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AAA Gets Update on Kepler Search for Earthlike Exoplanets

By Lynn Darsh

"Is Earth unique?" The Kepler Space Telescope's mission is to find the answer, according to Dr. Andrea K. Dupree, senior astrophysicist at the Smithsonian Astrophysical Observatory, part of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Speaking on "Searching for Exoplanets with Kepler" at the AAA's annual John Marshall Memorial Lecture at the AMNH March 4, Dupree said that she and her colleagues are searching for planets that could have liquid water. "We don't want it to be too hot, we don't want it to be too cold, we want it to be just right, and with a sufficient mass …so there would be some atmosphere."

The .95-meter Kepler telescope, launched in March 2009, searches a 100-square-degree field in Cygnus, between Deneb and Vega, looking along the Orion spur and slightly above the plane of the Milky Way for a distance of about 3,000 light-years. This field includes older stars that are slightly metal-poor. Some have traveled from other birthplaces, but, Dupree said, "The orientation and positioning of the satellite and the CCDs was exquisitely designed to avoid all the very bright stars."

A large array of CCD detectors, with 95 megapixels, images 156,000 target stars every 30 minutes, and collects additional data on a set of 512 additional targets every minute. Kepler's instruments are sensitive enough to pick up variations in the light output of a star as small as 80 parts in a million.

Kepler does its work in a heliocentric orbit so the Earth cannot block the view. The mission, designed to last for more than three and a half years, released the first 90 days of data last June. On February 1 of this year, the second data release of four months of observations included the discovery of 15 extrasolar planets and more than 1,200 "active planetary candidates."

"We have a handful in the habitable zone and this is only from the first four months of Kepler data," Dupree said. "Of the dwarf stars, about 19% of them have planets, with orbital periods less than 125 days. There are more planets around smaller stars than larger stars and this will tell us something about the formation of planets. This is already challenging what we know. Theoretically nothing really works at this point."

"The first five planets we have found are close in but they are very very massive." These are "the easy ones, the big ones." All are hot planets with orbits between 3.2 and 4.9 days. Four are larger than Jupiter, and the fifth is about four times the mass of Earth.

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Asimov Panelists Plumb Extra Dimensions, Universes

By Evan Schneider

Math structure connects quantum mechanics and gravity in the development of string theory, taking us to the possibility of extra dimensions, a panelist at the annual Isaac Asimov Memorial Debate declared last month.

Addressing the debate at the AMNH March 7, which had the theme of "The Theory of Everything," Brian Greene, Columbia professor and noted theoretical physicist, noted that although conceptual, M-Theory considers 10 physical dimensions plus a time dimension as the cornerstone of string theory. We're moving towards unify-

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What's Up

By Tony Hoffman

The Sky for April 2011

Lord of the Rings. Saturn is at its best this month, shining at mag 0.4, in Virgo. It lies above Spica in early evening, between the stars Gamma and Theta Virginis. On April 3, it's opposite the Sun, visible all night. Its rings have opened so they're tilted 9 degrees to our line of sight. Saturn's largest moon, Titan, is an easy target even for small scopes, and Rhea, Tethys and Dione can be seen on good nights in my 4-inch scope. So can Iapetus, at least for part of its orbit; it's best in early April.

April's Constellations. The brilliant winter stars are beginning to slip into the sunset. Orion and Canis Major disappear in the twilight by month's end, with Taurus soon descending to join them. Gemini and Auriga linger above the sunset glare, while Perseus and Cassiopeia swing down into the northwest. Leo stands near the meridian in the early evening. This is the best time of year to observe spring's trove of galaxies, from Leo to the Virgo Cluster, from Ursa Major to Canes Venatici. The Big Dipper swings high in the northeast, followed by Arcturus. The stellar circlet of Corona Borealis rises below Bootes, and Hercules climbs into the northeast. Hydra, an indistinct constellation except for Alphard, the bright orange star that marks its head, is sprawled across the southern sky. The parallelogram of Corvus the Crow lies below Virgo.

The two brightest planets are in the morning sky this month. Jupiter is emerging from the dawn glare and can be seen at the end of the month to the lower left of Venus, which blazes at mag -3.9. On April 30, a thin crescent Moon joins Venus, Jupiter and Mercury, which will be better for viewing in May. Mars lies near Jupiter, but this mag-1.2 planet will be hard to pick up in twilight.

April 3 New Moon at 10:32 a.m.; Saturn at opposition.
April 11 First-quarter Moon at 8:05 a.m.
April 17 Moon at perigee, 222,507 miles from Earth, 2 a.m.; Moon lies near Saturn; Full Moon at 10:44 p.m.
April 19 Mercury lies less than a degree from Mars (but is lost in twilight).
April 22 Lyrid meteor shower peaks.
April 24 Last-quarter Moon at 10:47 p.m. ■

Jovian Great Red Spot Fades; South Equatorial Belt Revives

By Joseph A. Fedrick

I watched Jupiter as it set earlier each night during March. I could clearly see, even with my 60mm refractor at 100x, that the South Equatorial Belt has grown darker in the past several months. As this belt has darkened, the Great Red Spot faded. During summer and fall, I could easily see the Great Red Spot with my refractor, but on March 1 and 3, when the spot should have been near the Jovian meridian, I could barely see a disturbance in the South Equatorial Belt, where the spot should have been.

Views of Jupiter on the Internet, taken with much larger telescopes, show the spot has faded and become surrounded by a ring of dark clouds extending from the South Equatorial Belt. As of March 3, Mercury hadn't appeared below Jupiter. But clearing weather in mid-March enabled seeing Mercury align with Jupiter before Mercury vanished into the solar glare in late March.

Saturn has been rising earlier each night and in early March, with my 60mm refractor, I barely glimpsed some slightly whitish streaks on it, perhaps from a stormy disturbance that erupted in December.

This winter's prolonged snow pack finally mostly melted by early March. With less light from streetlights reflected onto the sky, it's become darker, enabling me to see as many as eight stars in the Pleiades March 1.

Venus rose later and was low near the horizon at dawn in March. Its shrinking dazzling disk displayed a gibbous phase in my 60 mm refractor at 50x and 100x.

The Sun displayed a triangular grouping of sunspots in early March. Except for the appearance of occasional large dark sunspots associated with coronal mass ejections and aurorae, the solar disk hasn't been very active. .

