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A Neutrino's Encounter with a Terrestrial Detector

By Gerceida Jones

Dr. Glennys Farrar**, professor** of physics at NYU, heads the Center for Cosmology and Particle Physics there, and wants to use water towers on top of city buildings as a way to track the most mysterious particle in the universe, the elusive neutrino.

In the AAA's lecture at the AMNH April 9 on "High -Energy Astrophysics with a Neutrino Telescope in New York City," Farrar outlined her ingenious idea to create a starter array of 1,000 stations inside existing water tanks to form a neutrino telescope capable of detecting high-energy astrophysical neutrinos.

She explained that neutrinos belong to particles called leptons which come in pairs; each neutrino has a charged partner. Most were created in the few seconds when the universe was composed of elementary particles. Additional neutrinos are produced in stars, such as our Sun, some via beta decay and some from supernova explosions. The only confirmed extraterrestrial neutrino sources are the Sun and supernova SN1987A.

Farrar explained that since neutrinos are only weakly interactive with other particles, neutrino detectors must be very large in order to get a significant number of them. "They are extremely non-interacting and difficult to detect," she noted. Farrar said a 3,000 km2 detector would capture approximately 100 neutrinos.

In theory, neutrinos can interact via the neutral current (exchange of a Z boson) or charged current (exchange of a W boson), weak interactions. Depending on the acceleration sites, solar and reactor neutrinos have enough energy to create electrons and most accelerator-based neutrino beams can create muons and even a few taus. Farrar and her team use existing UHECR data to deduce properties of the source and the cosmic magnetic fields. Her findings show acceleration sites of low-energy cosmic rays from the Sun get carried along by the magnetic field, medium energy cosmic rays from the Milky Way tend to accelerate in supernovae but get confined by the galactic magnetic field and high-energy cosmic rays (ultra galactic) are gamma-ray bursts or active galactic nuclei, aka blazers and quasars.

Most neutrino experiments must address the flux of cosmic rays that bombard Earth's surface, resulting in a continuous background of noise. To eradicate--or minimize--this problem, researchers have placed detectors deep under water (the Antares neutrino telescope lies under about 7,500 feet of water) or ice (the IceCube collaboration for observing neutrinos at predominantly low energies at the South Pole).

Farrar called the telescope at the South Pole "the world's best detector" because it's a multi-purpose telescope that could provide an in-depth look at temperature variations in the ozone layer. She explained what happens as neutrinos pass through a thick layer of ice at amazing high speeds. They tend to slam into atoms, generating another type of elementary particle, primarily

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Lee Baltin is Dead at 90

At press time, word was received of the death of Elias (Lee) Baltin in Florida at 90. Until several years ago, Lee was a longtime member of the AAA board of directors and treasurer. Among other activities, he supervised the club's investments. More broadly, he was an active observer and was a constant source of advice and wisdom to club colleagues over several decades. More material on Lee will be in next month's *Eyepiece*.

What's Up

By Tony Hoffman

The Sky for May 2010

Venus Blazes in the Evening Sky. As the sky darkens, look to the west. That searingly bright orb is Venus. The "second rock from the Sun" blazes at magnitude -3.9 and moves from Taurus to Gemini this month. The best conjunction involving our sister world occurs at mid-month. On May 15, Venus will lie between the horns of Taurus, with a crescent Moon just below.

Nearly Ringless Saturn. Saturn is well-placed for evening observers, though its rings are nearly out of view. Late in the month, they'll be inclined less than 2 degrees to our line of sight. Several of Saturn's moons should be visible in a 4-inch telescope, while its largest moon, 8th magnitude Titan, can easily be seen in a smaller scope. Saturn lies near Beta Virginis and is of similar brightness to Virgo's brightest star, Spica.

Mars Soldiers On. Faded to first magnitude, Mars shines with but a pale shadow of last winter's brilliance, but it's still worth tracking as it moves from Cancer to Leo this month. Mars is now far enough away, and its disk small enough (~7 arc-seconds), that even a larger telescope will show little detail beyond perhaps the north polar cap. At the end of the month, Mars will lie 3 degrees from Regulus, which it outshines by a smidgen.

Jupiter Rules the Predawn. Our solar system's largest planet rises at about 3 a.m. Shining at magnitude -2.2, Jupiter lies below the circlet of Pisces. A small scope will reveal Jupiter's four Galilean moons. This month, the 6th magnitude planet Uranus lies in the same binocular field as Jupiter. At month's end, the two worlds will lie just a degree apart.

May 6 Last-quarter Moon at 12:15 a.m.
May 9 Moon lies near Jupiter.
May 13 New Moon at 9:04 p.m.
May 15, 16 Moon lies near Venus in evening sky.
May 20 Moon is at perigee, 229,742 miles from Earth, 4:45 a.m.; Moon lies near Mars; First-quarter Moon at 7:43 p.m.
May 23 Moon lies near Saturn.
May 27 Full Moon at 7:07 p.m

One Last Good View of Mars

By Joseph A. Fedrick

Mars was rapidly fading into the distance as Earth left it behind during March. Mars was dimming noticeably in the evening sky and its disk, as observed telescopically, was rapidly shrinking.

I used my 6-inch f/9 Newtonian reflector and an eyepiece yielding about 150x to observe Mars March 24 between 8:30 and 9 p. m. A dark-grayish highland area, Syrtis Major, was near the center of the Martian disk. Most of the rest of the disk was a coral pink-tan hue. Just south of Syrtis Major, a low region, Hellas, was bright, almost white and probably was filled by a frosty haze indicating the arrival of autumn in that part of Mars, while the North Polar Cap had become much smaller as spring had been underway there. The Martian disk appeared gibbous as Earth approached quadrature with Mars.

I slewed my Newtonian reflector toward Saturn after looking at Mars. Saturn's disk was a tan-yellow hue and displayed faint brownish cloud belts. The ring system was less than 5 degrees from edgewise so the various parts of the rings--A ring, Cassini Division and B ring--were barely discernable.

