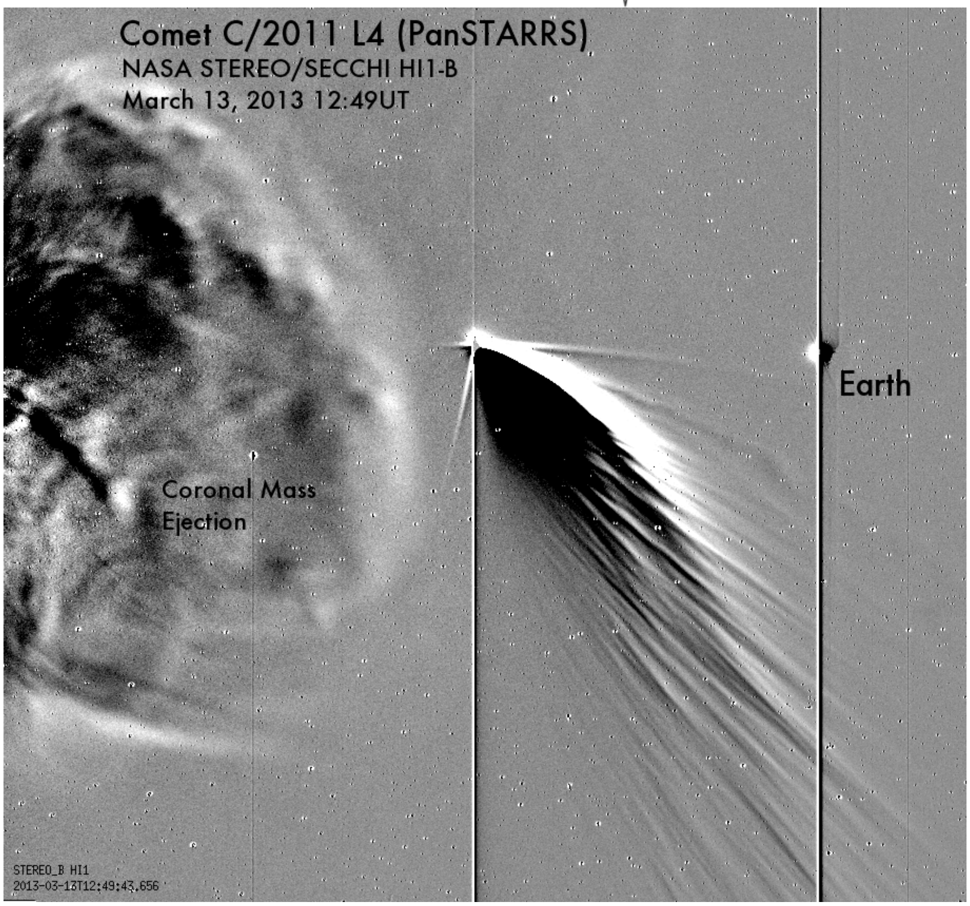
SkyWAAtch



PanSTARRS in Stereo

This remarkable interplanetary perspective from March 13 finds Comet PanSTARRS posing with the Earth as seen from the STEREO Behind spacecraft--one of two space-based observatories (one ahead of Earth in its orbit, the other trailing behind)--which were designed to record the structure and evolution of solar storms as they blast from the Sun and move out through space.

STEREO Behind is nearly opposite the Sun and looks back toward PanSTARRS and Earth, with the Sun just off the left side of the frame. At the left an enormous coronal mass ejection (CME) is erupting from a solar active region. Of course, CME, comet, and planet Earth are all at different distances from the spacecraft. (The comet is closest.) The processed digital image is the difference between two consecutive frames from the spacecraft's SECCHI Heliospheric Imager, causing the strong shadowing effect for objects that move between frames. Objects that are too bright create the sharp vertical lines. The processing reveals complicated feather-like structures in the comets extensive dust tail.

Image Credit: NRL / SECCHI / STEREO / NASA; *processing* - Karl Battams (NRL and @SungrazerComets)

Events for April 2013

WAA Lectures

"Black Holes and Galactic Evolution"
Friday April 5th, 7:30pm
Lienhard Lecture Hall, Pace University Pleasantville, NY

Our speaker will be Dr. Caleb Scharf, who will elaborate on the subject of his latest book, *Gravity's Engines*. Dr. Scharf is the director of the Columbia Astrobiology Center. He writes the Life, Unbounded blog for Scientific American; has written for the New Scientist, Science, and Nature, among other publications; and has consulted for the Discovery Channel, the Science Channel, the New York Times, and more. Dr. Scharf has served as a keynote speaker for the American Museum of Natural History and the Rubin Museum of Art, and is the author of *Extrasolar Planets and Astrobiology*, winner of the 2011 Chambliss Astronomical Writing Award from the American Astronomical Society. Free and open to the public. Directions and Map.

Upcoming Lectures

Miller or Lienhard Lecture Hall, Pace University Pleasantville, NY

On May 3rd, James W. Beletic, Ph.D., Vice President, Space & Astronomy at Teledyne Imaging Sensors, Inc. will present on Discoveries with Infrared Detectors. See an abstract of his talk on page 7. On June 7th, Alan Witzgall will present on the History of the Telescope. Mr. Witzgall is currently a Senior Optician for Fastpulse Optics in Saddle River, N.J. Lectures are free and open to the public.

Starway to Heaven

Saturday April 6th, Dusk
Meadow Picnic Area, Ward Pound Ridge Reservation, Cross River

This is our scheduled Starway to Heaven observing date for April, weather permitting. Free and open to the public. The scheduled rain/cloud date is April 13th. Participants and guests should read and abide by our General Observing Guidelines and Disclaimer. Directions.

New Members. . .

John Markowitz - Ossining
Alejandro Malespin - Rye

Renewing Members. . .

