SkyWAAtch

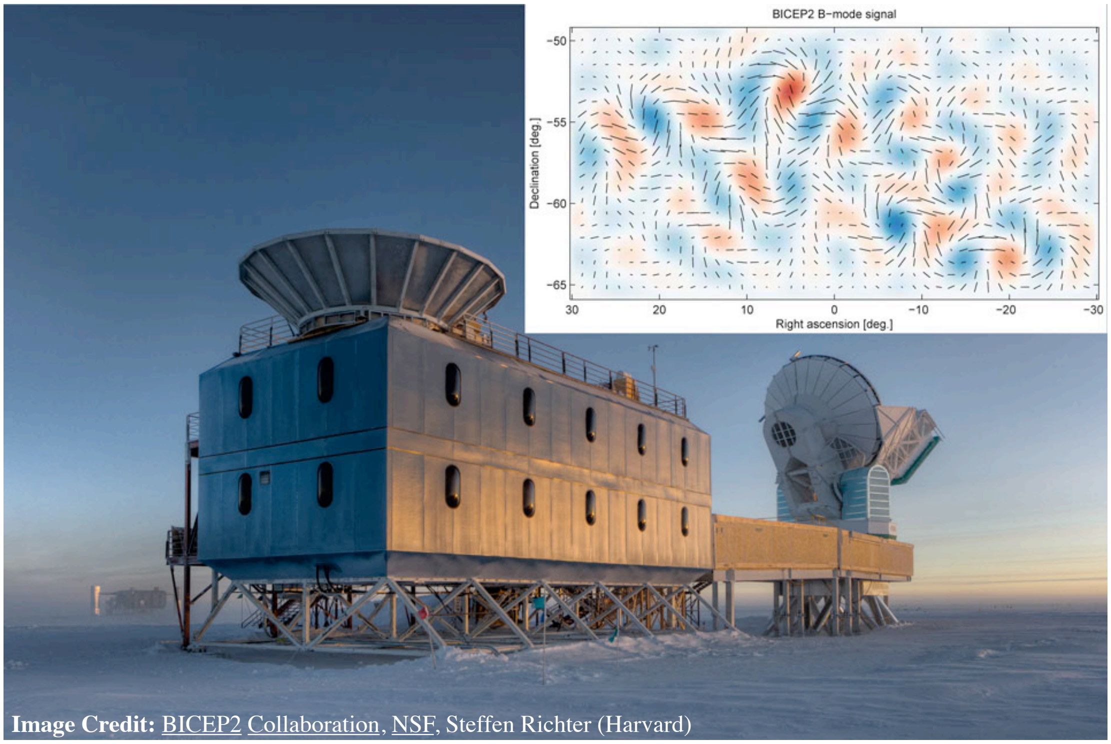


Image Credit: BICEP2 Collaboration, NSF, Steffen Richter (Harvard)

Cosmic Microwave Map Swirls Indicate Inflation

Did the universe undergo an early epoch of rapid expansion? Such an inflationary epoch has been postulated to explain several puzzles about the universe such as why it looks similar in opposite directions. Recent results showing an expected signal of unexpected strength bolster the prediction of inflation that specific patterns of polarization should exist in the cosmic microwave background radiation -- light emitted 13.8 billion years ago as the universe first became transparent. Called B-mode polarizations, these early swirling patterns can be directly attributed to squeeze and stretch effects that gravitational radiation has on photon-emitting electrons. The surprising results were discovered in data from the Background Imaging of Cosmic Extragalactic Polarization 2 (BICEP2) microwave observatory near the South Pole. BICEP2 is the building-mounted dish pictured above on the left. Note how the black polarization vectors appear to swirl around the colored temperature peaks on the inset microwave sky map. Although statistically compelling, the conclusions will likely remain controversial while confirmation attempts are made with independent observations. (source and credit: APOD).

In This Issue . . .

Events for April 2014

WAA April Lecture

“Astronomical Alignments of Hudson Valley Stone Sites”
Friday April 4th, 7:30pm
Lienhard Lecture Hall, Pace University Pleasantville, NY

There are hundreds of stone chambers, walls, and perched boulders in the Hudson Valley that have astronomical alignments. Are they colonial, Native American, or of some other pre-Columbian origins. Author and science writer Linda Zimmermann will discuss possible solutions to these questions. Ms. Zimmermann holds a BS degree in Chemistry and a Masters in English Literate. She has received honors and awards for her books on American history, and in 2011 she won the Independent Publishers Silver Medal for humor for her book *Bad Science.* Linda has lectured at the Smithsonian, West Point, and Gettysburg. Free and open to the public. Directions and Map.

Upcoming Lectures

Lienhard Lecture Hall,
Pace University Pleasantville, NY

On May 2nd, Dr. Anže Slosar will present on “The Universe: Our Mysterious Home.” Dr. Slosar received his Ph.D from the University of Cambridge in 2003. He worked at Oxford and Berkeley and is currently an Associate Scientist at the Brookhaven National Laboratory on Long Island. Lectures are free and open to the public.

Starway to Heaven

Saturday April 26th, 8 pm.
Meadow Picnic Area,
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for April, weather permitting. Free and open to the public. The rain/cloud date is May 3rd. **Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions.

WAA APPAREL

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

- **Caps and Tee Shirts, $10**
- **Short Sleeve Polos,**
- **Navy hoodies for $22.**

New Members. . .

Garfield Boston - Yorktown
Theresa C. Kratschmer - Yorktown Heights
James Meyers - Ossining

Renewing Members. . .