Mercury and Venus were barely above the rooftops of buildings to my west as I observed the planets from a street corner near my Bronx house at dusk on April 1. They were both visible in the same field of view in a pair of 10x50 binoculars, with Mercury being less than 4 degrees to the northwest (lower right) of Venus. Just before they sank behind the houses, Mercury became visible to my unaided eye.

The following morning, Jupiter appeared just above the rooftops of Co-op City to my southeast at dawn. I used my 60mm refractor at 50x and 100x on April 10 to find Jupiter's South Equatorial Belt had faded. In fact, I'd observed the belt had already begun fading in late January, just before I lost Jupiter in the southwest at dusk. Images of Jupiter's fading South Equatorial Belt during January can be found on Christopher Go's site on the Internet (http://jupiter.cstoneind.com/). Jupiter will soon be in conjunction with Uranus, so observing Jupiter will be especially interesting this year. ■

A Message from AAA President Richard Rosenberg

Hello, members:

The AAA's annual meeting will take place Wednesday, May 19 at headquarters. There will be a buffet dinner at 6:30 and the meeting itself will begin at 7:30. A highlight will be the appearance of Jacqueline Hakim, the niece of Donald Gerard, a member of the club until his untimely death in 1943. Ms. Hakim will bring some memorabilia from that period. I hope all of you will come and meet your fellow members.

We're continuing our efforts to make us to be better known in this tech-savvy world. Jason Kendall has us on Facebook, Tony Hoffman on Twitter, and we're appearing in several on- and off-line magazines. One of the latter is KidCity, which has posted our summer observing schedule on its website and on Examiner.

KidCity is also looking for parents living in New York City to answer the question "On a beautiful summer day, what is one of your favorite outdoor things to do with your family?" Your quote will appear in an upcoming book "101 Anytime Summer Adventures." I think early summer evenings qualify as much as "beautiful summer days." If you're interested, send me your reply and I'll forward it to the magazine.

Observing last month went off with a bang as AAA members set up their scopes all over the city. One highlight was resumption of observing at the High Line. We'll be there every clear Tuesday until October. In July and September, we'll be at a new location, Fort Greene Park in Brooklyn. Check our website—www.aaa.org—or contact me for info on other special observing sessions at locations such as Pier 1 in Brooklyn.

Our spring class began early in April and is still going on. Once again we have a large class, almost 30 students. I spoke for two weeks on the history of our solar system. Because I didn't cover everything and didn't have much time to answer questions, the presentation is now on our website (www.aaa.org/classes; click the "view slides" link). It is in PDF format so the movies won't show. I'll also devote some time to the solar system in our observers' group and seminar meetings for the next few months. The first such meeting will be Tuesday, April 27 at 6:30 p. m. at headquarters, 120 Warren Street. All are welcome to attend.

Rich Rosenberg, AAA President, president @aaa.org, (718) 522-5014

AAA's May 7 Lecture to Train a Lens on Astrophotography

Dr. Ruben Kier, a radiologist with a special interest in astrophotography, will wrap up the AAA's 2009-10 lecture series on Friday, May 7 when he discusses "Best Targets for Amateur Astrophotography and What They Reveal about our Universe." The free public lecture begins at 6:15 in the Kaufmann Theater of the AMNH.

Kier's talk lecture will focus on the choice of celestial objects for astrophotography. In choosing his list of the 100 best astrophotography targets, he has sought to identify compositions that inspire the viewer. "Furthermore," he says, "the object should be bright enough to image with a backyard amateur telescope, an average CCD camera and fewer than three hours of total exposures. The target needs to be large enough to show detail and high enough in the sky to be captured from northern latitudes. More than a third of the targets can be framed with a second object to create a more dynamic image."

Unlike the famous Messier, Hershel and Caldwell visual catalogs, Kier's list focuses specifically on the best objects for the amateur astrophotographer.

But photographing objects is only part of the enjoyment, Kier notes. "Study of the images enriches the experience of visual astronomy. For example, star clusters show patterns of color that help us understand stellar evolution. Reflection and emission nebulae show com-

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Recent-Advances Seminar: Diverse Topics, Diverse Attendees

By Jason Kendall

The monthly recent-advances seminar April 8 at NYU attracted a diverse crowd, with many NYU students in attendance. Board member Gerceida Jones brought her intro students for a perspective on astronomy from people who are passionate about it. I had invited Bernie Klingleman, Dr. Laird Whitehill and a student named Bernadette Davis to speak.

Bernie talked about energy. He observed that many people are unaware of how the word energy is used in a scientific context. Bernie provided a number of examples, from kinetic to quantum mechanical. Laird demonstrated Partiview, the free 3-D astronomical visualization software from the Hayden Planetarium. He had a good outline on how to operate it and see nearby stars. The script walked a new user who downloads the application through a treasure trove of astronomical data.

Laird showed how to see planets, nearby galaxies and the Milky Way's structure indicators--open and globular clusters, and pulsars. There were satisfying wow moments, such as when a first-time observer sees Saturn through a scope, and all of Laird's copies of his script were taken home by attendees. Partiview is available for download at http://www.haydenplanetarium.org, and I'll send Laird's script to anyone who contacts me via e-mail (jkendall@moonbeam.net).

Bernadette gave a promised report on rogue planets. In March, I'd challenged her to bring in a report, and Gerceida helped her with her subject. She impressed other students with her willingness to jump into the fray, learn something new and present it. She discussed not only what she'd had learned about planets that may have been expelled from their nascent solar systems by formation processes, but ably speculated about life on such a world, and what it would be like to "ride an exoplanet into interstellar space." What I liked best was how she wrapped up with questions she had from her reading.

This is the point of the seminar: What we talk about spurs learning at home. Furthermore, Gerceida encouraged Bernadette to start an astronomy club at NYU, and she's agreed. I hope club members will help support this club by presenting material at the seminar.

