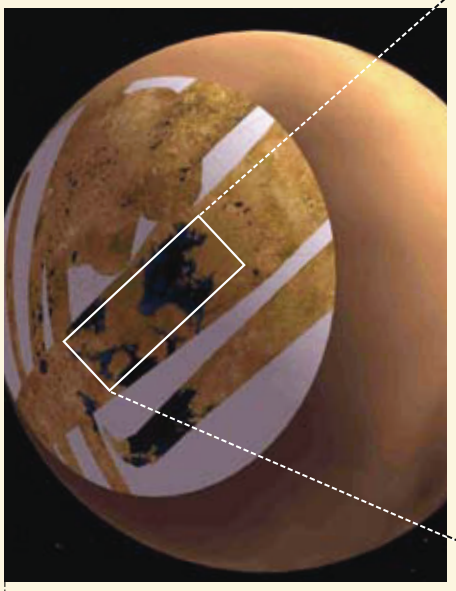
7 Cassini spies Titan's "Black Sea"

As NASA's Cassini spacecraft flew near the north pole of Saturn's largest moon February 22, its radar partially imaged a lake so big mission scientists are calling it a sea. What Cassini saw indicates this plus-sized pond takes up a greater percentage of Titan's real estate than the Black Sea does here on Earth.

The spacecraft, in orbit around Saturn since mid 2004, uses a radar beam to punch through Titan's smoggy atmosphere. The instrument has found numerous dark, smooth areas planetary scientists believe are lakes. "We've long hypothesized about oceans on Titan and now, with multiple instruments, we have a first indication of seas that dwarf the lakes seen previously," says Jonathan Lunine, a planetary scientist at the University of Arizona, Tucson.

While Cassini researchers lack definitive proof the terrain contains liquid, they find themselves increasingly comfortable with this conclusion. The surface smoothness, shore-like contours, and other properties of these features make it difficult to call them anything but lakes.

So, what are they filled with? Titan's frigid atmosphere holds much methane and ethane. Scientists expect any surface fluids will be a cocktail of these two substances.



EACH TIME Cassini sweeps over Titan, the craft's radar reveals another strip of the smoggy moon's surface. NASA/JPL/USGS

6 Welcome to Milkomeda

An oft-cited tidbit of astronomical lore is the pending collision between the Andromeda Galaxy (M31) and the Milky Way. In May, T. J. Cox and Abraham Loeb at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, presented the most detailed analysis yet of the future cosmic crash and its aftermath. The study showed the collision will happen sooner than previously thought — and may include a surprising twist for the solar system.

AT THEIR FIRST ENCOUNTER 2 billion years hence, Andromeda and the Milky Way may resemble NGC 2207 (left) and IC 2163. The interacting galaxies lie 114 million light-years away in Canis Major. NASA/HUBBLE HERITAGE (STScI)