John & Maryann Fusco - Yonkers
Paul Alimena - Rye
Rick Bria - Greenwich
Alex Meleney - Greenwich
Karen Seiter - Larchmont
Everett Dickson - White Plains
Lori Wood - Yonkers
Lucia and Jim Balestrieri - Tarrytown

Join WAA at NEAF, April 12-13 Rockland Community College, Suffern, NY

NEAF is one of the largest astronomy shows in the world. Besides the many equipment, book and supply vendors there are lectures and, weather cooperating, the Solar Star Party. WAA will again have a booth at NEAF and we hope you will donate an hour or more of your time to help man the booth. Meet and mingle with fellow WAA members and other astronomy enthusiasts from all over the country, express your enthusiasm for our hobby and have a place to leave your stuff.

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

Westchester
Amateur Astronomers

Almanac

For April 2014 by Bob Kelly

Apr 7 Apr 15 Apr 22 Apr 29

If you could see all the sunrises and sunsets all around the world in one night, what would you have? Either a very fast jet or a total lunar eclipse. Early in the morning on April 15th, the Moon will show off sunlight tinted red and blue by passing through the dust, clouds and ozone of Earth's atmosphere at the moment of sunrise or sunset, as seen from the Moon.

Unlike a solar eclipse, if you can see the Moon during the time of the eclipse, you'll get to see the eclipse, at the same time. Only your clock time will be different, depending on your time zone. Thus, the partial eclipse begins in the eastern daylight time zone at 1:58am and in the pacific daylight time zone at 10:58pm on the 14th. If you get up at 2am, watch for the stars around the Moon become more visible as the Moon darkens.

There is quite a collection of objects near the Moon in the sky that night, with Mars very noticeable nearby, Spica right next to the Moon and two asteroids, Ceres and Vesta, visible in binoculars nearby. The solar system objects near the Moon in the sky are about as bright as they get, since they, like the Moon, are near opposition to Earth, and we are closest to planets and asteroids around opposition.

At maximum eclipse, at 3:46am, watch for the variation in light across the Moon as the southern part of the Moon is close to the edge of the earth's shadow and will look brighter than the northern part of the Moon. The partial eclipse is over by 5:33am, as the sky begins to lighten with the Sun coming up at 6:16am in our area.

If you don't want to get up 'in the middle of the night', you can get up about 4am and see the second half of the eclipse, when the line of sunrises and sunsets will move across the Moon from 4:25am to 5:33am. The eclipsed Moon may be low enough in the southwestern sky to be seen from indoors, through a window. This 'picture window' eclipse allows viewing from the comfort of home.

This is the first of a series of four total lunar eclipses in a row, with another one this year and two in 2015. Three of the four will be visible from our area. Two of these lunar eclipses occur on the first night of Passover, but that's not as uncommon as it might seem. Passover is 14 days after the beginning of the lunar month, when the full moon occurs, which is the only time a lunar eclipse is possible.

Meanwhile, watch this month as the winter constellations, with all their bright stars appear to rush for the exits, leaving our evening skies for the season. To take their places, Leo the lion and the Big Dipper head for the overhead this month. Regulus, the brightest star in Leo, passes across the southern meridian during TV's Prime Time hours, as if to show us how no stars were harmed when asteroid Erigone passed in front of it last month (unfortunately clouds massed in front of both the asteroid and the star!).

This month is your best chance to view details on Mars. Crank the power up as high as the shimmering atmosphere of the Earth will allow. The best nights are when the jet stream is not over your observing site. We pass closest to Mars on the 14th, and Mars is the closest planet to Earth this month, but still not the largest in apparent size.

Jupiter spends most of the evening higher in the sky than Mars, thanks to its location in the northern latitudes of the constellations. It's 90 degrees from the Sun, so when the shadows of its moons are on the planet, the moons are mostly off to one side, giving the view the appearance of depth.

Among the things you can't see this month is the annular solar eclipse, with the annular portion visible in a small area of a remote part of Antarctica on the 27th. It'll be a partial eclipse in Australia, if you are going 'down under' this month.

Mercury is too close to the Sun to see easily this month, passing in back of the Sun, from Earth's point of view, on the 26th. Neptune might be observable near Venus on the 12th, but you'll need a telescope and good skies, at least.

Venus sits patently waiting, low in the southeast, well to the right of where the Sun will rise. It's half full (not the same as half-empty) at the start of the month. The phase is easiest to see in a telescope when the sky starts to brighten up. Venus is appearing smaller as it races out ahead of Earth, the same apparent size as Saturn by mid-month.

Speaking of Saturn, the ringed wonder is still a bit late for Prime Time, highest in the sky in the wee hours of the morning. It'll be more conveniently located in the evening sky in May, when it reaches opposition.

Even if you don't have a telescope, use your binoculars to view the Moon encroaching on the Hyades 'V' group of stars in the horns of Taurus the Bull on the evening of April 3rd. The stars will disappear as they pass behind the dark limb of the Moon, an awesome sight, with one of the brighter stars disappearing around 10:15pm EDT. Get out earlier to see the Moon 'sneaking up' on the star.

Look for Venus and the Moon posing together on the mornings of the 25th and 26th. The Moon also appears close to Saturn on the 17th. The International Space Station is visible in the dawn through the 4th and in dusk from the 4th through the 25th.

By April, three new crew members will have arrived via the Russian Soyuz capsule, bringing the station population back up to six. Japan Aerospace Exploration Agency (JAXA) astronaut Koichi Wakata is the station commander, the first Japanese astronaut to command the international outpost.

Old Tool, New Use: GPS and the Terrestrial Reference Frame

by Alex H. Kasprak

Flying over 1300 kilometers above Earth, the Jason 2 satellite knows its distance from the ocean down to a matter of centimeters, allowing for the creation of detailed maps of the ocean's surface. This information is invaluable to oceanographers and climate scientists. By understanding the ocean's complex topography—its barely perceptible hills and troughs—these scientists can monitor the pace of sea level rise, unravel the intricacies of ocean currents, and project the effects of future climate change.