Cirrus clouds in the morning sky March 4 caused a halo to form around the Sun. The halo had two bright perihelia at 22 degrees right and left of the Sun and an arc of light above it. Jupiter will re-emerge in the spring, when it will be joined by Venus, Mercury and Mars. ■

A Message from AAA President Richard Rosenberg

Hello members:

Spring is here, so all our observing sessions will be going this month, including the High Line (every Tuesday beginning in April), Brooklyn Heights (April 13), Prospect Park and Fort Greene Park (to be determined). Note we have moved from Cadman Plaza to the Brooklyn Heights promenade, at the end of Montague Street. We expect a large increase in pedestrian traffic as a result.

The Northeast Astronomy Forum (NEAF) will take place on April 16 and 17 at State University of New York in Suffern, N. Y. This has become the biggest astronomy expo anywhere, with many vendors offering great equipment at bargain prices. In between shopping, you can catch a talk by speakers such as Alex Filippenko, Bob Berman and Heidi Hammel. For more info, go to http://www.rocklandastronomy.com/neaf/index.html.

Member Stan Honda has taken wonderful images of the Space Shuttle Discovery's last launch. You can find these on our website at http://aaa.org/stslaunch2011.

Jason Kendall has finished his class on astrophysics to much acclaim from students. We hope to have another class (on a different topic) later this spring or in the fall. Watch for an observing session at Ward Pound Ridge for the class.

Wendy Freedman, director of the Carnegie Observatories, will be giving the Bampton Lectures. These talks will be presented on April 5 at the Hayden Planetarium, and April 7, 12 and 14 Columbia University. For more information, go to http://ircpl.org/bampton-lectures/.

If you're interested in joining the club's board of directors, there's still time. Contact me and I will put you in touch with Marcelo Cabrera, chair of our nominating committee.

Our annual meeting will be held on Wednesday, May 18 at 6:30 p. m. at headquarters, Downtown Community Center, 120 Warren St. Please come for an hour of socializing and food, followed by the business meeting. At the business meeting, I will give a report on the state of the club, those who run club activities will report on the past year and members of the board of directors will be elected. Come and rub shoulders with your fellow members!

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

AAA Lecturer April 1 to Discuss Using Space to Regreen the Earth

Dr. Greg Matloff, professor of astronomy at New York City College of Technology (CUNY), will address the AAA Friday, April 1 on "Regreening the Earth Using Space Resources." The free public lecture begins at 6:15 p. m. in the Kaufmann Theater of the AMNH.

"I will discuss use of solar-system resources to improve life on Earth, especially methods of diverting threatening asteroids. I will outline mining these objects for material that can be used to construct solar-power satellites to beam energy to Earth or to build sunshades at Earth-Sun L1 to fight global warming."

Matloff's latest book, "Paradise Regained," co-\authored with Les Johnson of NASA and artist C Bangs, is on regreening the Earth using solar-system resources.

Matloff is an expert in possibilities for interstellar propulsion, especially near-Sun solar-sail trajectories that might ultimately enable interstellar travel. He's a consultant with the NASA Marshall Space Flight Center, a Hayden Associate of the AMNH and a Corresponding Member of the International Academy of Astronautics. He's authored or co-authored such books as " Solar Sails," "Living Off the Land in Space," "Deep-Space

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AAA's Astrophysics for Amateurs Class is a Great Success

By Evan Schneider

On January 25, in the first session of a weekly class that ended early last month, AAA board member and NASA/JPL Ambassador Jason Kendall took an intrepid class of 50 club members on a journey into the complex world of astrophysics.

As a teaching guide, "Astrophysics is Easy, An Introduction for the Amateur Astronomer" by Mike Inglis, the class text, was used to frame Jason's lectures.

Understanding astrophysics begins with understanding our physical limitations and capacity for deductive reasoning. As earthbound astronomers, our ability to observe is limited to light we gather through ground-based telescopes, technology in the sky and unmanned space missions. Gathering light and understanding how it interacts with matter is key to developing mathematical formulas that explain how the universe works. Understanding the components of light provides us with methodologies to classify stars, galaxies and other celestial bodies.

Astrophysics provides perspective. Measuring a star's light must be understood in context with its distance. A star may be bright because it's near or bright because it's large but far away. The Stellar Parallax, an angular measurement of a star observed from two locations in Earth orbit, provides a formula to calculate these distances. With distance established, further star classifications can begin. Note that calculations shift dramatically as we observe stars farther away. This may skew observations, calculations and classifications.

Classifying stars through color (the Wien Law) provides insight into a star's temperature (low temperature is red to infrared, hotter blue to ultraviolet). Calculating luminosity and temperature, mathematics then allows determination of size and mass of a star. Astrophysics at work again!

Spectroscopy, creating a spectrum to identify the many elements within each star, is the next step. Different spectra help astronomers classify a star by its composition and life cycle. With these data, there's enough information to understand a star's evolution.

But for astrophysicists, understanding individual stars is just the beginning of understanding the universe. How many kinds of stars are there? How are stars classified?

We need the Hertzsprung-Russell diagram, a graphic plot of known stars developed in 1911, to understand star classifications. Utilizing luminosity, spectral type, surface temperature and absolute magnitude (calculated and classified through the observation of light and applied math), 90% of stars are placed on the H-R diagram along the Main Sequence. The rest are off the Main Sequence. All stars can be identified as giants, supergiants, red/white/brown dwarfs, etc.

We now have our basic understanding of stars and how they fit into the universe, but what about the space between stars? In the future collision of the Milky Way and Andromeda galaxies, scientists hypothesize that distances between stars in both are so great there may not be any star collisions. Matter occupying space between stars is called the Interstellar Medium, a composition of gas and dust. Scientists calculate that only 4% of the universe is comprised of "ordinary" matter (the remaining being 23% dark matter and 73% dark energy). In seeking to better understand the universe, we should remember we're only focusing on understanding a small part of what surrounds us.

Woven throughout the class was Jason's innate ability to reduce complex calculations to an understanding of basic principles. When discussing solar dynamics, for example, he explained a complex formula calculating temperature by stating, "Temperature is a measurement of the movement of particles in the medium it's in."

Understanding matter on an atomic and subatomic level provides deeper knowledge of the universe, and the basic forces of nature. Gravity, electromagnetic interaction, and weak and strong nuclear forces all work to affect who we are and what we observe.

"As physical beings, electromagnetic interactions keep us together," Jason observed. Thinking about ourselves held together this way was a little unnerving to the class.

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At the Space Center to Photograph Discovery's Final Flight

By Stan Honda

One of the most exciting and terrifying parts of my job as a photographer is watching images appear on the computer screen from a compact flash card in a remote-controlled camera at a space-shuttle launch. Did the camera fire? Did I get the picture? Is the exposure correct? Was the composition good? Was the camera aimed properly? Was it worth the hours of work?