Ruth and Eugene Fischer - Pleasantville
Everett Dickson - White Plains
Karen Seiter - Larchmont
Rob & Melissa Baker - West Harrison
Raymond Herbst - Mahopac

WAA APPAREL

Charlie Gibson will be bringing WAA apparel for sale to WAA meetings. Items include:

- **Caps, $10** (navy and khaki)
- **Short Sleeve Polos, $12** (navy).

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don't forget to periodically visit the WAA website.

N E A F
NORTHEAST ASTRONOMY FORUM

The Northeast Astronomy Forum will be held on April 20th (8:30am-6:00pm) and April 21st (10:00am-6:00pm) at Rockland Community College in Suffern, NY. This is the nation's largest space and astronomy show. It features more than 100 exhibitors as well as world-renowned speakers, daily solar observing, STARLAB planetarium shows and workshops for beginners and kids.

The WAA will have a booth; be sure to stop-by. If you would like to help man the booth, email Larry Faltz at: waa-president@westchesterastronomers.org.

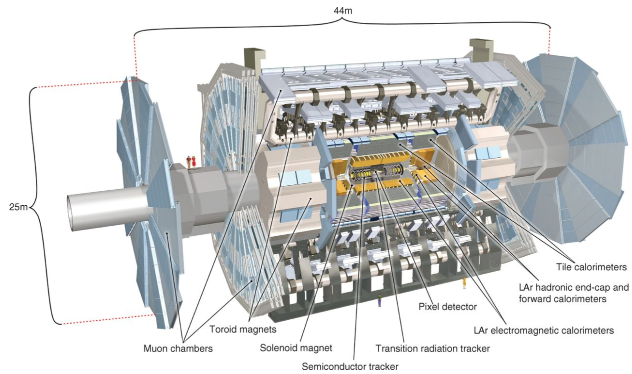
For more information go to the NEAF site.

Articles and Photos

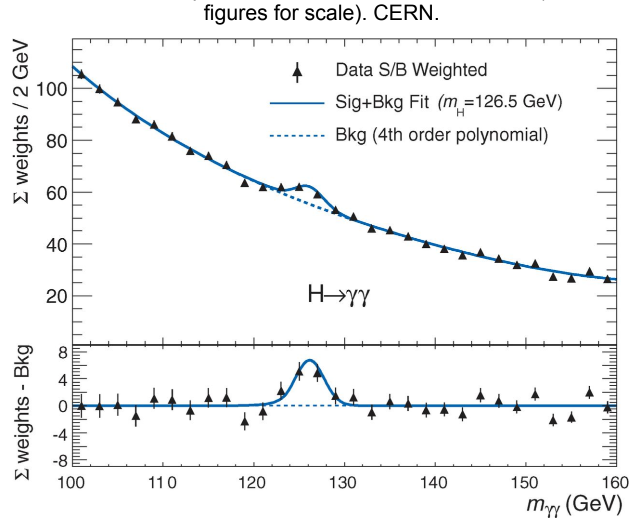
Getting to Cosmology
by Larry Faltz

One of the wonderful things about astronomy is its immense range. It encompasses all of physics, a good bit of geology and meteorology, some hydrology, much of inorganic and some organic chemistry and even rudimentary biology. Mathematics is its basic language. It's concerned with the structure of reality throughout its range but especially at its largest and smallest limits, and with the beginning and the end of everything. Its history parallels, indeed even energizes, the enlightenment of human thought and the emergence of rationality from superstition. (One can even argue that science is a necessary precursor of democracy. In 2006, NY Times science writer Dennis Overbye wrote, "[Science], which has transformed the world in the last few centuries, does indeed teach values. Those values, among others, are honesty, doubt, respect for evidence, openness, accountability and tolerance and indeed hunger for opposing points of view." These are certainly requirements in an effective, lasting democracy.) Astronomy has vast beauty, whether in a photograph of a complex and colorful deep space object, the glorious sight of a dark night sky or an elegant equation with profound meaning, like Newton's Second Law, **F**=m**a**, which explains how things move in our universe. It has both constancy (the laws of physics, the map of the night sky, the regularity of lunar phases) and change (a comet, the shifting face of the moon, a supernova, the Transit of Venus). There are heroes (Galileo, Herschel, Hubble, Einstein, Armstrong) and villains (Cardinal Bellarmine, clouds, light pollution). There are small achievements (first light on a new scope) and huge frustrations (the inevitable 3 weeks of clouds when you buy a new scope). There are toys and tools, big and small ones, and the shop talk that goes with them. And perhaps most of all, there's the fellowship of astronomers, a guild into which anyone with a little curiosity, patience and objectivity is welcomed. Plenty to learn about and write about, for sure!

There's been prodigious progress in astronomical and cosmological research in the last five decades, powered by technical developments: ever bigger telescopes, space-based instruments probing the extremes of the electromagnetic spectrum, the deployment of instrument packages to the Moon and planets, advances in computer speed and programming algorithms, telescope automation and the Internet, to name a few. At the other end of the spectrum, we've built a microscope so powerful that it can dissect the insides of elementary particles and the fabric of spacetime itself. The Large Hadron Collider at CERN in Geneva has apparently achieved its primary goal of finding the Higgs boson, a particle of the scalar field that exists at every point in space and gives other particles mass.



This is a microscope? The ATLAS detector at the LHC (note the figures for scale). CERN.