But these measurements would be useless if there were not some frame of reference to put them in context. A terrestrial reference frame, ratified by an international group of scientists, serves that purpose. "It's a lot like air," says JPL scientist Jan Weiss. "It's all around us and is vitally important, but people don't really think about it." Creating such a frame of reference is more of a challenge than you might think, though. No point on the surface of Earth is truly fixed.

To create a terrestrial reference frame, you need to know the distance between as many points as possible. Two methods help achieve that goal. Very-long baseline interferometry uses multiple radio antennas to monitor the signal from something very far away in space, like a quasar. The distance between the antennas can be calculated based on tiny changes in the time it takes the signal to reach them. Satellite laser ranging, the second method, bounces lasers off of satellites and measures the two-way travel time to calculate distance between ground stations.

Weiss and his colleagues would like to add a third method into the mix—GPS. At the moment, GPS measurements are used only to tie together the points created by very long baseline interferometry and satellite laser ranging together, not to directly calculate a terrestrial reference frame.

"There hasn't been a whole lot of serious effort to include GPS directly," says Weiss. His goal is to show that GPS can be used to create a terrestrial reference frame on its own. "The thing about GPS that's different from very-long baseline interferometry and satellite laser ranging is that you don't need complex and expensive infrastructure and can deploy many stations all around the world."

Feeding GPS data directly into the calculation of a terrestrial reference frame could lead to an even more accurate and cost effective way to reference points geo-spatially. This could be good news for missions like Jason 2. Slight errors in the terrestrial reference frame can create significant errors where precise measurements are required. GPS stations could prove to be a vital and untapped resource in the quest to create the most accurate terrestrial reference frame possible. "The thing about GPS," says Weiss, "is that you are just so data rich when compared to these other techniques."

You can learn more about NASA's efforts to create an accurate terrestrial reference frame here: http://space-geodesy.nasa.gov/. Kids can learn all about GPS by visiting http://spaceplace.nasa.gov/gps and watching a fun animation about finding pizza here: http://spaceplace.nasa.gov/gps-pizza.

Artist's interpretation of the Jason 2 satellite. To do its job properly, satellites like Jason 2 require as accurate a terrestrial reference frame as possible. Image courtesy: NASA/JPL-Caltech.

The Universe as a Dream: Quantum Mechanics
by Larry Faltz

Dante had his Beatrice, Don Quixote his Dulcinea, Richard Dreyfuss, in the film *American Graffiti*, the girl in the white T-Bird. Beautiful, seemingly perfect, necessary, promising transfiguration, but forever unreachable. I have…quantum mechanics.

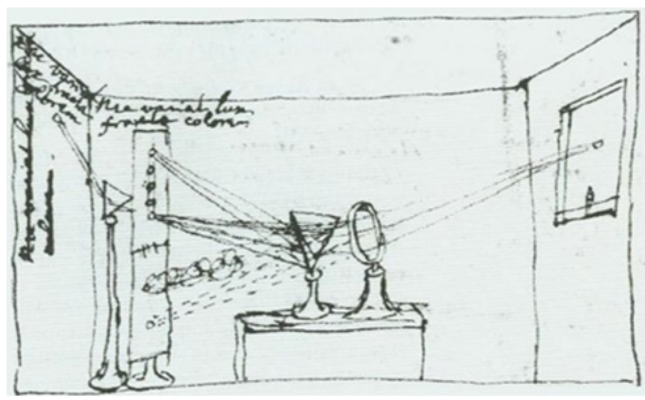
If you consider yourself a scientist, you try to envision the world, bring it into your mind, and create a picture of how things *are*. We want to model the world to find out its rules and its mechanisms. Dante wrote that Beatrice was the "light between truth and intellect." (*Divine Comedy, Purgatorio*, Canto VI) Quantum mechanics is the exact description of the structure of the universe at its fundamental level. Its equations allow us to predict the results of experiments with incredible accuracy, but don't allow us to draw a mental picture of what happens. It works, but we don't know how it works. We may never know. Where's the light?

Over many years of thinking about quantum physics, at least at the level of an informed amateur, I've read at least a dozen books that highlight major elements of the theory, including some that describe its fascinating birth at the beginning of the 20th century and its maturation in the 1920's under the influence of the powerful minds of the day: Einstein, Bohr, Born, Schrödinger, Heisenberg, Pauli and Dirac, among others. As I strive to understand the workings of quantum mechanics, I feel like I'm dreaming. I follow the arguments, but then, putting the book down and contemplating their meaning, the clarity slowly dissolves, as happens when you wake and your dream goes from Technicolor, to black-and-white, to gauzy vagueness and then almost to nothing. The concepts are beautiful, but they're hard to hold.

Quantum mechanics is critically important to astronomy. It's actually important to everything, since it's ultimately the Way Things Work. It's very likely that the Big Bang was a quantum phenomenon, and Inflation, now a fact, certainly was. All nuclear chemistry, radiation and spectroscopy operate by processes that can only be properly described by quantum equations. Electricity and magnetism, which certainly play a large role in astrophysics, are quantum phenomena. The resolving power of our telescopes is a function of the quantum properties of light.

More than any other aspect of science, quantum physics verges on the philosophical. To try to understand its rules means to grapple with the question of *how* it is that we actually *know* anything about the world. Possessing the answer may never be achievable, but it's irresistible to try. I find it fascinating, which reminds me of a quote from Mr. Spock: "Fascinating is a word I use for the unexpected." And indeed, in its details quantum mechanics is completely unexpected.