I'm looking for 10-minute extemporaneous talks using a 10-slide PowerPoint or image set. The goal is to cover a single topic in the news. After the presentation, we'll discuss its importance, going to the web to help answer questions. Topics should have appeared in popular news media, NASA/ESA websites or refereed journal articles. E-mail me if you'd like to present a topic. In March, this format encouraged a budding astronomy buff to return in April to share what she'd learned. Join us May 13!

Fort Tryon Lights Shielded for AAA

By Anne Kiefer

To mark the 75th anniversary of Fort Tryon Park April 14, the Inwood Astronomy Project under AAA board member Jason Kendall persuaded the city parks department to cover streetlamps on the site, similar to the earlier light shutoff in Inwood Hill Park.

More than 100 people gathered at Fort Tryon Park to celebrate the post-winter return of stargazing and the unveiling of a new telescope.

Kendall brought an Obsession 15, one of the largest amateur telescopes available for public use in the city. He explained that since the scope isn't fully enclosed, ambient light can severely constrict its success. Attendees often stood in front of a troublesome light to aid viewing.

Kendall showed Saturn in the scope. The rings and Titan, Tethys, Dione and Rhea were visible. He also pointed out the binary Alcor and Mizar in Ursa Major.

Kendall and Bruce Kamiat found Mars and the neighboring Beehive Cluster. They discussed the difference between Obsession and binocular views.

Kendall also worked to find what he called dark fuzzies, not visible to the naked eye. He located Messier 3, or the M3 globular cluster of cluster of some 500,000 stars more than 30,000 light-years away. The cluster looks like a fuzzy star in another scope, but in the Obsession 15 it's clearly defined. ■

What to Know in Buying Scope Batteries and Accessories

By George Hripcsak

I was recently researching batteries to power telescope mounts and dew removers, and I thought I would share what I found. Most amateur astronomers use lead-acid batteries to power their accessories. Although they're heavy, they're relatively inexpensive, they work at low temperatures and they last a long time.

In choosing a battery, you need to select a voltage and a capacity. Most telescope accessories run at 12 volts, although a few mounts run at 18. A battery's capacity is expressed in amp-hours (Ah). If you add up the current in amps for all your accessories (usually stated in the manuals) and multiply by the number of hours you'd like to run them in between charges, you get the Ah capacity you require. You'll generally want to double that number for your battery. Common sizes for astronomy are 7, 12, 17, 22 and 33 Ah.

Do *not* use a car battery to power your telescope. That battery is built for the very high but brief current needed to start a car, but it becomes damaged if discharged too deeply. For example, I had to replace my car battery after someone left the car lights on for the third time. Nowadays, sealed lead-acid batteries based on an absorbed glass mat (AGM) are the best and most common option. They have replaced older gel cells, although they look similar externally. These batteries are built for deeper discharging, but they, too, will last longer if they're only discharged to half their capacity.

Most amateur astronomers buy a power supply that contains a lead-acid battery in a plastic enclosure with a charger, flashlight and often such accessories as a radio or air pump. Two examples are the Orion Dynamo and Celestron Power Tank for around $100. I dislike the chargers they come with. They take 10-35 hours to recharge the battery, and they must be disconnected before too long to avoid overcharging the battery. They also seem a little expensive for the junky accessories they come with. The Kendrick Power Pack is a high-quality power supply, but the price hits $200.

I prefer to buy a separate battery and a high-quality charger. Modern lead-acid battery chargers are small, light, sophisticated and relatively inexpensive at $20. They recharge the battery in three stages. Add a $40 battery and you have nice system. B&B, CSB and Interstate are good battery brands.

I've purchased batteries and accessories from PowerStream, ZBattery and BatterySpace on the Internet with good results. BatterySpace has a 12V Portable Power Kit, which includes a 12V 12Ah sealed lead-acid battery, a 3-amp charger and a shoulder bag for $70. It takes only a few hours to recharge the battery, and you can leave the charger connected indefinitely without hurting the battery. PowerStream has a similar 12V 22Ah package with a 2-amp charger for $100. That charger has a rejuvenation function that detects and removes sulphate deposits from worn batteries; it actually worked on two old batteries I have.

Whatever you buy, make sure it has the right connector for your accessories, usually a car "cigarette lighter" adaptor. You'll want to recharge all your lead-acid batteries every two months even if you don't use them. Lead-acid batteries like to be topped off, and they slowly lose their charge. Letting the battery run down will shorten its life, and it won't be ready when you need it.

For specialized applications, like highly portable telescopes, other battery types may work better. For example, Li-Ion batteries are much lighter than lead acid, but they're much more expensive. ■

Obama Outlines New Space Goals

Speaking at the Kennedy Space Center April 15, President Obama unveiled plans to send astronauts to a nearby asteroid and ultimately to Mars in the mid-2030s.

Obama's plan includes resurrecting a pared-down version of the capsule-based Orion spacecraft initially slated to be scrapped under the President's cancellation of the Constellation Moon program in February.

By 2025, the U. S. should be ready to test manned spaceships for deep-space exploration, vehicles capable of exploring beyond the Moon on the first-ever manned trip to an asteroid, Obama said. ■

A Grand Tour of the Solar System, from the Moon to Pluto

By Evan Schneider

Where might NASA want to send astronauts to explore and live as we extend our reach into space? On April 6, AAA board member Jason Kendall provided insight to a Hayden audience.

His tour began with the Moon, where water ice exists in abundance. This is the cornerstone of potential life on planets and their moons. But the Moon is no longer on NASA's agenda. So we begin our real tour with Mercury, with an 800-degree surface temperature and water ice at the poles, where temps drop to 200 below. The terrain is spectacular, with the Caloris Basin running 800 miles across one quarter of the diameter of the planet and mile-high cliffs. During Mercury's evolution, the basin was created by an impact that flooded the area with lava. Ridges and fractures formed when volcanic rock contracted and stretched as it settled under its own weight.