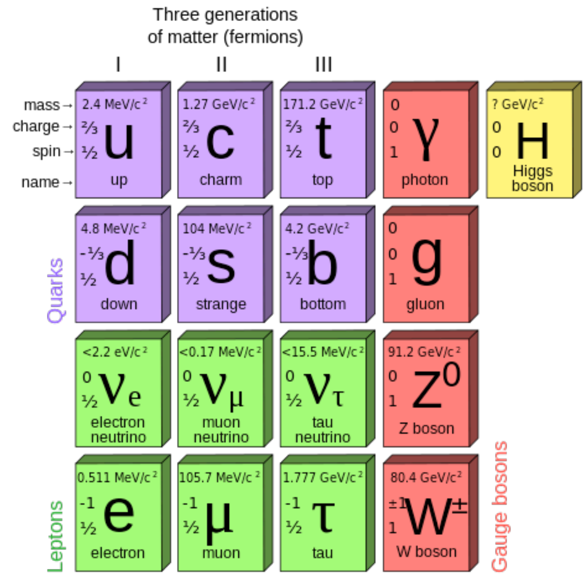


This is what a Higgs boson looks like: it's just data! (The ATLAS Collaboration, A Particle Consistent with the Higgs Boson Observed with the ATLAS Detector at the Large Hadron Collider, Science 2012; 338: 1576-1582)

I have always been interested in the subatomic world, having grown up in the "duck and cover" years. We learned early on about radioactivity, fission and fusion, which of course would provide an appreciation of the elegant science at work when a Russian H-bomb vaporized us. I did have a very solid education in math, chemistry and physics in high school and college (although I never took an astronomy course). My interest in cosmology was stimulated while I was working at the National

Institutes of Health in the mid-1970's, doing research on the chemical structure of cartilage. One of the journals that came to our lab was *Proceedings of the National Academy of Sciences*, and as I was scanning it for articles on macromolecular chemistry I came upon an article by Martin Rees, then a young (33) Cambridge astronomer and only later Baron Rees of Ludlow, OM, Kt, FRS, President of the Royal Society and winner of the Isaac Newton Medal. The article was entitled "Progress and Prospects in High Energy Astrophysics", and it was my first good exposure to the details and relationships of neutron stars, black holes, galactic nuclei and cosmology. At the conclusion of the article, Rees extrapolated backwards from the cosmic microwave background era (380,000 years after the Big Bang) through the nucleosynthesis era (100 seconds) to the Planck time (10^{-43} seconds), when "Einstein's theory cannot be an adequate description and a full blown theory of quantum gravity is required." (*Proc Nat Acad Sci USA* 1975; 72: 4685-4690).

Science essentially has two parallel components that must operate both together and against each other: theories (more correctly *models*) that allow us to make consistent statements about how things work in our world, and observations that confirm or refute these models. The current models that describe reality at its most fundamental level are special and general relativity (extending Galilean and Newtonian mechanics), quantum mechanics (extending Maxwell's electrodynamics), the Standard Model (extending the Bohr/Rutherford model of the atom) and thermodynamics. Each of these models makes predictions with amazing accuracy, but what's remarkable is that it is universally believed that they are not fundamental, but only approximations of a deeper model that's closer to "reality" (even if quantum mechanics can make predictions to 15 significant digits). This would be the "theory of everything" that was at work at the first instant of the Big Bang. What has been holding up the construction of this model is that, nearly 40 years after Rees, there is still no accepted theory of quantum gravity, or at least none that have any observational support. String theory is the current favorite, but it is as yet incomplete, terribly mathematically complex, and completely devoid of experimental verification. It makes no "falsifiable" predictions, a requirement for veracity in science.



The Standard Model. Confusing? It should be! And this isn't all of it: there are three "colors" for each quark and everything has an antiparticle. Yet it's a model that works. The mass of the Higgs is 125 GeV/c², unknown when this table was prepared by Fermilab.

Of the many observations that have had provocative impact on the development of models of the cosmos (rather than merely confirming what is generally accepted, as the discovery of the Higgs boson seems to have done), the ones that come to my mind as being the most profound in the last 150 years are the photoelectric effect, first observed by Hertz in 1887, the Michelson-Morely experiment that disproved the existence of a medium through which light is propagated, also in 1887, Becquerel's discovery of radioactivity in 1896, Vesto Slipher's detection of the redshift in 1912, Hubbell's recognition of the expansion of the universe in 1929, the discovery of charge-parity violation in 1964 by Cronin and Fitch (suggesting an explanation for the dominance of matter over antimatter), the detection of the cosmic microwave background by Penzias and Wilson in 1965 and the finding in 1998 that the expansion of the universe was accelerating. The science and personalities behind this last unexpected, almost shocking, discovery is beautifully summarized in Richard Panek's *The 4% Universe* (2011). Some observations confirm models, like the Higgs or Galileo's telescopic observations, while others force the creation of new ones.

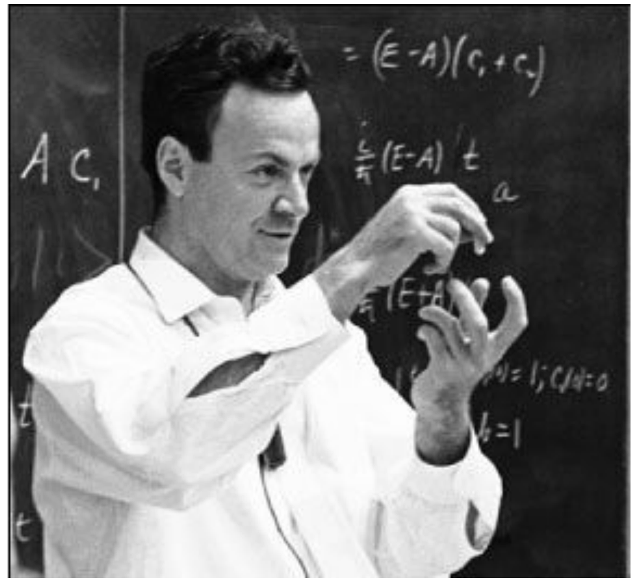
There are many fine books on the structure of the cosmos, relating its smallest and largest levels, starting with George Gamow's entertaining classic

One, Two, Three…Infinity (1947). Most include something about relativity and quantum mechanics, the Big Bang and the expansion of the universe. For a basic introduction to special and general relativity, I recommend Albert Einstein's own slim volume *Relativity*, first published in 1920. It uses simple geometry and very basic algebra to make its points. And it's from the horse's mouth, so to speak.