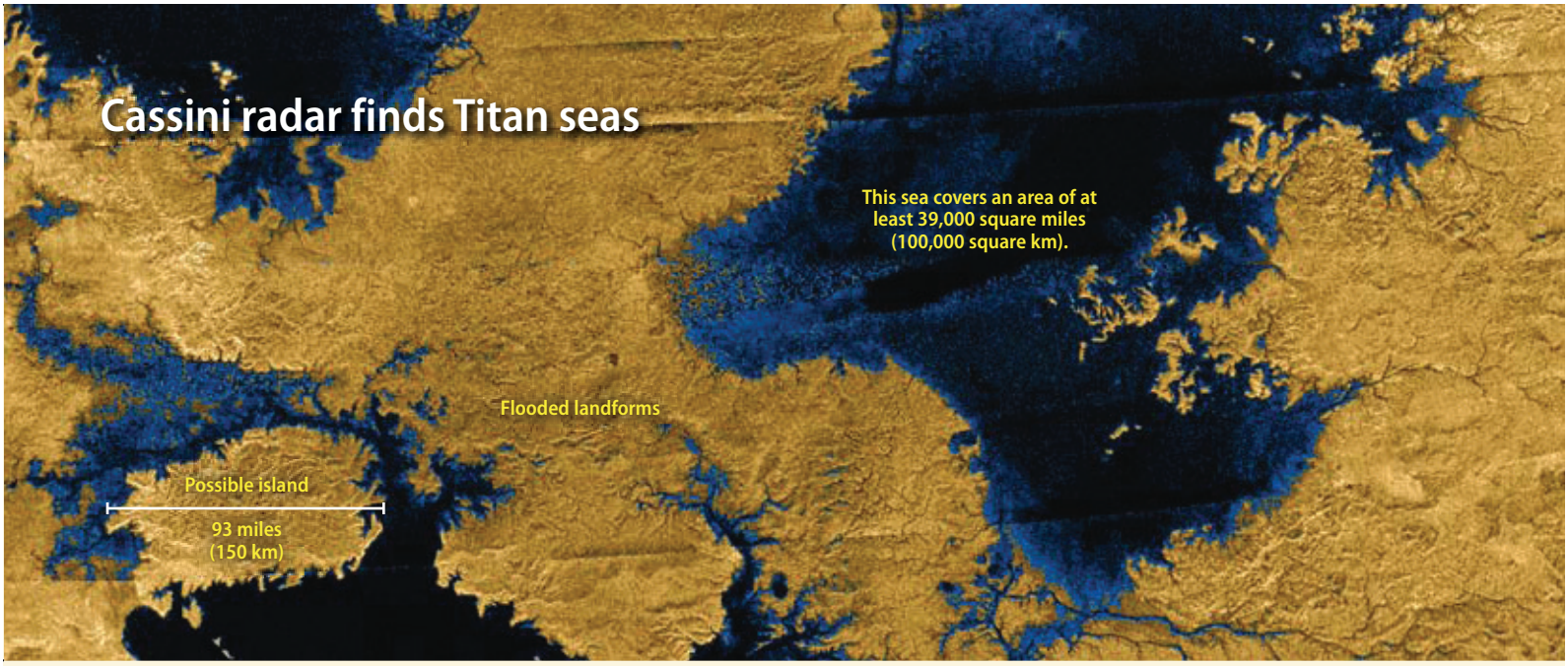
The researchers developed new computer models of both galaxies — including the gas and dark matter between them — and then simulated the crash. The two great spirals approach and pass one another multiple times before finally merging, and each interaction creates long tidal tails of stars. The merged object, which Loeb dubbed Milkomeda, undergoes only a modest increase in star formation. By the time the merger is complete, both galaxies will have used up most of their available gas quiescently making stars.

The most surprising aspect, say the researchers, is that the merger will take place within 5 billion years — before the Sun will burn out. The first pass will occur only 2 billion years from now, at least a billion years earlier than previous estimates. Intergalactic material and the galaxies' dark-matter halos sap much of the galaxies' orbital energy, which results in an earlier collision.

Another surprise was the solar system's fate. The astronomers compute a 10-percent chance the collision will sweep the Sun, its planets safely in tow, into one of those tidal streamers during the galaxies' first encounter. The next time around, there's a 50-50 chance the solar system will be cast out.

One unexpected possibility: The Sun could switch galaxies and become bound to M31 before the merger. "In effect, Andromeda will capture the Sun, and future astronomers in the solar system might see the Milky Way as an external galaxy in the night sky," Loeb muses. An exciting outcome, certainly, but the astronomers emphasize it's also an unlikely one. They compute only a 2.7-percent chance M31 will steal the solar system.

"The motivation for the study came from work I did in 2001 about the observational implications of living in an accelerating universe," Loeb explains. In the future, all distant galaxies will accelerate away from us, eventually reach the speed of light relative to us, and then fade from our view. Andromeda is the only massive galaxy that will remain bound to the Milky Way. "If you want to do extragalactic astronomy," Loeb jokes, "you'd better do it now."



CASSINI'S IMAGING RADAR scanned Titan's surface February 22. Brightness indicates rougher terrain. Bright, jutting shorelines suggest eroded and flooded landforms, and an island as large as Hawaii's Big Island appears in one lake. The largest lake, at far right, wasn't completely imaged. But what Cassini saw covers a greater fraction of Titan's surface than the Black Sea does on Earth. NASA/JPL/USGS

5 A stellar fossil uncovered

HE 1523–0901, an 11th-magnitude red giant, turns out to be one of the oldest stars known: 13.2 billion years. This means HE 1523–0901 formed about 500 million years after the Big Bang.

