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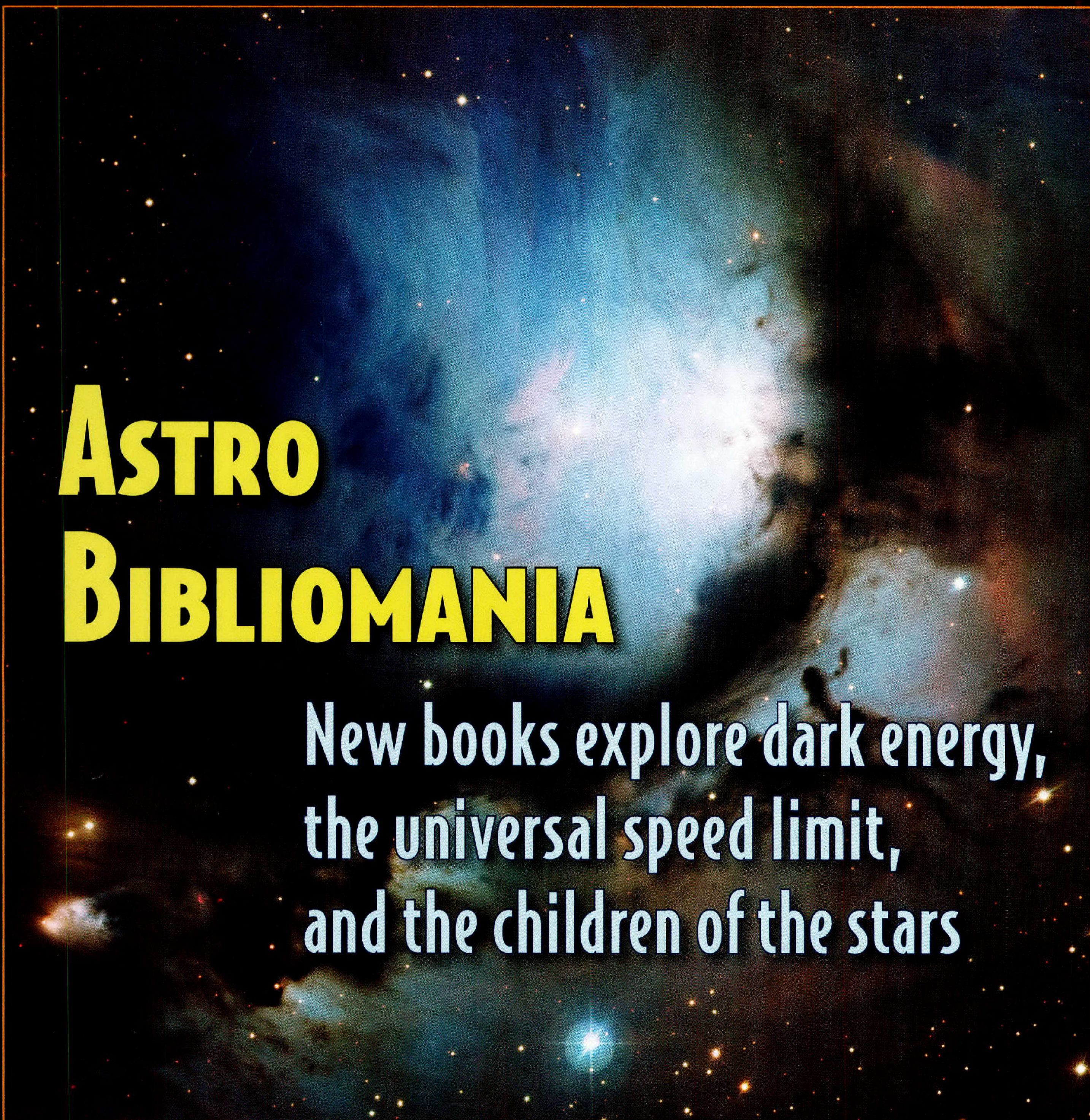

Astro Bibliomania

New books explore dark energy, the universal speed limit, and the children of the stars

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MAY/JUNE 2011 • Vol. 39, No. 3

Features

6 **Battling for the Fate of the Universe**
From *The 4% Universe: Dark Matter, Dark Energy and the Race to Discover the Rest of Reality*
By Richard Panek

9 **Grabbing an Exploding Star**
From *Stars Above, Earth Below: A Guide to Astronomy in the National Parks*
By Tyler Nordgren

16 **Relatively Speaking**
From *Universe: 50 Ideas You Really Need to Know*
By Joanne Baker

19 **New Books in Brief**

Departments

Merlin 3
Sky Calendar MAY/JUNE 10
The Stars in MAY/JUNE 12
AstroMiscellany 15
AstroNews 20
Cheaper by the Basketful
Beginning of the End?
Probing a Planetary Bowling Ball
Rainy Day Blues
Solar Revelations
Bursting the Bubble


ESO/IGOR CHEKALIN

On The Cover
Hot young stars light up M78, a nebula in the constellation Orion. The starlight reflects off tiny particles of dust in the cloud to create the blue and pink fields, which are shown in near-natural color. Dark lanes of cold dust weave through the nebula, which is about 1,350 light-years away.

This Page
A collision between spiral galaxy Arp 147 and an elliptical galaxy (not shown) caused a wave of star formation. Hot young stars are shown in optical light from Hubble Space Telescope (blue). Many of the massive young stars exploded, leaving behind black holes. Disks of gas around them produce X-ray jets (pink), seen by the Chandra X-ray Observatory.

Coming Up in July/August
In our next issue, astronomer Bradford Behr explains how to identify sky objects on sight, without the use of maps or guidebooks. And as always, we'll bring you two month's worth of skywatching tips and charts, Merlin's answers to your astronomy questions, and the latest astronomy news.

NASA/CXC/MIT/S. RAPPAPORT/STScI

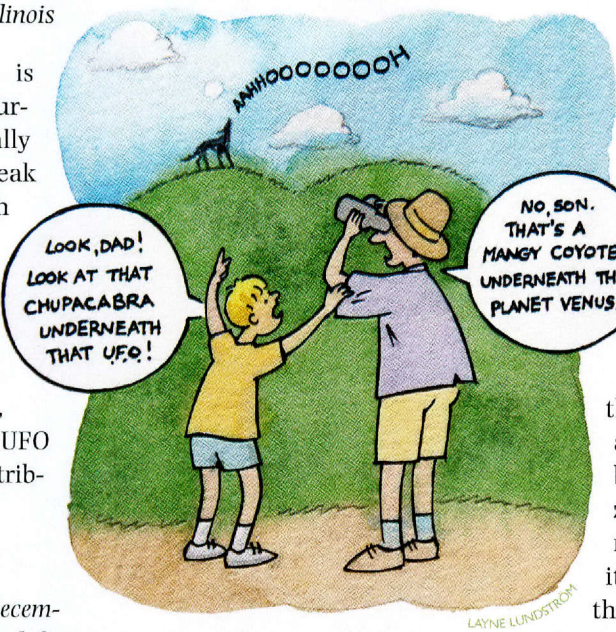
MERLIN

Dear Merlin,

To your knowledge, have there been any sightings of planets during the day?

Diane Frenster
Galesburg, Illinois

Absolutely. Venus is bright enough to see during the day, especially when it's near its peak brilliance, although you generally need a chart to help you find it through the glare. Once you find it, though, it shines through clearly. In fact, occasional daytime UFO sightings have been attributed to Venus.



Dear Merlin,

In your November/December 2009 issue, you stated that because of the expansion of the universe a galaxy that appears to be 13 billion light-years away is actually about 40 billion light-years away. My question is: How far was that galaxy when it emitted the light we see now?

Pascal Renault
Chester, Virginia

Merlin made a call to the bullpen for a relief wizard to answer this one: Eiichiro Komatsu, director of the Texas Cosmology Center at The University of Texas at Austin. His answer shows that he hasn't lost any speed off his cosmological fastball:

> To answer this question, one needs to know how much the universe has expanded since the time when the galaxy emitted its light. Then, one can find an answer by dividing today's observed distance by how much the universe has expanded. The current age of the universe is 13.7 billion years, so the galaxy in question emitted light when the universe was 0.7 billion years old. The universe has expended by roughly a factor of 9 since then, and thus the answer would be 13 divided by 9, which equals 1.4 billion light-years.

Dear Merlin,

Does the curvature of Earth and the distance of the stars allow us to see more than 180 degrees of the sky?

Gregg Schultz
Lynd, Minnesota

No, although another effect does. Earth's atmosphere acts like a lens, "bending" the light of astronomical objects when they are near the horizon — or even when they are below it. When you first see the Sun breaking the horizon in the morning, or when you last see it sinking from sight in the evening, it's actually already below the horizon, but the atmosphere curves its light up over the horizon, allowing you to see it a little longer.

This effect applies only to the brightest objects, such as the Sun, Moon, and a few planets and stars, because in addition to bending light, the atmosphere also absorbs it. The absorption is greatest right at the horizon, where you're looking through the thickest layer of air. As a result, fainter stars don't become visible until they climb a little bit above the horizon.

So except for the brightest objects, the view of the sky is less than 180 degrees.

Dear Merlin,

If I were standing on the dark side of the Moon, without any earthshine and without binoculars or any optical aid, what would the sky look like? I have always thought that stars were visible because their light gets reflected and scattered about by the atmosphere. Isn't starlight essentially pinpoint light and perhaps except for the biggest stars these pinpoints would not be visible with the naked eye?

Lyn Berry
Buena Vista, Colorado

The lunar night is ablaze with stars.

You are correct that the stars are no more than pinpoints of light, and that Earth's atmosphere smudges those pinpoints a little. The air does not, however, magnify the view — it only smears it out, like looking at the lights of a Christmas tree through a pane of frosted glass. On the airless Moon, the stars remain crisp pinpoints, with no twinkling, and are easily visible to the human eye.

The stars are visible during the lunar daytime, too, but to see them you would need to look toward the sky for a while to allow your eyes to adapt to the darkness. The sunlit landscape is quite bright, and your pupils contract in bright light, making it impossible to see the stars

That's also why stars don't show up in photographs snapped by the Apollo astronauts. The cameras were set to properly expose the landscape, with short exposure times and small f/stops. At those settings, the stars were just too faint to show up on film.