Brian Greene, by vocation a string theorist, published three very fine books that taken together provide an excellent explanation of the nature of the cosmos. *The Elegant Universe* (1999) naturally concentrates on the nature of space and the structure of elementary particles, primarily concerning itself with symmetry, string theory (his academic interest) and its requirement for hidden dimensions. *The Fabric of the Cosmos* (2004), elaborates on these topics with a bit more focus on cosmology. His most recent book, *The Hidden Reality* (2011), takes everything a step further and examines a spectrum of theoretical models of the universe, including inflationary scenarios, the "landscape" multiverse where every possible solution of string theory (of which there are at least 10^{500}) exists somewhere, and the "holographic" universe, where the 4-dimensional spacetime reality we experience is really just information encoded on the surface of a 3-dimensional membrane. Greene is a master of analogy, among the best at explaining these complex topics to a layperson.

There are other good books that focus on these topics, in particular Leonard Susskind's *The Cosmic Landscape* (2006), which makes the detailed case for those 10^{500} members of the multiverse, and Lisa Randall's *Warped Passages* (2005), which focuses on additional dimensions. For an anti-string theory perspective (in fact, a real bashing of string theory), I recommend Lee Smolin's *The Trouble with Physics* (2007). Smolin has been a proponent of a completely different model, "quantum loop gravity," outlined in his *Three Roads to Quantum Gravity* (2001). His own contribution to cosmology is *The Life of the Cosmos* (1997). I don't recommend Frank Wilczek's *The Lightness of Being* (2008) for neophytes; it's an explanation of the standard model but I think he expresses the concepts in a somewhat dense way that I found a bit hard to follow. Well, you don't win the Nobel Prize for the simple stuff.

I do recommend Richard Feynman's *QED* (1985), a brief and elegant explanation of quantum electrodynamics, which unites electromagnetism and the weak nuclear force and is the precursor to the Standard Model (which includes the strong nuclear force) from one of its founders. Read anything you can by Feynman, for a start his short books about basic topics in physics, *Six Easy Pieces* and *Six Not-So-Easy Pieces*, or anything *about* him for that matter. He was one of physics' most creative researchers, influential educators and interesting personalities, not to mention its finest bongo-drum player.



Richard Feynman (1918-1988)

When it comes to models, we have to be careful. There is a limit to what we can describe. With regard to quantum mechanics, Feynman explained,

> One might still like to ask: "How does it work? What is the machinery behind the law [of quantum mechanics only predicting probabilities]?" No one has found any machinery behind the law. No one can "explain" any more than we have just "explained." No one will give you any deeper representation of the situation. We have no ideas about a more basic mechanism from which these results can be deduced….So at the present time we must limit ourselves to computing probabilities. We say "at the present time," but we suspect very strongly that it is something that will be with us forever—that it is impossible to beat that puzzle—that this is the way nature really *is*. (*The Feynman Lectures on Physics*, Vol. III: Quantum Mechanics, chapter 1, emphasis his)

This shouldn't be a frustration, nor should it dissuade one from wanting to understand what's at the limit and even probe a little beyond. Those attempts are the way science proceeds. It's just that we have to acknowledge that as we learn more, we may find that certain questions can't be answered, at least not as a response to the way we've asked them. (This is most certainly *not* an appeal to a supreme being! Nature has its own supremacy.) That the "clockwork universe" of Newton doesn't exist ought to be reassuring. It reminds us that we do have free will, although we actually can't know why! There's an enlightening discussion of the relationship of quantum mechanics to the function of the human brain in Roger Penrose's *The Emperor's New Mind* (1989), a challenging and thrilling review of relativity, quantum mechanics, the structure of reality and even information theory (it has a very clear explanation of Turing machines) at a somewhat detailed level, with a foray into an examination of consciousness. It was in this book that I first encountered the daunting but utterly fascinating topic of phase space, where each particle in a system (which could be, if you choose, the entire universe) is described in 6 unique dimensions, 3 for position and 3 for momentum. Every possible "state" of the system (possible arrangements of *n* particles) corresponds to a point in a 6*n* dimensional space. For example, if you had a bottle containing one mole of O_2 atoms ($6.022x10^{23}$ of them, Avogadro's number), which would occupy 24 liters at 1 atmosphere, you'd plot all the possible atomic arrangements in a space of $6x6.022x10^{23}$ dimensions! But you can cleverly reduce that information to a simple 2-dimensional plot, which is helpful in explaining thermodynamics (the concept of phase space for this purpose was developed by thermodynamicists Ludwig Boltzmann and Willard Gibbs and mathematician Henri Poincaré in the 19^{th} century). Penrose does a lot better job of illuminating it than I ever could. But just the thought of it! A 10^{24}-dimensional space. Don't lose your car keys there.