Studies of the cosmic microwave background indicate the universe's first stars fired up about 400 million years after the Big Bang. Astronomers think these stars were extremely massive, tipping the scales at hundreds of Suns.

"The lifetime of the very first stars was rather short — a few hundred million years," says Anna Frebel at McDonald Observatory in Texas. At the ends of their lives, these stars exploded as supernovae and seeded the cosmos with new elements. Carbon and iron, so important for planets and life today, simply didn't exist in the universe until then.

To learn about the first stars, Frebel and her colleagues seek out the Milky Way's oldest stars, those with the smallest proportions of iron. That's where HE 1523–0901 comes in. The iron-poor star also contains the greatest amount of radioactive uranium ever found. "Very few stars display radioactive elements," Frebel says. "I'm looking at a rare subgroup of these already rare stars."

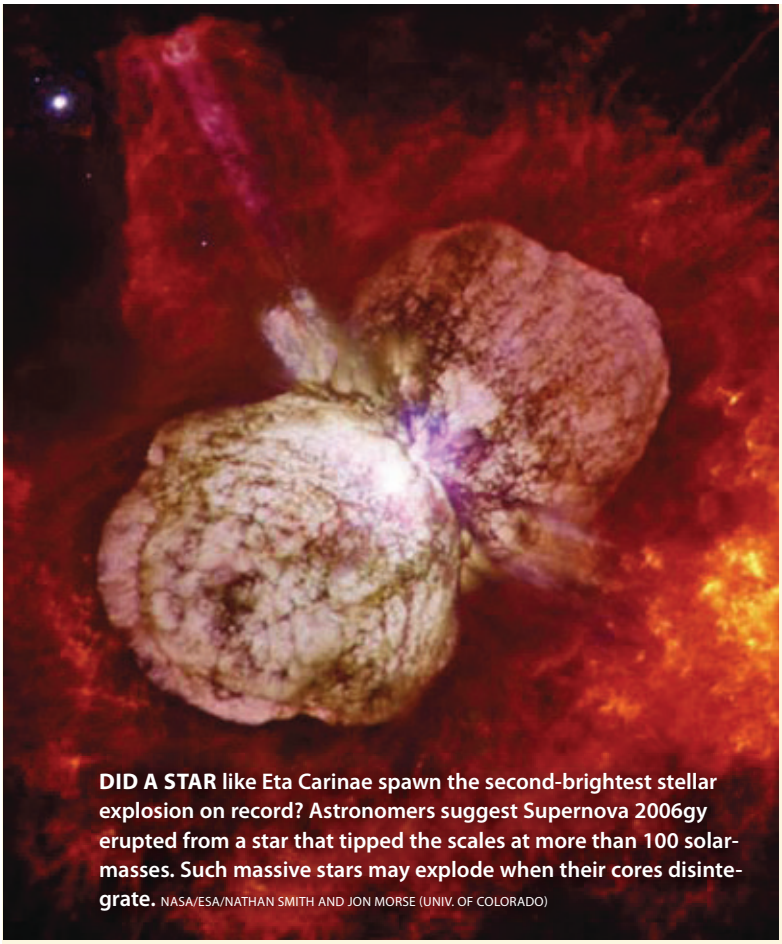
Because uranium decays over time, it serves as a natural timekeeper. Better yet, the spectrum of Frebel's uranium star shows other natural "clocks" — thorium, osmium, iridium, and europium. "We can now use several different ratios of different elements, not just one as in the past for a few other stars," explains Frebel. It's this fact that makes her findings so certain.

Theorists provide a starting point by estimating how much of these "clock" elements the first stars produced. HE 1523–0901 and stars like it will help astronomers get a handle on how hot and massive those short-lived first stars were.

Studying these ancient stars also helps constrain state-of-the-art simulations of the early universe. "Only now are computers getting powerful enough to carry out big simulations," says Frebel. "But the results need to be compared with observations, and the old stars I'm working on are the perfect pieces to the puzzle."