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

stardate.org/resources/

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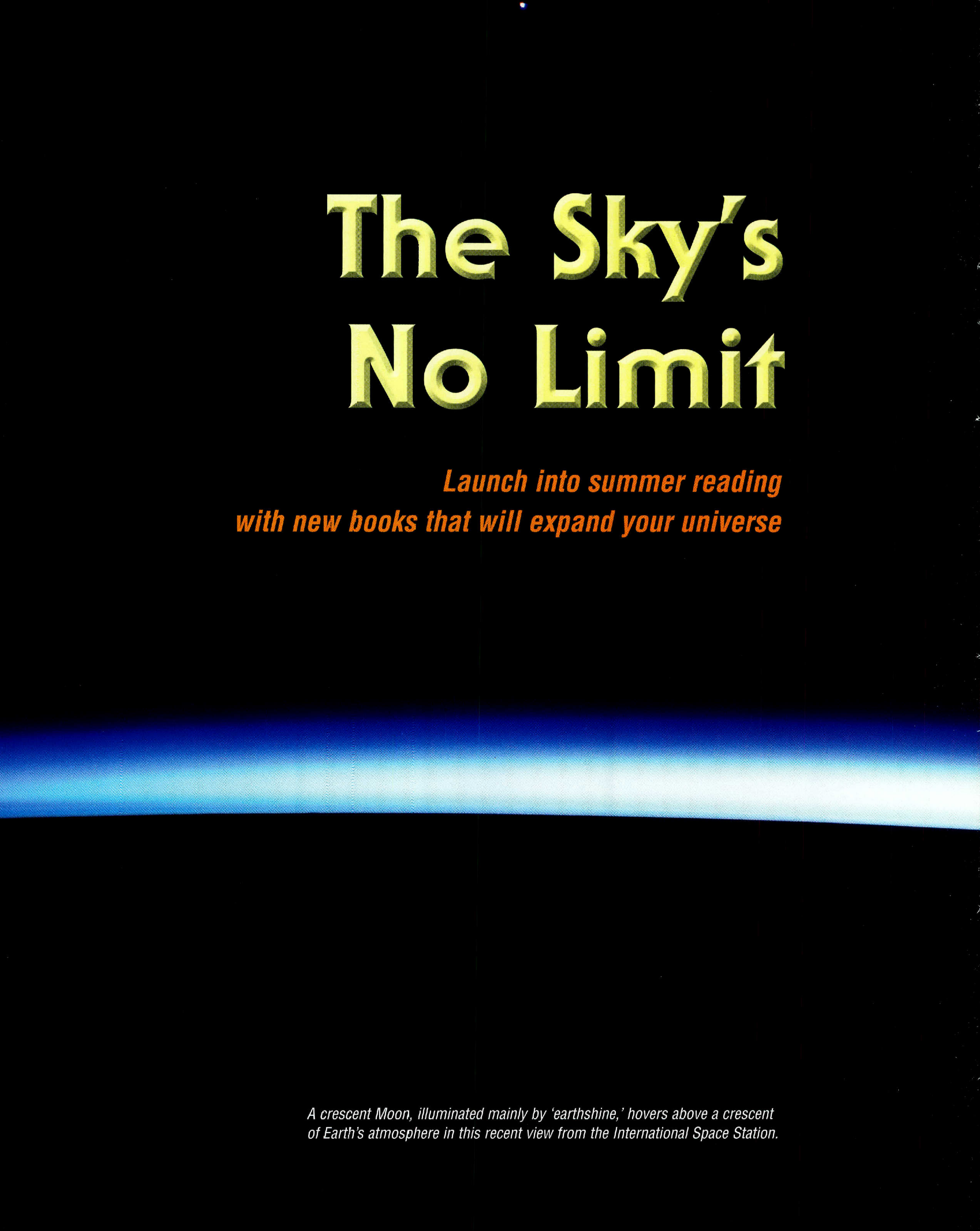


A crescent Moon, illuminated mainly by 'earthshine,' hovers above a crescent of Earth's atmosphere in this recent view from the International Space Station.

The 4% Universe

Dark Matter, Dark Energy and the Race to Discover the Rest of Reality

By Richard Panek

Stars Above, Earth Below

A Guide to Astronomy in the National Parks

By Tyler Nordgren

Universe: 50 Ideas You Really Need to Know

By Joanne Baker

NASA

Battling for the Fate of the Universe

In the 1990s, two teams of scientists raced each other to be the first to figure out if the universe would expand forever, or eventually contract

Today we know that the universe is expanding faster all the time, pushed apart by an unknown force dubbed 'dark energy.' The effect was discovered independently by two teams of scientists mining the skies for the exploding stars known as type Ia supernovae to use as beacons to trace distances across the universe. Here Richard Panek describes how even as the Supernova Cosmology Project team, led by physicist Saul Perlmutter and based at Lawrence Berkeley National Laboratory, enjoyed early success, a second team was forming that would nip at their heels.

In early 1994, a couple of astronomers got to talking. Brian Schmidt had just completed a doctoral thesis on supernovae at Harvard's Center for Astrophysics, and he was thinking about ideas for his next project as a postdoc. Nicholas Suntzeff had been an astronomer at the Cerro Tololo Inter-American Observatory in Chile since 1986, and he had been working on a supernova survey since 1989. As supernova specialists they had both been following the efforts of Berkeley's supernova project. Now, as they sat in the air-conditioned computer room at the observatory headquarters in the Chilean coastal town of La Serena, Schmidt mentioned that he'd been thinking about putting together a team to go up against LBL's [Lawrence Berkeley Lab].

Suntzeff didn't hesitate: "Can I be part of that?"

Now *that*, Schmidt thought, is the mark of a good problem in science. It's not when people say, "Oh, that's interesting." It's when they say, "*Ooo*, can I be part of that?"

Schmidt had to give Saul Perlmutter and the Berkeley team credit. They had seen, at long last, that supernovae might be used to do cosmology, and they were succeeding against enormous odds. They had been in the right place at the right time. But were they the right team?

Like many other astronomers, Schmidt had been skeptical that physicists — even physicists-turned-astrophysicists — would be able to consistently find distant supernovae. But even after the LBL team had found its first supernova, Schmidt and other astronomers remained skeptical that physicists-turned-astrophysicists — no matter how brilliant — could perform the kinds of follow-up observations and analyses that routinely strained even their own hard-won expertise. Seemingly everybody in the supernova game had been on the receiving end of a middle-of-the-night phone call from Saul, asking them to drop everything and perform a follow-up observation of a supernova candidate. Perlmutter had gotten a reputation in the community for being preternaturally persistent. But in Suntzeff's experience, every time he slewed his telescope to Perlmutter's target, the field was empty. "Must be too faint," Suntzeff would say diplomatically.

Schmidt and Suntzeff grabbed the nearest blue-and-gray sheet of IBM computer printout, flipped it over, and began scribbling. They continued the conversation in Suntzeff's office later that day and the next day as well, laying out their plan of attack.

Suntzeff, they decided, would be in charge of the observing. He would find the supernova candidates and do the follow-up measurements. Schmidt would be in charge of the analysis. He would take some existing software and create a new code that would clean the images, do the subtraction, and isolate the supernovae.

Suntzeff turned to Schmidt. "How long will it take you to write the new code?"

Schmidt was a self-described young — twenty-seven — and arrogant astronomer, and he had a wiseacre's side-of-the-mouth way of talking. Suntzeff preferred to think of him as not arrogant but as extremely optimistic. Yet even Schmidt had to hesitate. Then he reminded himself: *Saul's doing it.*

"Two months," he answered.

On his return to Harvard, Schmidt disappeared into his office for hours at a time, day after day, week after week, writing the code. But he also circulated through the halls, stopping colleagues and dropping into offices, letting a select group know that he and Nick Suntzeff were putting together a team to catch Saul. In each case he got the same response, expressed with the same level of eagerness: *Can I be part of that?* ...

So Berkeley had a six-year head start. So what? Schmidt and Suntzeff's team had astronomers — professionals who didn't need to learn how to do photometry and spectroscopy, who needed only to do them well and then to make improvements where necessary. ...

The Harvard and Chile guys regarded

the Berkeley team with some incredulity. "'I just heard about it, and I just thought about it, so — this is my subject!'" is how [Harvard astronomer and long-time supernova expert Robert] Kirshner characterized the SCP's [Supernova Cosmology Project] attitude toward supernovae. SCP team members were talking about timing their observations to the new moon — as if astronomers hadn't been doing just that for thousands of years. The "batch" method? Radio astronomers were taking that approach in the 1960s. Supernovae on demand? José Maza was delivering that in the 1970s.

Naturally, with all these scientists pursuing the same goal, meeting in the same place, there had been talk of a collaboration. But some of the members of Schmidt and Suntzeff's team left [the science conference in Aiguablava] Spain with the impression that, as Kirshner said, "working together meant working for them." Why would one of the world's most knowledgeable supernova specialists want to be a subordinate to Saul Perlmutter, Type Ia neophyte and ten years his junior? For that matter, why would any of these purebred astronomers put themselves in a position where they might be reporting to the purebred physicists? Perlmutter was talking about how "rare," "rapid," and "random" supernovae were. And they were! But Schmidt and Suntzeff's team preferred to put the emphasis on "dimness," "distance," and "dust" — how to tell whether a supernova is intrinsically dim, dim because it's distant, or dim because of dust. While the physicists were worrying about how to find distant supernovae, the astronomers were worrying about what to do with the distant supernovae once they found them.

Which they had (well, *a* distant supernova). But they still couldn't be sure what type it was. The problem had been there from the start. In the same April 6 e-mail that [Bruno] Leibundgut sent to Schmidt celebrating the difference that one supernova can make, he also mentioned, almost as an aside, that "the 'supernova' spectrum still has a lot of galaxy in it" — that the light from the apparent supernova was difficult to separate from the light of the host galaxy. The spectrum could tell you the redshift of the galaxy, and therefore the redshift of the supernova residing in it. But in order to see the spectrum of the supernova itself, you were going to have to isolate its light.

First Mark Phillips tried. One week after notifying the team of [Mario] Hamuy's calculations that the supernova was the most distant ever, he was ready to give up. "I've spent TOO MUCH time the last few days looking at this," he wrote the team. "The conclusion I've reached is that the SN spectrum is of such low S/N" — signal-to-noise, useful supernova light versus the optical equivalent of static from the galaxy — "that it is IMPOSSIBLE to tell what type it is."

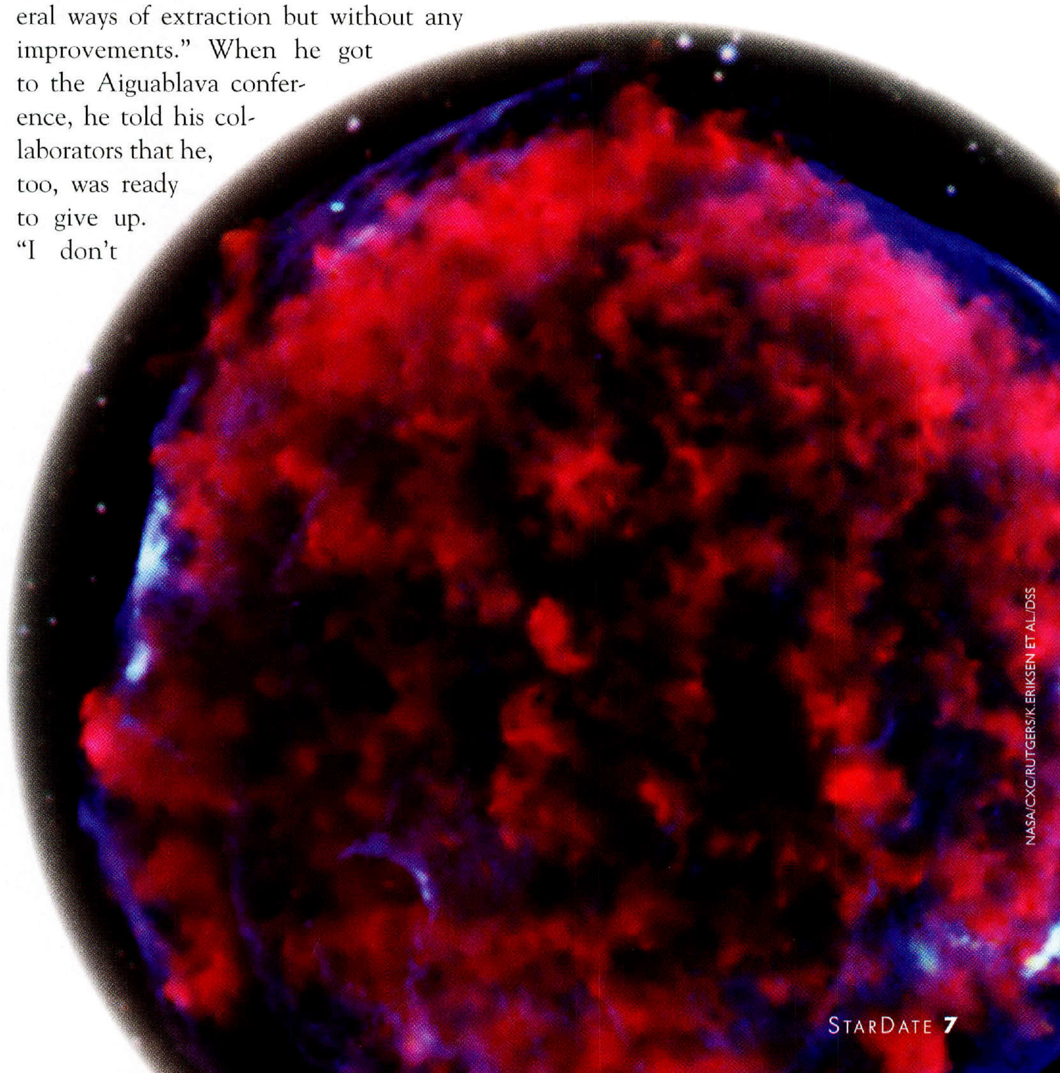
Leibundgut tried next. And tried. "And no to the spectrum," he wrote in an e-mail at the end of May. "I have tried several ways of extraction but without any improvements." When he got to the Aiguablava conference, he told his collaborators that he, too, was ready to give up. "I don't know what to do anymore," he said. "I'm not sure I can confirm it's Type Ia."