As you have probably figured out, I love reading about this stuff, even if my understanding is merely that of an interested amateur. I find it far more fantastic than fiction, and unlike fiction it's true. As Mark Twain said, "Truth is stranger than fiction, because fiction is obliged to stick to possibilities. Truth isn't." The truthful possibilities described by quantum mechanics are vaster and more surprising than the fictional possibilities available to Edmond Dantes, Lemuel Gulliver or even Rabelais' fantastic giants Gargantua and Pantagruel. It's a treat to stretch your mind around the idea of quantized energy states, or the curvature of space by mass, or even the very idea of neutrinos or dark matter. To try to have even a basic understanding of the number 10^{500}, the geometry of a closed universe or the "wave-particle duality" of quantum mechanics is an invigorating challenge. Reading about it from different authors' perspectives is also a treat, like going to a concert and hearing a new interpretation of the Beethoven Hammerklavier Sonata or the Brahms Fourth Symphony. Those are pieces so profound that it would be a tragedy to think you'd hear them only once and be expected to say, "OK, I've heard it, now on to other things." Repeated hearings increase your understanding and appreciation and open your mind, and they create links to other parts of the world of music (another of my passions). It's even more fun for me when some basic mathematics is brought into the picture, for there's something deep and eternal about mathematics itself. You can see that in one of the truly great math books for the non-mathematician, Kasner and Newman's *Mathematics and the Imagination* (1940), still in print. Sadly, my last formal math course was 48 years ago, and math, like tennis or playing the piano, two other things I enjoy and don't excel at, needs to be encountered daily to maintain real proficiency.

All of these books are fun and informative, but many popular books by scientists can sometimes be a bit of a slugfest, especially when the author is immersed in the importance and validity of his or her own research area, or has an academic bent and tries hard to link up all the details. If you're interested in dipping your toe into the world of cosmology, don't despair, because this year Wiley published a very readable and understandable book on the subject, *Edge of the Universe* (2012) by Paul Halpern, a prolific and skilled science writer who is Professor of Physics at the University of the Sciences in Philadelphia. Halpern was also the recipient of a Guggenheim Fellowship in 2002 and is a Fellow in Humanities at the university.

In just over 200 math-less and illustration-less pages, Halpern proves a crystal clear explanation of the scope of modern cosmology and the areas of controversy that need to be resolved. The book is structured in 15 chapters, each asking a fundamental question. To show you the breadth of this book, here they are:

1. How Far Out Can We See?: Voyage to the Edge of the Known Universe
2. How Was the Universe Born?: Revealing the Dawn of Time
3. How Far Away Will the Edge Get?: The Discovery of the Accelerating Universe
4. Why Does the Universe Seem So Smooth?: The Inflationary Era
5. What is Dark Energy?: Will It Tear Space Apart?
6. Do We Live in a Hologram?: Exploring the Boundaries of Information

7. Are There Alternatives to Inflation?: Extra Dimensions and the Big Bounce
8. What Builds Structure in the Universe?: The Search for Dark Matter
9. What is Tugging on Galaxies? The Mysteries of Dark Flow and the Great Attractor
10. What Is the "Axis of Evil"?: Investigating Strange Features in the Cosmic Background
11. What Are the Immense Blasts of Energy from the Farthest Reaches of Space?: Gamma-Ray Bursts and the Quest for Cosmic Dragons
12. Can We Journey to Parallel Universes?: Wormholes as Gateways
13. Is the Universe Constantly Splitting into Multiple Realities?: The Many-Worlds Hypothesis
14. How Will the Universe End? With a Bang, Bounce, Rip, Stretch or Whimper?
15. What Are the Ultimate Limits of Our Knowledge about the Cosmos?

At first, I thought the absence of illustrations about topics that have so much visual information associated with them would be a huge barrier. But Halpern's prose is clear and concise, and illustrations might have had the perverse effect of taking your mind away from the flow of the narrative and even deflating your mental conceptions by reducing them to two-dimensional cartoons (although I have to admit my penchant for illustrating my articles). Halpern provides just the right amount of information to give the reader a solid understanding of what the big questions are, where the evidence is, and how these seemingly diverse topics are interrelated. I don't know how much my previous reading about cosmology and fundamental physics helped lubricate my understanding and visualizations, but this book seems to me to be a perfect introduction and overview of where things stand in the universe right now for someone whose curiosity about these enormous questions is just being whetted. Perhaps that will be you.

The Fantastic Discoveries of Astronomy Made Possible by Modern Infrared Detectors

by James W. Beletic, Ph.D.

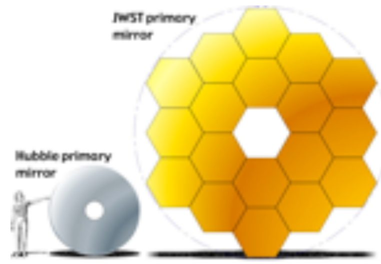
The universe is an amazingly huge place. While humankind has directly explored Earth's sister planets with space probes, we don't have the means to venture beyond the solar system, and so almost all information about the universe comes from sensing light that happens our way. Astronomy is constantly striving to find better ways to sense the feeble amount of energy from distant stars and galaxies. This quest has led to a new generation of very large telescopes (up to 10-meter diameter) on the ground and the deployment of the 2.4-meter Hubble telescope in space. Ground-based astronomy will soon begin construction on an even more ambitious generation of 30-meter class extremely large telescopes (ELTs), and the James Webb Space Telescope's 6.5-meter mirror will launch by the end of the decade. Possibly more important than the development of bigger telescopes is the rapid advancement in solid state detector technology. The detector revolution was led by silicon CCDs (IV material) starting in the 1970's for sensing visible light, but the II-VI materials (HgCdTe) that were developed during the past two decades for sensing infrared light have made the most significant difference in astronomy. Long before the CCD, astronomers could detect visible light with the human eye and photographic plates, but until recently, infrared astronomy was not possible.