When HE 1523–0901 lit its nuclear fires, the Sun's birth lay 9 billion years in the future. Is it fair to take a bit of poetic license and call this star a witness to the birth of our galaxy? "Well," Frebel says, smiling, "I guess that isn't so far from the truth."

HE 1523–0901, ILLUSTRATED HERE, is one of the oldest stars known. The 0.8-solar-mass red giant lies 7,500 light-years away in Libra. Astronomers determined the star's 13.2-billion-year age thanks to a rare combination of "cosmic clock" elements. ESO



DID A STAR like Eta Carinae spawn the second-brightest stellar explosion on record? Astronomers suggest Supernova 2006gy erupted from a star that tipped the scales at more than 100 solar-masses. Such massive stars may explode when their cores disintegrate. NASA/ESA/NATHAN SMITH AND JON MORSE (UNIV. OF COLORADO)

4 A tale of two supernovae

In May 2007, a team of astronomers led by Nathan Smith at the University of California, Berkeley, crowned Supernova 2006gy the most luminous supernova on record. But the reign of this "supernova king" lasted only until October. That's when Robert Quimby at the University of Texas in Austin and his colleagues announced an earlier, even brighter blast.

Quimby heads the Texas Supernova Search project, which discovered both events. The search caught Supernova 2006gy on the rise September 18, 2006, near the core of galaxy NGC 1260, some 238 million light-years away. With a peak luminosity of 50 billion Suns, 2006gy was 10 times brighter than the average type Ia supernova and 100 times brighter than a representative type II.

But in October 2007, following a lengthy analysis, Quimby's team announced an earlier event, named 2005ap, actually shone roughly 2 times brighter than 2006gy.

Explaining either of these superbright supernovae is a challenge. Smith's team thinks 2006gy could be the first case of a supernova triggered by a theoretical process first described 40 years ago: pair instability. A star with more than 100 times the

3 The first 3-D map of dark matter

In January 2007, an international team of astronomers presented the first three-dimensional map of dark matter. The project, called the Cosmic Evolution Survey (COSMOS), is the largest ever undertaken with the Hubble Space Telescope.

Dark matter — a substance known only through its gravitational effects on normal matter, like stars, planets, and galaxies — accounts for most of the universe's mass. "For the first time, we've been able to map out this invisible and mysterious dark matter," says Caltech's Richard Massey, who headed the Hubble side of the research team.

Using the space telescope's Advanced Camera for Surveys, astronomers acquired 575 images covering a 2-square-degree patch in Sextans. "This is 9 times larger than any previous Hubble survey," notes Nick Scoville, also at Caltech, who led the overall project. The milestone study required nearly 1,000 hours of Hubble time over 2 years.

The project also needed 400 hours of observations with the European Space Agency's XMM-Newton X-ray satellite. XMM-Newton mapped hot, X-ray-emitting gas in galaxy clusters within the survey region. The gas makes up about 4 times the stellar mass in these clusters. The European Southern Observatory's Very Large Telescope in Chile and the Canada-France-Hawaii, Subaru, and Keck telescopes in Hawaii provided color information that allowed the astronomers to determine the galaxies' distances.

But the Hubble images allowed the team to glimpse weak gravitational lensing — distortions in the shapes of background galaxies caused by the light-bending gravity of intervening dark matter. The result is a 1- to 2-percent distortion of each galaxy's shape.

"We understand statistically what those galaxies are supposed to look like," Massey says. "As the light gets deflected, it distorts the shapes of the background galaxies. So, we end up seeing them in a distorted way, as if through lots of little lenses — and each of those lenses is a bit of dark matter."

"This is the first clear view of the cosmic web," says team member Richard Ellis, also at Caltech. The largest visible structures are filaments spanning 60 million light-years and containing some 2 trillion times the Sun's mass. But because the COSMOS map includes information about the objects' distances, it's also the first direct measure of galaxy growth over time. More distant "slices" of the map show the universe's state at earlier times.

"Dark matter collapsed first," says Massey. "Without it, the universe as we know it today wouldn't exist." The COSMOS map shows visible galaxies then formed within the framework the dark matter established.

"This is a tremendously exciting time," notes Ellis. Weak lensing, he says, has become one of cosmology's basic tools.