Next stop: Venus. Again, we find an inhospitable environment. With the surface facing the Sun, there's a thick and highly pressurized atmosphere of carbon dioxide and nitrogen, as well as sulfur dioxide and sulfuric acid, and extensive volcanic plains.

We arrived on Mars. Extensive data suggests Mars once contained a significant amount of water, and 2008 data identified water ice under the soil at the North Pole. Mars is our current focus for a visit. Among the planet's interesting features is the Mariner Valley, a 4,000-mile-wide area 10 times deeper than the Grand Canyon and 20 times wider, with a rim at 25,000 feet. We flew over Mars and saw contrasts in digital data depicting highlands and lowlands. Ridges and surface features abound, creating exploration opportunities.

But our solar neighborhood needs further exploration, so Jason flew us to Jupiter. Instead of a candidate to visit, we found a planet that wanted to be a star. Filled with an atmosphere of hydrogen and helium but not big enough to create its own nuclear fusion, the gas giant provides a visual spectacle, with a giant red spot and 64 moons, but no opportunity for surface exploration.

But it has an interesting moon, Europa. In 2015, a joint NASA-ESA probe will visit Europa to observe what appears to be a surface of ice, and possibly water ice and liquid water below the surface. There's evidence of salt staining and sulfide chimneys, which may yield discovery of life, even if in bacteria form. Earth has similar chimneys under oceans that harbor life.

We then approach Saturn, following the path of Cassini. As a gas giant with winds of hundreds of miles per hour, Saturn would prevent exploration. But we've explored Saturn's moon Titan, where Cassini/Huygens landed and observed lakes of methane gas and liquid. Scientists say there was pre-biotic chemistry, indicating conditions that may have been Earth-like 4 billion years ago. If warmer, Titan could have sustained life.

We spin further around Saturn and stop at Enceladus, a big ball of water ice 300 miles across. Photographs show jets of salty water shooting through cracks in the ice 30 miles above the surface. Again, there's the possibility of a life-sustaining environment but no proof.

We arrive at ice giant Uranus, a pale blue planet with rings of dark dust and rocks. Tilted 90 degrees on its side, it's the third largest and fourth most massive planet in our solar system, composed of hydrogen and helium. This isn't a planet for a visit given its 500 mph winds.

We reach Neptune. Voyager approached Neptune in 1989 amid a huge anticyclonic storm. The surface displayed a blue spot the diameter of Earth. This area gradually resolved itself as the atmosphere stabilized and the storm subsided. With its atmosphere of frozen methane, Neptune is not a candidate for a surface visit.

Jason completed his tour with a brief review of Pluto, recently added to the dictionary as a verb "to be plutoed," or demoted. Although now classified as a dwarf planet, it retains NASA's interest through the New Horizons spacecraft speeding its way at 36,250 mph, currently about midway between Earth and Pluto, and due to arrive in 2015. Not much is known about Pluto due to its distance--light takes seven light-hours to reach Earth--but New Horizons promises to unlock some secrets. ■

The Future May Not Be Bleak—Let's Regreen Earth

By Greg Matloff

In 2010, we're all too familiar with the predicted effects of expanding human population upon our planet's fragile ecosystem. Daily reports of diminishing resources, disappearing species, melting glaciers and increasing pollution fill the media. For both amateur and professional astronomers, light pollution has served as a sad reminder of the approaching "crunch" time.

As is true for many others, I became aware of these problems during the 1970s, with the rise of environmental movements. There was a short glimmer of hope a few years later, when various astronomers, physicists and engineers outlined far-reaching plans to enhance humanity's resource base and effluent sink—where we put garbage and pollution--by moving certain industries into cis-lunar (near-lunar) space. Since the space shuttle never lived up to its promise as a low-cost, routine method of accessing orbital space, these early concepts languished.

But as discussed in my latest book, "Paradise Regained", co-authored with Les Johnson of NASA's Marshall Space Flight Center and artist C Bangs (Springer-Copernicus, $27.50), the future isn't necessarily bleak. As the world enters this critical environmental period, many national space agencies are developing interplanetary capabilities. It isn't impossible that some of these new technologies can help ease the Earth through the period of peak human population.

Sometime around the middle of this century, human population is expected to peak around 9 billion. Must we expect an endless cycle of misery, war, famine and plague as people compete over limited resources? Not necessarily, says Arizona-based architect Palo Soleri. If we redesign living and office space so many human activities occur in thousand-foot high, space-habitat-like "arcologies," he believes, the environmental footprint of a large human population may be reduced to manageable levels. Since space-inspired hydroponic agriculture could be situated near the vertical cities, fossil-fuel requirements for freight transportation may be greatly reduced. The first prototype arcology is under construction and partially occupied in the Arizona desert.

During the next few years, the Japanese space agency plans to launch and deploy the first test versions of space solar-power plants to beam energy to Earth. Although this technology may not be essential in the relatively underpopulated U. S., it may be an ultimate necessity for China and India.

There's been much interest recently in technologies necessary to divert Earth-threatening asteroids. But if we have to alter the orbits of these objects, why not mine them? Material obtained may be very useful in creating an Earth-circling array of orbital solar-power plants.

Even if we limit fossil-fuel use, enough carbon dioxide has been released that climate shifts may be inevitable. One suggested use of space technology is to disassemble an Earth-threatening asteroid to create a "sunshade" at an Earth-Sun Lagrange point to reduce solar insolation (input solar flux) by a few percent to compensate for the rise in greenhouse gases.

The biggest uncertainty is the willingness of people to work together for common benefit. If we can overcome such difficulties as the conflict between globalists and tribalists, our technology may ultimately allow a regreening of Earth where all people (and many other species) can enjoy a comfortable and fulfilling lifestyle.