Infrared light is the only way to study a wide range of astronomical phenomena. As known from terrestrial applications, infrared light propagates through dust and infrared light is required for sensing cooler objects. More important for astronomy, the universe has been expanding since the Big Bang and the expansion of the universe has redshifted the ultraviolet and visible light of distant objects into the infrared. The distant universe is an infrared universe and several of the next generation facilities (JWST, dark energy missions, the ELTs) will rely mainly, if not entirely, on infrared detectors which enable modern astronomy. My May 3rd talk will present the cutting edge astronomy that is made possible by the outstanding properties of modern infrared detectors, including:

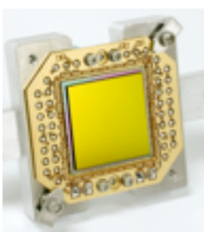
- ability to tune the cutoff wavelength to optimize instrument performance
- substrate removal that enables simultaneous detection of visible and infrared light
- extremely low dark current (0.01 electrons per pixel per sec for 5 micron cutoff)
- high quantum efficiency (>80%)

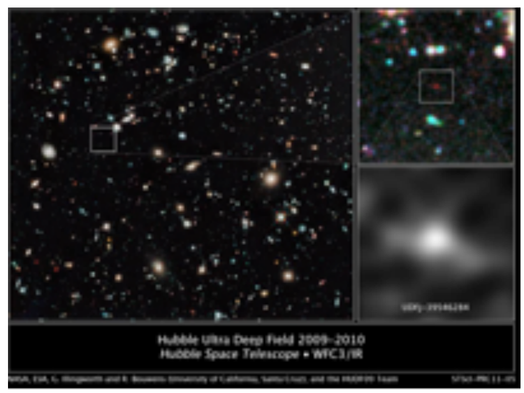
- very low noise readout (3 electrons rms, after multiple sampling)
- large format arrays (2K×2K is standard today, and 4K×4K is in development)
- high operability (>99%).

Editor's Note: This is an abstract of Dr. Beletic's talk, which he will present at the May 3rd WAA meeting. Dr. Beletic is Vice President, Space & Astronomy, Teledyne Imaging Sensors.

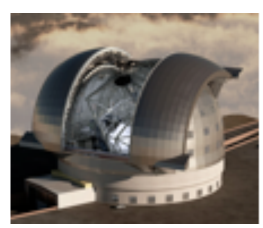


The 2.4-meter Hubble Space Telescope (left), the 6.5-meter James Webb Space Telescope (center) and a comparison of the size of the primary mirrors of the two telescopes (right). In addition to larger size, the JWST mirror is cooled to 50K whereas Hubble's mirror is heated to room temperature to retain its shape. The JWST, with a much larger mirror that emits very little thermal radiation, will be an extremely sensitive facility for infrared astronomy. Only infrared detectors are used in the JWST instruments.





The Wide Field Camera 3 (WFC3) of the Hubble Space Telescope uses a 1K×1K HgCdTe array (left) for the sensor of the infrared channel. Combined with Hubble's 2.4-meter aperture, in space beyond the blurring of the Earth's atmosphere, the WFC3 is the most advanced infrared imager in astronomy. A 23 hour exposure of the visible and infrared channels of the WFC3 were combined to produce an image of Stephan's Quintet (center), a collection of galaxies that range from 40 to 290 million light years from Earth. The Hubble ultra deep field (87 hour exposure) taken in the infrared (right) contains the farthest object yet found in the universe (see red object, top right), a galaxy whose light travelled 13.2 billion years to reach the Earth. (A NASA press release on December 12, 2012 announced that even more distant galaxies have been identified in the Hubble Ultra Deep Field 2012.)

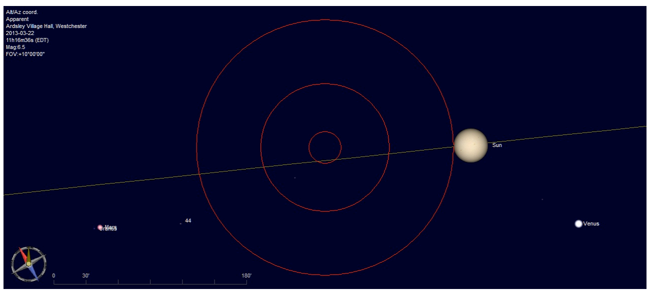


The four 8.2-meter telescopes of ESO's Paranal Observatory (left) are four of the 17 ground-based optical telescopes with greater than 6.5-meter diameter commissioned in the past two decades. The present era of very large telescopes will soon be superseded by the extremely large telescopes (ELTs), such as the European Extremely Large Telescope (right). To prepare for the ELT era, which will predominantly have infrared instrumentation, the U.S. National Science Foundation has funded the development of the 16 megapixel 4K×4K H4RG-15 infrared sensor (center).

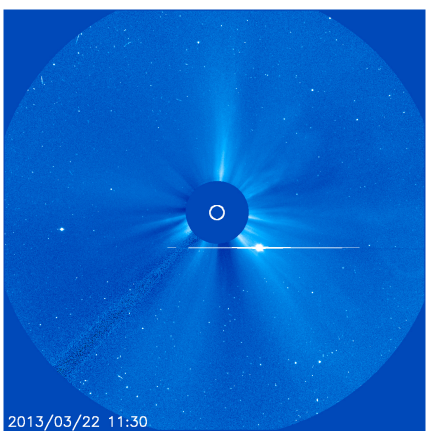
Mars, Venus and Uranus in the SOHO C3 Camera View
by Bob Kelly

The SOHO solar-observing spacecraft watches the area around the Sun for solar mass ejections. Its C3 camera can see these large, but faint, exhalations of solar particles by blocking out the Sun. In the vacuum of space, the sunlight isn't scattered as it is by our atmosphere. So SOHO can see stars and planets near the Sun in the sky that we can't see from Earth. Now, Venus, Mars and Uranus are in the C3's field of view.