"Crap!" Suntzeff said. "Saul's pulling in supernovae by the handful, and we only have one, and we can't even tell if it's a Ia!"

At one point Leibundgut was discussing the problem with Phillips in the lobby of the hotel. The ocean was outside. They were inside. Phillips turned to Leibundgut and said, "Why don't you subtract the galaxy?"

"Subtracting the galaxy" is just about the first thing you do if you're trying to get the spectrum of a supernova. If you want to isolate the supernova light, you take a spectrum from the part of the galaxy containing the supernova, which is flooded with light from the galaxy, and then you take a spectrum from a different part of the galaxy, away from the supernova, and then you subtract the second reading from the first. Ideally, the spectrum of the supernova itself pops out.

This supernova, however, had been so



Tycho's Supernova, a type Ia, is seen in X-rays in this view from Chandra superimposed on an optical view of background stars.

overwhelmed by galaxy light that Leibundgut hadn't tried the obvious. Nobody had. From Aiguablava he flew to Hawaii for another conference, and then home to Munich. He fiddled a little with the overall galaxy light, dividing its intensity by ten. Why ten? No reason. The spectrum from the galaxy would still be the same; he wasn't changing the quality of the data. He was just changing the amount of it. He subtracted this spectrum from the supernova spectrum (which also contained the galaxy spectrum), and out popped a beautiful supernova spectrum.

"The spectrum of 95K looks great!" Phillips wrote him on August 1. "I'm now very convinced that this was a genuine type Ia."

They were back in the game. Now what they needed was a game plan, so to speak. They needed to formalize their existence as a team.

From the start — during their first discussions in La Serena, in early 1994 — Schmidt and Suntzeff knew what kind of team they would want. Theirs wouldn't resemble a particle physics collaboration. It wouldn't have the same rigid top-down hierarchy, the same plodding bureaucracy, the same assembly-line mentality. Instead, their collaboration would follow a traditional astronomy aesthetic. It would be as nimble, as independent, as Hubble on Mount Wilson, as Sandage on Mount Palomar.

Already that approach had paid off. Like the professional astronomers they were, they had asked what they considered the key question first: Are type Ia supernovae really standard candles? Only when they knew that Type Ia could be calibrated did they actually go looking for a distant one. And they almost hadn't found it. But in the end they did find their high-redshift supernova, and it was indeed a Type Ia. They'd salvaged their collaboration, and maybe their credibility, by making the discovery "on the smell of an oily rag in a quasichaotic fashion," as Schmidt liked to say. But they'd done it. They'd made the discovery. It hadn't been pretty — it was, Suntzeff thought, more like "anarchy" — but it was astronomy.

And yet, astronomy itself was changing. The traditional go-it-alone aesthetic was disappearing. The diversity of the science and the complications of technology were forcing the field into greater and greater specialization. You couldn't just study the heavens anymore; you studied planets, or stars, or galaxies, or the Sun. But you didn't study just stars anymore, either; you studied only the stars that explode. But you didn't just study supernovae, either; you studied only one type. And you didn't study just Type Ia; you specialized in the mechanism leading to thermonuclear explosion, or you specialized in what metals the explosion creates, or you specialized in how to use the light from the explosion to measure the deceleration of the expansion of the universe — how to perform the photometry or do the spectroscopy or write the code. A collaboration could easily become unwieldy.

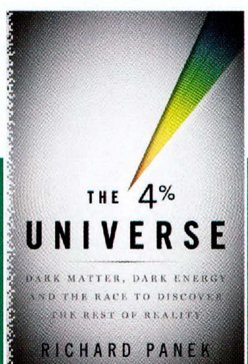
Suntzeff and Schmidt recognized that their team would have to reflect the reality of increasing specialization. As the project evolved from the back of the sheet of computer paper in the spring of 1994 to actual astronomers chewing antacid tablets at observatories, they had to consider not only who would work hard but who possessed what areas of expertise and who had access to the right telescopes. The team's first foray into legitimacy, the September 1994 proposal for observing time at Cerro Tololo the following spring, cited twelve collaborators at five institutions on three continents. After the team confirmed that they'd found their first distant supernova during that run, in early April 1995, Schmidt sent around a reminder of who they were: fourteen astronomers at six institutions. The paper announcing the discovery in the *ESO Messenger* that fall carried seventeen authors at seven institutions.

Yet even as the collaboration grew, Schmidt and Suntzeff wanted to preserve the dexterity afforded by the old-fashioned astronomy — and to turn their familiarity with that tradition to their advantage. They were, after all, playing catch-up.

"We can only do it if we're fast," Suntzeff said. "The only way we're going to get this done is if we recruit as many young people as possible." Young astronomers. Postdocs. Graduate students.

They also wanted the collaboration to be fair. "I'm tired of seeing people get screwed by the system," Suntzeff said — the system where the postdoc did the work and the senior astronomer who had tenure would be first author, getting the credit and going to conferences, while the postdoc wound up without a job.

By the time Schmidt and Suntzeff gathered their collaborators at Harvard in the late summer of 1995, they had formulated a strategy for delegating responsibilities in a way that would move the project forward quickly and fairly. Each semester, one of the sponsoring institutions — Harvard, or Cerro Tololo, or the European Southern Observatory, or the University of Washington — would be in charge of gathering the data from all the collaborators, reducing it, and preparing a paper for publication. And whoever did the most work on the paper would be the first author.



The 4% Universe

Dark Matter, Dark Energy and the Race to Discover the Rest of Reality

By Richard Panek
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Richard Panek is the author of The Invisible Century *and* Seeing and Believing. *He has frequently written for* The New York Times, Discover, *and other magazines.*

Grabbing an Exploding Star

An ancient handprint suggests that pueblo dwellers recorded a supernova — and considered it a sacred event

The people of Chaco Canyon, New Mexico, paid close attention to the sky. They carefully tracked the motions of the Sun and Moon, and recorded unusual events in the sky — including a possible supernova. This excerpt connects their observation to our modern understanding of these exploding stars and what they mean for life on Earth.

Even in secular circles, children still learn to wish upon a star, while millions of adults regularly read their horoscopes published in nearly every major newspaper. A complaint against modern science is that it seeks to divorce us from our cherished connection to the heavens, and at first glance this is certainly true. I am very clear with my students that there has never been any scientific evidence that astrology works in any way, shape, or form. Yet far from the stars being a simple instrument for telling us who we should love and what days are auspicious for business ventures, modern astrophysics reveals a much more powerful connection we share with the stars, a connection that has been going on for over five billion years and is responsible in nearly every way for making us who we are today.

It is with these thoughts that I am once more brought back to our early morning hike through [Chaco] canyon. We are making our way out to Penacso Blanco in the frigid predawn hours to test a winter solstice alignment marker between the far western pueblo and a small peak along the eastern horizon. If we are correct, then on the winter solstice the first rays of the rising Sun should just touch this distant point as viewed from a ruined kiva at the heart of the great house. If this alignment is true, it might explain why this great house is located where it is. Testing this hypothesis is at the heart of what it means to be a scientist.

Only a few hundred yards beyond a frozen wash (that by day will be several feet of slippery, grey mud) the trail reaches the low western wall of the canyon. At its base we cross under a red painted pictograph located high under a yellow sandstone overhang. Overhead a star, a crescent, and a hand print are revealed in the light of our head lamps under a still dark sky. On this spot the view of the eastern sky is completely uninterrupted. Anyone standing here a thousand years ago, at the height of the Chacoan culture, would have seen a new star rise in the east next to a thin cresent moon on the morning of July 5, 1054. Chinese astronomers recorded that on that day a strange new star appeared that was four times brighter than Venus and for 23 days it was so bright that it was visible in broad daylight. For nearly two years this strange new star joined the common constellations in the sky before finally fading away to invisibility.

It is this event, an event so rare that no human being in the last four hundred years has seen its equal, that some believe is depicted here under this quiet overhang. What ancient Chinese and Chacoan astronomers saw is the explosive destruction of a star. It's what we call a supernova. Like so many of the other astronomical connections in Chaco, what this pictograph panel actually represents is still the subject of vigorous debate. There is an historical account of a site among the Zuni that also features a pictograph panel of a star, moon, and a hand, but is said to mark a Sun-watching station (while other contemporaneous descriptions fail to mention any other sign of hand, or alternately, a crescent). And though there are five or six other rock art locations around the southwest that feature a star and a cresent, only Chaco's adds the feature of a hand, a symbol believed to mark a sacred ceremonial site.

Whatever the reason this pictograph was painted, what is certain is that in this canyon, on this spot, a strange and startling sight was witnessed a thousand years ago that intimately links us to the stars above. Whether or not anyone chose to record it here, we are the offspring of the phenomenon they saw; we are the children of supernovae.

Take for instance, the red in the paint of the pictograph. It's due to atoms of iron and oxygen that we call rust. Both of these atoms are found within me, in the red blood cells pounding in the pulse I feel in my veins after the long cold hike to this spot. At the turn of the last century, scientists found that every element we see in the world, the wood of the tree, the sandstone in the rocks, the air we breathe is all

DAMOND BENNINGFIELD

The Chaco Canyon supernova pictograph

Continued, Page 16

SKY CALENDAR

by Alan MacRobert

As spring heads into summer, the planet Saturn dominates the evening sky. Four other planets — Jupiter, Venus, Mercury, and Mars — shine together before dawn in mid-May. And the three bright stars of the Summer Triangle — Altair, Deneb, and Vega — are climbing into view in the east.

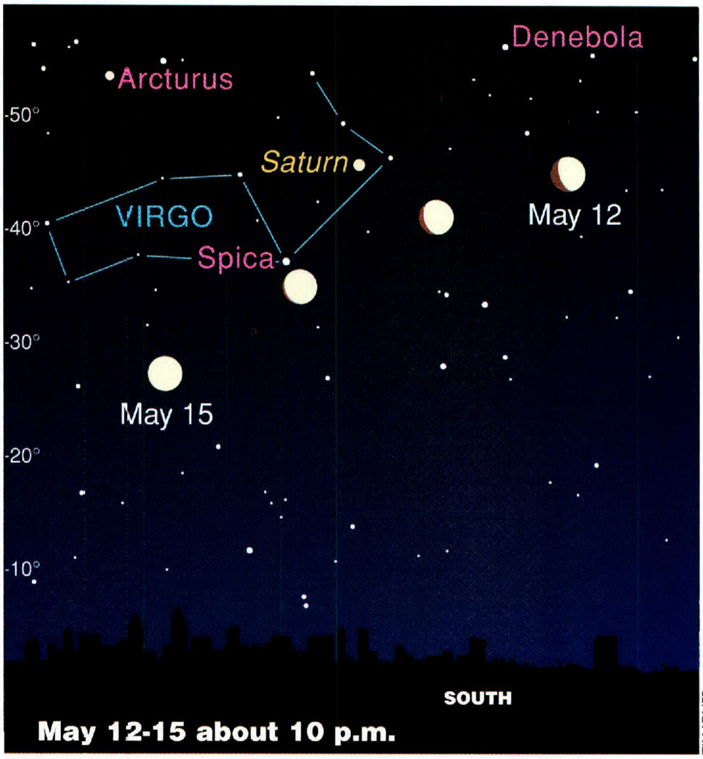
MAY 1 - 15

Saturn is the planet of spring this year. Look for it high in the southeast as soon as the stars begin to come out. Similarly bright Spica shines below it by more than the width of your fist at arm's length.