I was at Kennedy Space Center February 24 to photograph shuttle Discovery's last flight for Agence France-Presse, the French news agency I work for. This is the 10th shuttle mission I've covered. I joined Bruce Weaver, a freelance photographer, who works for AFP during shuttle activities and helps coordinate coverage.

The media center is across from the huge Vehicle Assembly Building, where the shuttle's prepared and where the giant Saturn V rolled out during the Apollo program.

The closest we can shoot the launch is from manned positions three to four miles away. But photographers are allowed to set up remote-controlled cameras inside a safety perimeter just over a mile from the pad.

Early on February 23, one day before the launch, the wire-service pool gathered for a 6 a.m. security check by dogs. We were allowed anywhere inside the safety perimeter to place cameras.

Bruce put his cameras up first, placing his custom-made box holding two cameras and a sound trigger on each tripod. Made of thin pressed wood, the box holds one camera horizontally and another vertically, with the top extending out to form a hood. This protects the cameras from most weather; a removable back allows access to the equipment.

Gene, the driver, combined sound meters and a relay to produce a sound trigger. We spliced together cords so two cameras can work off one trigger. The sensitivity can be adjusted. Once the sound reaches a certain level, a circuit closes and the camera fires. As the shuttle rises and the sound level drops, the camera stops. It's a simple solution to the problem of firing the camera.

I put a camera in a marsh about three-quarters of a mile southwest of the pad, wearing waders since the swamp is often under a foot of water. Aiming the cameras in the box is tricky. I first pointed the vertical camera at the pad. Then I leveled the box, using the virtual horizon built into the camera. I loosened the screw, securing the horizontal camera, and rotated the camera until it aimed properly. It takes a lot of readjusting to get horizontal and vertical cameras properly set. I've put a 35mm lens on the horizontal camera and a zoom lens at about 100mm for the vertical shot.

We were allowed a quarter-mile from Pad 39A to place cameras, as close to the shuttle as any civilian is allowed. I decided to put a tripod with four cameras at a spot about 800 feet from the shuttle at a point where we were looking up at the gantry and vehicle. I put a 16mm fisheye lens on a horizontal camera and a 50mm on a vertical. Sand bags on the tripod legs are mandatory; NASA doesn't want cameras flying around the pad from the blast. We wrapped each camera in plastic bags, remembering to cut a hole for the lens. In all, we put out 17 remote cameras.

I shot with three Nikon D3 cameras attached to a 400mm with a 1.7x converter, making it a 680mm; a 70-200 zoom clamped to the railing in front of me, fired with a hand remote cord; and a wide-angle lens on a table-top tripod behind me, fired by a radio trigger.

The launch was beautiful. Two minutes into flight, a small puff appeared as I peered through the telephoto. Then two small orange lights began moving left and right. More than 28 miles up, 25 miles down range and at Mach 4, the solid rocket booster separated. A small white dot—the shuttle and its main engine—continued into space.

After sending our pictures, we collected the remote cameras. It usually takes 1½-2 hours to get the all clear to proceed inside the safety perimeter. I had my computer so I could view and send photos, using an air card from the field. The computer opened the images on the screen. Rows of pictures appeared, a good sign because

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Review: Pluto as the Watchman of the Solar System

By Thomas Haeberle

Who watches the watchman? Astronomers and scientists, that's who, hoping to learn more about "Pluto, the Sentinel of the Outer Solar System," the title of Barrie W. Jones' fine new book (Cambridge, $35.99). This account explores the bodies at the end of the solar system and describes its most significant member.

This is nothing like Neil deGrasse Tyson's book, "The Pluto File," a humorous look at his decision to demote Pluto and the public's perception about the planet that's not. This book takes the subject of dwarf planets and their kin very seriously.

My first thought was, "Oh no, another book cashing in on Pluto," but it was very thought provoking and refreshing. The book is intelligently crafted and full of facts, and Jones' boxed texts are relevant for "those wishing to go deeper" into the subject matter. None of these sidebars require math skills beyond high-school algebra. The author's most in-depth equations deal with spectral analysis of planetary bodies. There are exceptional charts and figures, such as one showing comparative radii of spherical bodies of the solar system and another explaining why Pluto and Neptune, with overlapping orbits, can't collide.

There's a quick run through of planet hunting and discovery, including David Jewitt's and Jane Luu's discovery of 1992 QB1, the object that fulfilled the prophecy of Kenneth Edgeworth and Gerard Kuiper. Jones confesses to not liking the term Kuiper Belt objects because it robs Edgeworth of his contribution of their existence. Yet, to abbreviate, he uses the term KBOs anyway because of its popularity. Curiously, Pluto's "rival" Eris and its discoverer, Mike Brown, are scarcely mentioned.

Jones explains in detail the reasoning for the new planetary classification. He leads up to concluding that based on Pluto's composition, diminutive size and the company it keeps, its demotion was inevitable. "There is a dramatic distinction between the planets and the dwarf planets in terms of size," even when compared to Mercury, the smallest of the "large" planets. Jones dislikes this new "dwarf" class. He would prefer a distinction as classes of "large" and "small" planets.

An overview is given of the International Astronomical Union's 2006 decision to demote Pluto, and what didn't happen three years later. The issue of classification was brought up again by a group of amateur astronomers but was quickly quashed. "So now we are left with a flawed, incomplete classification system for planets. Any definition should apply to other star systems. This would include defining bodies unlike those in our solar system."

There's much discussed about the New Horizon mission due to arrive at Pluto in 2015. The mission's primary objective is to study the geology of Charon and Pluto as well as the latter's atmospheric escape rate and potential to precipitate. The fact that Pluto was ignored during the golden age of unmanned exploration was solely due to its small size and isolation.

As our knowledge of the outer solar system grew, so did our interest in sending a spacecraft to Pluto. The fact that Pluto is so like Triton and that Triton might be a captured moon of Neptune is intriguing to scientists and begs the question: Is Pluto a twin of Triton and does it have geysers too? "It is reasonable [to assume] that New Horizon will yield a cornucopia of new data on Pluto"—and other small planetary bodies?

Regrettably, there's a lackluster ending in the chapter "Gateway and Beyond." I was hoping for a more exciting possibility for the rejected planet, but the author concludes that Pluto wouldn't make a useful launch platform to the stars after all, except for astronauts possibly erecting a large robotic telescope that can be remotely operated after humans have left.

The "further reading" section lists key scientific papers, books, Internet links and magazines that enable readers to explore various topics in greater detail. This isn't just a book about Pluto; Jones covers a range of astronomy topics. Sidebar texts tend to draw you in and are themselves very intriguing to the point they become distracting.