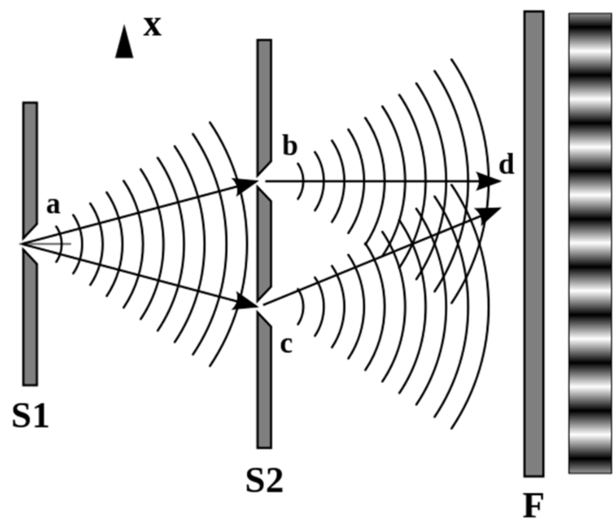
The universe to Aristotle and Newton was a recognizable place. It was smooth and continuous. Things were discrete and moved along specific paths. Phenomena were predictable. Cause led to effect. But not so in the quantum world. The outcome of any quantum process can only be stated as a probability. Position and momentum can never both be exactly specified. Space is not continuous. An electron can get from "here" to "there" without ever being "in between." Photons as they travel may actually be everywhere in the universe at the same time.



Newton's sketch of his prism experiment

Quantum mechanics, like astronomy, is easier to comprehend (up to a point) if you know its history. Scientists build models of the universe on the basis of observation. Newton, in his *Opticks* (1704), conceived of light as particles ("corpuscles") that moved through space, subject to the same gravitational forces as other particles. It made sense (didn't gravity affect everything?--and we know now that it does). He explained the spectrum created by passing sunlight through a prism by postulating that particles of different colors had different masses, and therefore would experience different gravitational forces as they passed through the glass. However, as the 19th century opened, objections to the corpuscular theory appeared because it could not explain certain phenomena.

Thomas Young, a brilliant physician, scientist and linguist, performed a simple but critical experiment in the 1820's. He passed a beam of light through a slit, and then through another barrier with two slits. He argued that the resulting pattern of light and dark areas only made sense if the light was behaving like a wave, with peaks and valleys interfering with each other. He even constructed a "ripple tank" to demonstrate the identical phenomenon with water waves.



Young's double slit experiment

Electricity and magnetism began to be heavily researched in the late 18th and early 19th centuries, and in 1862, James Clerk Maxwell published a mathematical description of these forces (the four equations that bear his name were actually codified by Heaviside 20 years later). He described the interaction of electric and magnetic "fields", which are continuous and fill space. The mathematics uses partial differential equations and other continuous functions (the gradient and curl functions).

$$\nabla \cdot \mathrm{E} = \frac{\rho}{\varepsilon_0} \qquad \nabla \times \mathrm{E} = -\frac{\partial \mathrm{B}}{\partial t}$$

$$\nabla \cdot \mathrm{B} = 0 \qquad \nabla \times \mathrm{B} = \mu_0 \left(\mathrm{J} + \varepsilon_0 \frac{\partial \mathrm{E}}{\partial t} \right)$$

Maxwell's Equations

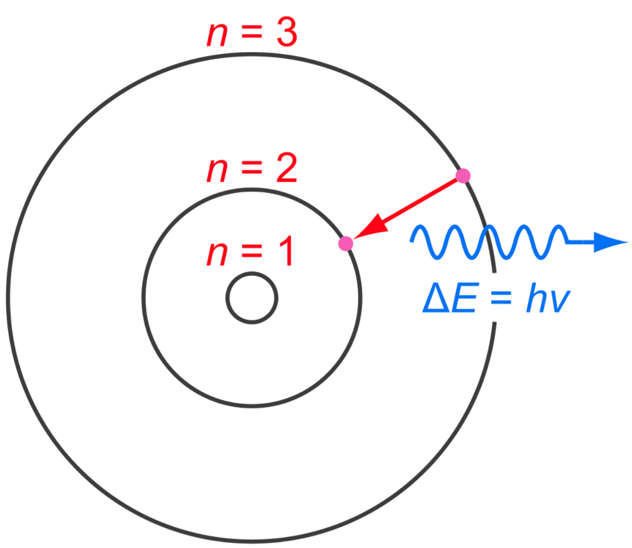
A continuous, differentiable reality is called "classical."

The famous Michelson-Morley experiment in 1887 utilized interference from a split beam of light to prove that there was no "ether" in which electromagnetic waves moved. By eliminating the ether, it challenged the classical construct of space as having substance, but the presence of interference reinforced the wave theory of light.

The view of electromagnetic energy as waves held sway until the beginning of the 20th century. However, a number of new phenomena couldn't be explained using the classical rules, particularly blackbody radiation, the photoelectric effect, and the origin and location of spectral lines. The classical formulation of radiation emitted by a blackbody (for example, a heated piece of metal) at any temperature implied that the emissions should be infinite. This obviously wrong result is known as the "ultraviolet catastrophe". Max Planck suggested in 1901 that the emitted wavelengths could only take on discrete values, which he determined were proportional to a constant, $6.62606957 \times 10^{-34}$ Joule-seconds, now known as Planck 's constant, universally notated as *h*. There was a maximum energy value for the emitted light. However, his argument, based on equations of harmonic oscillators, was a mathematical treatment developed more for the purpose of "saving the phenomenon" rather than actually proposing that there were quantized energies.

Einstein, in one of his four 1905 papers (and the one for which he was awarded the Nobel Prize) made the quantum real. The photoelectric effect, discovered by Hertz in 1887, occurs when light displaces electrons (although they weren't known then as electrons) from a metal surface. It was presumed that raising the light intensity would raise the energy of the displaced electrons (measuring a higher voltage). But what was actually found was that raising the intensity resulted in more electrons being emitted, but they still had the same energy (measuring a higher current). Einstein correctly deduced that this result could only occur if the light itself came in discrete packets, with energies proportional to Planck's constant. "Raising the intensity" of light meant sending more packets of the same energy, not the same number of packets of a higher energy. So Newton's "corpuscles" were reborn. Einstein's interpretation, though, means that electrons, even though they were particles, also have a frequency. Since their energy is described by Planck's formula $\varepsilon = h\nu$, they also must have wave-like characteristics (frequency ν and wavelength λ are properties of all waves, related by $\nu = 1/\lambda$).