As darkness comes further on, you'll spot a fainter star next to Saturn: third-magnitude Porrima or Gamma Virginis. As night advances they all shift to the south, and Spica swings up to shine at Saturn's lower left.

In a telescope this year, Saturn presents its most dramatic aspect — in my opinion anyway. Its rings are still tipped near to our line of sight, presenting a narrow slash rather than the wide hat-brim they'll show us in coming years. A three-inch 'scope will also show Titan, Saturn's largest moon. Titan never ventures more than four ring-lengths from Saturn in its 16-day orbit around the planet. A six-inch telescope will also show Saturn's moons Rhea, Dione, and Tethys on nights of good seeing. My 12-inch usually adds Enceladus without too much trouble.

And while your telescope is pointed that way, examine Porrima, too. Porrima is a famous double star that closed up and appeared single around 2005. Now it's widening again and should be resolvable in a good three-inch at high power on a night of excellent seeing (steady air). The two stars of Porrima, equally bright, are 1.7 arcseconds apart this spring. They will continue widening in their long orbit until 2088.



May 12-15 about 10 p.m.

Look for brighter Arcturus far to the left of Saturn and Spica at dusk. By midnight, it swings up to shine above them. Arcturus, the "spring star," is the brightest point high in the evening sky.

Look low in the northeast after dark for Vega, Arcturus' equal for brightness. In the next few months, Vega climbs high after dusk to displace Arcturus and earn its own title as the "summer star."

In the northwest, meanwhile, similarly bright Capella is heading toward the horizon and out of view for the season. All three stars, Acturus, Vega, and Capella, are magnitude zero, the next step brighter than the classical definition of "first-magnitude" stars.

Look higher in the west, far to Capella's upper left, for Pollux and Castor lined up almost horizontally. The waxing Moon shines below them on May 7. And to the lower left of Pollux and Castor, look for Procyon.

If you can get up and out during dawn in the second week of May, look just above the eastern horizon as daylight brightens, about a half hour before sunrise. Four planets are having a conjunction there. The brightest is Venus; next brightest is Jupiter. Bring binoculars to help catch the other two: Mercury and, to the lower left of these three, faint, difficult Mars.

Venus and Jupiter appear closest together on the morning of May 11, just 0.6 degree apart. On that morning little Mercury is 1.5 degrees to Venus' lower right, and fainter Mars is 5.6 degrees to Venus' lower left.

MAY 16 - 31

Are you keeping watch on Saturn and little Porrima next to it, high in the southeast to south during evening? Saturn is closing in on its dimmer companion. They began May 1.5 degrees apart, about a finger-width at arm's length. By May 15, they're separated by 0.75 degree, and by the 31st they close to within 0.3 degree of each other. This means that for the second half of the month, if you point a telescope at them, they'll both fit into a low- to moderate-power field of view. To examine each of them well, however, switch to a higher-power eyepiece.

As spring warms up, the Big Dipper reaches its highest stance overhead right after dark. Face north and look nearly straight up (depending on your latitude). There's the Big Dipper lying upside down, as if dumping water.

Follow the curve of the Dipper's handle around in an arc by a little more than a Dipper-length, and you come to bright Arcturus. 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, keeping him in line.

So much for the mythology. Arcturus is actually an orange-giant star, much larger and brighter than our Sun but 37 light-years distant, and it's passing rapidly through our corner of the Milky Way. Arcturus is an interloper from another galaxy that fell into the Milky Way and merged with it billions of years ago. Arcturus still retains some of this infalling galaxy's high velocity. It's moving fast enough that its naked-eye position with respect to background stars changes detectably over the course of several centuries. For most stars, this takes thousands or tens of thousands of years.

JUNE 1 - 15

Saturn shines highest in the south right at the end of twilight, with little Porrima only 0.3 degree to 0.5 degree from it for all of June. Late twilight is the best time to get your telescope on them, for two reasons. First, this is when they're highest in the steadiest air. Second, the air is sometimes unusually steady for a while after sunset — when the ground is no longer heated by the Sun but before it begins cooling down rapidly after dark.

Spica, meanwhile, is 14 degrees to Saturn's left.

Vega is now the brightest star shining high in the east. If your sky is properly dark — that is, if you're far from light-polluted population centers — you'll see that Vega floats just above the frothy star-foam of the vast Milky Way band, which is rising to span the entire eastern sky.

Look right in the centerline of the Milky Way for Deneb, the brightest star to Vega's lower left (by two or three fist-widths at arm's length). Deneb forms the head of the big Northern Cross, which is currently lying on its side with the bottom of its shaft to the right, beneath Vega. The main part of the Northern Cross runs through one of the Milky Way's richest star clouds.

Rising due east much farther to Vega's lower right (three or four fists at arm's length) is Altair, with its third-magnitude attendant star Tarazed glimmering above it and a bit to the left. Vega, Deneb, and Altair form the huge Summer Triangle. It's a poetic name but not entirely accurate; the Summer Triangle is in evening view from mid-spring all the way to the beginning of winter.

Follow the Milky Way far to the left of the Summer Triangle and you'll see that it passes through W-shaped Cassiopeia, which is low in the north. Follow the Milky Way the other direction, and you'll see that it dips below fiery orange Antares in Scorpius, which is already visible in the south-southeast.

JUNE 16 - 30

Saturn and Porrima are now high in the southwest at twilight's end. They sink low earlier in the night now, a process that will continue until they disappear into the sunset this September.

Once full darkness arrives (around 10 or 10:30 p.m.), you'll find the huge Summer Triangle of Vega, Deneb, and Altair now looming higher in the east, with the Milky Way running horizontally through it (visible in a dark-enough sky).

Just as Orion is the signature constellation of winter, Scorpius is the brightest and most distinctive of summer. Look for it nearing its high point in the south late these evenings. It's highlighted by bright orange-red Antares. Scorpius and Antares are rather low if you live at the latitudes of the northern U.S. or Canada, but higher as seen from the southern U.S.

Antares marks the scorpion's heart. Two fainter stars accompany it just to its right and lower left; their ancient name, Al Niyat, means "arteries of the heart." Farther to the upper right is a nearly vertical row of three stars marking the scorpion's head. The rest of its body curls far down from Antares to the lower left. Whether this pattern looks exactly like a scorpion or not, Scorpius is certainly one of the most distinctively shaped constellations, and once you know it you'll never forget it.

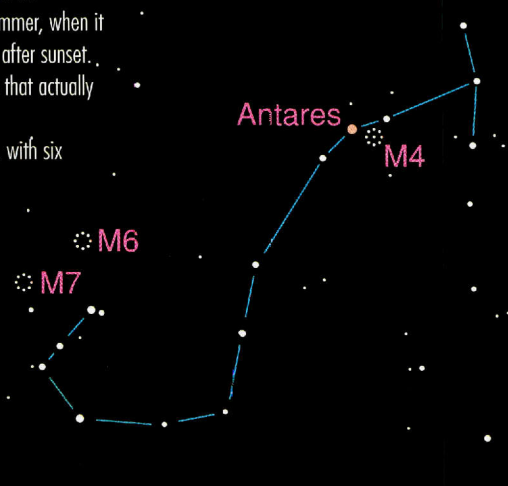
And if you're up before dawn's early light in the last half of June, look for Jupiter shining brightly in the east-southeast.

Alan MacRobert is a senior editor of Sky & Telescope *magazine (skyandtelescope.com).*

Summer Means Scorpius

Scorpius, the scorpion, is one of the signature constellations of summer, when it hangs over the southern horizon after sunset. It's one of the few constellations that actually looks like its namesake.

Scorpius is full of bright stars, with six of second magnitude or greater (including first-magnitude Antares), and nine of third magnitude. Most of them are members of a group called the Scorpius-Centaurus Association. The massive stars formed just a few million years ago, and most will explode a few million years from now.



Antares
The scorpion's brightest star is a red supergiant. Its name means "rival of Mars." It's so large that if you replaced the Sun with it, it would extend almost to Jupiter. It has a companion star, but you need a telescope to see it.

M4
A globular star cluster with hundreds of thousands of stars tightly packed together. It is about 7,000 light-years away and about 12 billion years old.

M6
A cluster of about 80 stars, 1,600 light-years away. It is about 100 million years old.

M7
A cluster of about 80 stars, 1,000 light-years away. It is 220 million years old.

Meteor Watch

The Shower
Eta Aquarids
Named for the constellation Aquarius, the water bearer, which climbs into view by around 3 a.m.

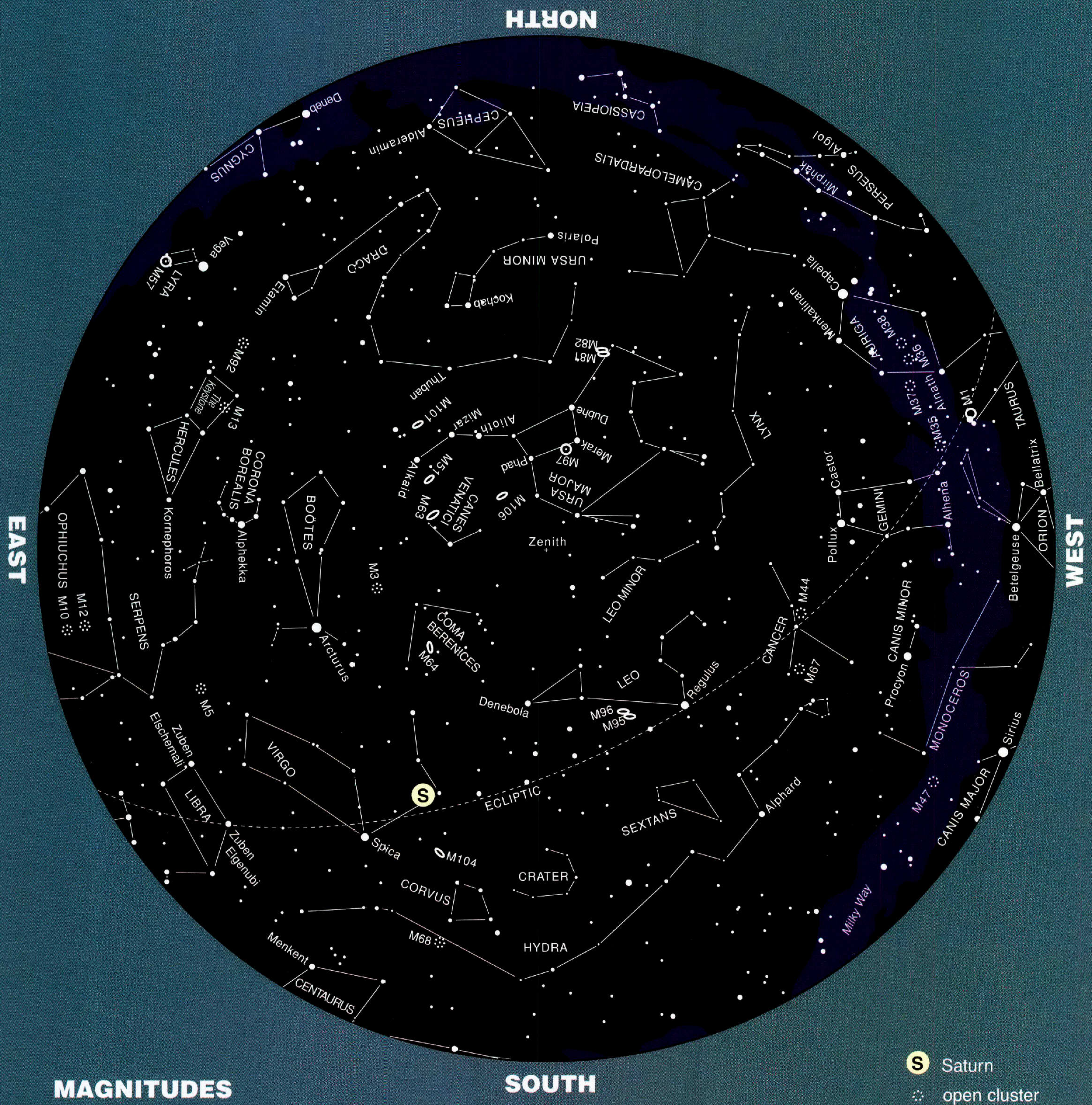
Peak
May 6, before dawn

Notes
The Moon sets before midnight, so it won't interfere with the shower. At the shower's peak you may see an average of about one meteor per minute.