Despite the demotion of Pluto, Jones shows it's still and always will remain of interest as one of the largest known objects orbiting beyond Neptune. ■

A Roundup of Newly Published Books on Astronomy

By Dan Harrison

"**Massive: The Missing Particle that Sparked the Greatest Hunt in Science**" by Ian Sample (Basic Books, $25.95) discusses the genesis of the Large Hadron Collider and probes what one observer calls "its most famous particulate quarry," the Higgs Boson particle. Sample, a Guardian science correspondent, raises the question of what gives objects mass and explains current theory behind this question, a theory based on the mysterious Higgs Boson.

Another mysterious particle is the neutrino. In "**Neutrino**," by Oxford physics professor Frank Close (Oxford University Press, $18.95), the author probes what he calls "the commonest and weirdest" of all the things that make up the universe." He notes that neutrinos are "so shy that half a century after their discovery, we still know less about them than all the other varieties of matter that have ever been seen."

Are you Galileoed out? Think there's no room for yet another biography of the great man? Think again. There are not one but two new bios. One is "**Galileo: Watcher of the Skies**" by David Wootton (Yale University Press, $35), professor of history at the University of York in Britain. "Our task—our impossible task—is not just to read what Galileo wrote, but also to rediscover what he thought," the author says. "To do so, we need to catch the echoes of long-lost conversations." The other title is "**Galileo**" by J. L. Heilbron (Oxford University Press, $34.95), emeritus professor of history at U Cal Berkeley. "I've tried to bring together not only his well-known work on astronomy and mathematics, but also his less-known work on literary matters. Before he was a mathematician and long before he was a martyr, he was a literary man." And he adds: "At the very end of my book, I offer a suggestion which will end the Galileo affair to everybody's satisfaction in no less than another 400 years."

Two other seminal figures in the history of astronomy are the subject of "**Discoverers of the Universe: William and Caroline Herschel**" (Princeton University Press, $29.95) by Michael Hoskin. The book sheds light on a productive but complicated relationship, setting their numerous scientific achievements in the context of their personal struggles, larger-than-life ambitions and bitter disappointments. Hoskin is a fellow at the University of Cambridge.

Also from Princeton are two more titles. "**Strange New Worlds: The Search for Alien Planets and Life Beyond our Solar System**" ($24.95) is by University of Toronto astrophysics professor Ray Jayawardhana. The author recounts stories of the scientists and the breakthroughs that have ushered in this new age of exploration. He reveals how technology is rapidly advancing to support direct observations of Jupiter-like gas giants and super Earths, and how astronomers use biomarkers to seek possible life on other worlds.

Joshua S. Bloom, associate professor of astronomy at U Cal Berkeley, has authored "**What Are Gamma-Ray Bursts?**" ($27.95). In recent years, gamma-ray bursts have gone from being little understood to being revealed as playing a role in diverse phenomena.

"**Moon: A Brief History**" by Bernd Brunner (Yale University Press, $25) is a cultural examination of our nearest celestial neighbor through history, science and literature, from ancient times to the present. The Moon's effects on life on Earth are included. Vintage photos and illustrations pepper the book.

"**Visions of Mars: Essays on the Red Planet in Fiction and Science**" (McFarland & Company, $49.95)--edited by Howard V. Hendrix, George Edgar Slusser and Eric S. Rabkin--contains 17 essays exploring the evolving scientific understanding of Mars, and the relationship between that understanding and the role of Mars in literature, the arts and popular culture. Essays in the first section examine approaches to Mars by scientists and writers Jules Verne and J.H. Rosny. Section Two covers the uses of Mars by such writers as Wells, Burroughs and Bradbury. The third section looks at Mars as a cultural mirror in science fiction. Essayists include writers, scientists and literary critics. Hendrix teaches English at Cal State Fresno. Slusser is professor emeritus of comparative literature at U Cal Riverside. Rabkin is professor of English language and literature at the University of Michigan. ■

When a Loved One Decides to Go Against Society's Grain

By Ron McCullough

Having heard about "Starry Messenger" from two sources, one personal and one through the AAA, I decided to catch the play about Galileo, which ran at the Theater for the New City recently.

A trellis of greenery spotted with large five-pointed stars and round lanterns symbolizing moons or planets bordered the staging, and a spiral pattern of speckled light projected onto a purple floor gave one the impression of a spiral galaxy. An antique telescope stood humbled in isolation in the center of the circular audience's scrutiny, as if it were on trial and surrounded by its accusers.

The play opened with church bells chiming as Galileo stood at center stage. Four people stood off from him at the four cardinal points of the compass. The scene ended without any words or movements from any of the characters, leaving me perplexed as to its meaning.

The play then depicted Galileo in a series of scenes, interacting with various characters. First was Galileo's assistant and mentoree, Benedetto Castelli, as Galileo revealed Jupiter's moons to him. Ambitious and anxious for Galileo's discovery to put an end to the church, Castelli is also concerned for Galileo's safety. But the desire to challenge the church increases steadily, outweighing his concerns for Galileo's well being.

Cardinals Borgia and Zacchi next confronted Galileo. They were wonderfully contrasted: a thin pointed-nose cynic and a portly priest apparently self-satisfied with gluttonous overindulgences.

The final three characters were Galileo's illegitimate children. Much of the play is about the love Galileo had for them, they for him and how they were affected by Galileo's refusal to repudiate his statement that Earth isn't the center of the universe.

Galileo's son, Vincenzio, was portrayed as a self-centered individual whose only concern was petitioning for legitimacy so he could advance his career and social status, and how Galileo's refusal to repudiate his work damaged this effort.

Galileo's daughters were in a convent, but any similarities end there.

Celeste was all but consumed by the conflict between her love and belief in her father and her vows to the church. She believed the plague would come if Galileo didn't reverse his position.

As palpable as was the mutual love and respect between Galileo and Celeste, the relationship between him and his second daughter, Arcangela, was viscerally ominous. Arcangela suffered from dementia, possessed by a demon that only allowed her to communicate in a litany of disjointed prophetic words and phrases: sub-atomic, black holes, Pluto, electrons, Big Bang, $E=MC^2$, and the like. Galileo is naturally confounded by these words and why Arcangela ties a Pandora's box of releasing evil that can't be undone to his refusal to recant.

There was little science in "Starry Messenger." It only stated that Galileo supported the theory that Earth moves and isn't the center of the universe. Instead of being about science, the play was a glimpse into how personal lives are impacted and threatened when a loved one goes against society's grain.