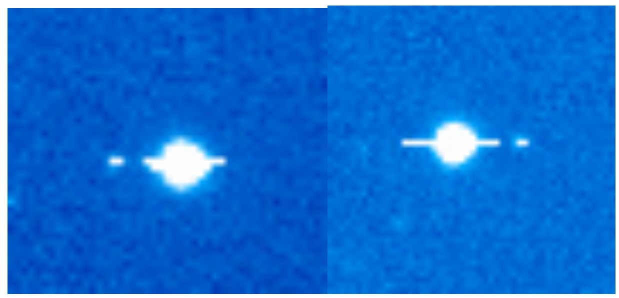
Here's what Venus and Mars look like near the Sun, thanks to the Cartes du Ciel planetarium program:



Here's the photo from SOHO C3:



The position of the Sun is marked by the center white circle. To the lower right of the Sun is Venus, overpowering the detector. To the left is Mars. When this photo was taken, Uranus was in conjunction with Mars as seen in these magnified sections of two photos taken 11 hours apart on March 22nd. Mars passes by more distant Uranus between these two photos.



The ring-like effect (more pronounced for Venus' image) is from the brightness of Mars spilling out from its image into adjoining bins in the camera pixels.

According to the SOHO transit web site, here is when these planets will be visible in SOHO's C3 camera, so you can see for yourself:

Feb24-Apr24	Venus	mag. -3.9	right to left
Mar14-May20	Mars	mag. +1.1	left to right
Mar21-Apr06	Uranus	mag. 5.9	left to right

Tackling the Really BIG Questions
by Diane K. Fisher

How does NASA get its ideas for new astronomy and astrophysics missions? It starts with a Decadal Survey by the National Research Council, sponsored by NASA, the National Science Foundation, and the Department of Energy. The last one, New Worlds, New Horizons in Astronomy and Astrophysics was completed in 2010. It defines the highest-priority research activities in the next decade for astronomy and astrophysics that will "set the nation firmly on the path to answering profound questions about the cosmos." It defines space and ground-based research activities in the large, midsize, and small budget categories.

The recommended activities are meant to advance three science objectives:

1. Deepening understanding of how the first stars, galaxies, and black holes formed,
2. Locating the closest habitable Earth-like planets beyond the solar system for detailed study, and

3. Using astronomical measurements to unravel the mysteries of gravity and probe fundamental physics.

For the 2012-2021 period, the highest-priority large mission recommended is the Wide-field Infrared Survey Telescope (WFIRST). It would orbit the second Lagrange point and perform wide-field imaging and slitless spectroscopic surveys of the near-infrared sky for the community. It would settle essential questions in both exoplanet and dark energy research and would advance topics ranging from galaxy evolution to the study of objects within the galaxy and within the solar system.

Naturally, NASA's strategic response to the recommendations in the decadal survey must take budget constraints and uncertainties into account.The goal is to begin building this mission in 2017, after the launch of the James Webb Space Telescope. But this timeframe is not assured. Alternatively, a different, less ambitious mission that also address the Decadal Survey science objectives for WFIRST would remain a high priority.

The Astrophysics Division is also doing studies of moderate-sized missions, including: gravitational wave mission concepts that would advance some or all of the science objectives of the Laser Interferometer Space Antenna (LISA), but at lower cost; X-ray mission concepts to advance the science objectives of the International X-ray Observatory (IXO), but at lower cost; and mission concept studies of probe-class missions to advance the science of a planet characterization and imaging mission.

For a summary of NASA's plans for seeking answers to the big astrophysics questions and to read the complete Astrophysics Implementation Plan (dated December 2012), see http://science.nasa.gov/astrophysics/. For kids, find lots of astrophysics fun facts and games on The Space Place, http://spaceplace.nasa.gov/menu/space/.

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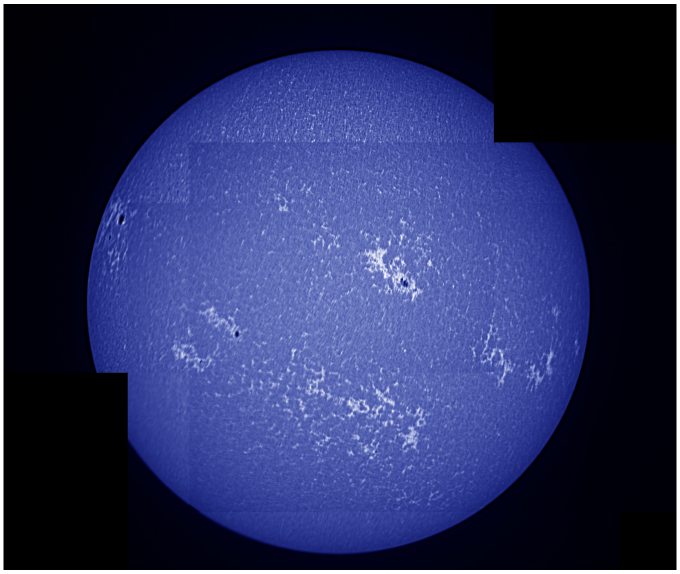
Clusters of galaxies collide in this composite image of "Pandora's Cluster." Data (in red) from NASA's Chandra X-ray Observatory show gas with temperatures of millions of degrees. Blue maps the total mass concentration (mostly dark matter) based on data from the Hubble Space Telescope (HST), the European Southern Observatory's Very Large Telescope (VLT), and the Japanese Subaru telescope. Optical data from HST and VLT also show the constituent galaxies of the clusters. Such images begin to reveal the relationship between concentration of dark matter and the overall structure of the universe.