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.**



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

S Saturn
open cluster
globular cluster
nebula
planetary nebula
galaxy

Charts produced with Voyager II software.

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
- 1
- 2
- 3
- 4 and fainter

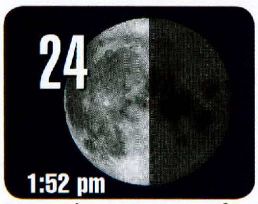
- Saturn
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

Charts produced with Voyager II software.

Sky Highlights

by Damond Benningfield

May



Moon phase times are for the Central Time Zone.

1 "Morning-star" Venus stands to the right of the Moon before sunrise. Fainter Mercury is to the lower left of Venus. It is so low in the sky that you may need binoculars to see it.

10 Venus and Jupiter, the brightest points of light in the night sky, stand side by side as dawn paints the sky, with brighter Venus to the right. Much fainter Mercury is to the lower right of the Moon, by about the same distance as between Venus and Jupiter. You probably will need binoculars to pluck Mercury from the glow of twilight. After today, Jupiter will move up and away from Venus. It will stand close to the upper left of Venus on the morning of the 11th, and farther to the upper right on the 12th.

10/11 Regulus, the brightest star of Leo, is to the upper left of the Moon at nightfall on the 10th, and to the upper right on the 11th.

13 The golden planet Saturn is to the left of the Moon at nightfall.

14 Spica, the leading light of the constellation Virgo, the virgin, is the bright star to the left of the Moon this evening, with Saturn above them.

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

17 Antares, the brightest star of Scorpius, the scorpion, is just below the Moon as they rise in mid-evening. Antares shines with a distinctly orange hue. (See sidebar box, page 11.)

29/30 Jupiter, the largest planet in the solar system, rises to the upper left of the Moon in the wee hours of the morning on the 29th, and to its upper right on the 30th. Jupiter looks like a brilliant ivory- or cream-colored star.

June

1 A partial solar eclipse is visible across northern Alaska and Canada. The lunar disk will obscure no more than a third of the Sun from these locations, however, so it won't be much of a show.

7 Regulus, the "heart" of Leo, is the bright star to the upper right of the Moon this evening.

9/10 The Moon cruises past the planet Saturn and the star Spica. On the 9th, Saturn stands to the upper left of the Moon at nightfall, with Spica farther to the Moon's left. The following night, Spica is closer to the Moon.

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

10 Saturn scooches to within about half a degree of Porrima, one of the brightest stars of Virgo. They are well up in the south at nightfall. Porrima is just to the right or upper right of much brighter Saturn.

14 Antares, the brightest star of Scorpius, hunkers to the right of the Moon at nightfall. They remain in view for most of the night.

15 A total lunar eclipse will decorate the skies of most of the world tonight, but not North America.

21 Summer arrives in the northern hemisphere at 12:16 p.m. CDT, which is the summer solstice.

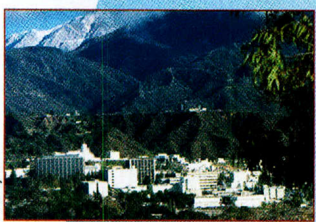
25/26 Brilliant Jupiter blazes near the Moon before dawn on these dates. Jupiter is to the lower left of the Moon on the morning of the 25th, and closer to its lower right on the 26th.

28 Mars is close to the lower left of the Moon at first light. They are low in the east. Mars looks like a modest orange star. It will climb higher into the morning sky through the rest of the year.

Space Travels

Immerse yourself in astronomy and space exploration with these special events in May and June

House of Planets


NASA/JPL

The Jet Propulsion Laboratory, home to most of NASA's planetary missions, will host an open house May 14 and 15. It offers exhibits, demonstrations, and Q&A sessions with laboratory scientists and engineers. Free admission and parking.

www.jpl.nasa.gov/events/open-house.cfm

All-Star Saturday

Schools, observatories, planetariums, and other organizations offer free public events on May 7 as part of Astronomy Day, a celebration of the night sky organized by the Astronomical League. Many events are held in shopping centers and other easily accessible sites, and include stargazing, lectures, displays, and other activities.

www.astroleague.org/al/astroday/astroday.html

The Stars at Night...

The Texas Star Party offers up those big-and-bright Texas stars May 29-June 5. The event is held outside Fort Davis, just 12 miles from McDonald Observatory. Special programs are offered for novice and binocular stargazers. Admission is $150 per person.

www.texasstarparty.org

Other star parties

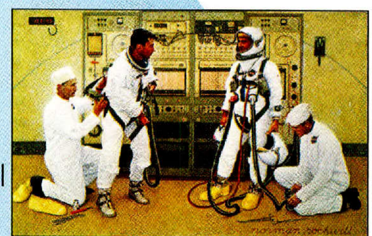
Golden State Star Party	*June 29-July 3*	*www.goldenstatestarparty.org*
Rocky Mountain Star Stare	*June 29-July 3*	*www.rmss.org*
Wisconsin Observers Weekend	*June 30-July 3*	*www.new-star.org*

Messages from Mercury

Sean Solomon, lead scientist for the MESSENGER mission to Mercury, will brief the public at the National Air & Space Museum in Washington, D.C., on May 12. Admission is free; advance registration required. The museum also offers a live webcast.

www.nasm.si.edu/events/eventDetail.cfm?eventID=2770

Picture This


SMITHSONIAN INSTITUTION

Grissom and Young, *by Norman Rockwell (1965)*

A traveling exhibition by the National Air & Space Museum settles in at the museum's National Mall facility May 28-October 9. *NASA | ART: 50 Years of Exploration* offers 72 works commissioned by the NASA Art Program. Featured artists include Annie Leibovitz, Norman Rockwell, Andy Warhol, and Jamie Wyeth. Free admission.

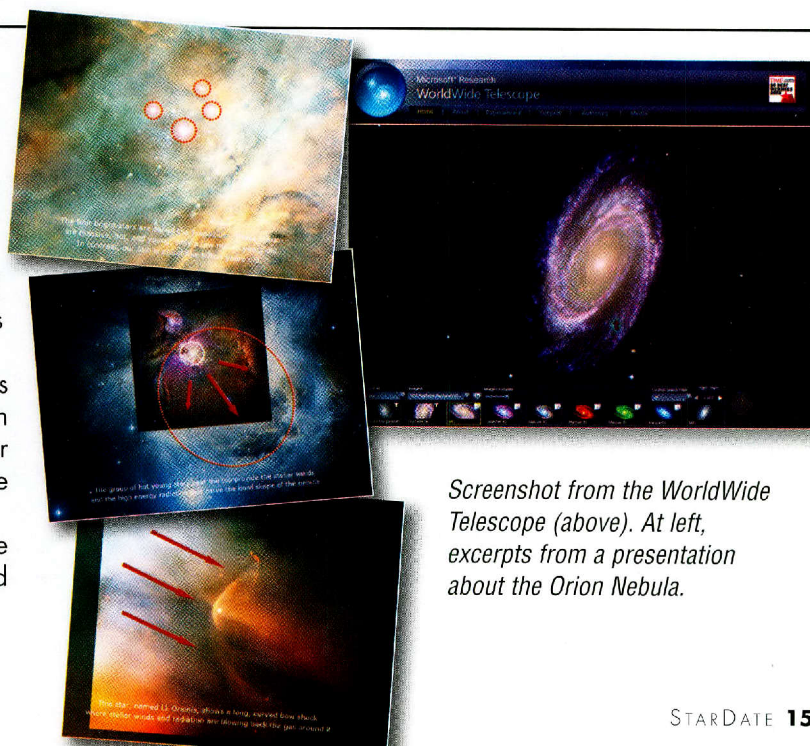
Universe on a Desktop

The WorldWide Telescope (WWT) is a free software package and website from Microsoft Research. It works as a virtual telescope on your computer, allowing you to find objects in the night sky. Its maps of the sky include data from the Spizter, Chandra, and Hubble space telescopes, and ground-based observatories like Gemini and Kitt Peak. It also includes several interactive tours you can watch.

WWT's three-dimensional visualization software is only available for PCs so far, but a 2-D online version is available for Mac users. The web version works for PCs, too, and requires the user to install Microsoft's free program Silverlight.

On first look, WWT is quite complex. However, the site's extensive introductory information, FAQs, and videos will help you get started.

www.worldwidetelescope.org



WORLDWIDE TELESCOPE (4)

Screenshot from the WorldWide Telescope (above). At left, excerpts from a presentation about the Orion Nebula.

Continued from Page 9

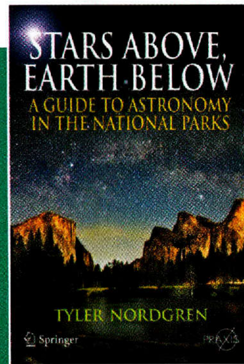
made of atoms and those atoms are made from only three simple building blocks: protons, neutrons, and electrons. The cottonwood tree in the wash is primarily carbon, a collection of six positively charged protons, glued to six neutrally charged neutrons forming a tight bundle called a nucleus. Around this nucleus is a dizzying quantum cloud of six negatively charged electrons held in place by the force of their equal but opposite charge to the nuclear protons. The sand in the sandstone is made primarily of silicon with an atomic number 14, meaning 14 protons, 14 neutrons and 14 electrons. ...

The simplest element of all is hydrogen, one proton and one electron. Hydrogen, carbon, oxygen and nitrogen (the most common element in our atomsphere) combine in a myraid ways to make up the molecules required for all organic life on Earth. It is strange beyond almost all words that the only difference between the yellow sand whose roughness gently scratches my outstreched finger tips and the cold crisp, life-giving air I breathe into my lungs is nothing more than an extra six protons, neutrons and electrons, and that that is nothing more than an atom of carbon.

The power and beauty of the atomic structure of all matter is that we are all related at an atomic and sub-atomic level. If you have the power to combine one oxygen atom and one carbon atom you literally make an atom of silicon. The dream of the alchemists to turn lead into gold is a physical reality, provided you are willing to pay for the energy to do so.

And that is the difficulty. To make silicon you must combine the positivitly charged nuclei of two atoms. As with life, opposites attract in the sub-atomic world, and like charges repel. As an analogy, attempt to force two magnets together in the wrong way and one is met with futility and strain. But reverse one magnet and the two fly together. Forcing two positivley charged nuclei together requires enormous energy and the larger nuclei (the greater the number of protons) the more energy required. There is one place in nature where the combination of heat and pressure is just enough to force the simplest of all elements together: the hearts of stars.

Look around you. The component atoms of everything you see, including yourself, began life in the center of a star. The astronomer Carl Sagan, said it simply and best, "We are star stuff."



Stars Above, Earth Below
A Guide to Astronomy in the National Parks
By Tyler Nordgren
©2010 Springer
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Tyler Nordgren is an astronomer and associate professor of physics at the University of Redlands in California.

Relatively Speaking

In 1905 an unknown Swiss patent clerk turned the world of physics on its head

Joanne Baker's new book *Universe: 50 Ideas You Really Need to Know* is made up of short chapters on everything from the Big Bang to black holes to the formation of the solar system and astrobiology. Here, she explains the how the discovery of the limited speed of light led Einstein to develop his Theory of Special Relativity.

By thinking about relative motions, Albert Einstein showed in 1905 that strange effects happen when things move very quickly. Watching an object approach light speed, you'd see it become heavier, contract in length and age more slowly. That's because nothing can travel faster than the speed of light, so time and space distort to compensate when approaching this universal speed limit.