The play ended as it began: Galileo standing at the center, with Celeste, Arcangela, Vincenzio, and the assistant Benedetto standing at the cardinal points of the compass, again with no movement and no dialogue. It was just as puzzling, until a few weeks later it dawned on me. It wasn't Galileo in the middle of compass points. He represented Jupiter and the four people around him were the moons. They pulled on him with an emotional force as strong as gravity, while he stood steadfast in his resolution, a giant, holding them in orbit around him. ■

Contacting the AAA

General club matters: president@aaa.org. Membership business, such as dues and change of address: members@aaa.org. *Eyepiece:* editor@aaa.org. Lectures: lectures@aaa.org. Classes: classes@aaa.org. Seminar: seminar@aaa.org. Observing: president@aaa.org. Please visit us on the web at www.aaa.org. ■

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It will take time to find a possible "Goldilocks planet." The Kepler team estimates the geometric probability of a planet being in the correct plane to transit its star from Kepler's vantage point is 0.5%-10%. Many stars must be observed, almost continuously, for three years, to discover terrestrial planets in habitable zones or show that terrestrial planets are rare.

The size of this habitable zone changes. "When stars are very hot, the habitable zone is further out. And simply observing a transit is just the beginning. When one observes a transit, a lot more needs to be done to verify that it is not something else. There could be another star in the field that produces the signal mimicking a transit." Kepler also measures radial velocities of a star to confirm it's moving in a way that agrees with the transit.

Dupree described the "exciting" Kepler 10 system that has at least two planets. "The transit tells us the size of the planets. Then we measure radial velocity to determine a planet's mass. With this knowledge, we know the radius and the mass, and it turns out it is a planet which is rocky, just like Earth. It has a period of about .84 days. It has a radius about 1.4 times the radius of Earth and a mass 4.6 times Earth's. This rocky planet…is locked into the host star. One side is very hot--1,800 degrees, the temperature of molten lava--and the other is very cold."

Kepler 11 is a star with six planets. If the six were placed in our solar system, they'd be within Venus' orbit. "They're bigger and more massive than Earth, and more massive than Kepler 10, which is the rocky planet. So they're probably a mixture of things, where they have hydrogen and helium, and maybe some are a little bit rockier than others."

The common transiting method of finding exoplanets is far more successful (122 planets found) than the other direct techniques of imaging and coronagraphy, and the indirect planet finding techniques of astrometry, pulsar timing and gravitational microlensing. Another indirect planet-finding technique, radial velocity, has found more than 400 extrasolar planets by measuring changes in a star's velocity caused by the gravitational tug of a planet, and is being used with Earth-based telescopes to confirm Kepler's findings. ■

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ing mathematical perspectives, but are only in the theoretical stages of understanding the relationships of various string theories and how they relate to our universe, Greene said.

Six theoretical physicists, astrophysicists and cosmologists constituted the panel. Discussion revolved around understanding the universe on macro and micro levels, how advances in technology and math have expanded early theories into observable models and how string theory will help explain unsolvable problems.

"As we look farther back to see imprints in the cosmic microwave background," stated Katie Freese, University of Michigan theoretical physicist, "we can observe quantum fluctuations and inflate them to look at interactions of elements on an atomic and subatomic level." Explaining how these building blocks of the universe evolved provides a way to support mathematical theories predicting quantum mechanical and general gravitational reactions, she added.

Einstein waded into these waters, and general relativity evolved into special relativity, opening our vision of interrelationships between space and time. Some of his work continues through string theory, the core of the debate.

Janna Levin, professor of physics and astronomy at Columbia, added her perspective of using mathematics to describe space/time. "Speed may be the answer to pushing matter into another dimension," she explained. Levin theorized that extra dimensions predate string theory.

Panelists agreed that science produces mathematical models. Scientists then seek observable proof to validate theories. These theories develop into laws, which explain the "what" of the universe, but not the "why."

Theoretical physicist Lee Smolin, a researcher at the Perimeter Institute for Theoretical Physics and an adjunct professor of physics at the University of Waterloo, both in Waterloo, Ont., believes we're heading toward "multiverse" models which will change the way we understand our universe.

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Briefs: Possibly More Than 50 Billion Planets in Milky Way

Scientists estimate there are 50 billion or more planets In the Milky Way. At least 500 million are in the not-too-hot, not-too-cold zone where life could exist. The numbers were extrapolated from early results of NASA's planet-hunting Kepler telescope. Scientists took the number of planets they found in the first year of searching a small part of the night sky and then made an estimate on how likely stars are to have planets. Kepler has found 1,235 candidate planets, with 54 in the zone where life could possibly exist. Its main mission is not to examine individual worlds, but give astronomers a sense of how many planets, especially potentially habitable ones, are likely in our galaxy. They would use the one-four-hundredth of the night sky Kepler is looking at and extrapolate from there. Scientists figured one of two stars has planets and one of 200 stars has planets in the habitable zone. That's a minimum because these stars can have more than one planet and Kepler has yet to get a long enough glimpse to see stars further out from a star. To estimate the total number of planets, scientists then took the frequency observed already and applied it to the number of stars in the Milky Way. For many years, scientists estimated 100 billion stars in the Milky Way, but last year that was upped to closer to 300 billion.

A new instrument will help Kepler confirm and characterize potential alien planets. It's a new precision spectrograph instrument, HARPS-North. HARPS stands for High-Accuracy Radial velocity Planet Searcher. It's designed to detect the tiny radial velocity signal induced by planets as small as Earth if they orbit close to their star. Kepler provides the size of a planet, based on the amount of light it blocks when it passes in front of its star. Scientists now need to measure planetary masses. That will allow them to distinguish rocky planets and water worlds from ones dominated by atmospheres of hydrogen and helium. HARPS-N will partner with Kepler to characterize worlds enough like Earth they might support life as we know it. First measurements are expected in a year.

NASA's Messenger spacecraft made history March 17 when it became the first spacecraft to enter into orbit around Mercury. The spacecraft will soon begin mapping Mercury and studying the planet's composition, geology and tenuous atmosphere. The Messenger (Mercury Surface, Space Environment, Geochemistry and Ranging) Mission launched in August 2004. During the past 6 1/2 years, Messenger has been a solar-system wanderer, completing 15 orbits of the Sun and traveling about 4.9 billion miles. During this time, it made one flyby of Earth, two of Venus and three of Mercury, primarily to slow the probe down in preparation for the orbital-insertion maneuver. Messenger also took pictures and did science work during these close encounters. Its Mercury observations were the first spacecraft data returned from the planet since NASA's Mariner 10 probe made three flybys in the mid-1970s. Messenger will scrutinize Mercury from a highly eccentric orbit for the next year: as close as 124 miles and as far away as 9,300 miles. The overall goal is to use an increased understanding of Mercury to learn more about how our solar system, and solar systems in general, formed and evolved.