Sun's mass eventually forms an oxygen core so hot that colliding gamma rays spontaneously create a pair of particles — an electron and a positron.

Formation of these particles removes pressure from the core, which begins to collapse, then detonates in runaway thermonuclear reactions. This may one day be the fate of Eta Carinae, one of the most massive stars known.

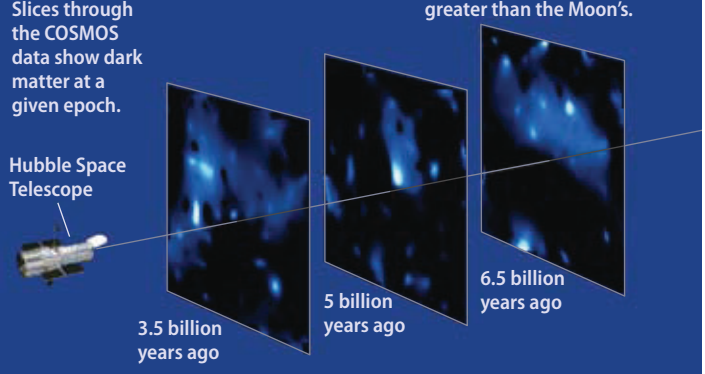
"That's why 2006gy is so exciting to us," Smith explains. "It may finally give us some evidence this process actually works in nature." Most of a supernova's light comes from the radioactive decay of nickel-56, an isotope formed in the blast. "But, if 2006gy is our guide," he says, "a pair-instability explosion could release 100 times more nickel than a normal supernova."

The pair-formation model fits 2006gy, which remained exceptionally bright for more than 200 days. But it can't explain 2005ap, which quickly rose to and fell from its record-setting peak luminosity. In fact, Smith says, the star's behavior appeared similar to a normal type II, just much brighter.

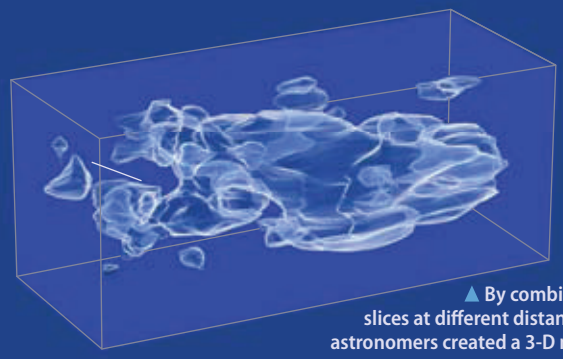
The Texas Supernova Search found 2005ap March 3, 2005, in a dwarf galaxy some 4.7 billion light-years away. This distance initially made Quimby doubt the find was a supernova, but observations he received from Keck Observatory, Hawaii, in December 2006 changed his mind. The explosion's spectra are so unusual, he says, "It took some time for me to put all the pieces together and convince myself that it was, in fact, a supernova — and the most luminous one ever, at that."

Astronomers map dark matter in 3-D

HUBBLE, XMM-NEWTON, and powerful ground-based telescopes provided data that let astronomers map dark matter in space and time. NASA/ESA/R. MASSEY (CALTECH)



▲ Dark-matter clumps appear more pronounced in recent times (left) than in the early universe (right).



▲ By combining slices at different distances, astronomers created a 3-D map.

ENGINEERS LOWERED this massive end cap for the Compact Muon Source (CMS) experiment into the Large Hadron Collider (LHC) cavern January 9, 2007. CERN/MAXIMILIEN BRICE

2 Monster machine

After some minor setbacks in 2007, technicians have begun commissioning the world's biggest scientific instrument — the Large Hadron Collider (LHC). Scientists expect to conduct the first high-energy science runs by summer.

For the past 13 years, the LHC has been taking shape a few hundred feet beneath France and Switzerland. Its mission is straightforward: Recreate conditions not seen in the universe since less than a billionth of a second after the Big Bang.

The $8 billion facility is the brainchild of the European Organization for Nuclear Research (CERN) in Geneva. The LHC will accelerate trillions of protons in opposite directions inside two pipes around a ring 17 miles (27 km) in circumference. Superconducting magnets cooled to –456° F (–271° C) will bend the beams around the ring. Traveling at 99.9999991 percent the speed of light, the particles will make the trip more than 11,000 times a second.