We approached this project from different points of view. Les, a NASA manager, looked at the space-environment interface as someone who implements space projects. I, an astronomer, was concerned with theoretical aspects of space-environment interaction. C, an artist who's been supported by NASA, elected to create chapter frontispieces by merging park, desert and garden scenes with NASA space imagery and photos of AMNH dioramas. C and I have created a short movie including this art, aided by video artist Kenn Bass. It's at www.youtube.com/user/BangsMatloff#play/all. ■

A*AA member Greg Matloff's "Paradise Regained" was published in January. He's assistant professor of physics at New York City College of Technology.*

Why Nebulae around Massive Stars Don't Disappear

The birth of the most massive stars--those 10-100 times the mass of the Sun--has posed a riddle for decades. Massive stars are dense enough to fuse hydrogen while they're still gathering material from the gas cloud, so it was a mystery why their brilliant radiation doesn't heat infalling gas and blow it away.

New simulations by researchers affiliated with the American Museum of Natural History, University of Heidelberg, the National Autonomous University of Mexico and the Harvard-Smithsonian Center for Astrophysics show that as the gas cloud collapses, it forms dense filamentary structures that absorb the star's radiation when it passes through them. One result: The surrounding heated nebula flickers like a candle flame.

"To form a massive star, you need massive amounts of gas," says Mordecai-Mark Mac Low, curator in the astrophysics department at the museum. "Gravity draws that gas into filaments that feed the hungry baby stars."

Stars form when huge clouds of gas collapse. Once the central density and temperature are high enough, hydrogen begins to fuse into helium and the star begins to shine. The most massive stars, though, begin to shine while the clouds are still collapsing. Their ultraviolet light ionizes the surrounding gas, forming a nebula with a temperature of 10,000 Celsius. This suggests growth of a massive star should taper off or even cease because surrounding gas should be blown away by the heating.

First author Thomas Peters, a researcher at the Center of Astronomy at the University of Heidelberg, a former Annette Kade Fellow at the museum, and colleagues ran gas dynamical simulations on supercomputers at the Texas Advanced Computing Center and at the Leibniz and Jülich Computing Centers in Germany. The results showed interstellar gas around massive stars doesn't fall evenly onto the star but instead forms filamentary concentrations because the amount of gas is so great gravity causes it to collapse locally while falling to the star.

The local areas of collapse form spiral filaments. When the massive star passes through them, they absorb their ultraviolet radiation, shielding the surrounding gas. This shielding explains not only how gas can continue falling in, but why the ionized nebulae observed with radio telescopes are so small: The nebulae shrink again as they are no longer ionized, so that over thousands of years, the nebula appears to flicker, almost like a candle.

"These ionized nebulae were just thought to be expanding bubbles of hot gas, and the measured size of these bubbles was used by observers to infer the age of its central star," Peters says. "Our results are of particular importance because the simulations show there is, in fact, no direct relation between the size of the nebula and the age of the massive star, so long as the star is still growing. This is the case over a significant fraction of the total lifetime of a massive star." ■

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muons. These particles, in turn, emit light as they pass through the ice. The photon detector making up IceCube detects them, and measures several properties before they completely decay. The problem with this particular scope is that the vast majority of muons detected are generated by cosmic rays that interact with the upper atmosphere rather than the atoms themselves.

Farrar talked about other experiments used to detect neutrinos, such as the Super-Kamiokande detector in Japan. This site is a large mine filled with 50,000 tons of ultra-pure water surrounded by 13,000 photo-multiplier tubes that watch for Cherenkov radiation. This radiation is emitted when a charged particle, such as an electron, passes through an insulator at a constant speed, creating an "optical shockwave," a ring-like pattern of activity on an array of photomultiplier tubes.

Super-Kamiokande discoveries include evidence of non-zero neutrino mass and mixing. Neutrinos produced in the Sun are electron neutrinos, with those arriving on Earth morphing into muon and tau neutrinos. Different neutrino species oscillate near each other.

Farrar feels she's on the verge of answering questions such as composition of dark matter, the nature of magnetic fields between galaxies and the source of Ultra High Energy Cosmic Rays.

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Review: How We—and the Universe—Might End

By Lynn Darsh

Chris Impey, author of "How it Ends: From You to the Universe" (Norton, $26.95) knows that "In this universe full of magical moments, it doesn't matter what happens in THE END." He also knows how to tell compelling stories about scientists advancing the frontiers of astronomical fact and speculation: It's the journey that matters. And what a time to take that journey! So many new results, problems and cosmological questions peeking over the horizons of the recently discovered!

This is a book that's easy to like and read. Impey is an award-winning teacher, a much-published research astronomer at the University of Arizona in Tucson and a well-read writer with a taste for apt Shakespearean quotes and "Dark Lord" references. He's produced a lively and up-to-date introduction to planetary science and astronomy that encompasses broad themes as he weaves a story of our origins and possible ends. As Impey writes in the introduction: "The material in the book is rooted in fact but it extends into conjecture."

Impey's website, colorful and easy to use, is keyed to the main topics of his book and references fascinating recent-advances articles. See http://www.thebookofendings.com/universe.html

Wide-ranging and curious, Impey has spoken to many scientists of different disciplines, including James Lovelock, designer of the Gaia hypothesis. "Lovelock's flash of enlightenment in 1965 was the thought that the air we breathe keeps a constant composition and so something must be regulating it. That something is life." Lovelock now thinks "global warming is irreversible and nothing can stop large parts of the planet from becoming too hot to inhabit, sinking underwater, or causing mass migration, famine, and epidemics."

In his search for information about how everything will end, Impey covers extensive territory, describing what scientists have confirmed and inferred about what has been, what is and what might be. From the extremophiles living in Earth's deep oceans to the possibilities of life so different from our current conceptions of its characteristics that philosopher Carol Cleland of the University of Colorado has speculated that we might be sharing Earth with alien life forms, Impey has written a thought-provoking guide to our civilization's search for answers. "Our methods are designed to detect life as we know it, not life as we *don't* know it. For example, biological sensing equipment on Earth (and eventually to be used on Mars) will use a polymerase chain reaction, the standard method for amplifying small fragments of DNA. An organism that doesn't use nucleic acids for storing and transmitting information will not register as alive with this equipment. Biology not based on carbon or life that uses exotic energy sources might also be missed by standard testing equipment. We look for what we know."