Einstein, who was ultimately skeptical of quantum mechanics even though he had pride of parentage (he famously said "God doesn't play dice with the world"), went on to develop the special and general theories of relativity, which describe a continuous, macroscopic reality (and are not compatible with quantum mechanics, even though they both seem to be correct models of the world). At the same time, experimental physics began to probe deeper into the atom. In 1911, Ernest Rutherford proposed that atoms are composed of a tiny, dense nucleus surrounded by a cloud of electrons. This model was based on experiments done two years earlier by Geiger and Marsden under Rutherford's direction. They examined the paths taken by alpha particles passing through a thin gold foil. Just two years later, Niels Bohr proposed that the electrons travel around the nucleus in circular orbits, whose dimensions (and energies) were quantized. The orbiting electron was described by the formula $L = nh/2\pi$, where L is the angular momentum. h is Planck's constant and n is an integer >0. The energy needed to force a jump or released when the electron spontaneously jumps to a lower-momentum orbit is in the form of a photon of a specific frequency v, according to Planck's formula, $\Delta E = hv$ (higher frequency=shorter wavelength=higher energy). These discrete energies account for spectral lines.

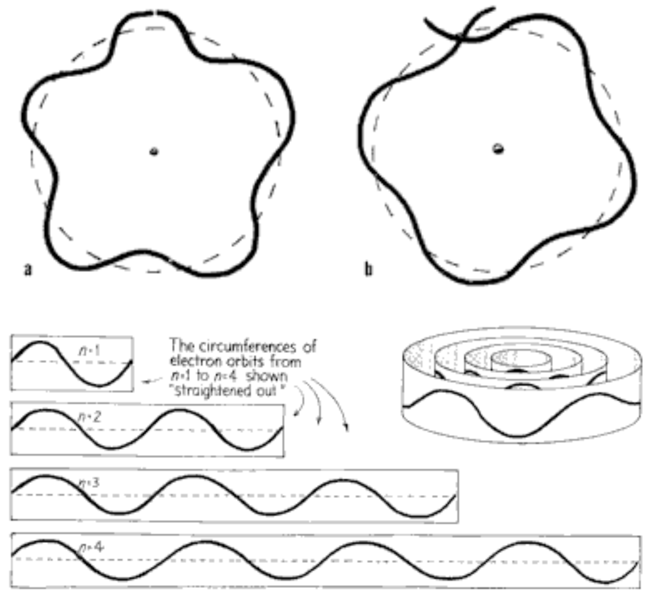


The Bohr model of hydrogen, with a photon emitted as an electron drops from a higher energy level to a lower one (this particular transition gives rise to the H-alpha line, 656.28 nanometers)

Bohr's model explained the origin of the Rydberg constant, related to the spectral wavelengths of an atom. The Rydberg is the most accurately known physical constant, currently calculated and measured to 13 significant digits. In case you need it right away, it's $1.09373731568547 \pm 0.0000000000008 \times 10^7$ m^{-1}.

This model has one interesting property that came to embody the conceptual problem for all of quantum mechanics: the electron, when it jumps from one orbit to another, doesn't spend any time in between. The movement between orbits is not "classical" in the sense that we can plot a trajectory over space and time. Dimension does not enter into the transition.

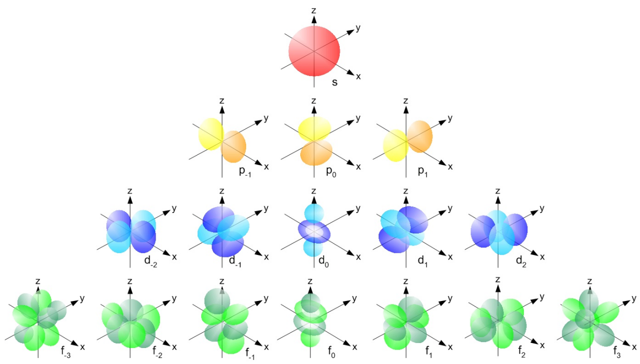
The golden years of quantum mechanics were the 1920's. In 1924, Louis de Broglie postulated that matter, not just energy (photons), had wave-like properties, and when Young's dual-slit experiment was repeated with electrons, the same interference pattern of light and dark fringes appeared. DeBroglie suggested that the electrons had to exist as "standing waves" in discrete integer divisions of their orbital circumference, much like a musical overtone on a violin string is a discrete integer fraction of the string length.



Electrons in orbit as standing waves (a, not b)

Quantum mechanics took its mature form in the mind of Max Born, who correctly merged the wave and particle conceptions into a single, cohesive entity. What Born realized was that the waves that describe photons and electrons are not waves that define their position and momentum in space, but only the *probability* that they will be found in a certain place or have a certain momentum. Furthermore, a photon or electron can be in two places (or more) at once and when that happens it's best described not as being either "here" or "there" but has being in a "superposition" of "here" and "there", only to be "here" or "there" (and not the other place) when we observe it. This is where quantum mechanics gets to be dream-like and utterly fascinating, and where my Dulcinea lies.

In the atom, electrons do not orbit, but exist as clouds of probabilities where the electron might be found, called “orbitals”, defined by several different quantum numbers. Higher quantum number orbitals, those in atoms with multiple electrons, have geometric shapes, which accounts for atoms’ chemical reactivity.