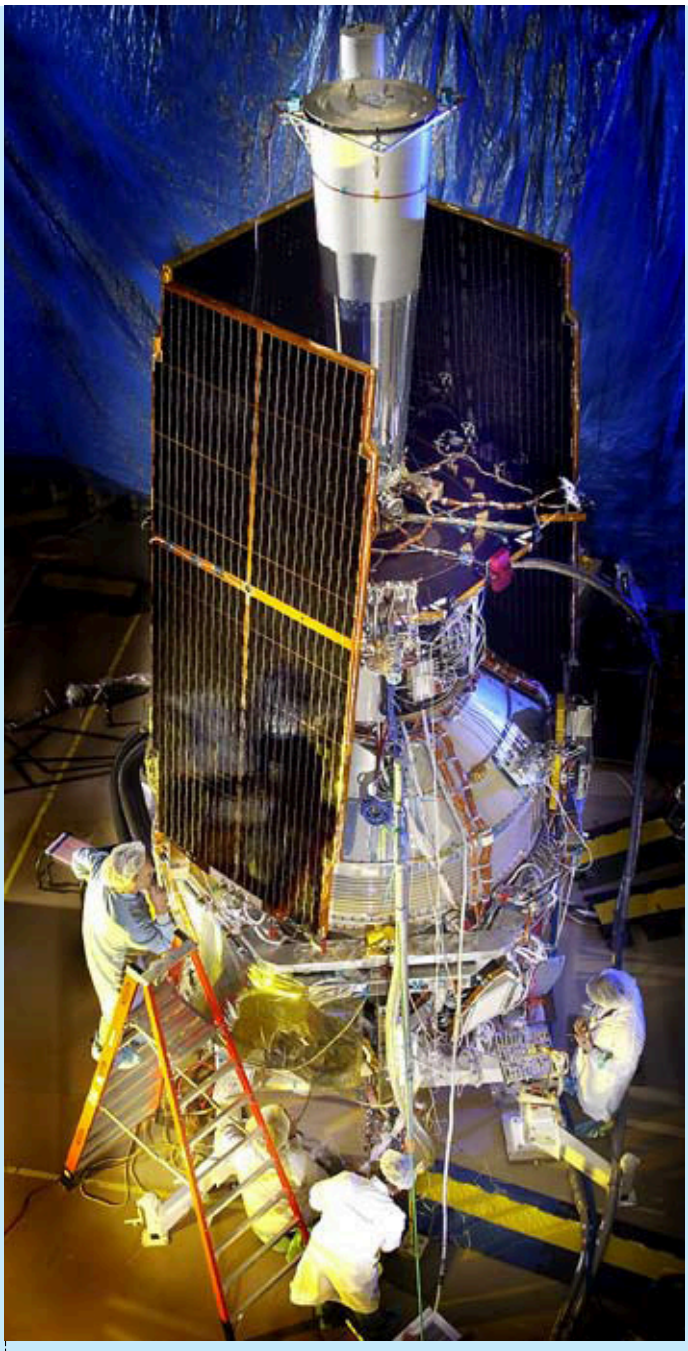
As the two beams enter detectors built along the ring, magnets deflect them so some of the protons collide. The two primary experiments — called ATLAS and CMS — are the most sophisticated ever built. (ATLAS alone weighs 7,000 tons, the equivalent of about 100 jumbo jets.) These experiments will

record the wreckage of up to 600 million proton collisions each second. The flood of data could fill enough CDs to reach the Moon and back twice each year. To deal with it, CERN — the laboratory that brought us the World Wide Web — developed a system that harnesses tens of thousands of computers around the globe.

Highest on physicists' list of LHC objectives is finding the Higgs boson, the particle thought to confer mass to every other particle. "Discovering the Higgs boson — or perhaps a set of them — and measuring their properties will be crucial to refining our thinking about the universe just after the Big Bang," explains Michael Barnett, a physicist at Lawrence Berkeley National Laboratory and a member of the ATLAS team.