While the book is always clear in its explanations, a few charts look as if plucked straight out of a more advanced textbook. For example, a confusing graph with multiple overlapping points complete with error bars and equations appears with the caption "Distance from SGR A* (parsecs)". The text offers a much cleaner basic explanation: "When a supermassive black hole dines on infalling matter, the resulting luminous object can outshine the entire surrounding galaxy." Only a few diagrams are indistinct and hard to interpret. They're also easy to ignore, and not central to the flow of the narrative. But these are minor flaws in an excellent book.

If you've been attending AAA lectures, you may have heard Paul Steinhardt speak about his and Neil Turok's cyclic universe theory, using a form of string theory called "M-theory," and Alan Guth talk about his inflationary theory and the Big Bang. Both theories can't be right. Impey succinctly introduces these competing theories about the universe, then concludes "The critical testing ground will be gravity waves. The standard Big Bang predicts that inflation flooded space with gravity waves, while colliding branes produce no gravity waves. The decisive observations will come from Planck and upcoming gravity wave experiments."

If you, like me, wonder about progress being made on solving huge remaining mysteries about ourselves, our Earth and our universe, try this book. Impey's interests and curious scientific mind have produced a quirky guide to a sometimes funny, frequently insightful, always captivating, journey through space and time to the end.■

Briefs: Venus Has Had Recently Active Volcano Hotspots

New evidence for recently active volcano hotspots on Venus like those that created the Hawaiian Islands has been found in new observations. The potentially active surface features could yield clues to how Venus has resurfaced over the last billion years, which in turn could help better understand its interior dynamics, and climate change there and on Earth. An instrument aboard an earlier probe mapped thermal emission from the southern hemispheres which indicate differences in surface composition. Unusually high emission patterns were seen around three of nine known hotspots that could be imaged. Old surface regions would be expected to have low emission patterns because of long exposure to weathering; high emissivity of these hotspots indicate recent volcanic lava flows. Scientists estimate the lava flows are younger than 2.5 million years.

New images of two stars, where one passes in front of the other to block its light periodically as seen from Earth, are beginning to give up the secrets of the stellar pair. The star system, Epsilon Aurigae, some 2,000 light-years away, experiences the eclipse every 27 years. For the first time, scientists have directly imaged the dark companion that blocks its companion's light. Astronomers wondered why the star companion was so difficult to see. Some researchers suggest it's a faint star with a thick cloud of dust orbiting it, obscuring some of its light. But the alignment of the cloud, the star, its companion and Earth would have to be just right for this to be the case. The new data support this idea.

Hubble has snapped a stunning photo of a peculiar galaxy caught in the middle of two other galaxies that appear to be stretching it out. The oddball spiral, Messier 66, is one-third of the Leo Triplet, a group of three interacting galaxies about 35 million light-years from Earth. Messier 66 is larger than its fellows, but it appears they have a strong effect on the central galaxy. The spiral arms on Messier 66 look out of whack. Most spirals have symmetrical arms where thickets of gas, dust and newly born stars twist around the galaxy's center. But in Messier 66 the arms are asymmetrical and climb above the galaxy's main disc. Even the dense cluster of material at the center, the nucleus, appears to be displaced. Gravitational tugging of the galaxy's neighbors, Messier 65 and NGC 3628, has distorted Messier 66 over time.

Hundreds of asteroids that have been undetected in our solar system are being discovered every day by NASA's newest space telescope. The Wide-field Infrared Survey Explorer (WISE) was designed to search for dark objects. Many asteroids it's spotting are darker objects likely missed by past surveys' visible-light scopes. Finding them could be important if any are headed close to Earth. Most asteroids seen by WISE are in the main asteroid belt between Mars and Jupiter, but some are approaching Earth. Potentially hazardous asteroids pass within 5 million miles of Earth's orbit. One WISE discovery will cross Earth's orbit less than 700,000 miles away. Between now and late October, when the mission ends, WISE will find some 100,000 asteroids, mostly in the main belt, and hundreds of NEOs.

The Large Hadron Collider (LHC) reached a much-anticipated milestone March 30 when it began smashing subatomic particles together at half its maximum power. Earlier in March, the "Big Bang machine" had broken its own energy record when it sent two 3.5-trillion-electron-volt (TeV) proton beams racing in opposite directions around the collider's 17-mile-long underground tunnel near Geneva. Operators smashed those beams of protons together to create a record-shattering 7-TeV collision. A large part of the excitement was relief that previous electrical problems had no lasting effect on the machine's ability to perform as expected. The plan is to run the LHC at 7 TeV continuously for 18-24 months. Then it will shut down for up to a year to prepare for 14-TeV collisions, the atom smasher's maximum operating energy. The LHC's record-breaking smashups could uncover evidence of dark matter, discover new forces in physics, unveil new dimensions and even find the Higgs boson, aka the God particle, a theoretical particle that physicists think is responsible for mass in the universe.

A planet recently found orbiting another star has the potential to host water in its atmosphere. The suspected temperate nature of the planet, whose surface temperature is somewhere between minus 4 and plus 360, means it could have liquid water. But this water wouldn't be in the form of Earth-like oceans, but more likely in the form of clouds with water droplets. In announcing discovery of the planet, CoRoT-9b, astrono-

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Briefs: Galaxy Births Stars 100 Times Faster than Milky Way

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mers described it as a Jupiter-sized world that orbits its star at about the orbit of Mercury. This distance is actually further out than many known Jupiter-sized exoplanets, so CoRoT-9b likely escapes the wild temperature extremes those planets have.