Electron orbitals

The best explanation that I’ve found for non-mathematical readers of how waves describe only probabilities and not certainties is in *Absolutely Small: How Quantum Theory Explains Our Everyday World*, by Michael D. Fayer (AMACOM, 2010). Fayer is Professor of Chemistry at Stanford. His book is primarily about how quantum mechanics underlies chemistry (which is how I first learned it from Professor C. Ronald Breslow in my freshman chemistry course at Columbia). Using the Michelson-Morley experiment as an illustration, Fayer shows that wave-like interference occurs even if a *single* photon is in the apparatus, and he goes on to patiently explain how that can be and why it makes sense to speak of probability amplitude waves rather than merely light or matter waves.

Competing mathematical formulations of quantum mechanics appeared in the 1920’s, the product of brilliant minds and a lot of discussion and arguing, some of it in public at the famous Solvay Conference in 1927. Werner Heisenberg’s matrix mechanics, which was completely non-classical, and Erwin Schrödinger’s wave mechanics, which tried to preserve smooth properties of the universe, were ultimately shown to give the same results, as did the later path-integral approach of Richard Feynman. That the universe is truly non-classical was argued by Bohr, who favored Heisenberg’s treatment over Schrödinger’s. The implication of quantum theory at the end of the 1920’s was that matter is both wave-like and particle-like. Depending on what experiment you do (or what mathematical treatment you choose) you will encounter one or the other of those natures, but never both. This is called “complementarity” and it is an essential feature of the universe at its microscopic level.

Any time we measure a quantum particle, which is the only way we can know anything about it, we disturb it, changing its state and making the assessment of its state before the measurement uncertain. Bohr wrote of

> …the impossibility of any sharp separation between the behavior of atomic objects and the interaction with the measuring instruments which serve to define the conditions under which the phenomena appear.

Heisenberg proved that the position and momentum of a particle can’t be specified to absolute precision. The Heisenberg Uncertainly Principle states that the precision of a measurement of position x and momentum p is given by the equation $\Delta x \Delta p \geq h/4\pi$. Just from the algebra you can see that neither Δx nor Δp can be zero, and since $h/4\pi$ is a constant, the larger Δx gets, the smaller Δp has to get, and vice versa. All books on the subject go through an explanation of this phenomenon. One of the consequences of the wave treatment of quantum mechanics is that if you could measure the momentum of a free electron exactly, its position could be anywhere in the universe, and if you could specify its location exactly, it could have any momentum from 0 to ∞. But you can’t specify its momentum or position exactly.

As you get further into the subject, things get even stranger: superpositions, entanglement, hidden variables, the Bell inequality, non-locality. These are difficult concepts at the limit of my understanding and in any case considering them would be far too complex for this brief article. Here’s where you have to bite the bullet and read one of many excellent books on the subject (in addition to Fayer). A recent non-mathematical treatise that explains the science along with a detailed exposition of the historical development of quantum theory and superb portraits of the players involved is Jim Baggott’s *The Quantum Story: A History in 40 Moments* (Oxford University Press, 2011). Roger Penrose’s relatively concise description in *The Emperor’s New Mind* (Oxford, 1989) combines philosophical and simple mathematical approaches. A more extensive description with some math, including Paul Dirac’s *bra-ket* notation, is Giancarlo Ghirardi’s *Sneaking a Look at God’s Cards* (Princeton, 2004), although this book is translated from Italian and the prose may be a little heavy at times. No one should miss Richard Feynman’s brief and fascinating *QED: The Strange*

Theory of Light and Matter (Princeton, 1985), which takes a mechanistic view, using the seemingly simple phenomenon of the reflection of light from a mirror as a jumping-off point.

Unlike any other field in science, quantum mechanics seeks to explain the very nature of reality. This is what I find most fascinating about it and most difficult to envision. The implication of the Heisenberg Uncertainty Principle is of particular importance in this regard. What do we *know*? Does the evidence of our senses allow us to form a definite picture of how the world is structured and what is cause and effect? Isn't that the purpose, and expected outcome, of science?

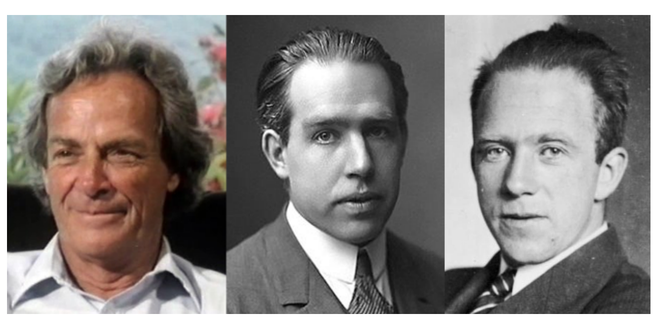
Philosophers and scientists have grappled from earliest times with the dual questions of how the universe is put together and what it means for us to actually know anything. Plato, who believed in an unchanging reality, talked about archetypes in heaven and their imperfect reflections in the real world (his "Theory of Forms"), the famous image of the cave being the example most cited from his work. Aristotle, in his *Metaphysics*, recognized change as a universal aspect of reality and proposed a Prime Mover who was ultimately responsible. Idealism, which had support from Kant, Hegel, Schopenhauer and others, holds that reality is fundamentally mental: everything that exists really does so only in our minds. My symbolic logic professor at Columbia, whose name I've forgotten but our nickname for him, *Modus Ponens*, will be forever remembered (*Modus Ponens* is the logical argument "If P→Q, given P is true, therefore Q is true"), once came into class all excited, with a dab of shaving cream still on his earlobe, because the *NY Times* had that very morning published a story about newly discovered correspondence between the obscure German philosopher Alexius Meinong and famed British philosopher and logician Bertrand Russell, dating from around World War I. Meinong was interested in how we know that things exist, and posed the question "Does the Golden Mountain exist?" Even if it doesn't, Meinong asserted to Russell, merely *thinking* of it gives it some kind of existence. Logical positivists, on the other hand, would deny the existence of the Golden Mountain. They would contend that you can only know what you can observe through scientific measurement. Anything not measured simply does not exist. We can talk about those things but we must acknowledge that when we do so we are in the realm of non-reality, in essence fantasy. Thinking of it does not make it exist. The Copenhagen interpretation of quantum mechanics, which was championed by Bohr and Heisenberg, is essentially a logical positivist view. We can actually say *nothing* about the locations, momenta or energies of particles until we measure them. Until we do they have the quality of being metaphysical, not real. Their properties are only probabilities, embodied in the wavefunction that encodes probability amplitude waves. When we make a measurement, we cause the wavefunction to "collapse" to a discrete value, instantaneously and everywhere in the universe. Then we actually *know* something. Although we can prove that electrons and photons have both particle-like and wave-like features, we can never do an experiment that shows both at the same time. The act of measuring determines the properties of what's measured. That's a fundamental feature of complementarity and a major element of the dream-like quantum world.