But that's just the beginning. Other finds could include new particles responsible for dark matter or even mini black holes. "I would love to see evidence for extra dimensions," he says. This would raise scientists' hopes that string theory — a candidate unified physical theory that lacks experimental verification — is real.

How great an advance over existing particle accelerators does LHC represent? In terms of the number and speed of particle collisions, says Barnett, "It's like replacing the old ferry across San Francisco Bay with the Golden Gate Bridge." But he thinks of the facility's importance in far grander terms. "The ATLAS and CMS experiments have the potential to transform our thinking about the universe in the way that Copernicus and Einstein did," he says.



RUSS UNDERWOOD/LOCKHEED MARTIN CORPORATION

TECHNICIANS INSTALL THE SOLAR PANELS that powered GP-B, arguably the most sophisticated unmanned spacecraft ever flown.

1 Putting Einstein to the test

Scientists designed NASA's Gravity Probe B (GP-B), a $750 million polar-orbiting satellite launched in 2004, to make the most stringent tests of general relativity ever attempted. Einstein passed with flying colors.

"We're very happy about the mission," says lead researcher Francis Everitt. "We'll be even happier when we've done all the data reduction." After 18 months of painstaking analysis, the GP-B team released preliminary results in April. Months of work remained, however, to understand subtle differences between the experiment's four gyroscopes. The researchers expected to present their final report in early December 2007.

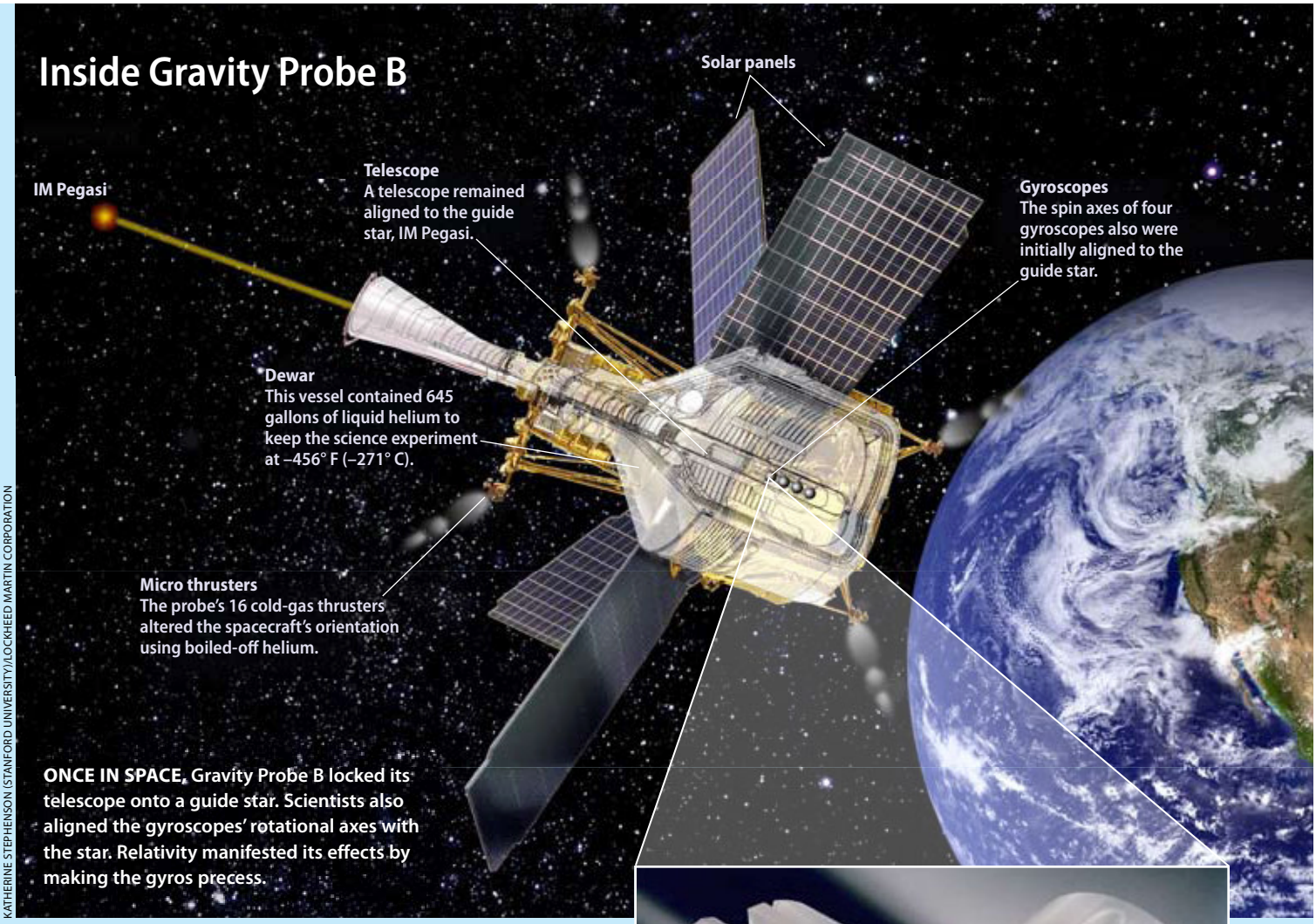
While Einstein's 1916 theory of gravity has earned its place as a cornerstone of modern physics, it remains poorly tested. "In the realm of black holes and the universe," Caltech physicist Kip Thorne once put it, "the language of general relativity is spoken, and it is spoken loudly. But in our tiny solar system, the effects of general relativity are but whispers."