NASA pulled the plug on the WISE spacecraft (Wide-field Infrared Survey Explorer) in February. The spacecraft will remain in hibernation without ground contacts, awaiting possible future use. WISE launched in December 2009 for a 10-month mission to collect data to be stitched together into a composite map of the entire sky. The spacecraft surveyed the cosmos in infrared, allowing it to peer through layers of dust to capture photos of previously unseen objects in unprecedented detail. In addition to asteroids and comets, WISE is designed to detect the faint glow of distant objects, such as brown dwarfs. WISE scanned the sky one-and-a-half times, taking about 1.8 million images, including stars and galaxies. It spotted 19 previously unseen comets and more than 33,500 asteroids, including 120 near-Earth objects. In September, WISE ran out of coolant to chill its infrared detectors. Without coolant, WISE operated on two of its four detectors, detecting objects in the solar system.

An expedition to see if some form of life ever existed on Mars and a journey to Europa to study its underground ocean should be NASA's highest-priority missions in the next decade, a National Research Council report asserts. "Vision and Voyages for Planetary Science in the Decade 2013-2022" warns, however, that budget woes might delay some or all of these missions. Sample return is viewed as key to gauging possible past life on Mars. The third priority for a large-scale mission would be the Uranus Orbiter and Probe mission, the first

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Briefs: How Much Dark Matter Is Needed for Stars to Form?

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to explore the internal structure and composition of an ice giant. On medium-size missions, the committee recommended two extra missions for its New Frontiers program, which explores the solar system with frequently launched, mid-size spacecraft. The report lacked recommendations for small missions. The committee also urged NSF to complete the Large Synoptic Survey Telescope to detect hazardous near-Earth objects and help analyze main-belt asteroids, Kuiper Belt objects and comets.

A new study has pinpointed the lower limit of dark matter needed to ignite a frenzy of star formation: a mass equal to 300 billion Suns. Dark matter is a vital ingredient for galaxies in star formation. The 300 billion solar masses' worth of dark matter is 10 times less than the amount previously estimated. If one starts with too little dark matter, a developing galaxy would peter out. If there's too much, gas doesn't cool efficiently to form one large galaxy, and you end up with lots of smaller galaxies. But if you have the just the right amount of dark matter, a galaxy bursting with stars will pop out. Such galaxy characteristics as brightness and stellar mass are directly related to the size of their dark matter halo. Scientists studied a patch of sky the size of the Moon in Ursa Major to make their discovery. This wedge of sky is ideal for studying objects outside our galaxy because of low dust contamination from the Milky Way.

Several space telescopes have viewed a giant ring of black holes across different parts of the light spectrum. Two interacting galaxies, known collectively as Arp 147, about 430 million light-years away from Earth, set the stage for the view. Arp 147 contains leftovers from the collision of a spiral and elliptical galaxies that unleashed an expanding wave of star formation. The wave of stars creates the ring effect. But these stars are short-lived, lasting no more than a few million years before they explode as supernovas or collapse into black holes. The black holes pepper the ring, with their powerful X-ray emissions appearing as bright pink specks.

A Japanese spacecraft has spotted two huge holes in the Sun, gateways for solar material and gas to spill into space. These are gaps in the magnetic field that make a hole through the corona, allowing gas to escape. In the image, one coronal hole appears near the top center of the Sun while another, a polar coronal hole, is visible near the bottom of the view. The holes appear darker than other parts of the Sun because they're relatively cool compared with active regions nearby.

Researchers studying new images of coronal mass ejections (CMEs) have spotted ripples of instability along their flanks similar to those on the edges of Earth's clouds or in ocean waves. The observation may provide insight into why CMEs appear to both rotate and be deflected from following a straight path from the surface of the Sun. If instabilities form on just one flank, they may increase drag on one side of the CME, causing it to move slower than the rest of the CME.

A telescope in Hawaii has set an asteroid-hunting record: 19 discovered in one night, the most by a single telescope. Two asteroids' orbits will bring them extremely close to us in the next 100 years. By taking numerous images, then comparing them to find moving asteroids in deep space, astronomers picked up 30 potential asteroids January 29. They then spent three nights searching for the asteroids.

Supermassive black holes gobble up material so greedily they fling away huge amounts of perfectly good "food," a new study suggests. Researchers studying a faraway galaxy detected a huge amount of gas and dust spewing from the supermassive black hole at its core. This exodus is depriving the black hole of the food it needs to continue growing, and it's limiting the galaxy's ability to churn out new stars. The galaxy is Markarian 231, about 600 million light-years from Earth, in the direction of Ursa Major. In the final stages of a violent merger with another galaxy, it's gobbling dust and gas so voraciously it's spawning a powerful quasar. Gas and dust are streaming from the galactic core for at least 8,000 light-years in all directions, at more than 2.2 million mph, accelerated by the quasar's immense power. The outflow is removing gas from Mrk 231's inner regions more than 2.5 times as fast as stars can form.

A telescope that will be one of the largest in the world

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Briefs: Pre-Solar System Dust Grains Bounced Around

Briefs continued from page 11

has been given the green light to be built atop Mauna Kea. The University of Hawaii will build and operate the $1.3 billion Thirty Meter Telescope. The multi-year vetting process took the project's cultural and environmental impacts into account. The new scope will work in a range of wavelengths, from ultraviolet to mid-infrared. Its 98-foot-wide primary mirror will give the scope nine times the power of today's most powerful scopes in the optical/infrared. An advanced adaptive-optics system will provide images more than 12 times sharper than the Hubble's. The new instrument could start making observations around 2020.

Dust grains that eventually coalesced into our solar system's planets bounced around over vast distances nearly 4.6 billion years ago, a new meteorite study suggests. Scientists studying a tiny chunk of a meteorite say it likely formed close to the Sun, was ejected near today's asteroid belt, then returned to the scorching inner reaches thereafter. Scientists investigated a pea-size piece of the Allende meteorite that landed in Mexico in 1969. The bit they looked at is a calcium-aluminum-rich inclusion, or CAI. CAIs often get fused into larger meteorite pieces such as Allende. Scientists believe CAIs were among the first solids to condense from the swirl of gas and dust as the planets were forming. The team measured concentrations of two oxygen isotopes in the space rock's various layers. Concentrations of oxygen-16 and oxygen-17 varied from place to place while the solar system was forming. So by analyzing their relative abundances in different parts of the CAI, the team was able to learn much about its extensive travels.

The south polar region of Saturn's moon Enceladus churns out far more heat than Yellowstone National Park, a new study finds. Using Cassini data, researchers determined the far southern reaches of Enceladus produce about 15.8 gigawatts of heat-generated power, roughly equivalent to the output of 20 coal-fired power plants. That's 2.6 times the output of all hot springs in and around Yellowstone, and 10 times more than scientists had predicted. The new find adds evidence for the likelihood of a liquid-water ocean under Enceladus' icy shell. But researchers aren't sure where the heat is coming from. The new results make Enceladus a more attractive candidate to support life as we know it.