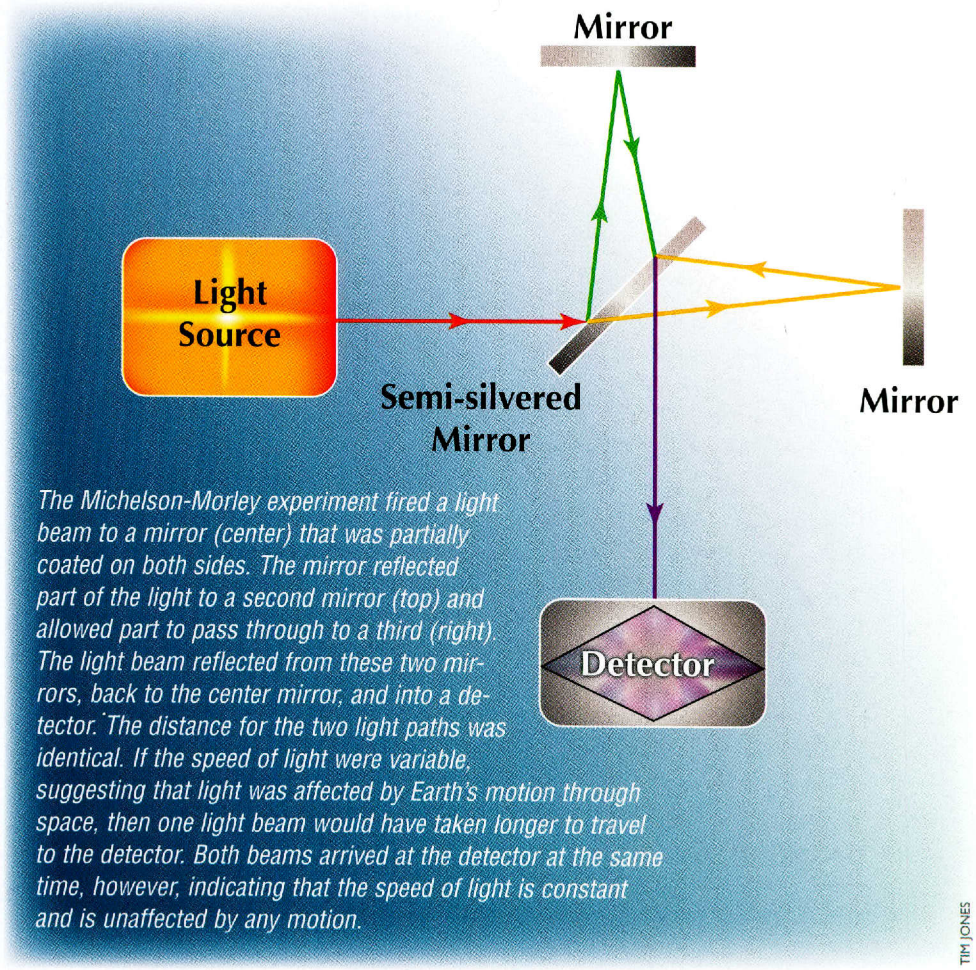
It is true that 'in space no one can hear you scream': sound waves ring through air, but their vibrations cannot be transmitted where there are no atoms, whereas light can spread through empty space, as we know because we see the Sun and stars. Is space filled with a special medium, a sort of electric air, through which electromagnetic waves propagate? Physicists at the end of the 19th century thought so, believing that space was effused with a gas or 'ether' through which light could radiate.

Light speed

In 1887, however, a famous experiment proved the ether did not exist. Because the Earth moves around the Sun, its position in space is always changing. Albert Michelson and Edward Morley devised an ingenious experiment that would detect movement against it if the ether were fixed. They compared two beams of light travelling different paths, fired at right angles to one another and reflected back off the identically faraway mirrors. Just as a swimmer takes less time to travel across a river from one bank to the other and back than to swim the same distance upstream against the current and downstream with it, they expected a similar result for light. The river current mimics the motion of the Earth through the ether. But there was no such difference — the light beams returned to their starting points at exactly the same time. No matter which direction the light travelled, and how the Earth was moving, the speed of light remained unchanged. Light's speed was unaffected by motion. The experiment proved the ether did not exist — but it took Einstein to realize this. ...

[T]his meant that there was no fixed background grid against which objects moved. Unlike water waves or sound waves, light appeared to always travel at the same speed. This was odd and quite different from our usual experience where velocities add together. If you are driving a car at 50km/h and another passes you at 65 km/h, it is as if you are stationary and the other vehicle is travelling at 15 km/h past you. But even if you were rushing at hundreds of km/h, light would still travel at the same speed. It is exactly 300 million metres per second whether you are shining a torch from your seat in a fast jet plane or from the saddle of a bicycle.

It was this fixed speed of light that puzzled Albert Einstein in 1905, leading him to devise his theory of special relativity. Then an unknown Swiss patent clerk, Einstein worked out the equations from scratch in his spare moments. Special relativity was the biggest breakthrough since Newton and revolutionized physics. Einstein started with the assumption that the speed of light is a constant value, and appears the same for any observer no matter how fast they are moving. If the speed of light does not change, reasoned Einstein, something else must change to compensate.



The Michelson-Morley experiment fired a light beam to a mirror (center) that was partially coated on both sides. The mirror reflected part of the light to a second mirror (top) and allowed part to pass through to a third (right). The light beam reflected from these two mirrors, back to the center mirror, and into a detector. The distance for the two light paths was identical. If the speed of light were variable, suggesting that light was affected by Earth's motion through space, then one light beam would have taken longer to travel to the detector. Both beams arrived at the detector at the same time, however, indicating that the speed of light is constant and is unaffected by any motion.

Space and time

Following ideas developed by Edward Lorenz, George Fitzgerald and Henri Poincaré, Einstein showed that space and time must distort to accommodate the different viewpoints of observers travelling close to the speed of light. The three dimensions of space and one of time made up a four-dimensional world in which Einstein was able to exercise his vivid imagination. Speed is distance divided by time, so to prevent anything from exceeding the speed of light, distances must shrink and time slow down to compensate. So a rocket travelling away from you at near light speed looks shorter and experiences time more slowly than you do.

> 'The most incomprehensible thing about the world is that it is at all comprehensible.'
>
> -Albert Einstein

> 'It is impossible to travel faster than the speed of light, and certainly not desirable, as one's hat keeps blowing off.'
>
> -Woody Allen

Einstein worked out how the laws of motion could be rewritten for observers travelling at different speeds. He ruled out the existence of a stationary frame of reference, such as the ether, and stated that all motion was relative, with no privileged viewpoint. If you are sitting on a train and see the train next to you moving, you may not know whether it is your train or the other one pulling out. Moreover, even if you can see that your train is stationary at the platform you cannot assume that you are immobile, just that you are not moving relative to that platform. We do not feel the motion of the Earth around the Sun; similarly, we never notice the Sun's path across our own galaxy, or our Milky Way being pulled towards the huge Virgo cluster of galaxies beyond it. All that is experienced is relative motion, between you and the platform or the Earth spinning against the stars.

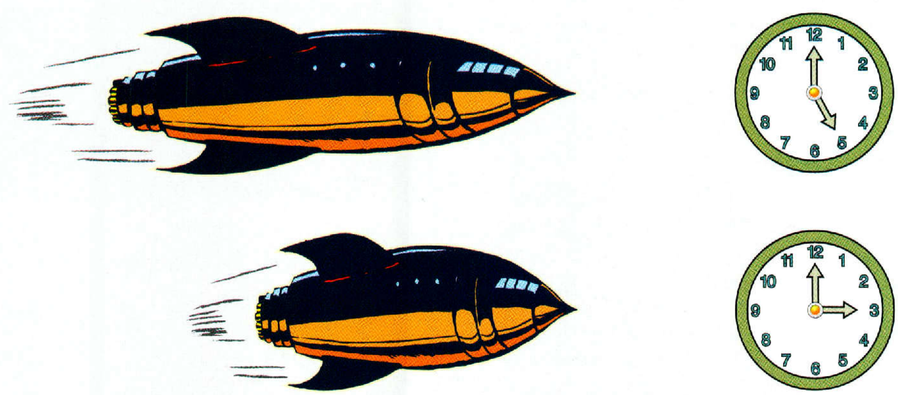
Einstein called these different viewpoints inertial frames. Inertial frames are spaces that move relative to one another at a constant speed, without experiencing accelerations or forces. So sitting in a car travelling at 50 km/h you are in one inertial frame, and you feel just the same as if you were in a train travelling at 100 km/h (another inertial frame) or a jet plane travelling at 500 km/h (yet another). Einstein stated that the laws of physics are the same in all inertial frames. If you dropped your pen in the car, train or plane, it would fall to the floor in the same way.

Slower and heavier

Turning next to relative motions near the speed of light, the maximum speed practically attainable by matter, Einstein predicted that time would slow down. Time dilation expressed the fact that clocks in different moving inertial frames may run at different speeds. This was proved in 1971 by sending identical atomic clocks on scheduled flights twice around the world, two flying eastwards and two westwards. Comparing their times with a matched clock on the Earth's surface in the United States, the moving clocks had each lost a fraction of a second compared with the grounded clock, in agreement with Einstein's special relativity.

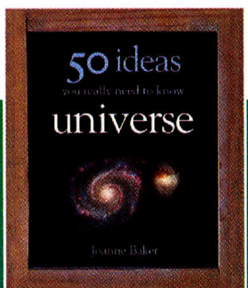
Another way that objects are prevented from passing the light-speed barrier is that their mass grows, according to $E=mc^2$. An object would become infinitely large at light speed itself, making any further acceleration impossible. And anything with mass cannot reach the speed of light exactly, but only approach it, as the closer it gets, the heavier and more difficult to accelerate it becomes. Light is made of mass-less photons so these are unaffected.

Einstein's special relativity was a radical departure from what had gone before. The equivalence of mass and energy was shocking, as were all the implications for time dilation and mass. Although Einstein was a scientific nobody when he published his ideas, they were read by top physicist Max Planck, and it is perhaps because of his adoption of the theory that it became accepted and not sidelined. Planck saw the beauty in Einstein's equations, catapulting [Einstein] to global fame.



Twin paradox

Imagine if time dilation applied to humans. Well it could. If your identical twin was sent off into space on a rocket ship, fast enough and for long enough, they would age more slowly than you on Earth. On their return, they might find you to be elderly when they are still a sprightly youth. Although this seems impossible, it is not really a paradox, because the space-faring twin would experience powerful forces that permit such a change to happen. Because of the time shift, events that appear simultaneous in one frame may not appear so in another. Just as time slows, so lengths contract also. The object or person moving at the speed would not notice either effect; it would just appear so to another viewer.



Universe: 50 Ideas You Really Need to Know

By Joanne Baker
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Joanne Baker studied physics at the University of Cambridge and earned her PhD in astrophysics at the University of Sydney in 1995. She is the author of the best-selling 50 Physics Ideas You Really Need to Know *and is an editor at* Nature *magazine, where her specialty is space and Earth science.*

New Books in Brief

Before the Big Bang
The Prehistory of the Universe

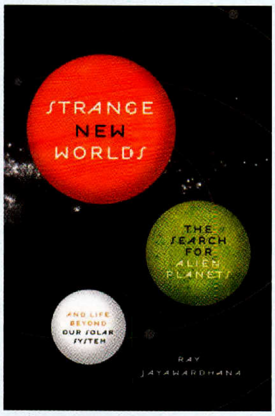
By Brian Clegg © 2011 St. Martin's Griffin $14.99

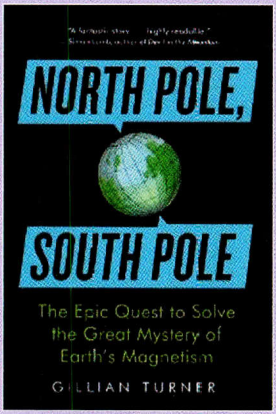
'The reason it is thought that time began with the Big Bang is because this wasn't the emergence of the universe into space, but rather the emergence of space itself. Before the Big Bang, the standard theory assumes, there was no space: not empty space, just nothing. And the Einsteinian picture of the universe merges space and time into a single entity: no space, no time, because the whole thing is one: spacetime.'