By 1960, two physicists, George Pugh at the Pentagon and Leonard Schiff at Stanford University, independently suggested orbiting gyroscopes could measure these subtle effects, and GP-B was born. Everitt joined the project in 1962; NASA funding followed 2 years later.

"Nothing about this was easy," Everitt says. "Gravitational physics experiments are gruesomely difficult. You have to invent new technologies for them." By April 20, 2004, when GP-B blasted into orbit, the project had weathered no less than seven potential cancellations.

Yet, in essence, GP-B was simple. The satellite was basically a telescope, four gyroscopes, and a thermos bottle filled with supercold liquid helium. Once in orbit, the scientists pointed the telescope at a guide star, then they spun up the world's most precise gyroscopes on the same axis. Tiny thrusters maintained the telescope's lock on the guide star, but relativity's whispers ensured the gyros would not.

Everitt and his team estimated they'd be taking data 40 days after launch, but lots of small, unexpected problems cropped up. "It was 128 days before we could start gathering science.



ONCE IN SPACE, Gravity Probe B locked its telescope onto a guide star. Scientists also aligned the gyroscopes' rotational axes with the star. Relativity manifested its effects by making the gyros precess.

KATHERINE STEPHENSON (STANFORD UNIVERSITY)/LOCKHEED MARTIN CORPORATION

Meanwhile, the helium is boiling away," he recalls. "Nerve-racking, but we finally got it."

General relativity predicts that an Earth-sized circle drawn in empty space will lose 1.1 inches (2.79 centimeters) in circumference when an Earth-mass is placed within it. This so-called geodetic effect is what made GP-B's gyros drift off the guide star, and it's readily apparent in the probe's 17.3 months of data. "You can see the relativity staring you in the face," Everitt says.

A second, more subtle, effect, called frame-dragging, has not yet fully revealed itself. This twist in space-time occurs near rotating masses. Everitt explains the data show "clear hints" of frame-dragging, but the case isn't yet rock solid.

The geodetic results, however, agree with Einstein's predictions to within 1 percent. And the team hopes its final analysis will improve on this value by about 100 times. A

GRAVITY PROBE B sported the world's most spherical gyroscopes. Each is an almost perfect 1.5-inch (3.81 centimeters) polished sphere made of specially-fused solid quartz. Enlarge one of these spheres to Earth's size, and the highest peak or deepest valley would lie only 8 feet (2.44 meters) from sea level. DON HARLEY

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- **ON JANUARY 15, NASA's MESSENGER probe will return the first close-up images of Mercury in 33 years.**
- **IN OCTOBER, MESSENGER makes a second Mercury flyby.**
- **NASA'S PHOENIX probe lands on Mars May 26.**
- **INDIA'S LUNAR ORBITER, Chandrayaan 1, will launch in late June, and NASA's Lunar Reconnaissance Orbiter will follow it by year's end.**