Voyager 1 **last month performed** a precision maneuver to gear up for new studies of the solar wind. The spacecraft, launched in 1977 and cruising toward the edge of the solar system, rolled itself 70 degrees counterclockwise, then held the position for more than two hours. The goal was to start positioning the probe, the most distant spacecraft, to study how charged particles streaming from the Sun behave deep in space. It was the first such roll-and-stop move for Voyager 1, or its sibling Voyager 2, also launched in 1977, since 1990. However, the craft have performed rolls, without any stops, regularly to help calibrate instruments and take data on the Sun's magnetic field. The craft are traveling through a turbulent region of the solar system known as the heliosheath. It's the outer shell of a bubble around our solar system created by the solar wind. Astronomers believe the solar wind banks as it approaches the outer edge of this bubble, where it runs up against the interstellar wind. Last June, when Voyager 1 was 10.6 billion miles from the Sun, data showed net outward flow of the solar wind was zero. That zero reading has continued since. Scientists don't think the wind has disappeared in that area, but likely turned a corner, in line with predictions.

A NASA probe speeding toward Pluto hit a major checkpoint March 19 when it crossed the orbit of Uranus. The New Horizons spacecraft encountered Uranus' orbit while flying 1.8 billion miles from Earth. The spacecraft is expected to reach Pluto and its moons--Charon, Nix and Hydra--in July 2015, after which it might encounter smaller bodies in the Kuiper Belt. New Horizons launched in January 2006. It has traversed 20 times the distance between Earth and the Sun, including a 2007 flight through the Jupiter system for a gravity-assisted speed boost. New Horizons is currently in electronic sleep mode, and since Uranus was 2.4 billion miles from the spacecraft when the probe crossed the planet's orbit, scientists didn't take pictures of the gas giant during its pass. This month, scientists will begin searching for potential flyby targets in the Kuiper Belt. The next planetary milestone for New Horizons will be to cross Neptune's orbit on Aug. 25, 2014, 25 years after Voyager 2 made its exploration of the planet. ■

Youngster Finds Supernova

It may have only appeared as a tiny, glowing spot hovering over a distant galaxy, but the sight made a precocious 10-year-old amateur astronomer the youngest person ever to have detected a supernova, space.com reported.

Kathryn Aurora Gray of Fredericton, New Brunswick, Canada discovered the supernova explosion in galaxy UGC 3378, within the faint constellation of Camelopardalis. The galaxy is about 240 million light-years away. “I'm really excited. It feels really good,” she told the *Toronto Star*.

Gray made the discovery January 2 using images taken of UGC 3378 New Year's Eve. The supernova was then verified by Illinois-based amateur astronomer Brian Tieman and Arizona-based amateur astronomer Jack Newton, who then reported it to the International Astronomical Union’s Central Bureau for Astronomical Telegrams.

Gray reported the supernova under the supervision of her father, Paul, who’s made six supernova discoveries, and family friend David Lane, who’s found three others. The photos of UGC 3378 were taken using a telescope belonging to Lane.

A new supernova reveals itself as a bright point of light not in previous observations. Since a supernova can outshine millions of ordinary stars, it’s often easy to spot one with a modest scope, even in distant galaxies.

Despite being the discoverer of this one, Gray didn't get to bestow a name on the object, which is known simply as Supernova 2010lt. ■

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it meant the camera fired on time.

We waited outside the pad for the okay to head inside. Once inside, we picked up the closest tripod. The fisheye lens was coated with something; it could be just moisture. We pulled the disks out and images appeared on the computer. Relief! The cameras fired. That spot produced dramatic shots. ■

To see Stan Honda's photos, go to www.aaa.org and click on gallery.

Paper-Mill Worker Builds Homemade Planetarium

A Wisconsin paper-mill worker who once dreamed of being an astrophysicist has brought the stars within his grasp, building an elaborate planetarium in his own backyard.

Frank Kovac, 45, spent 15 years building his planetarium in the small northern Wisconsin community of Monico, CBS News reported. The spherical structure is 22 feet across and weighs two tons, and is the world’s largest rolling, mechanical, globe planetarium.

Kovac couldn't afford a projection system that mimics the rotation of the Earth, so he spins the planetarium itself, using an electric, variable-speed motor controller. He hand-painted 5,000 stars on the ceiling, giving each its proper location and brightness. “I took luminous paint and painted every star you would see in the night sky,” Kovac told CBS News.

Years ago, Kovac wanted to be an astrophysicist, but college math proved too much for him. So he took a job at the local paper mill, according to CBS News. Although Kovac still works at the mill part-time, he devotes much of his time and energy to the Kovac Planetarium, which opened to the public a few years ago.To be a planetarium director, you need college,” Kovac told CBS News, “but if you build your own, you can run it!” ■

Class continued from page 4

No study of the universe would be complete without a discussion of neutron stars, the speed of light and black holes. We visited the Crab Nebula, 6,500 light-years away, whose neutron-star explosion in 1054 A. D. was so bright it was visible in daylight and lit the sky enough to read outside at night. Light thrown off by this star wasn’t from the star itself, but from rapid expansion of its magnetic field. As it approached the speed of light, light emitted.

The class’ discussion of black holes involved the principles of relativity, the space/time interval and the curvature of space. Given the nature of these complex concepts, I recommend independent study and, some day, joining your fellow AAA members in one of the club’s classes. ■

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S. James Gates Jr., particle physicist and John S. Toll Professor and director of the Center for String and Particle Theory at the University of Maryland, called his view of the universe “supersymmetrical.” Gates’ recent theories have identified computer codes in the mathematics of string theory. Computer drawings were displayed above panelists. When Gates revealed their significance, the forms took on new meaning.

Moderator and Hayden Planetarium director Neil deGrasse Tyson noted there’s been considerable debate about what direction string theory will take. Einstein accomplished so much in a short time on his own, he said, yet a large number of theoretical physicists haven’t moved his work along at the same speed.

In defense of the rate of discovery and development of new theories, Marcelo Gleiser, professor of physics and astronomy at Dartmouth College, stated that although he doesn’t see how we can unify string theories, “It’s the accuracy of instruments that determine results, and new technologies will reveal other things and change existing theories.”

Gleiser spoke recently at the AMNH about his book, “A Tear at the Edge of the Creation.” His work involves determining how fundamental particles interact, bringing the four forces of nature--gravity, electromagnetic interaction, and weak and strong nuclear force--into a single force. The book argues that in a supersymmetrical universe, it’s asymmetry that provides nature with the ability to evolve.