Feynman points out that the mechanism of the collapse is an eternal mystery.

> Do not keep saying to yourself, if you can possibly avoid it, "But how can it be like that?" because you will get "down the drain," into a blind alley from which nobody has yet escaped. Nobody knows how it can be like that. (Richard Feynman, *The Character of Physical Law*, 1965)

So trying to understand quantum mechanics is like dreaming of that unattainable, ideal beauty. In a way, it unites the opposites of philosophy: even though it's consistent with logical positivism, accepting it means we have to agree that there are archetypes and ideal forms. Is an electron a wave *and* a particle? Perhaps it's *neither* one, something utterly inconceivable beyond our remarkable ability to write exact rules about its behavior. Isn't the probability amplitude wave, which has both real and complex (a multiple of *i*, the square root of -1) components, something like an ideal Platonic form?

Well, maybe we shouldn't really worry. Feynman, one of my candidates for smartest person who ever lived, once wrote, "I think I can safely say that nobody understands quantum mechanics."



Feynman, Bohr, Heisenberg

New Planetarium at the Hudson River Museum
by Pat Mahon

Once the long time abode of our WAA meetings, I was pleased to have received an invitation to attend the March 6th reception for the unveiling of the new planetarium at the Hudson River Museum in Yonkers. That evening I stepped into an atmosphere charged with political personalities, museum enthusiasts and the presence of the Channel 12 news media.

Undaunted, with drink and hors d'oeuvre in hand, I went over to say hello to Channel 12's Joe Rao. Upon eyeing my WAA I.D. badge, he immediately began to reminisce about how much he always enjoyed being one of our guest speakers. Unfortunately, a prior 8pm news commitment for Channel 12 prevents him from continuing in that role. However , Joe would like us to know that he will be a guest lecturer at the up and coming NEAF where he will be speaking on the large meteor shower anticipated for May. Always a fan of the WAA, Joe will be stopping by our booth to visit with us and to say hello.

Our large socializing group eventually found themselves being led down through the side corridors towards where we were to witness the main event of the evening. Along the way I met up with our old friend, the Zeiss M0 1015 (1987-2013) projector. Built in Oberkochen Germany, it possessed the capacity of producing 5,000 stars, which at the time was comparable with other planetariums such as the Hayden. Nevertheless, years of technical malfunctions coupled with a shortage of replacement parts warranted the HRM to search for a new planetarium system. Upon being ushered through the planetariums' entrance, we were each given a fluted glass of champagne.

The program began with welcoming remarks by the museum's director, Michael Botwinick. This was followed by Yonkers Mayor Mike Spano who spearheaded the financial effort by Yonkers for the new planetarium. He spoke of how he enjoyed coming to the planetarium while he was growing up and how important it was to continue its educational programs, especially now that it has become part of an elective credit in Astronomy/Physics taken by students in the Yonkers public schools.

Upon lifting our champagne glasses, the Mayor, under the guidance of Marc Taylor (planetarium manager), executed a series of steps which resulted in the activation of HRM's new computerized-optical projector known as the MEGASTAR II. Although manufactured by Ohira Tech, this newest technology was originally conceived in the mind of a Japanese engineer by the name of Takayuki Ohira. Less cumbersome than the Zeiss, it is a compact unit of 46 cm in diameter and weighs 27kg. It's basic design employs a star globe, a star plate and an ultra bright LED light. It can produce a visual of 10 million stars in comparison to the 5,000 by the Zeiss. In addition, the planetarium utilizes 2 digital video projectors and the Digital Sky 2 software by Sky-Skan. The planetarium uses a vast database compiled by NASA. The total cost was $1.5 million dollars.

Retrieving the controls from the honorable Mayor, Marc Taylor took over “the helm” and transported us back to the evening skies of September 12, 1609. It was as if we had been with Henry Hudson as he anchored his ship, the Half-Moon, in an area which was later to become the city of Yonkers. Marc made mention that the planet Saturn had been part of the observable sky on that night. Imagine the absence of light pollution!

Marc Taylor then proceeded to give a 20 minute demonstration of the capabilities of the MEGASTAR II--how it would enhance the planetarium experience of the audiences which would follow. The broad spectrum included the creation of orbital planes, a close range visual of planets and nebulae, three-dimensional star clusters, infrared and weather images; and last but not least, the landing of Curiosity on Mars. The versatile MEGASTAR II can run commercial shows as well as original shows based on one's own design.

As the lights of the dome were raised, the audience expressed how truly impressed they were by what they had experienced. Following the fanfare of press interviews, I went over to Marc to congratulate him on behalf of the WAA and to wish him well. Always happy to see a representative from the WAA, he graciously began to explain the controls on the computer console required to perform basic maneuvers by the projectors. He then instructed me to take a seat in the now emptied planetarium, as he lowered the lights and brought over an iPad with controls identical to those found on the larger console. Under Marc's tutelage, I was able to bring up and maneuver various planets, star clusters and an infrared of the Sun.