Strange New Worlds
The Search for Alien Planets and Life Beyond our Solar System

By Ray Jayawardhana © 2011 Princeton University Press $24.95

'There is something exciting about a picture of a planet circling another star. For most people I've spoken with, reading about hundreds of planets discovered through Doppler surveys, transit searches, and microlensing just does not compare with seeing an actual photograph of one. Somehow the photo makes it a "real" world, even if it is just a faint dot next to a bright, overexposed star. Those people will be happy to hear that the era of direct imaging is here at last.'





North Pole, South Pole
The Epic Quest to Solve the Great Mystery of Earth's Magnetism

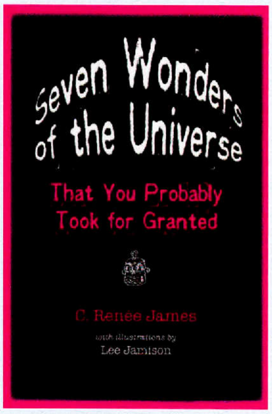
By Gillian Turner ©2011 The Experiment $15.95

'Before this, though, [Edmund] Halley scored another first for science when in 1698, in what has been claimed to be the first specially commissioned nautical geophysical expedition, he set out to measure and chart the magnetic declination (or "variation" as it was still called) over the Atlantic Ocean. Halley had been adamant that the route to understanding geomagnetic declination and secular variation, and possibly determining longitude at sea, lay in collecting and documenting as much information as possible. He had made his case to the king, William III, and to the British Admiralty and been awarded a captain's commission.'

Seven Wonders of the Universe
That You Probably Took for Granted

By C. Renée James ©2011 The Johns Hopkins University Press $25

'It's hard to escape the irony behind all the nicknames of our solar system's second planet. One of the more striking objects to show up in our evening or morning sky, it's often called the Evening Star or Morning Star, despite the fact that it's not a star at all. Even more ironic is that the Romans named it for the goddess of love, which makes it the poster child (or poster planet, as the case may be) for jilted lovers and cynics. 'Sure, it looks pretty from the outside, luminous and inviting, but once you actually get there, it's a horrible, stifling, crushing, hellish place.''



by Rebecca Johnson and Damond Benningfield

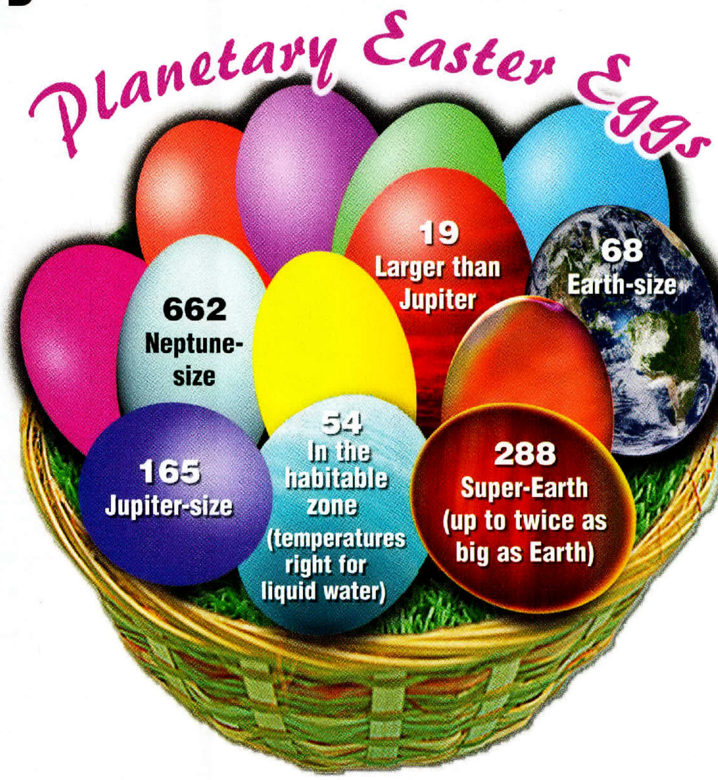
LYNETTE COOK/GEMINI OBSERVATORY/AURA

Beginning of the End?

A quasar at the center of the galaxy Markarian 231 is beginning to shut itself down by blowing away the surrounding gas and dust, as shown in this artist's concept. The galaxy is the result of a merger, in which two galaxies coalesced to form a single one. This process funneled gas and dust toward the central supermassive black hole. As the material poured in it formed a hot disk around the black hole, creating a quasar — an object smaller than our solar system but brighter than a full galaxy of stars. The quasar produces so much radiation that it pushes away the remaining gas and dust around it. Eventually, this will deprive it of new fuel, and the quasar will grow quiet. Although such a process has been hypothesized, the astronomers who studied Markarian 231, using the Gemini telescope, say this is the first time the process has been observed.

Cheaper by the Basketful

For the scientists who study planetary systems beyond our own, Easter came a little early this year — in early February, to be exact, when scientists with the Kepler mission handed them a basketful of about 1,200 possible new planets. If all of them are confirmed, they would more than triple the number of known exoplanets.



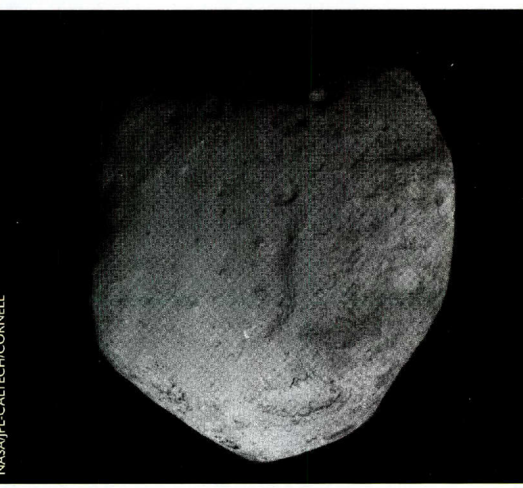
Kepler spotted the possible planets during its first four months in orbit. Team members are using telescopes at McDonald Observatory and elsewhere to confirm the discoveries.

Kepler keeps a constant eye on more than 150,000 Sun-like stars, looking for their brightness to dip as planets pass in front of them, blocking a tiny bit of the stars' light.

Kepler's goal is to find Earth-size worlds in Earth-like orbits. Although it will take another year or two to find and confirm such planets, Kepler is finding many other worlds that are much closer to their parent stars than Earth is to the Sun. Such planets cross in front of their stars every few days or weeks instead of once every year or so for planets in Earth-like orbits.

The Kepler team has already confirmed one of the largest planetary systems yet discovered. Known as Kepler 11, the system contains at least six planets orbiting a star that is about the same size, mass, and temperature as the Sun, but perhaps a few billion years older.

All of the Kepler 11 planets are bigger and heavier than Earth. They are less than half as far from their parent star as Earth is from the Sun, too, so they are too hot for liquid water, which is a key ingredient for life as we know it. **DB**

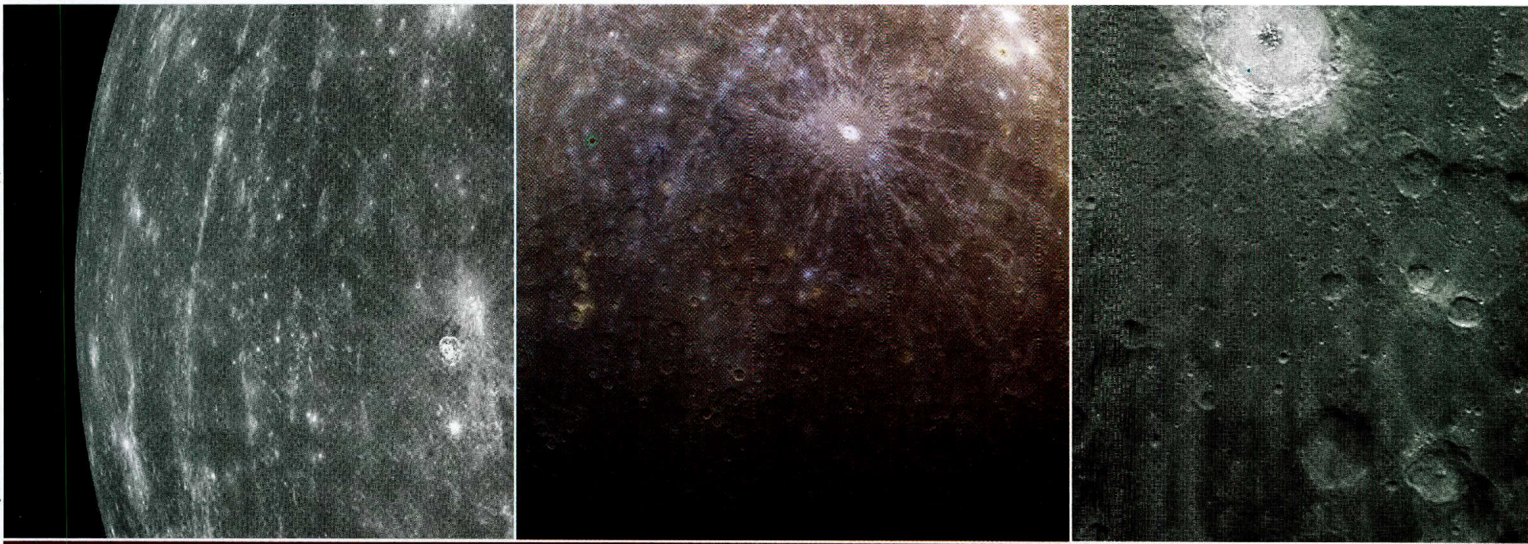


NASA/JPL-CALTECH/CORNELL

Comet Check-Up

NASA's Stardust spacecraft flew by Comet Tempel 1 on Valentine's Day. It was bonus science for Stardust, which completed its mission to Comet Wild 2 in 2006. The craft then headed for Tempel 1 to look for changes there since the 2005 engineered crash of Deep Impact on the comet's surface. Scientists are still analyzing Stardust's images of Tempel 1. Early results indicate the comet's nucleus (left) is fragile.

NASA/JHUAPL/CARNEGIE INSTITUTION OF WASHINGTON (3)



From left: Bright young impact craters highlight a wide view toward Mercury's limb; the first color view from orbit, with the crater Debussy at top center; a close-up of Debussy, showing the crater's layered rim and a massive central mountain peak.

Mercury Orbiter Ready to 'Drill' into Planetary Bowling Ball

Mercury is the bowling ball of planets. Its dense metallic core probably accounts for about 75 percent of the planet's diameter, which is more than twice the ratio of Earth's core. Explaining why Mercury's core is so large is one goal of MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging), which became the first spacecraft in history to orbit the solar system's smallest planet when it arrived March 17. It snapped its first pictures 12 days later, and was scheduled to begin full science operations April 4.

MESSENGER's instruments will map Mercury's surface, measure its magnetic field, and chart the mineral and chemical composition of its surface, which are the keys to understanding the planet's structure.

There are three leading ideas to explain the unusual heft of Mercury's core: It was born that way; Mercury was born with thicker outer layers of lightweight rock, but they were boiled away by the heat of the nearby Sun; or the rock layers were blasted away by a collision with a giant asteroid. Each of these explanations would leave its own unique chemical fingerprint in the rocks at Mercury's surface. So by revealing the composition of the rocks, MESSENGER's observations should go a long way toward explaining Mercury's birth and evolution.