Astronomers have spotted a galaxy going through a huge growth spurt, creating stars 100 times faster than the Milky Way. Scientists are seeing the galaxy as it would have appeared about 10 billion years ago, just 3 billion years after the Big Bang. Stars aren't forming uniformly throughout the galaxy, SMM J2135-0102. Instead, star formation appears to be concentrated in four main areas, each about 100 times brighter than any star-forming regions in the Milky Way. The galaxy is birthing about 250 Sun-like stars a year. The discovery adds to evidence that many young galaxies went through periods of vigorous star creation in the early universe.

A study of nearly 500,000 deformed galaxies observed by the Hubble has revealed proof of acceleration of the universe's expansion. Astronomers looked at more than 446,000 galaxies in 557 overlapping photographs, the largest survey ever performed by the Hubble. The observations are the latest confirmation that dark energy is driving the universe to expand at an ever-faster pace. Astronomers used the so-called weak gravitational lensing effect of distorted distant galaxies to measure distribution of matter across the universe on a cosmic scale. They also measured the distances to 194,000 of the galaxies using ground-based telescopes.

Extremely rare Arctic springs could serve as Earth's mini version of Europa, helping scientists picture what life might face on the Jovian moon. Europa is covered with sulfur-rich materials concentrated along cracks and ridges on its icy surface, which could hold the only clues we have about composition of its hidden underground ocean. These compounds in the ice might even contain organic material that migrated from the sea below. Galileo spectrometers captured near-infrared signals from Europa that could help identify what various substances are. To help identify the compounds, scientists investigated potential copycats on Earth. Combinations of sulfur-rich springs and glacial ice are very rare on Earth, but researchers found one in the Canadian Arctic, where springs stain a surrounding glacier yellow with sulfur, gypsum and calcite. Scientists also probed how these materials appear at various scales, from orbital remotely-sensed data to high-res lab analysis. The spectral properties of the ice proved similar to materials on Europa.

A new study has found quasars likely form when two massive galaxies collide. Not just any large black hole becomes a quasar; the distinction is reserved for supermassive black holes that are growing. So in order to have a quasar, a galaxy must contain a sufficient store of mass in its center ready to be eaten by the supermassive black hole there. And the best way to get this supply of food concentrated in the galactic center is a merger between two large, gas-rich galaxies. Researchers think newborn quasars are often hidden from view, but over time surrounding material falls into the black hole, leaving the quasar visible.

It was long-term climate change, rather than a rogue asteroid, that killed the dinosaurs. So says German paleontologist Michael Prauss, who studied 65-million-year-old fossils in Texas and argues that radical changes to the flora and fauna of the era began long before arrival of the massive space rock. Prauss maintained the impact was just one in a chain of events that caused huge environmental upheaval. Those events include massive, years-long volcanic activity in what is now India, and which, like the Chicxulub asteroid impact, is used by paleontologists to separate the Cretaceous and Paleogene periods. The Cretaceous, with a relatively warm climate a high sea levels, was the last era of the dinosaurs and large marine reptiles that lived at the same time. Prauss also disputes paleontologists' use of Chicxulub as the historical demarcation point, asserting the impact took place well before the geochemically and micropaleontologically defined Cretaceous Paleogene boundary. Appearance and distribution of fossils demonstrate that significant and persistent variations of the ecosystem built steadily over the late Cretaceous and continued over several million years, Prauss said. They can especially be seen in sea-level fluctuation and productivity of marine algae, and a widespread surge in fern spores that signaled

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landscapes were repopulating after an ecosystem was destroyed. This fern spike began well before the Paleogene period began, and the Cretaceous-Paleogene boundary, and the asteroid impact marked only the peak of a trend that began millions of years earlier, Prauss said.

Drops of liquid helium raining on Jupiter may explain its odd lack of neon high in its atmosphere, a new study suggests. Neon may be leeched from its original location by combining with condensed helium and then raining down to lower atmospheric levels. Neon, which mixes easily with helium, dissolves in helium raindrops, and together they fall to the interior of Jupiter. Scientists used computer simulations to predict the link between Jupiter's missing neon and helium rain. Helium rain has also been proposed to explain Saturn's excessive brightness and temperature. Saturn is slightly warmer than it should be based on its age and predicted rate of cooling. Scientists think falling helium rain releases heat, accounting for warmer temperatures.

Chemical fingerprints of potentially life-building molecules have been detected in the Orion Nebula. Researchers used an instrument which looks at the cosmos in the far infrared, to provide more insight into how organic molecules form in space. By sifting through the pattern of spikes in the nebula's spectrum, they identified a few common molecules that are precursors to life, enabling such molecules as water, carbon monoxide, formaldehyde, methanol, dimethyl ether, hydrogen cyanide, sulfur oxide and sulfur dioxide. This new spectrum is an improvement on previous ones taken of the nebula.

The top of the gigantic conveyor belt of plasma moving inside the Sun has been running at record-high speeds for the past five years, a new study reports. This might be the reason the Sun has continued to have so few sunspots recently when it should be ramping up the production of them. The speedup coincided with the deepest solar minimum in nearly 100 years, contradicting models that say a fast-moving belt should boost sunspot production. But instead of boosting sunspots, it seems a fast-moving conveyor belt can suppress them by counteracting the Sun's magnetic diffusion.

The sight of a relatively bright star suddenly vanishing as a faint asteroid crosses in front of it, and just as suddenly reappearing several seconds later, is exceedingly rare. But it recently happened. The occulting body was tiny asteroid 824 Anastasia. The star is Zeta Ophiuchi, the third brightest star in Ophiuchus. At magnitude 2.6, it's a star bright enough to easily see with the naked eye. The path of this stellar eclipse, 25 miles wide, ran from Southern California, north-northeast through central Nevada, west-central Idaho, northwest Montana and into Alberta. It was the brightest asteroid occultation in North America that involved an asteroid this large.