I highly recommend taking advantage of what the HRM's planetarium has to offer, whether by group or single visit. Increased financial backing has given them extended hours of operation. They currently are running 3 shows geared to different levels of audiences. However, I am confident it signifies the beginning of things to come. Please check out their web site at: http://www.hrm.org/

During my conversation with Marc, he told me of one of his ideas which he would like to try with the new planetarium. He would like to mount a camera on a telescope from the outside and feed live images into the planetarium onto the dome for people to view. I found that to be a rather intriguing idea. What an interesting participatory undertaking that would be for a certain astronomy club that I know (I will leave it for your consideration).

The manning of the computer console controls had been a lot of fun for me. It was then I realized that I had been given a rare opportunity by someone, namely Marc Taylor, who thinks the world of the Westchester Amateur Astronomers or better known as, the WAA.

Suggested Reading: A Student's Guide to Maxwell's Equations

reviewed by Tom Boustead

While reading Larry's article, "The Universe as a Dream: Quantum Mechanics" (see page 5), I once again came across a reference to Maxwell's equations. As an avid reader of astronomy books, that happens a lot. After all, aside from a few Moon rocks the bulk of what astronomers know about the universe comes from analyzing the electromagnetic spectrum. Astronomers dissect each cranny of spectrum with an impressive array of instruments--the Fermi Gamma-ray space telescope, the GALEX ultraviolet scope, the Spitzer infra-red scope to name just a few examples.

Maxwell's equations provide the classical description of electromagnetism. The equations look daunting, especially when college calculus is an uncomfortably distant memory. But if you're willing, Daniel Fleisch's short book, *A Student's Guide to Maxwell's Equations* (Cambridge University Press), can help ease the path.

Dr. Fleisch, an associate professor of Physics at Wittenburg University, doesn't eschew the math; he explains it. The book is divided into five chapters, the first four dealing with the equations:

(1) Gauss's law for electric fields $\nabla \cdot \mathrm{E} = \frac{\rho}{\varepsilon_0}$

(2) Gauss's law for magnetic fields $\nabla \cdot \mathrm{B} = 0$

(3) Faraday's law $\nabla \times \mathrm{E} = -\frac{\partial \mathrm{B}}{\partial t}$

(4) Ampere-Maxwell law. $\nabla \times \mathrm{B} = \mu_0 \left(\mathrm{J} + \varepsilon_0 \frac{\partial \mathrm{E}}{\partial t}\right)$

Each of these chapters is further divided into two sections--one dealing with the integral form of the law the other with the differential form of the law. Two roads to the same destination (the differential forms are shown above).

For each equation, Fleisch starts with a plain description of the equation. So, for Gauss's law for electric fields, he states "The left side of this equation is a mathematical description of the divergence of the electric field--the tendency of the field to 'flow' away from a specified location--and the right side is the electric charge density divided by the permittivity of free space." Dr. Fleisch does not leave the reader hanging but instead embellishes upon each term such as the meaning of a "field" and the "permittivity of free space."

Next comes a succinct statement of the main idea of the law. For Gauss's law: " The electric field produced by electric charge diverges from positive charge and converges upon negative charge." Thereafter, each symbol of each equation receives its own section explaining its meaning. For example, there is a section explaining nabla ∇ as an operator and another on how nabla when dotted with "E" forms the divergence of the electric field. All of this is explained at an intuitive level aimed not only at science/engineering students, but also at life-long learners in general.

The final chapter shows how Maxwell's equations lead to the wave equation and reveals how the equations in combination provide a theory of electromagnetism. There is a website for the book, which includes podcasts on the chapters and solutions to the problems.

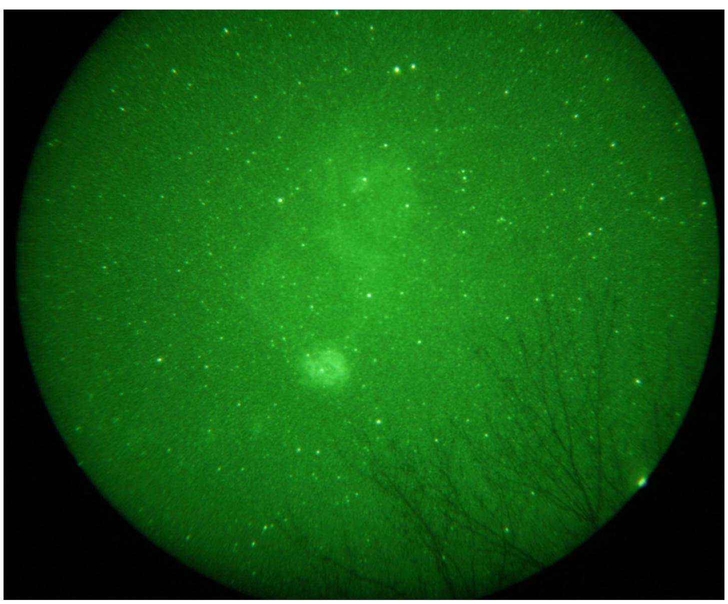
Westchester
Amateur Astronomers

Astrophotos

◀Barnard's Loop

John Paladini captured this image of Barnard's loop in Orion with a 50mm lens using the Binocular Photon Machine (BiPH). He enhanced the image with Photoshop.

Barnard's loop is an emission nebula thought to be part of a large molecular cloud that includes the Orion nebula and Horse-head nebula. It is about 1600 light years away and 300 light years across.



◀Rosette Nebula

John Paladini also captured this image of the Rosette nebula in Monoceros (Caldwell 49) using the BiPH.

The Nebula lies some 5000 light years away and spans some 155 light years. Notes John: I like shots that show trees; it help give apparent size