MESSENGER is scheduled to orbit Mercury for one Earth year, continuing observations it began during three flybys of the little planet during its circuitous 79-month journey. Each flyby reduced the craft's speed, allowing it to use its rocket engine to enter orbit. **DB**

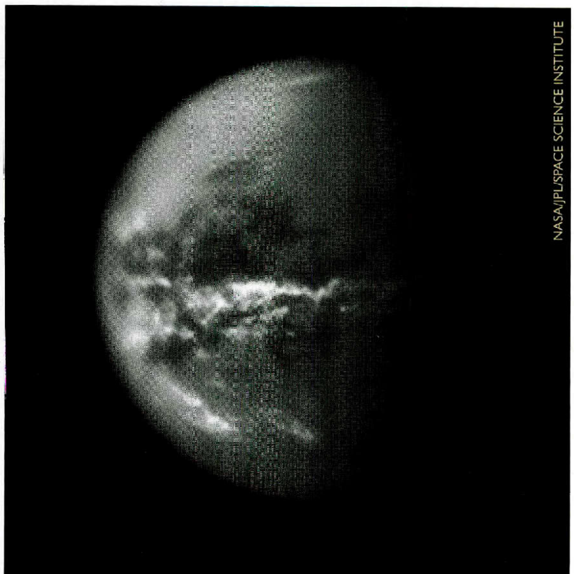
A Case of the Rainy Day Blues

The rain in Spain may fall mainly on the plain, but on Saturn's moon Titan it's been falling on giant dune fields that girdle the equator, turning them noticeably darker.

Bright cloud formations began appearing above the equator in images from the orbiting Cassini spacecraft last September, as spring advanced across Titan's northern hemisphere. As the clouds parted, the images showed that dune fields that cover hundreds of thousands of square miles were much darker than before. The most likely explanation, according to mission scientists, is that the dunes were soaked by rain.

On Titan, though, surface temperatures are around –290 degrees Fahrenheit (–180 C), so the raindrops are made of liquid methane, not water. They probably are filling riverbeds and lake basins seen in earlier Cassini images.

Cassini had already detected clouds, rain, and lakes at higher latitudes on Titan, but this is the first time any liquid has been observed at the equator. Mission scientists say the rains probably are the result of the change in seasons. Spring arrived in the northern hemisphere in August 2009, and will last for about seven Earth years.

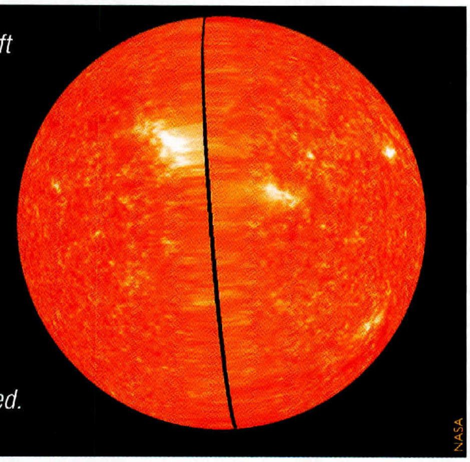


NASA/JPL/SPACE SCIENCE INSTITUTE

Bright clouds hover above dark regions at Titan's equator in this October 2010 view from Cassini.

The Quiet Sun, Revealed

The Sun is now coming out of an especially long quiet period known as solar minimum, marked by an absence of sunspots and solar flares. For 780 days from 2008 to 2010, no sunspots appeared on the Sun. While a quiet period is a standard part of the Sun's 11-year activity cycle, the sunspot-free period usually lasts about 300 days. Solar scientists have been trying to figure out what prolonged the solar minimum that's now coming to an end.



Twin STEREO spacecraft recently completed their deployment to opposite sides of the Sun. Their positions allow astronomers a continuous, 360-degree view of the Sun, as seen in this February image compiled just before the final gap was closed.

NASA

Computer simulations by Andres Munoz-Jaramillo, a visiting research fellow at the Harvard-Smithsonian Center for Astrophysics, suggest that changes in the flow of hot plasma inside the Sun caused the long minimum.

"The Sun contains huge rivers of plasma similar to Earth's ocean currents," Munoz-Jaramillo says. He used computers to model the flow of plasma rivers between the Sun's equator and higher latitudes. These currents move out from the equator and flow back toward it at about 40 miles per hour, taking about 11 years to make a cycle. The models extended through 210 solar cycles, covering a period of about 2,000 years.

The simulations showed that the plasma rivers speed up and slow down like a malfunctioning conveyor belt. A faster flow in the first half of a solar cycle, followed by a slower flow in the second half, can lead to an extended solar minimum.

The project's objective is to predict the Sun's future minimum and maximum activity times. During solar maximum, hot plasma hurled from the Sun can disrupt Earth's communications, electrical grids, and orbiting satellites. During solar minimum, Earth's atmosphere shrinks, affording our planet less protection from cosmic rays. **RJ**

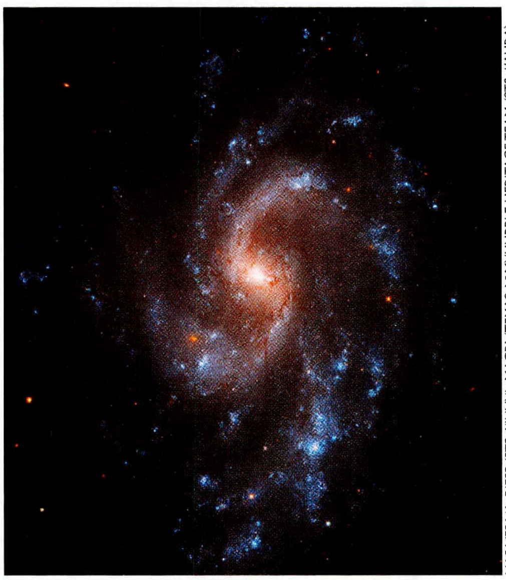
Bursting the 'Bubble Theory'

Hubble astronomers rule out a possible alternative to dark energy

A little more than a decade ago, astronomers discovered that the universe is expanding faster all the time. This still-unexplained phenomenon, akin to throwing a ball into the air and having it not return, but speed away faster and faster, has been pinned on an unknown force called dark energy. The idea was so radical that scientists came up with several alternatives that could explain the apparent motions of galaxies without invoking a mysterious new force.

One alternative, the bubble theory, suggested that our galaxy lives at the center of a great cosmic void, or bubble. Because there are few galaxies — less mass, and therefore less gravity — inside this bubble, space within it would expand faster there than in the rest of the universe. From our viewpoint within the bubble, it would appear that the entire universe's expansion is speeding up, when in fact, outside the bubble — in the rest of the universe — the expansion would be slowing down as expected.

Astronomers using Hubble Space Telescope say they have measured the universe's rate of expansion (called the Hubble constant) so precisely that they can rule out the bubble theory.



NASA/ESA/A. RIESS (STScI/JHU)/L. MACRI (TEXAS A&M)/HUBBLE HERITAGE TEAM (STScI/AURA)

Riess' team found 250 Cepheids and a type Ia supernova in NGC 5584, one of eight galaxies studied to calculate the universe's expansion rate.

Adam Riess of the Space Telescope Science Institute led a team of astronomers using Hubble to measure how fast galaxies at different distances are rushing away from us. They used Hubble's new Wide Field Camera 3 to look for specific types of stars — type Ia supernovae and Cepheid variables — that would enable them to measure the host galaxies' speed, direction, and distance.

The data from Hubble's sensitive camera enabled them to measure the Hubble content to be 73.8 kilometers per second per megaparsec, with an error margin of just 3.3 percent. That means that for each additional million parsecs, or 3.26 million light-years, a galaxy is from Earth, the galaxy appears to be traveling 73.8 kilometers per second faster away from us.

The astronomers say the new value for the Hubble content is a 30 percent improvement in accuracy. It invalidates the bubble theory, which requires a slower expansion expansion rate of about 60 to 65 kilometers per second per megaparsec. **RJ**

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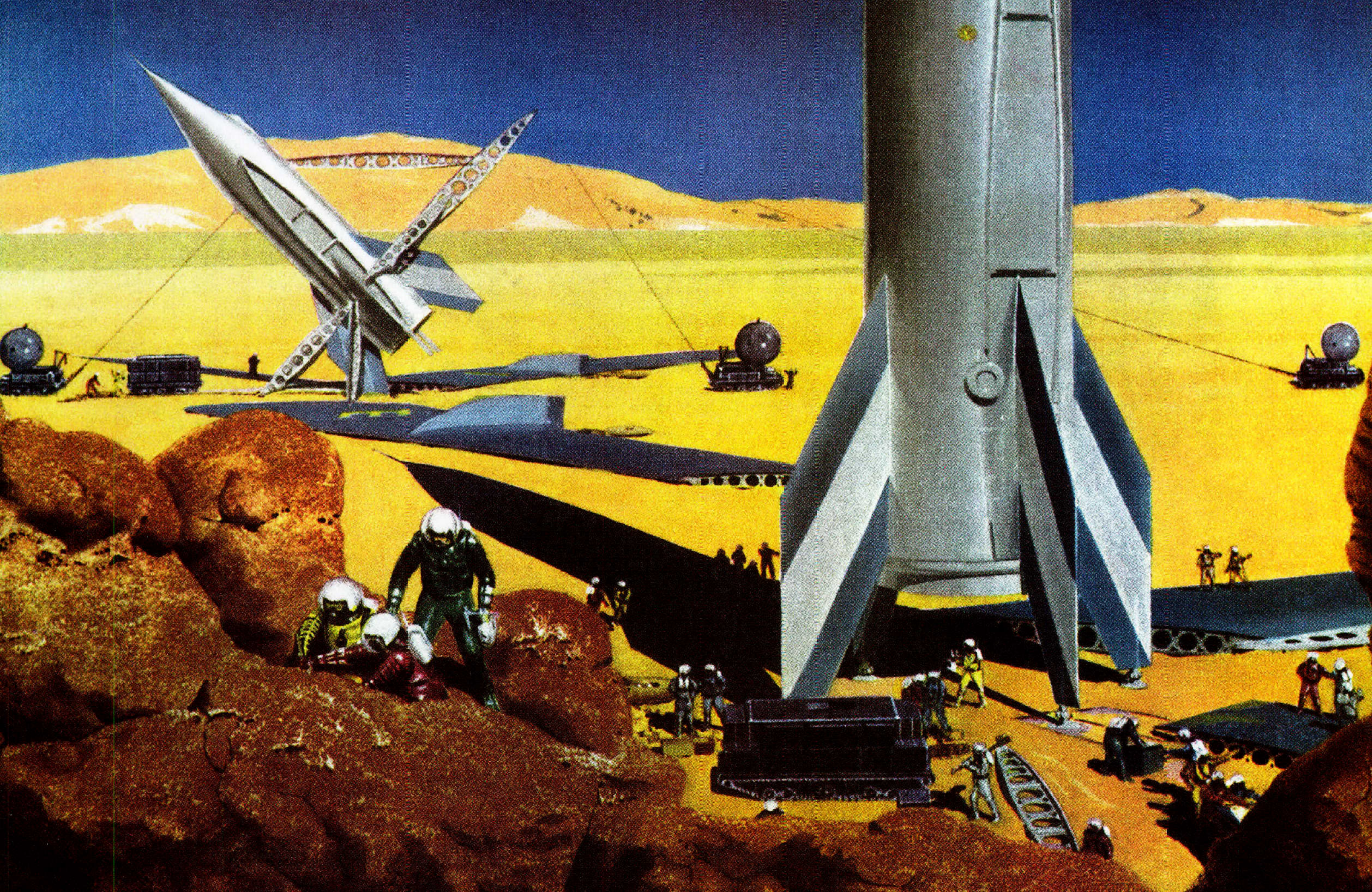

The giant spiral galaxy NGC 2841 shines majestically in this image from Hubble Space Telescope. A bright 'bulge' of old stars dominates the galaxy's center, with spiral arms surrounding it. Lanes of dark dust outline the arms. The galaxy has relatively few stellar nurseries, which are regions where new stars are born. NGC 2841 is 46 million light-years away in the constellation Ursa Major, the great bear.

NASA/ESA/HUBBLE HERITAGE (STScI/AURA)/ESA-HUBBLE COLLABORATION