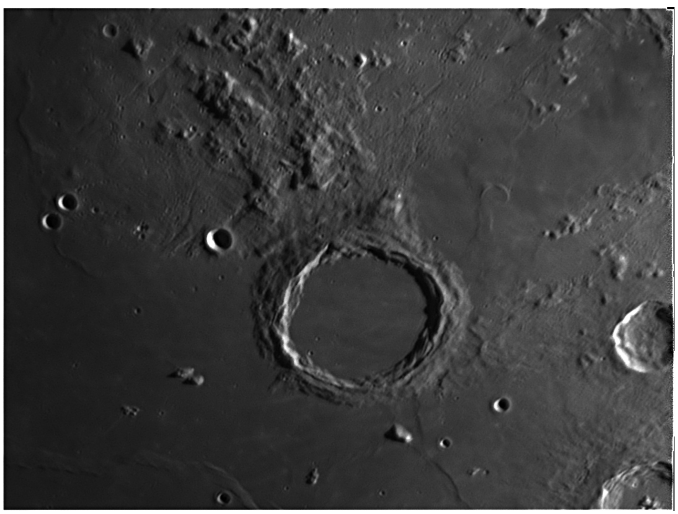
The Second Annual Savoy Star Party

This event will be held at the Shady Pines Camp Grounds in Savoy, MA from August 2nd through 11th, 2013. A $5.00 per person charge will be part of the registration for coffee, cups and other amenities. Shady Pines Camp Ground rates apply for camping. You can stay one night or all 10 days. There are plenty of local day trips and daily activities. The night skies at Shady Pine are excellent as are the facilities (rest rooms, showers and a snack-bar). This event is not associated with any astronomy club. Last year people came from NY, NJ, FL, CN, MS, MA and VT. For registration, daily events and other information you can visit www.savoystarparty.webs.com . You can also visit www.shadypinescampground.com to get information about the camp site and the rate schedule.



◀ Solar Composite

Courtesy of John Paladini is this composite image of the Sun take with a Chameleon Point Grey camera through a 60mm Lunt solar telescope. John merged the individual frames with Imerge.



◀ Crater Archimedes

John Paladini captured this image of the crater Archimedes with a Point Grey Chameleon camera through a Celestron C11 telescope. The crater is some 80kms in diameter and is notable for its smooth floor due to lava flooding. Below the crater in this image is the Sinus Lunicus (Bay of Luna). It was the landing site for the first lunar probe (Luna 2) in 1959.

◀ PanSTARRS

As we go to press, recent unimpressive weather has hampered viewing of Comet PanSTARRS. Larry Faltz took this picture with his DSLR camera from the Quaker Ridge School.

Almanac

For April 2013 by Bob Kelly

Apr 4 Apr 10 Apr 17 Apr 25

After spending evenings hoping that clouds would clear out and desperately peering into evening twilight trying to tease out Comet PanSTARRS, one could be convinced that this whole great comet thing is just an tease or even an April Fool's joke, just a bit early. But PanSTARRS does exist! Observers (not me!) have described the comet as a tiny, jewel-like object with a tiny tail in binoculars. They say it was hard to find unless you looked right at it and it was surprising how intensely bright it was.

PanSTARRS will get further away from the Sun into a darker sky, but not too much further from the horizon in April. Of course, we'll search again at our monthly star party. We should have better results this time. PanSTARRS passes by M32, the Andromeda Galaxy around the 5th. They will be low in the sky, where fuzzy objects tend to blend into the hazes near the horizon, but they will be a good sight if you can catch them. See Carl Lydon's photo of M32, PanSTARRS, and himself, on our facebook page, for an example.

But, back to the easier-to-find objects. Everyone notices Jupiter, high in the southwest. Once they find Jupiter, the nearby star clusters add to the joy. Jupiter looks a bit smaller, at 34 arc seconds wide, than it did back at 48 arc seconds at opposition last December.

Jupiter and the nearby clusters are great for taking photos with most cameras, and the Moon joins the scene on the 13th and 14th. Most times, the Moon overwhelms the fainter star clusters in the area, but now, the Moon's thinner crescent phase allows the nearby clusters to shine through.

As if that wasn't enough, waiting in the wings is magnificent Saturn, ruling the post-twilight skies in April and May. We make our annual closest approach to Saturn on the 27th and 28th, at 800 million miles away, Saturn will cover 19 arc seconds and its rings will spread out 43 arc seconds wide.

Venus comes out of the solar glare at the end of April, moving out from behind the Sun and into the evening sky for the rest of the year.

Mercury is low in the morning sky, a binocular object at best. It's still the closest planet to Earth, a title it holds all year until late August. Go to the Southern Hemisphere for a better view. On the 25th, the Moon will be partially eclipsed by the Earth's shadow. Only 1.5% of the Moon will be covered by dark shadow. Go to the Eastern Hemisphere for a better view. Part of the Moon will see a colorful grazing eclipse of the Sun by the Earth. Go to the northern polar region of the Moon for a better view.

The Lyrid meteor shower is usually not much to talk about. This highly variable shower has produced a couple of mini-storms of over a meteor-a-minute, but we have too little data to determine when this could happen again. The best time to watch for the average of 10 meteors per hour is on the morning of April 22nd a few hours before sunrise, as the bright Moon is setting. Watch the part of the sky with the Moon at your back in order to see the most meteors.

Super-bright meteors have been reported much more often since the stupendous fireball in Russia last month (see http://www.amsmeteors.org/fireballs/faqf/ for a graphic with meteor terminology). While we hear more of these reports due to the increased sensitivity of the press to this kind of event, it's also nice to see that more people are looking up and reporting what they see in the sky. With Astronomy Day on Saturday, the 20th, it's a great time to introduce the sky and its wonders to friends and strangers alike.

In April the Moon is its usual helpful self – pointing out other lesser lights as it arcs through the skies, but even a star like first magnitude Spica ends up drowning in a puddle of Moonlight on the evening of the 24th, slipping behind the Moon entirely for Central and South America and parts of Africa. The waxing Moon makes a dot at the bottom of the backwards question mark of the lion's head (Leo) on the 20th.

The International Space Station passes through the dawn sky through the 6th and during dusk from 6th through the 26th. Tiangong 1 is a evening flyer from the 4th through 17th. Can you find any times when the ISS and the Chinese space station will be in the sky at the same time? Note that the exact times are subject to change during the month as their mission control centers adjust their orbits.

Bob's Heads UP blog is at bkellysky.wordpress.com.

Westchester Amateur Astronomers