After a sustained lull of very little solar activity, the Sun is finally coming back to life. In mid-December, scientists observed a large group of sunspots on the surface, the largest group to emerge for several years. The last minimum was much deeper and longer than predicted. For two years, the Sun exhibited little activity on its spotless face more than 70% of the time. Recently, several large, active areas have moved across the face. In March, New Mexico amateur astronomer Thomas Ashcraft observed a strong, radioactive burst and sent the news over his radio telescope. But scientists say it's premature to conclude recent events prove the Sun is headed toward another energetic cycle. The strength of a solar cycle is determined by strength of magnetism at the poles, currently very weak, so astronomers don't anticipate major changes to the solar cycle. Until the last few years, solar activity was unusually high, so this period can be considered a return to more normal levels, rather than a drop and resurgence. ■

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Will such an ambitious undertaking come to fruition? Manpower, funding and legal issues could crimp progress. Farrar wants volunteers to help move the project ahead. She began this work by creating a summer course for high school teachers and students working as a team to build a UHECR telescope, a joint effort between NYU, Columbia, Barnard and city public schools.

The prototype neutrino telescope was put together in summer 2005. The tyvek-lined water tank is on top of the Silver Center building at NYU. The tank has three photo-multiplier tubes (PMTs) submerged in water. A cable running from PMTs to a control station (computer) reads out and stores the data that are later analyzed. ■

Events on the Horizon
May 2010

M: members; P: open to the public; T: bring your telescopes, binoculars, etc.;
C: cancelled if cloudy;
HQ: at AAA headquarters, Downtown Community Center, 120 Warren St.
AMNH: For ticket information, call (212) 769-5200

For directions to AAA observing events, check the club's website, www.aaa.org.

Saturdays May 1, 8, 15, 22, 29, 8 p. m.
Observing at Inwood Hill Park, Manhattan, P, T, C
Next dates: Saturdays in June.

Tuesdays May 4, 11, 18, 25, dusk-10 p.m.
Observing at the High Line, Manhattan, P, T, C
South of 14th Street. Next dates: Tuesdays in June.

Tuesday, May 4, dusk-10 p. m.
Observing at Cadman Plaza, Brooklyn, P, T, C
Next date: June 8.

Wednesdays May 5 and 12, 6:30-8:30 p. m. HQ
Last sessions of the spring AAA class.
There will be an observing session at Ward Pound Ridge Park in Westchester on May 26 from 7:30-10 p. m. for class members.

Friday, May 7, 6:15 p. m.
AAA lecture, FREE, P
Dr. Ruben Kier, a radiologist with a special interest in astrophotography, will discuss "Best Targets for Amateur Astrophotography and What They Reveal about Our Universe" in the Kaufmann Theater of the AMNH.

Monday, May 10, 7:30 p. m.
Hayden Planetarium lecture, P, AMNH
In "The Origin of the Universe and the Arrow of Time," CalTech physicist Sean Carroll will delve into the nature of time and the origin of the universe.

Wednesday, May 12, 8:30-10 p. m.
Observing at Fort Tryon Park near The Cloisters, Manhattan, P, T, C. Next date: June 9.

Thursday, May 13, 6:30-8:30 p. m.
Recent Advances in Astronomy Seminar, M, HQ
Pre-meeting dinner at 5:15 at Gee Whiz Diner, Warren and Greenwich streets. Next date: June 10.

Saturday, May 15, dusk
Observing at Great Kills Gateway National Park, Staten Island, P, T, C Next date: June 19.

Wednesday, May 19, 6:30 p. m.
AAA annual meeting, M, HQ
A buffet dinner at 6:30 will be followed by the business meeting at 7:30, at which committee chairs will report on events of the past year and president Richard Rosenberg will report on the overall state of the organization. A board meeting will follow the annual meeting.

Friday, May 21, dusk-10 p. m.
Observing at Carl Schurz Park, Manhattan, P, T, C
Next date: June 18.

Friday, May 21, 8-10 p. m.
Observing at Floyd Bennett Field, Brooklyn, P, T, C
On the model airplane flying field. Next date: June 18.

Tuesday, May 25, 6:30-8:30 p. m.
Observers' Group, M, HQ
Pre-meeting dinner at 5:15 at the Gee Whiz Diner, Warren and Greenwich streets. Next date: June 29.

Wednesday, May 26, 8-11 p.m.
Observing at Prospect Park, Brooklyn, P, T, C
Next date: June 16.

Saturday, May 29, 10-noon
Solar Observing at Central Park, P, T, C
At the Conservatory Waters. Next date: June 26.

AAA Annual Meeting May 19

In accordance with the AAA bylaws, the annual meeting will be held Wednesday, May 19 at headquarters, Downtown Community Center, 120 Warren St. 6:30 p. m.: social gathering. 7:30 p. m.: annual meeting, for all members.

The 7:30 p. m. meeting will include elections to fill vacancies on the AAA board of directors. Nominations, besides those made by the nominating committee, may be presented to the AAA president or to the recording secretary no later than seven days before the annual meeting. Each such additional nomination requires the signatures of at least 18 AAA members.

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plex interactions that blur the distinction between the objects. Within distant galaxies, the patterns of star-forming regions create insights far beyond Hubble's traditional 'tuning fork' diagram.

This year, Kier summarized a decade of experience with CCD imaging in a book, "The 100 Best Astrophotography Targets: A Monthly Guide for CCD Imaging with Amateur Telescopes," which he'll sign after the lecture. His goal has been to show how amateur astronomers, using moderately priced equipment, can obtain excellent images rivaling those obtained with the most costly telescopes.

His presentation will showcase beautiful astrophotographs, explain how they help us understand what we can see at the eyepiece and provide tips for imaging. Kier's talk should appeal to both photographers and visual astronomers. More of his images are available on his website, http://www.stardoctor.org.

Kier's photos have been published in *Astronomy* and *Sky & Telescope*, and he's lectured on such topics as "Building a Backyard Astro-Shed," "Astrophotography from Light Polluted Suburbs" and "What Astrophotography Teaches Us about Astronomy." ■

Amateur Astronomers Association
Gracie Station
P. O. Box 383
New York, NY 10028

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Correction Requested

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