Smolin echoed these thoughts, agreeing that in particle physics, “Gravity is symmetrical but primordial gravitational waves evident during Big Bang inflation are asymmetrical from quantum gravity (as opposed to symmetrical modes--energy density fluctuations in plasma). String theory is being sought in the CMB. Looking far enough back may hold the key to making mathematical connections missing in current assumptions and calculations.

In mapping details of the CMB, the Planck satellite will bring us closer to this goal. String theory is being developed mathematically through observation and measurement of the universe’s expansion. String theory is being combined with other theories in an attempt to explain our universe and to explore the possibility of multiple dimensions and universes. Quantum mechanics’ consideration of subatomic particles’ interactions and general gravitational theories must be combined to build a unified string theory.

AAA board member Shana Tribiano asked: “Forgetting the Xenon dark-matter search experiment (aiming at building the next-generation dark-matter detector) and the Large Hadron Collider and space/time discoveries, what else would you measure to support string theory?" The question was directed to Gleiser, who asserted a method to measure gravitons, a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory, should be pursued to prove the relationships of gravity and photons. Seeing the particles would add further support to current theories and mathematics of string theory.

The debate ended with musings of the likelihood of success in 10 years. All panelists ventured an opinion, but it was Greene who was the most reserved. “Hold until 2020. I guess we’ll have to wait. ■

Lecture continued from page 3

Probes,” “More Telescope Power,” “Telescope Power,” “The Urban Astronomer” and “The Starflight Handbook.”

In addition to his interstellar-travel research, Matloff has contributed to SETI (the Search for Extraterrestrial Intelligence), modeling studies of human effects on Earth’s atmosphere, interplanetary-exploration concept analysis, alternative energy, in-space navigation and the search for extrasolar planets.

Matloff is a graduate of Queens College and holds M. A. and Ph.D. degrees from NYU.

The final lecture in the AAA’s 2010-11 series will be on Friday, May 6. NASA’s David Thompson will speak on “Exploring the Extreme Universe with the Fermi Gamma-ray Space Telescope.” ■

Events on the Horizon April 2011

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

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

Friday, April 1, 6:15 p. m.
AAA lecture, FREE, P
Dr. Greg Matloff, professor of astronomy in the physics department at New York City College of Technology, will speak on "Regreening the Earth Using Space Resources" in the Kaufmann Theater of the AMNH.

Saturday, April 2, 7:30-11 p. m.
Observing at Great Kills Gateway National Park, Staten Island, P, T, C Next date: May 7.

Tuesdays April 5, 12, 19, 26, 7:30-9:45 p. m.
Observing at the High Line, Manhattan, P, T, C
Next dates: Tuesdays in May.

Tuesday, April 5, 7 p. m.
Hayden Planetarium presentation, P, AMNH
In "The Size and Age of the Universe," the first of the Bampton lectures, Wendy Freedman will describe how Edwin Hubble discovered galaxies and the Universe's expansion, how astronomers measure distances to galaxies and how the Hubble measures the universe.

Thursday, April 7, 6:30-8:30 p. m.
Recent Advances in Astronomy Seminar, M, HQ
NYU, 726 Broadway, 6th floor conference room.
Next date: May 5.

Thursday, April 7; Tuesday, April 12; and Thursday, April 14, 6:30 pm
Davis Auditorium, Schapiro Hall, Columbia University, 530 W. 120th Street, P
Bampton lectures continue. Wendy Freedman will discuss "Much More Than the Eye Can See," "A Runaway Universe" and "Giant Telescopes of the 21st Century."
Info: http://ircpl.org/bampton-lectures/

Friday, April 8, dusk-10 p. m.
Observing at Carl Schurz Park, Manhattan, P, T, C
Next date: May 6.

Fridays April 8 and 22, 8-11 p. m.
Observing at Inwood Hill Park, Manhattan, P, T, C
Next dates: May 13, 27.

Monday, April 11, 7:30 p. m.
Hayden Planetarium lecture, P, AMNH
MIT professor Linda Elkins-Tanton will present "A Hitchhiker's Guide to Habitable Planets in Our Galaxy."

Wednesday, April 13, dusk-10 p. m.
Observing on the Brooklyn Heights Promenade at the end of Montague Street. P, T, C

Friday, April 15, 8-10 p. m.
Observing at Floyd Bennett Field, Brooklyn, P, T, C
Next date: May 13.

Saturday, April 16 and Sunday, April 17
Annual Northeast Astronomy Forum and Telescope Show at State University of New York, Suffern, N. Y., sponsored by Rockland Astronomy Club. 8:30 a. m.-6 p. m. Saturday, 10 a. m.-6 p. m. Sunday. Vendors, speakers, workshops, observing, planetarium shows, classes for beginners, events for kids. Preceded by Northeast Astro Imaging Conference April 14 and 15.
Info: http://rocklandastronomy.com/neaf.

Tuesday, April 26, 6:30 p. m.
Hayden Planetarium presentation, P, AMNH
"Exoplanets Revealed" with Emily Rice. Exoplanets were first discovered in 1995, but only indirectly. Since then, astronomers have obtained actual images.

Saturday, April 30, 10-noon
Solar Observing at Central Park, P, T, C
At the Conservatory Water.
Next date: May 28. ■

AAA Annual Meeting May 18
All Members Are Welcome!

In accordance with the AAA bylaws, the annual meeting will be held Wednesday, May 18 at headquarters, Downtown Community Center, 120 Warren St. 6:30 p. m.: social gathering with buffet. 7:30 p. m.: annual meeting.

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.

David Greenberg Dies at 69; Led AAA Lecture Committee

David Greenberg, a former AAA board member and former chairman of the association's lecture committee, died March 4 at his home in Mount Kisco, N. Y. He was 69.

A native of Maywood, N. J., Greenberg graduated Phi Beta Kappa from Rutgers University. He received his M.A. from NYU's Courant Institute and his Ph.D. from Polytechnic Institute of Brooklyn, where he was a teaching fellow.

Greenberg worked for IBM until his retirement in 1993. Under an IBM faculty-loan program, the company paid full salary to employes who spent a year teaching in the community. Greenberg taught remedial math and an advanced math course at City College.

After leaving IBM, Greenberg worked as a New York state court-system analyst. In 2001, he returned to teaching as an adjunct professor of math at Pace University, where he taught until his death.

Greenberg is survived by his wife of 43 years, the former Gail Dreier; a daughter, Cassandra; a son, Larry; a brother, Lewis; a sister, Mona Shapiro; and one grandson. ■

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